NEW COMPLEXITIES:

converging spaces of connectivity, communication, and collaboration

Kingsley L. Dennis

BA English Literature & American Studies
MA Globalisation, Identity & Technology

Submitted for doctoral degree in Sociology
November 2006

Department of Sociology
Lancaster University

‘…we are not just an accidental anomaly, the microscopic caprice of a tiny particle whirling in the endless depths of the universe. Instead, we are mysteriously connected to the universe, we are mirrored in it, just as the entire evolution of the universe is mirrored in us…The moment it begins to appear that we are deeply connected to the entire universe, science returns…in a roundabout way, to man and offers him his lost integrity. It does so by anchoring him once more in the cosmos’

Vaclav Havel – ‘The New Measure of Man’

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ACKNOWLEDGEMENTS

My thanks go to my supervisors John Urry and Adrian Mackenzie for their smooth steersmanship, collegiality, words of experience, and for turning this wayfarer into a more acceptable associate of academic research. I have greatly appreciated their involvement and consider this to have been a significant part of this rewarding journey. I owe them a great deal of respect.

Thanks also go to those individuals in the Sociology department who have shown many kindnesses and support, and for answering many queries along the way. The Sociology Department at Lancaster has been an incredibly supportive environment in which to work, develop, and learn.

Thanks to LD – for providing the space & place for work and peace. I'll think of you when I'm gone.

Babu – thanks for offering the caravanserai for chai and chat upon this complexifying voyage. I'd like to think we found order in this chaos (and didn't feed the moon!)

Finally, my immeasurable gratitude extends to my parents – Jeff & June – for their unconditional love and support. Always and in Everything.

I thank this Universe for conspiring with my Will.

'Alterius non sit, qui suus esse potest'

I declare that this thesis is my own work and has not been submitted in substantially the same form for the award of a higher degree elsewhere.

ABSTRACT

The 1990s saw the social sciences engaging with complexity in terms of books, articles, conferences, and workshops, leading some to label this more modern incursion into the social and cultural sciences as the *complexity turn*. This thesis examines this very notion of a *turn* and maps the shifts in discourse, theory, metaphors, and epistemological framings of knowledge. It asks the question whether the social world has changed significantly enough to warrant a shift in discourse towards complexity theory. Emerging trends such as the convergence of physical-digital scapes, social movements and locatedness - as exemplified by ad-hoc social networks via text messaging - blogging, and digital mappings are analysed and evaluated through the lens of complexity theory. Recent phenomena suggest that the observer is increasingly a part of observed systems, and as such complexity is questioned in its usefulness to analyse and understand these positions. The research I present here emphasises the *new complexities*: the re-configuring patterns of connectivity, communication, and collaboration. This constitutes not only an epistemological shift from structure to process thinking, but also in the understanding of the ubiquitous and pervasive nature of embedded physical-digital networks, and the increasing complex convergences between the two. Technologies that facilitate mobile communications – such as the mobile phone/SMS messaging and web-based applications – inform emerging patterns of mobility such as self-organised protest grouping ('smart mobs'), and physical-digital locatedness. Such 'complex mobilities' seem to be dynamic, nonlinear, and utilise information feedback flows. This thesis offers a complexity perspective on these developments and addresses the issues involved in contemporary debates on mobilities from this viewpoint.

INTRODUCTION

> 'The opportunity to become Renaissance people or solve complex problems in interdisciplinary teams has been increasingly lost. PhD research has become so narrow and deep it has almost become invisible.'
>
> Joseph Pelton (2000)

Although historical epochs often involve change, those changes have often not been perceptible to those living at the time. The early years of the twenty-first century are no exception: they seem to have been, and continue to be, times of great changes, shifts, developments and flux. The world appears to be incessantly in flux and susceptible to impacts, whether local, global, or non-terrestrial; and constantly adapting to social and environmental influences. Previous historical epochs contain their own examples of a world of flows, of dynamic change and processes of non-causality. The Chinese *Book of Changes* (often referred to as the *I-Ching*), as well as early Greek thinkers such as Heraclitus show early attempts at integrating inter-linked processes, movement and unexpected phenomena into accounts of the everyday world (Loye, 1991). More recently, technological advancements have allowed many global social, economic, geophysical fluctuations to be visualised, mapped, and analysed to an extent not possible in previous epochs. Today it is possible to learn more about what is happening in the global world, whilst simultaneously 'knowing' less about the unpredictability of multiple global processes, especially at a time when global flows of people, information, and artefacts have escalated significantly in degree and intensity. It has been an ongoing human project to learn about how the natural and social world operate, and to gain mastery, or at least knowledge/control, over some of these processes. From gods to guardians, the responsibility and interdependency with the world has induced a need to know. Within this need to know is situated sociological thought, amongst many other fields.

Earlier attempts to theorise political and social forces, such as in the writings of Karl Marx and Friedrich Engels (1952/1848) can now be viewed in the light of dynamic interrelations that can produce effects greater than the sum of their parts. In reference to Marx, Urry notes how relations of production can be understood not only as the outcome of linear social processes but also as being produced by the inherent necessity of contradictions as fundamental to change (2005a). In the literature of the social sciences there are instances where historical dynamic forces that somehow do not quite sit comfortably within existing theoretical restraints have tried to be accounted for (De Landa, 2000). Philosophy too has had to deal with the ebb and flow of dynamic processes and energies. Instability and unpredictability are reminiscent of Nietzsche's view of the world. As he writes in *The Will To Power*:

> And do you know what "the world" is to me? Shall I show it to you in my mirror? This world: a monster of energy, without beginning, without end; a firm, iron magnitude of force…as a play of forces and waves of forces, at the same time one and many, increasing here and at the same time decreasing there; a sea of forces flowing and rushing together, eternally changing, eternally flooding back…out of the simplest forms striving toward the most complex, out of the stillest, most rigid, coldest forms toward the hottest, most turbulent, most self-contradictory, and then again returning home to the simple out of this abundance. (Nietzsche, 1968/1922: 550)

The ebb and flow, from the complex back to simplicity again, from cold and rigid to the hottest, characterise moments of extreme fragility and sensitivity, and the thin line between order and chaos. Nietzsche was describing a world he saw as being formed through forces of turbulent energy.

This thesis will take the position that the 21st Century is an era where 'complexity' is becoming a major metaphor, model, and mode of analysis for occurring changes and events; and that an understanding of complexity theory is essential for an understanding of dynamically interrelated global processes and occurrences. Today's forms of mobility suggest that lives are increasingly lived in fluid relations where electronic information flows, material and virtual bodies, and physical locations are intersecting and integrating in more prolific, engaging, and interesting ways. As networks of movements and relations move beyond boundaries, the issue is whether the 'social' remains fixed - whether by conception or imagination or through everyday lives. The social can be imagined as becoming ever more filled with the *élan vital* of global flows; a new form of vitalism as the material world becomes more permeated with the continuity, the flux-flowing-becoming as described by Bergson (1944/1910). This seems to find a correlation with Durkheim's notion of 'organic solidarity' (1984/1893) in which a complex division of labour sees individuals as ensuring their interdependence, and development of social ties, through acquisitioning different functions within the whole. This newer division replaced the previous mechanical solidarity found through kinship, religious, and other formalized ties more prevalent in smaller communities. The parts that individuals play within organic solidarity were likened by

Durkheim to organs within a living body, in a manner which has been generally construed as a functionalist approach.

More recently, however, this functionalist strand of thought has been updated by a handful of modern theorists who posit the concept of living/social systems, and the globe, as a super-organism/brain (Bloom, 2000; Heylighen and Bollen, 1996; Miller, 1978; Russell, 1995; Stock, 1993;). These ideas can be seen as forerunners to a real-time global environment interconnected through communication technologies. Durkheim's claim that society, as an object, is made from more than an association of individuals suggests that it forms a whole greater than the sum of its parts (Durkheim, 1984/1893). In the context of emerging global relations those 'parts' are not bounded by the nation, nor are they defined to particular material locations. In this present era of uncertain futures it is necessary to update Durkheim by introducing dynamism and unpredictability into the social system, and to re-evaluate what it meant by social equilibrium. In this thesis I argue that mechanisms of social cohesion cannot be explained by processes of positive equilibrium maintenance. In some ways the dynamic instabilities and energies contained in Nietzsche's writings are more relevant. The social sciences increasingly recognise that global processes function within varying degrees of chaos; that positions of stability are achieved within dynamic states, and as such the 'social' is in continual phases of negotiation, informed through flows, processes, and increasingly complex global interrelationships.

In recent decades there has also been a shift in discourse away from mechanistic Newtonian epistemologies towards systemic thinking (Capra, 1985). The systems thinking to emerge in the 1950s came out of cybernetics and moved towards characterising systems as being open and sustained through flows of energy, rather than the earlier cybernetic forms of closed systems. And systems thinking, the language of process thinking and networks, began to be informed through new discoveries in the natural sciences, such as in molecular biology. Discourses in the social sciences too began to be more transdisciplinary as solutions and additions to social phenomena were sought from more and varied sources. It became necessary to find ways to understand and evaluate apparently increasing patterns of conflict, unpredictability, flows, dynamic equilibrium, breakdowns, breakthroughs, and transnational relations. Approaches that proposed linear analysis and closed systems became increasingly unsatisfactory in providing means to interpret nonlinear global interrelations and social formations. The issue then was in how social science could effectively analyse patterns of non-causality, where small anomalies or impacts can result in large-scale shifts; where multiple actors/parts of a system can create emergent 'whole' effects greater than the sum of the system's parts; where phases of equilibrium are maintained not through stability but dynamic instability or 'order through chaos'; where contradictions work as part of a system; and when decentralised and bottom-up processes are increasingly becoming more effective against top-down hierarchical structures.

In this thesis I put forward the notion that complexity theory, as part of the complexity sciences, is valid and important for social science in order to better grasp and contend with dynamic change and flux. According to a major report from the Gulbenkian Commission:

> nonequilibria, with its emphasis on multiple futures, bifurcation and choice, historical dependence, and, for some, intrinsic and inherent uncertainty resonates well with important traditions of the social sciences. (GCRSS, 1996: 64)

Complexity science not only resonates well with traditions of the social sciences, it also may help to bridge the gap between the natural and the social sciences, between disciplines and fields of knowledge. It encourages, and in some way demands, a shift to systemic thinking. Complexity thinking also urges a break from mechanistic, linear, and causal methods of analysis towards viewing interdependence and interrelation rather than linearity and exclusion. Processes, flows, feedback cycles, fluctuations, networks, order from chaos, and dynamism are all features of the complexity sciences. These phenomena are not new, yet it is timely that they be dealt with as part of social analysis of trends, both local and global. This thesis argues that not only is complexity theory timely for analysing a world increasingly characterised by events not easily understood by linear frameworks but also that a 'complexity lens' provides a better grasp on seeing the possible paths that current trends may take. A complexity theory perspective engages with a future world that is unpredictable, uncertain and often on the fringes of instability, whilst also maintaining adaptability, re-configuration, and non-randomness. Complex systems may involve chaotic relations yet they also make room for discernable patterns.

This approach towards dynamic systems also displays similarities with the 'paradigm shift' theory of scientific development proposed by Thomas Kuhn (1996/1962). Here, Kuhn notes how advancement and progress is not a smooth, linear process but rather occurs when the existing stability of accepted thought is destabilised by the perturbations caused by emerging anomalies. In order to regain stability, the anomalies that can no longer be ignored or excluded form the core of the new body of accepted knowledge, thus affecting a 'jump' to a new paradigm. In biology too there are parallel findings. Palaeobiologists Stephen Jay Gould and Niles Eldredge in 'Punctuated Equilibria: An Alternative to Phylogenetic Gradualism', first published as a paper in 1972, described how evolution occurs not as a smooth process but when a dominant group within a species is environmentally destabilised and overtaken by subspecies on the periphery (Eldredge, 1985). Again, the dynamic 'jump' manifests here within the body of neo-Darwinian biology.

All of these shifts mentioned, from philosophy to evolutionary biology, mark what Capra, writing in the early 1980s, referred to as a *turning point* (Capra, 1985). More recently, Urry has noted that the 1990s saw the social sciences engaging with complexity in terms of books, articles, conferences, and workshops that began to spring up, leading him to term this as the *complexity turn* (2005b). This thesis deals with this very notion of a *turn,* or paradigm shift: a comprehensive shift in thinking and understanding. In this thesis I map the shifts in discourse, metaphors, models, and epistemological and ontological framings of knowledge. The thesis puts forth the notion that complexity theory is a useful and legitimate tool with which to analyse and evaluate some current trends within global phenomena. Yet the very idea of 'complexity' is itself a trend: it can itself be over-applied and over-enthusiastically appropriated for myriad purposes – a panacea for the social sciences. Complexity theory has already, to some degree, infiltrated aspects of New Age thinking and various ecologically-minded treatises (Thrift, 1999). I will be more cautious.

One of the central questions I pose early on is why some systems do not always run down, as would be expected from the presence of entropy and the second law of thermodynamics, but instead develop and complexify. In living systems the answer would lie in the constant flows of matter-energy-information that behave as an open system. Thus, one of the central concepts of this thesis is to examine the degree to which information and communication technologies constitute open systems that use information in a similar way to which energy is used in living systems. This is not to make the reductionist argument that social systems of communication resemble living systems, or vice versa. Rather, it is to examine the resonance of patterns and behaviour that cross over disciplines, in order to better understand the various influences that increasingly pervasive informational systems are posing in people's daily lives.

This thesis examines complexity theory within the domain of the 'social'; that is, I have deliberately shifted complexity discourse from its origins in the natural sciences over to the social so as to approach the subject not as a natural scientist but to use and see it as a model for understanding social phenomena. In this manner complexity theory is a lens used to view the movements and mobilities of people, artefacts, and information. This approach requires a familiarity with both the technical discourse of complexity from the natural sciences, as well as a familiarity with sociological discourses and theories. In this thesis I present some of the technical background so as to explain the processes that characterise complex phenomena. However, the main emphasis here is on the metaphors and models of complexity that can be used – in ‘performance’ – to better explain various social phenomena. The readings covered in this research are diverse and range from some of the natural sciences, including biology and quantum physics, to sociological and popular literature on socio-tech mobilities including the latest research on mobile phone and Internet usage.

I also use a combination of methods in my research. First, and foremost, there is the combination of desk and web-based research: the tracking of weblogs, online communities, mobile users, and the latest up-to-date information on social networks. For my research on protest groups and smart-mobs (Chapter Five) I tracked online communities and their discussions about these activities, as well as individual responses published on the Internet. Qualitative Internet research was undertaken to examine the scale and significance of the use of information with first-hand reports from various users and ‘smart mob’ participants. Similarly, for my research on the Indian Ocean tsunami (Chapter Six) I spent three months tracking websites, blogs, and online media sites to gather information on how people were articulating a response. This involved following blog-tracking sites and both first-hand, second-hand, and third-hand accounts of the experience and critical comments upon the individual and collective relief efforts. I also monitored several relief organisations as well as various emergency responses and followed their published recommendations.

Further, using a news aggregation software I was able to keep track of the latest postings on specific topics. I also kept a regular presence within the blogosphere in order to follow reactions to some of the latest developments in networking communications, which formed a large part of my web-based research. In this manner I moved from close-up 'reflexive positions' within the complex flows of online information, to more distanced and critical positions. Due to the nature of the Internet some of the data gathered, such as Internet and blogging statistics, can become rapidly superseded and out-dated. This thesis presents the data as recent as is possible bearing in mind the delays inherent in getting research into print. I attempted to position myself as close to 'real-time' events as possible through online networks, with observations being rendered more objective when transferred to written analysis.

Secondly, I have collected together quantitative data to examine the extent, scale, and significance of the impact of new technologies on communication, via various statistical reports and online-tracking sites and databases, etc.

Finally, I use textual analysis within a wide range and breadth of domains, such as the social sciences; telecommunications; physics; quantum mechanics; geography; future studies; evolutionary socio-cultural theory; and trade press books.

This thesis is thematically divided into two parts: Part One, Chapters One – Four, deals with theorising complexity; both the epistemological background as well as contextualising the emergence of complexity theory within the social sciences. A much broader historical perspective was used for this theoretical framing of the research. Part Two, Chapters Five – Eight, presents research on complexity theory as applied to particular social events; in other words, complexity 'in performance' using some case studies. This approach presents a shift in how the material is dealt with, as the research moves from a theoretical and historical positioning to one where events are more recent and happening close to 'real-time'. In this regard my position relative to the material has had to become more involved and reflexive; a kind of reflection upon the reflexive characteristics of complex systems. The events I discuss in Chapter Five, social organisation around mobile phones and blogging networks, involved tracking and tracing the flow of debates, news, and 'chatter' on these issues, some of which were several months old, to others which were very recent in the blogging community.

In Chapter Six especially, where my research engages with a complexity theory analysis of social movements and networks around the response to the Indian Ocean tsunami, much of the material available was close to real-time, which forced me to adopt a more distanced and critically reflective position when writing up. In such a quick-time environment the information, debates, reflections and responses were moving rapidly, and so any critical reflection in my research must necessarily 'freeze' such moments. However, this provides an opportunity to move between immersion in both micro and macro practices. By this I mean that a micro-engagement was possible whereby I discussed and outlined some of the bottom-up 'on-the-ground' behaviour of participants involved in the events and action. At the same time I was able to pull back from the events and view the larger social and systemic patterns of behaviour as a means to contextualise these particular case studies within a larger complexity theory framework. In both instances my approach was to maintain an observer's position rather than that of participant in order to preserve a critical engagement and perspective.

Thus, in regard to the research of this thesis I have a two-fold position. Concerning the historical and theoretical contextualisation my position is from a distanced critical and analytical perspective. However, for some parts of the case studies research it was necessary for me to adopt a more drawn-in engagement in order to both follow events that were happening closer to 'real-time', as well as to strengthen my experiential contact with the reflexive practices of which I was observing. This movement in my critical and reflexive positioning was required to enable me to gain a more complete understanding of the complex flows of information and social action, and for me to better understand how a complexity theory approach could be made relevant to these issues and events. I turn now to describe the chapters in greater detail.

Chapter One begins by examining the rise of the complexity sciences through earlier academic developments and disciplines such as cybernetics, general systems theory, information theory, and chaos theory. It traces the empirical shift from mechanistic and linear viewpoints into the paradigmatic 'turning point' (Capra, 1985) towards a systemic understanding of feedback-responsive processes. Here, the discourse is shown to have changed from one of structures to one of process; from closed systems to open systems; and from linear causality to dynamic far-from-equilibrium states at 'the edge of chaos'.

Chapter Two considers the multiple and complex sites where complexity theory is produced and consumed as discourse and methodology. The research examines the many overlaps, and interplays, where aspects of the complexity sciences have crossed over into other disciplines, and are being appropriated within the social sciences. The locations examined are urban growth and policy studies; art and literature; business management; war; civil society; and Gaian thinking. Notions of complexity theory in civil society, which are to be addressed later in the thesis, find an early place in this chapter.

Chapter Three focuses on how the complexifications of social processes are aligned with the irreversible flow of increased availability of free energies, and that historical processes manifest long periods of little change interspersed with periods of rapid change. The complexity discourse in this chapter views technologically driven social change as interrelated with increased flows, storage, and consumption of energy. Here is seen the importance of information flows: information as a catalyst for increasing complexity and as a core component to understanding complex systems. Thus, information technologies are shown to both develop and harness the transmission, storage, and utilisation of information, aligning such technologies within the scope and parameters of the complexity sciences. Also examined in the context of complex informational flows are biological information (bacterial evolution and genomic webs); information and entropy; and cultural information.

Chapter Four examines the structures of networks and how complex systems contain and incorporate networks. I examine how at both the micro levels (biological), and the macro (transport, telecommunications, etc.), processes are often interpreted through analogies and understandings of the network. This recent emergence of networking metaphors, epistemological framing, and arguments have also developed into using complexity models, from the complexity sciences, as becoming a legitimate approach to examining tenets of the global infrastructure, whether it concerns information/data flows, financial markets, transport routes, travelling and mobility of people and artefacts, amongst others. Recent emerging collective groupings that form through complex arrangements of informational networks are addressed in the concluding part of Chapter Four. Issues here include that of collective intelligence, mobile social movements, blogging, and other non-physical modes of interconnectivity and 'meetingness'.

Chapter Five describes how newly emerging technologies of information and communication sharing are contributing to a shift in social dynamics of presence and action. The focus is on both mobile and Internet-based technologies – the mobile phone, and blogging specifically. The chapter shows how social information-sharing, non-localised formations/movements are beginning to infringe on, influence, and change the behaviours of social practice. The discussion focuses on how emerging technologies of mobile phone communications are shaping, and being shaped by, social practices; such as grassroots protest movements. Further, I examine how technologies of communication are being appropriated and adapted into social practices of mobility and complex groupings, and the feedback of technologies to facilitate this. The research takes several empirical events and case studies to show how new technologies are enmeshed with increasing civil practices. This line of enquiry asks whether such cumulative efforts are facilitating the emergence of a newly constructed global civil society. I address whether complexity theory can offer significant understandings on the formations of spontaneously mobilised crowds, organised and coordinated through mobile phones and text messaging. Finally, Chapter Five examines the rise of the blogosphere and blog demographics, and analyses this through the lens of complexity theory.

Chapter Six continues with blogging/phone networks and examines how mobile collectives can be formed in both local and global groupings, both physical and digital, in order to work together, as individuals towards a collective goal. The research looks at the response to the December 2004 Indian Ocean tsunami disaster and examines how mobile communication devices, as well as the Internet, were used, both individually and in clusters, in order to bring safety, survival, and relief to many affected people. The chapter begins by discussing the literature on the traits and benefits of collectives – the 'wisdom of the crowd' scenario - before examining the Indian Ocean tsunami disaster in order to elicit working examples of emerging practices of complex and mobile connectivity and information flows. I suggest here that complexity theory is able to offer a more appropriate analysis of events that accounts for the self-organising nature of the response to the disaster, as well as the nonlinear nature of post-tsunami networks of technically-mediated groups. I show that the 'success' of the response can be accounted for through emergent effects and that, consistent with complexity theory, many of the participants were unaware of their relationship to the whole event, yet were nonetheless instrumental in the overall emergent dynamic system established during this time. Using complexity theory I then address what this implies for the future of global informational networks in terms of both security and social connectivity. My research thus looks at systemic responses to disaster relief, the role of mobile phones in disaster recovery, blogging disaster relief (web complexities of action), and subsequent preparations for a collective response.

Chapter Seven examines how recent interrelations of complex flows of connectivity and information are contributing to more bottom-up, and distributed, forms of civil participation. This chapter examines aspects of global civil society and argues that complexity theory offers a constructive analysis of increased strategies of civil participation and cooperation in the global social sphere. I examine this claim in reference to several urban projects in civil participation, including grassroots digital mapping, and show how complexity theory describes these dynamic webs of engagement. Drawing on previous research into blogging and mobile phone ad-hoc networking this chapter shows that these practices are the forerunner to a more significant global civil society that is increasingly showing signs of distributed activity. I again argue that complexity theory is a useful lens in which to view, analyse, and comment upon these social practices. In this context are also examined 'technologies of cooperation', whereby an increasing number of individuals who are investing in information-access, increased mobility, and knowledge-sharing, are also investing in multiple networks of participation, contribution, and cooperation. My research here addresses the new scapes of mobility and social connectivity that are being largely driven by user-created applications. Also discussed are technologies of non-cooperation, which is a forerunner to some of the discussion on 'clandestine complexities' in the final chapter.

Chapter Eight, the final chapter, begins by addressing social time in terms of the hyper-complex and satellite and GPS technologies. This leads to a discussion on military technologies and forms of distributed and networked surveillance. Also discussed is the military approach taken to complexity as informing a vision of *full spectrum dominance*. The chapter then examines complex cartographies of digital mapping: how digital geocoded data and information is replacing traditional cartographic methods of landscape mapping through layering simulations of geophysical data obtained through satellite imaging, and physical environmental sensors. The research here on socio-technical forms of complex global processes and phenomena concludes by suggesting present trends are heading into a new era whereby social environments become increasingly permeated by ubiquitous computing and networked objects. Again I argue here that complexity theory is an appropriate epistemological tool with which to analyse and understand the merging of physical-digital spaces. I conclude by highlighting possible future(s) suggested by this convergence of spaces and information flows.

The research presented in this thesis contributes to what has been termed the *complexity turn* (Urry, 2005b). Although the social sciences have previously worked with complexity in such areas as economics (Arthur, Durlauf and Lane, 1997), history (Artigiani, 1987; De Landa, 2003), culture and the arts (Hayles, 1991; Taylor, 2001; Cilliers, 1998), philosophy (Rescher, 1998), and sociology (Byrne, 1998; Chesters and Welsh, 2005; Cilliers, 1998; Eve, Horsfall and Lee, 1997; Law and Mol, 2002; McLennan, 2003; Thrift, 1999; Urry, 2003a; 2005a), it has lacked an engagement with the emerging convergences of physical-digital scapes, movements, and locatedness as is exemplified in the research here on ad-hoc social networks via text messaging, blogging, and digital mappings. My research emphasizes what I term the new complexities: the re-configuring patterns of connectivity, communication, and collaboration. This constitutes the very notion of a *turn*: not only as a paradigm shift from structure to process thinking, but also in the understanding of the ubiquitous and pervasive nature of embedded physical-digital networks, and increasingly complex convergences. The main argument of this thesis is that changes in social communications and technically-mediated information flows and connectivity make it imperative to use and develop complexity theory in order to better understand social processes that are dynamic and nonlinear, and for increasingly interdependent relationships of people, artefacts, and information. Thus, this thesis offers a creative perspective on these developments and attempts to pose some significant sociological questions.

CHAPTER ONE

Discourse In Flux: The Rise of Systems Theory & The Complexity Sciences

'Nothing endures but change.'

'There is nothing permanent except change.'

'All is flux, nothing stays still.'

'Abundance of knowledge does not teach men to be wise.'

Sayings of Heraclitus

Relatively recent discourses that have referred to the 'nonlinear' revolution, the shift away from the 'clockwork universe' approach of classical Newtonian science, signify a turn towards a systemic, process philosophy. It could be said to be a return swing of the pendulum; from the '*everything flows*' of Heraclitus, to the atomistic Cartesian matter-mind split, and back again to a view of the relationships between things – the flows, networks, patterns – rather than of structure. This chapter addresses the shifts in discourse that have accompanied moves in various academic disciplines towards a more systemic epistemology. Systemic thinking recognises that systems can manifest properties of the whole that cannot be reducible to their parts (Capra, 1996), and that systems can incorporate varying states of complexity.

A systemic approach treats relationships and processes as fundamental, and where action, agency, and function operate within web-like networks. It is my argument that a return to systemic thinking may indeed be a timely and constructive shift in terms of better understanding the processes, flows, and networks of an increasingly interconnected world. I argue that to consider an increasingly interdependent global world from such a systemic perspective is not only productive and insightful, but also necessary.

I begin this chapter by tracing the rise of earlier academic developments and disciplines such as cybernetics, general systems theory, information theory, and chaos theory. I map the empirical shift from mechanistic and linear viewpoints into the paradigmatic 'turning point' (Capra, 1985) towards a systemic understanding of feedback-responsive processes. Here, I show how some of the natural and social science discourse has shifted from one of structures to one of process; from closed systems to open systems; and from linear causality to dynamic far-from-equilibrium states at 'the edge of chaos'. I finish by outlining how these shifts have produced what are understood as the 'complexity sciences', and what is meant by this field of knowledge.

A Systemic Approach

The complexity sciences emerged from a background of the biological, physical, and chemical sciences, with epistemological roots in systems theory and process thinking. In the 1920s the English philosopher Alfred North Whitehead put forward a strongly process-oriented philosophy that emphasised notions of flux and flow; concepts that were, it seemed, out of fashion at the time with an atomistic-favoured approach. Whitehead traced the processes of flux and flow back to Hebrew poetry, Greek philosophy, and Anglo-Saxon thought as part of an integral experience (Whitehead, 1929: 295). Whitehead, in *Process and Reality* (1929), attempted to theoretically construct a system that could reconcile permanence and change. In his cosmology, existence was a 'process' and classical science was unable to recognise creativity as an inherent property of nature.

Around the same time as Whitehead's process philosophy, the physiologist Walter Cannon was taking Claude Bernard's idea of an organism maintaining its internal environment and refined it into the principle of homeostasis: the maintenance of internal balance against fluctuations. These developments in philosophy and biology were influential upon Ludwig von Bertalanffy and inspired him to formulate a new theory of open systems (Bertalanffy, 1995/1968). Bertalanffy, largely credited as the founder of *General Systems Theory*, first presented his idea of a 'General System Theory' in a seminar at the University of Chicago in 1937. Bertalanffy's *General Systems Theory* was grounded in process thinking and a holistic framing of biology to describe the organisation of living systems. This concept of the organisation of living systems was then presented within the framework of open systems, which were influenced by external environmental factors. Whereas process thinking and the holistic paradigm were not new concepts Bertalanffy, as a biologist, recognised that the biological sciences needed a new perspective; one that went beyond the traditional path of the physical sciences whilst maintaining a solid biological foundation.

The systems approach put forward by Bertalanffy saw scientific thinking not in terms of mechanistic Newtonian forces but of the developments of relationships, patterns, and change. This change was considered by Bertalanffy to be of the nature of evolutionary processes and he recognised systemic thinking as having a long history. He notes that although the 'system' label was not accredited directly, the concept was present within the thinking of a long lineage of illustrious thinkers:

> As "natural philosophy", we may trace it back to Leibniz; to Nicholas of Cusa with his coincidence of opposites; to the mystic medicine of Paracelsus; to Vico's and ibn-Khaldun's vision of history as a sequence of cultural entities or "systems"; to the dialectic of Marx and Hegel, to mention but a few names from a rich panoply of thinkers (Bertalanffy, 1995/1968: 11)

Bertalanffy noted that when he began his life as a scientist, 'biology was involved in the mechanism-vitalism controversy. The mechanistic procedure essentially was to resolve the living organism into parts and partial processes' (Bertalanffy, 1995/1968: 89). Bertalanffy formulated by contrast a systemic approach that attempted to view the world in terms of integrated systems and to focus attention upon the whole as well as on the interrelationships among the parts.

To overcome the dilemma of increasing entropy, as stated by the second law of thermodynamics, Bertalanffy recognised biological metabolism as a self-regulatory system transferable to general open systems. Although Bertalanffy recognised the need for open systems to operate outside of classical thermodynamics, he was unable to explain them as being anything other than stable systems. This led to Bertalanffy publishing his *General System Theory* in 1968 positing a 'general science of wholeness' inclusive of individual organisms and their parts, social systems and ecosystems. This was a significant shift in the approach of scientific thinking in that Bertalanffy regarded knowledge as being constructed not through the structure or parts of a system but rather within the interdisciplinary processes, relationships, and patterns that create the overall wholeness of the system. A general systems theory was 'not of systems of a more or less special kind, but of universal principles applying to systems in general' (Bertalanffy, 1995/1968: 32). These 'universal principles' were outlined as follows:

> i) There is a general tendency towards integration in the various sciences, natural and social.
> ii) Such integration seems to be centered in a general theory of systems.
> iii) Such theory may be an important means for aiming at exact theory in the non-physical fields of science.
> iv) Developing unifying principles running 'vertically' through the universe of the individual sciences, this theory brings us nearer to the goal of the unity of science.
> v) This can lead to a much-needed integration in scientific education. (Bertalanffy, 1995/1968: 38)

Although general system theory grew out of biology, it soon saw its applications reaching into the humanities, in such areas as social work, mental health, and the political and behavioural sciences, as noted by Laszlo and Laszlo (1997). Other investigators who put their name to general system theory included Paul Weiss, Anatol Rapoport, and Kenneth Boulding, and a wide field of research workers have been influenced by this approach (Gray and Rizzo, 1973; Laszlo, 1972b).

The return to systemic thinking, and a general systems theory approach, can be seen as a unifying framework that brought together divided disciplines, and which heavily paralleled the rise in the self-regulatory feedback of cybernetics, and pre-dated Prigogine's self-organisation of dissipative structures. In fact, Bertalanffy sees cybernetics, information theory, game theory, decision theory, topology, and factor analysis as 'a number of novel developments intended to meet the needs of a general theory of systems' (Bertalanffy, 1995/1968: 90). In these terms, Bertalanffy's integrated approach to the organisation of living systems reinforced the perspective of viewing systems within the framework of both the natural and social sciences.

The transdisciplinary nature of general systems theory is emphasised by Bertalanffy's explicit statement that '*Social science is the science of social systems*' (Bertalanffy, 1995/1968: 195 – italics in original). Later both Parsons, within the sociological theory of the 1950s and 60s, and Luhmann, in the 1980s and 90s, examined social systems with this natural science framework. Luhmann's work claimed that social systems regulated themselves through monitoring information coming from external environments in order to become more autonomous and independent. The discrepancy between Luhmann and the approach taken here is that Luhmann saw social systems as moving towards reducing complexity and greater stability rather than towards an increased complexification through fluctuating processes and flows. Whilst a cybernetic application would give rise to a stabilising system, due to internal negative feedback mechanisms, it would not fully absorb a positive feedback understanding of complex systems. Cybernetics, however, was an important contribution to the rise of systems theory, and a recognised influence upon recent formulations of complexity theory.

Cybernetics

Cybernetics, from the Greek *kybernetes* meaning 'steersman' (a term coined by Wiener, although first used in 1834 by the physicist André-Marie Ampère), is an interdisciplinary body of research that primarily sprang from military thinking during the Second World War, when Norbert Wiener and colleagues were working on missile feedback mechanisms (Rose, 1994). This new perspective in science was geared towards shaping a unified approach to concepts of communication and control. Cybernetics investigated patterns of communication within closed loops and networks, leading to ideas of feedback and self-regulation, which steered cybernetics towards the notion of self-organisation. Information, such as a coded message, essentially operated as a pattern of organisation under modification through a constant regulatory system of negative feedback. Negative feedback is that which aims to return a system to its pre-set order when fluctuations appear, as does a room thermostat. This gave rise to the concept of 'information processing' within networks of increasing organisation, which closely paralleled Claude Shannon's famous 'Information Theory' model that was concerned with the transfer of a signal, or information, through a given medium.

This thinking led Wiener to consider machines, living organisms, and society, as representing the manifestations of similar phenomena, which continues Bertalanffy's notion of a transdisciplinary theory. Initially Wiener defined cybernetics as the science of ‘control and communication in the animal and the machine’ (Wiener, 1961: 4) Wiener, it seemed, believed that machines, animals, human brains and human societies were all based on communication information processes of varying degrees. Cybernetic systems generally operate through negative feedback – that is, they operate to maintain a homeostatic interior, thus producing a goal-directedness or purpose.

As was the case with Bertalanffy’s general systems theory, cybernetics as a method and theory found itself being appropriated into a variety of transdisciplinary uses, such as teaching and education, organizational management, industrial processes, ergonomics, ecology, and neurological medicine, as well as military command and control structures (George, 1965; Parsegian, 1972; Rose, 1994). Cybernetics was also an influential springboard for the early electronic mapping of the brain’s neurological feedback mechanisms (von Neumann, 1959), which was the precursor for the field of Artificial Intelligence. This new cybernetic perspective in science was geared towards shaping a unified approach to concepts of communication and control, and included such notable academics as John von Neumann, Claude Shannon, Stafford Beer, and Ross Ashby. Keeping within the transdisciplinary tradition, this collection of academics and thinkers included experts in mathematics, neuroscience, social science, management, and engineering. Whereas general systems theory approached the concept of systemic organisation from principally a biological perspective, the cyberneticists examined processes of communication and patterns of cognition through various channels within both mechanical and neural structures. In effect, they were seeking a systemic understanding of cognitive functioning that could be applied to mathematical models for computer circuits that would later lead to theories of artificial intelligence. From Wiener's perspective, cybernetic feedback loops could assist in the formulation of information processing within a variety of contexts and could serve to be the central metaphor for communication.

This systemic conceptualization of communication was central to what became known as 'information theory'. Shannon published his mathematical information theory in 1948 (published in 1949 with added commentary by Weaver), five years before James Watson and Francis Crick developed the structure of DNA at the Cavendish Laboratory at Cambridge. With the double helix of DNA being revealed as an information system, the notion of 'information' became a key concept at this time and inspired communication systems as well as molecular biology. Shannon's theory, however, is largely based upon the field of communication engineering and consists of an information source, transmitter, communication channel, receiver, and a destination (Goonatilake, 1991). Shannon's theory deals more in the transfer/communication aspect of information rather than its inherent meaning, and because of this it is generally considered by many social scientists to be too narrow a concept for modelling social processes (Goonatilake, 1991).

In contrast, open systems use information of their environments to organize and coordinate responses, making information more of an organising medium. Overall, information theory does not cover the growth of a system nor of information that is generated internally. In this respect, it is able to measure information in terms of organization and transmission, yet unable to place it within *contextualised meaning*. Wiener, however, viewed information within the cybernetic model as part of a systemic pattern of organisation and wholeness, and was aware of the effects of cybernetic dynamics on social systems. Wiener, it seems, was moving towards viewing processes as patterns of relationships rather than as parts, as was revealed in a later work titled *The Human Use of Human Beings: Cybernetics and Society*:

> To describe an organism, we do not try to specify each molecule in it, and catalogue it bit by bit, but rather to answer certain questions about it which reveal its pattern: a pattern which is more significant and less probable as the organism becomes, so to speak, more fully an organism (Wiener, 1954: 95).

This view would come back into favour and prominence during the nineteen-seventies when the concept of self-organisation retook the stage as a principle paradigm for system theorists.

Self-Organisation

Although the idea of self-organisation had been implicit in the cybernetics of the late forties and early fifties, it wasn't until the nineteen-seventies and eighties that this model was refined into its present form by the contributions of various researchers working independently in several countries – Ilya Prigogine in Belgium, Humberto Maturana and Francisco Varela in Chile, and Erich Jantsch in the US. Jantsch (1975, 1980, 1981a), an Austrian astrophysicist by training, contributed by placing the self-organising paradigm within an evolutionary perspective. Further, he worked towards applying self-organisation as a unifying model for biological, physical, and socio-cultural disciplines.

Self-organisation can be viewed as the spontaneous emergence of new structures and new forms of behaviour in open systems that are far from equilibrium. Jantsch recognised how such processes 'take over' from random behaviour and develop themselves, through regulatory feedback, to facilitate the emergence of complex order. In this way order can be viewed as the product of the creativity of a system attempting to formulate its own internal organisation through informational feedback cycles. It is thus a 'dynamic principle underlying the emergence of a rich world of forms manifest in biological, ecological, social, and cultural structures' (Jantsch, 1980: 19).

This newly refined model of self-organisation recognised that no living structure could be permanently stabilised and that 'equilibrium is the equivalent of stagnation and death' (Jantsch, 1980: 10). To regard equilibrium as a deathblow to living structures was a significant shift from earlier models. Jantsch, a trained physicist, recognised that both Bertalanffy's and Wiener's earlier approaches had been developed on the basis of a biological perspective. This, however, was limited as 'the original vision of achieving an understanding of macroscopic order across the boundaries between the animate and the inanimate world remained vague and inconclusive' (Jantsch, 1980: 24). To balance this and, like Bertalanffy before him, to deal with the problem of entropy, Jantsch looked towards physics, and specifically Prigogine's work on chemical dissipative structures, for the answers of providing a model of an open system that was not a stable order. This could then solve Bertalanffy's central difficulty in that open systems, for Bertalanffy, were prescribed stable states despite being subject to external influences. One of the characteristics of the new model was that it described open systems far from equilibrium. This meant that a constant flow of energy and matter flowed through the system, rather than it being closed, thus moving away from an enclosed model of the cybernetic, regulatory feedback system. The second law of thermodynamics, which states that the amount of free/available energy decreases in a closed system leading to disorder, was thus counter-acted.

Whilst this thermodynamic law was seen as being a constant, the fact that open systems could maintain themselves with their own flow of energy and matter meant that a new type of stability could exist in a state far from equilibrium. This allowed novelty to be a key factor since the system was evolving in dynamic flows rather than breaking down under entropy. This understanding promoted, in line with general systems theory, processes and the relationships between parts rather than the parts themselves. This principle of creativity allowed for the emergence of new structures and system behaviour.

These developments shifted the emphasis away from stability towards dynamic flows, thus providing for increased systemic unpredictability. Order began to be recognised as the product of the creativity of a system attempting to formulate its own internal organisation through feedback cycles. This pattern of ordering opened up a way of thinking that could offer profound implications for human and social sciences by understanding that complex, nonequilibrium states, creativity and novelty, are patterns of development within an emerging paradigm of evolutionary systemic theory. As Jantsch remarked, 'biological, sociobiological and socio-cultural evolution now appear as linked by *homologous* principles (i.e. principles related through their common origins) and not just by analogous (formally similar) principles' (Jantsch, 1980: 8). Self-organisation is thus seen as a 'process structure' (Jantsch, 1980; Capra, 1996; King, 2002), rather than as a solid, or physical, structure. In this way the concept of self-organisation is a natural successor both to Bertalanffy's *General Systems Theory* and to Wiener's cybernetics, as well as being compatible to an emerging science concerning autopoietic systems, to which I now turn.

Autopoietic Systems

Autopoiesis, according to Maturana and Varela (1980), refers to autonomous living systems. Within autopoietic systems it is the function of each component to assist in the production of other components in the network, effectively maintaining itself through an 'awareness' of its own processes. Thus, an autopoietic system, according to Laszlo, can be defined as a 'network of interrelated component-producing processes such that the components in interaction generate the same network that produced them' (1996: 40). In other words, for a living system to remain within a dynamic state it must be able to reproduce its structure in response to changing environmental conditions. Autopoiesis involves how these internal processes make up a unity of living organisation and also how this unity encodes information about the environment (Maturana and Varela, 1980).

According to Maturana and Varela, living systems manifest a circular organisation that 'constitutes a homeostatic system whose function is to produce and maintain this very same circular organization by determining that the components that specify it be those whose synthesis or maintenance it secures' (Maturana and Varela, 1980: 9). It is this circular organisation that turns a living system into a unit, or body, of interconnected relationships, such that the structure of internal relationships and the processes therewith constitute the unity of the whole. At this stage, however, the autopoietic system is still a closed one, and the notion of internal dynamism is in line with the maintaining of some form of internal pattern which requires a patterned circular feedback – in a form of information – in order to maintain itself. This seems to suggest that the potential for growth within living systems may not be pre-determined but rather is pre-patterned. Autopoiesis explains that unity in living systems is a product of their own processes, and it is through the maintenance of this unifying organisation that, according to Maturana and Varela (1980; 1998), cognitive behaviour is manifested.

A cognitive system is here described as one in which 'organization defines a domain of interactions in which it can act with relevance to the maintenance of itself, and the process of cognition is the actual (inductive) acting or behaviour in this domain' (Maturana and Varela, 1980: 13). This acting 'with relevance' requires that a system processes the information received about its environment. In other words, autopoietic behaviour can be viewed as the *behaviour of relevant self-maintenance in accordance with information*.

At a similar time to Maturana and Varela's theory arose the Gaia Hypothesis, later known as the Gaia Theory (Lovelock, 1988), which proposed that the earth is a living, self-regulating organism:

> This postulates that the physical and chemical condition of the surface of the Earth, of the atmosphere, and of the oceans has been and is actively made fit and comfortable by the presence of life itself. This is in contrast to the conventional wisdom which held that life adapted to the planetary conditions as it and they evolved their separate ways...I now think that regulation, at a state fit for life, is a property of the whole evolving system of life, air, ocean, and rocks. (Lovelock, 1988: 144)

In Gaia the earth itself is a living system, one that through its own feedback mechanisms the biosphere maintains its capacity for life. Similar to Lovelock's view is that of Lewis Thomas who, shortly after the publication of Lovelock's initial hypothesis, himself published *The Lives of a Cell* (1980) which sees the earth as a living cell: its component parts - organelles etc - as elements within society, and the biosphere as the cell membrane. It seems that within the space of a couple of years there was an emergence of scientific theories regarding life, and living systems, as holistic, self-regulating bodies. The classical mechanistic paradigm of science was being challenged from several disciplines, and a holistic perspective was again finding favourable exposure, albeit still predominantly amongst a minority of adherents.

The relationship between autopoiesis and the Gaia hypothesis is that the system relies upon the influx of matter/energy for its regulatory processes as the incoming matter/energy is distributed into the system in order to 'combat' the entropic pull towards decay. Jantsch notes that,

> autopoiesis is most useful where it provides a focus for studying the holistic behaviour of a self-organizing system...autopoiesis may now be recognized as one of the ways in which the self-organization of nonequilibrium systems manifests itself (Jantsch, 1981b: 66).

Jantsch sees autopoiesis as a central characteristic of self-organisation, both of which became forerunners to the theory of chaotic systems – or 'chaos theory'. Chaos theory is often considered to be a forerunner itself to the complexity sciences.

Chaos Theory

Much of the original thinking behind chaos theory came out of problems involved in the Newtonian mechanistic approach to natural science. The equations used in the mechanistic paradigm were a two-body model of motion, such as the sun's effect on a planet, whilst to obtain a more accurate reading, the effects of other bodies would have to be included (Goerner, 1995). The next simplest model to use is then the three-body one: this however crosses a tipping point and the whole problem multiplies in its messiness. What became dubbed as the 'three-body problem' became an infamous agenda for the best mathematical minds for over 100 years. Finally, it was the French mathematician Henri Poincaré who made some inroads into the problem by approaching the situation in a reverse manner. By declaring that the fundamental approach of 'classical physics' cannot even handle the interactions of three or more bodies, a model of more than two bodies was beyond the standard direct cause and effect relation (Goerner, 1995). In this way, Poincaré came early to the understanding that a mechanical breakdown of components into linear functioning is not always applicable to universal laws. Classical scientific equations can seem appropriate to a more simplified view of the universe, yet when more bodies become included, the whole situation becomes messy – or nonlinear. Chaos then confronts a nonlinear model of the world. However, this does not necessarily delineate an unordered world.

The interaction within nonlinear dynamics, instead of being based on the causal two-body model, became a more interconnected multi-body acting through positioning numerous attractors (a stable pattern of interactive flow), and numerous feedback loops (Gleick, 1998; Goerner, 1995). Nonlinearity, as characterised in chaotic systems, manifests sensitivity to initial conditions such that the behaviour of a system appears to be random even though the system is deterministic. Deterministic in this context refers to a system that has well defined parameters. A central feature of such chaotic systems is that of the attractors, or 'strange attractors', which, as Mackenzie notes, has 'continued to lie at the heart of the development of non-linear systems and complexity theory' (2005: 46). The attractors are a way of describing 'phase changes' or bifurcations, and in many cases chaotic behaviour, often as a sub-set within a larger system, takes place around, or 'on', an attractor which creates an orbital-like influence around its position. A well-known example is that of a three-dimensional model of a weather system derived from the equations of Edward Lorenz in 1963 that was used to model atmospheric convection patterns. Lorenz's patterns showed how the state of a dynamical system evolved within a complex, irreversible system (Gleick, 1998; Goerner, 1995; Mackenzie, 2005).

The Lorenz attractor is one of the best-known examples of a chaotic attractor since its pattern resembles the wings of the butterfly, and gave rise to the 'butterfly effect' (often quoted as the idea that a butterfly flapping its wings in California can ultimately result in an avalanche in the Himalayas). From here arises the phenomenon of systems, in which a small local disturbance can have a disproportionate global significance. Examples of such systems include the weather and economics (the 'economic bubble' or 'market bubble'), the latter being explored by Arthur, Durlauf, and Lane in *The Economy As An Evolving Complex System* (1997). The notion of attractors will become significant later in this research when focus is placed upon network structures, especially in the context of the Internet, and how specific nodes 'attract' a greater density of linkages and pathways.

From this new model of an interconnected nonlinear 'random' global world comes a reinterpretation of classical scientific perspectives. Thus, simple deterministic equations were able to produce intricate complexity (Capra, 1996; Stewart, 1990). Goerner summarises the main points of this nonlinear mode of thinking as

i. Small effects vary and have greater importance than previously thought.
ii. Prediction is only possible for limited time periods and under certain conditions.
iii. A system's normal internal dynamics are capable of causing abrupt and erratic behaviour.

iv. It is often possible to get the basic dynamics of very complex systems out of much simpler models.
v. One equation can produce many different patterns of organisation.
vi. Separately analysed components can never create a fully adequate description of the whole.
vii. Interaction effects may be more important than independent effects. You need maps of how the system responds in different contexts and models of how it evolves.
viii. Causality may appear to come from the bottom-up or top-down.
ix. Global order may be hidden in local vicissitudes; overall order may house infinite variety and uniqueness.
x. Attraction toward a form is a well-understood result of interactive causality.

(Goerner, 1995: 57-8)

The shift of the sciences from the classical two-body equation to the nonlinear behaviour of dynamic systems brought with it a realisation that mechanical determinism was no longer a feasible model. It also implied that it was not necessarily complex to understand complex systems – it only required that one needed to get to the root of the fundamental rules that trigger processes of complexification. One of these rules turned out to be that of the dissipative structure model proposed by Prigogine, and far-from-equilibrium systems. The dissipative structure model is especially important since it provides a central aspect of the complexity sciences, and Prigogine's discoveries can be seen as having catalysed the rise of complexity theory.

Dissipative Structures

One of the most influential fields of understanding to have contributed to a self-organising systemic theory, and also to complexity theory, is the theory of dissipative structures by the Belgian physicist and chemist Ilya Prigogine.

Prigogine was interested in knowing how living and non-living structures maintained themselves within states of nonequilibrium, especially since the law of entropy should designate their demise, and how stability at nonequilibrium could be achieved. Prigogine's research went beyond Bertalanffy's model of the systemic patterns of open systems to express the idea that at far-from-equilibrium states, moments of increased instability could trigger structures of increased order and stability to emerge and replace the existing instability. That is, through feedback loops of amplified instabilities/fluctuations, an open system, being interconnected to a constant through-flow of energy and matter, takes on a pattern of irreversible processes that emerge in creativity and form bonds of increased complexity. Prigogine named this as 'order out of chaos', in what can be seen as a forerunner to chaos and complexity theory, as it required a minimum amount of complexity to instigate the process (Prigogine and Nicolis, 1977). Prigogine further remarked that in general such a theory could be interpreted as an evolutionary paradigm of increasing complexity as it included 'open systems that evolve to higher and higher forms of complexity' (Prigogine and Stengers, 1985: 298). While such amplified feedback loops ('positive' rather than 'negative') were seen as unfavourable, and possibly destructive, to the earlier cybernetic regulatory model, this new understanding put forward by Prigogine saw such processes as self-evolving. Whereas the classical science model of nature was the clock, and a mechanical universe, Prigogine invested nature with an irreversible, dynamic, and creative evolution towards an increasingly complex state:

> it is essential that in this perspective we no longer see the internal feeling of irreversibility as a subjective impression that alienates us from the outside world, but as marking our participation in a

> world dominated by an evolutionary paradigm (Prigogine and Stengers, 1985: 298).

Prigogine's work (1977, 1980, 1985, 1997) on dissipative systems showed how open systems existed far from equilibrium and sustained their existence through maintaining energy flows, thus shifting from entropic reactions to negentropic ones.

Systems in states far from equilibrium, it was now discovered, were able to increase in complexity through an internal generation of networks by using a through-flow of energy from an external environment, while constantly maintaining a dynamic state of stable order. At first this may seem like a paradox - to be both dynamic yet stable. Such stability is maintained by a continual inflow/outflow of energy that 'feeds' a system yet the resultant stability is inherently open to external fluctuations and perturbations that have the potential to provide a 'shock' to the dynamic order. Perturbations may come in the form of, for example, an overload in energy influx such as an environmental catastrophe, or a social revolution. How the open system responds to such perturbations will show whether it will adapt to the new circumstances in terms of growth, or whether it will collapse. A system that is unable to maintain its stability within its present structure has an alternative other than breakdown: this is known as bifurcation.

Bifurcation (from the Latin *bi*, meaning two, and *furca*, meaning fork) literally means a split into two. As a scientific term it refers to the behaviour of complex systems when exposed to high degrees of stress and instability, and characterises the leap into a possible new steady state. Dynamic open systems do not progress, or adapt, in a smooth linear path but through destabilisations and periods of chaotic activity before a new steady state can be found (Nicolis and Prigogine, 1989; Prigogine and Stengers, 1985). Complex systems that are in dynamic, far-from-equilibrium states have a greater variation of steady states to choose from, and so the outcome is never wholly predictable as the choice is not predetermined. In other words, the more stable the system, the more predictable is its next move. However, with a complex and unstable system the choice of the next state to move into is largely unpredictable. Although having multiple new steady states as an alternative, the system can only ultimately choose one outcome. Thus, when and *if* the system bifurcates, only one path is chosen as an alternative to its present state, explaining why it is named after the 'two fork' metaphor. This can be imagined if a person is walking in a forest and their path reaches a fork. The person must either choose one of the paths before them or else return back, breaking down the journey. Bifurcation then means the possible leap from the present unstable state to a new steady state. If the system does not bifurcate, it must either maintain its present state through internal feedback, or it will break down and collapse (Prigogine and Nicolis, 1977). This behaviour led Prigogine to observe that a nonequilibrium system 'may evolve spontaneously to a state of *increased complexity*' (1997: 64 – italics in original).

This increase in the complexity of a system is a successful utilisation of the energy influx that, at times, is created by the disturbance itself; nothing, it seems, is left to waste. Complex systems are thus open systems that self-organise their dynamic interior networks in response to a 'reflexive' relationship with the external environment. Prigogine's model, as well as being central to the sciences of complexity, is itself a successor from earlier models. In this way complexity science can be seen as being a unifying theory from earlier systemic models. In other words, complexity science incorporates the insights and processes of Bertalanffy's *General System Theory*, Maturana and Varela's *autopoiesis*, Wiener et al's *cybernetics*, and such *self-organisation* models as provided by Jantsch. From these interdisciplinary discourses views about the world began to shift towards a paradigm of increasing complexity, as informational flows become ever more present. These discourse developments in the natural sciences also began to filter through to the social domain and to register as an influence upon both scientific and social thinkers.

Shifts in Scientific and Social Discourse

Scientific knowledge that emerged at the beginning of the twentieth-century gradually began to shift away from classical notions of structure towards a more interconnected and process-oriented viewpoint. Physicists Kafatos and Nadeau noted how this shift began to allow for the recognition that 'the knowledge claims of science derives in part from the failure to appreciate that the mechanistic view of the cosmos in classical physics has been displaced by a very different view of the cosmos in the new physics' (Kafatos and Nadeau, 1999: 193). In a similar manner natural scientist Mae-Wan Ho, speaking at a conference in New York titled "Future Visions': State of the World Forum', stated that this new understanding

> has been gathering momentum across the disciplines within the past 20 years, from the study of nonlocal phenomena in quantum physics and nonlinear dynamics in mathematics to complexity in ecosystems, the fluid genome in the new genetics and consciousness in brain science. The message everywhere is the same: nature is nonlinear, dynamic, interconnected and interdependent. The linear, static paradigm of mechanistic science based on interactions between separate, independent parts is a travesty of organic reality (Ho, 2000).

Such a perspective acknowledges that natural science can contribute to transformational thinking upon a grander scale. However, I feel it is important to note here that such movements in the natural sciences do not guarantee that these changes will manifest in the social sphere, where macro world-views must share a space with the intricacies of daily interconnected lives. Yet there are a number of thinkers from both the natural and social sciences who are beginning to publish claims that a Newtonian linear point of view is inadequate for an emerging global world (Capra, 1985; 2002; Ferguson, 1981; Goerner, 1999; Ho, 1996; Laszlo, 1994; Sahtouris, 1998).

A post-Newtonian view, where interrelated parts form a whole that is greater than the sum of its parts, is close to the latest findings in the complexity sciences. Complexity theorist and physicist Fritjof Capra notes the correspondences between the natural and social sciences when he writes that

> At the same time, researchers in several scientific disciplines, various social movements, and in numerous alternative organisations and networks are developing a new vision of reality that will form the basis of our future technologies, economics systems, and social institutions. What we are seeing today is a shift of paradigms not only within science but also in the larger social arena. (Capra, 1988: 145)

Capra sees this new world view, this newly emerging 'paradigm', as holistic, or ecological. By this Capra means that social processes are a part of the interconnected and cyclic manifestations of natural phenomena, as he sees 'the fundamental interdependence of all phenomena and the embeddedness of individuals and societies in the cyclical processes of nature' (1988: 145). Capra suggests a new social paradigm to incorporate these emerging conceptions, which he states in terms of five related shifts in emphasis, from which I quote at length:

> 1. Shift from the part to the whole - the properties of the parts must be understood as dynamics of the whole: What we call a part is merely a pattern in an inseparable web of relationships. The shift from the parts to the whole was the central aspect of the conceptual revolution of quantum physics in the 1920s.
>
> 2. Shift from structure to process - every structure is a manifestation of an underlying process, and the entire web of relationships is understood to be fundamentally dynamic.
>
> 3. Shift from objective to 'epistemic' science - descriptions can no longer be viewed as objective and independent of the human observer and the process of knowledge, and this process must be included explicitly in the description.
>
> 4. Shift from 'building' to 'network' as a metaphor of knowledge - phenomena exist by virtue of their mutually consistent relationships, and knowledge must be viewed as an interconnected network of relationships founded on self-consistency and general agreement with facts: Since we perceive reality as a network of relationships, our descriptions, too, form an interconnected network of concepts and models in which there are no foundations...Physical reality is seen as a dynamic web of interrelated events.
>
> 5. Shift from truth to approximate descriptions - the true description of any object is a web of relationships associated with concepts and models, and that of the whole that constitutes the entire web of relationships cannot be represented in this necessarily approximate description: This new approach immediately raises an important question: if everything is connected to everything else, how can you ever hope to understand anything? Since all natural phenomena are

> ultimately interconnected, in order to explain any one of them we need to understand all the others, which is obviously impossible... in the new paradigm, it is recognised that all scientific concepts and theories are limited and approximate. (Capra, 1988: 147-9)

Capra's conclusion, that 'physical reality is seen as a dynamic web of interrelated events', I argue is an attempt to merge scientific discourse with the social. As well as recognising the scientific background to the complexity sciences Capra is also attempting to shift this discourse into the social domain. Complexity theory can thus be utilised as a medium to bridge transdisciplinary discourse between the natural and social sciences, as I now move to examine.

Complexity: meanings, metaphors & analogies

Complexity theory, as a development from chaos theory, has emerged as a useful theoretical approach for psychologists, social theorists, management consultants, organisational behaviourists, international relations, military strategists, and more besides. The pluralistic capacity of the complexity sciences is noted by Griffin, Shaw and Stacey in that 'there is as yet no single science of complexity but, rather, a number of different strands comprising what might be called the complexity sciences' (2000: 85). These different strands include chaos theory, dissipative structure theory, and the theory of complex adaptive systems. It will be now useful to examine the general meaning of 'complexity' within chemical processes, and to focus on some of the meanings that have been drawn from the concept of 'complexity'.

The idea of complexity theory is itself not easy to define since it covers a range of models that find validity within both macro stellar evolution (Chaisson, 1987; Chaisson and Chaisson, 2001; Davies, 1988; Kauffman, 1993) and micro-chemical processes (Prigogine and Nicolis, 1977; Prigogine and Stengers, 1985). The original Latin word *complexus* suggests an entwining or twisting together, inferring that the term complexity incorporates a form of connectivity beyond linear bonds. Francis Heylighen, a social theorist with a background in physics and cognitive science, affirms that complexity as a phenomenon can only exist when both aspects of order and disorder are present (Heylighen, 1997). Heylighen goes on to conclude that complexity increases when both the variety and connection of a system's parts increase. Heylighen's work infers that both cognition and connectivity are associated with complexity as a phenomenon. As a form of cognition this makes reference to both self-organisational and autopoietic behaviour. As was stated earlier, within autopoiesis it is the function of each component to assist in the production of other components in the network, effectively maintaining itself through an 'awareness' of its own processes. Similarly, self-organisation is inherently dynamic and seeks to maintain growth through a continual re-organisation, using incoming energy. This means that a constant flow of energy and/or matter permeates the system in the form of input/output. One of the characteristics of such open systems is that they are functional far from equilibrium. It has been described how these systems that are in states far from equilibrium increase in complexity through an internal generation of networks by using a through-flow of energy from an external environment, while constantly maintaining a dynamic state of stable order.

This increase in the complexity of a system is a successful utilisation of the energy influx that, at times, is created by the disturbance itself. Prigogine observed how such systems evolve spontaneously to a state of '*increased complexity*'. Complex processes manifest when open systems self-organise their dynamic interior networks in response to their relations with the external environment. This increase in the number of intertwining connections due to increased energy/matter input can be said to result in an integration, or convergence. Complexity theory, seen in this manner, infers an increased connectivity between the parts or components of any system. The sense of disorder comes from both the degree of nonlinear interrelations of the parts as well as the dynamic, nonequilibrium state of the system as a whole.

Another way to perceive of a complex system – as *complexus* – is to recognise that this Latinised translation can also mean 'fabric': instead of inferring an entwining, or twisting together, as Heylighen notes, it can instead refer to forces, processes, and interactions that operate within a field. The points of attraction within this potential field may well be the nodal points of some kind of network, yet the processes may influence wider collectives, or sub-sets, of complex systems, which my research addresses later.

Yet another approach towards complex processes is that of 'complex adaptive systems' (Holland, 1996), where the basic components of complex adaptive systems (*cas*) are agents. Agents work to maximise and adapt the system they are a part of by learning from their environment. Thus, when dealing with *cas* it is important to select the appropriate stimuli as this will determine the strategy of the component agents. John Holland, a leading researcher in this area, describes how complexity analysts set up these *cas* processes:

> Once we specify the range of possible stimuli and the set of allowed responses for a given agent, we have determined the kinds of rules that agent can have. Then, by looking at these rules acting in sequence, we arrive at the behaviours open to the agent. It is at this point that learning or adaptation enters. (Holland, 1996: 8)

Just as a biological organism adapts to fit its environment, such learning processes can also apply to such entities as business corporations, political parties, scientific communities, species, and the ecosystem. Holland sees the economy as an 'example par excellence' of complex adaptive systems (Waldrop, 1994). Holland tells us that in the brain the agents are nerve cells, in an ecology the agents are species, whilst in an economy the agents could be individuals, families, or businesses, etc, (Holland, 1996). Regardless of the example used, each agent finds itself in an environment produced by its interactions with the other agents in the system, and 'is constantly acting and reacting to what the other agents are doing. And because of that, essentially nothing in its environment is fixed' (Waldrop, 1994: 145). Also, control within a *cas* tends to be dispersed, decentralised, so that the coherence of any such system is through the adapting interaction of its agents. However, this does not detract from the fact that the economy rests on the many and varied economic decisions made every day by millions of individual people (Waldrop, 1994).

Such complex systems are constantly revising themselves through the adaptations of their agents to new stimuli, just as a company reshuffles itself, or a governing party rearranges its members. Further, Holland states, *cas* anticipates the future by the agents making reference to their internal models of the world. Again, just as stock investors look towards predicting a crash based on share prices and global economic forecasts, so do agents, albeit in a more micro-manner, assess the environment and put it through their own internal picture of the world. Holland views *cas* as incorporating all the elements of self-organisation, autopoiesis, and dissipative structures, yet within a more unified concept (Holland, 1996). An understanding of the type of order inherent in such systems comes from using nonlinear equations, and by having some knowledge of the types of stimuli and previous experience of similar responses, often by the use of computer simulation that can help to map internal models. In this way, there is some indication that may help to predict the way the system may operate.

Sally Goerner however, who is the director and co-founder of the Integral Science Institute, recognises the term 'complexity' to be misleading: 'one of the new insights is that much of what *looks* complex is actually very simple…complex systems theory shows simplicity hidden in complexity' (Goerner, 1995: 33). For Goerner, such labels as 'complexity' and 'chaos' are 'both pop labels for a new science emerging around the expanded understanding of *interdependent dynamics*' (Goerner, 1999: 21 – italics in original). Again Goerner stresses that such web-like interdependencies are not new, only that 'we couldn't see them before', implying that it is our tools that have named the complexity sciences rather than any single, sudden discovery.

Today such changes are labelled as nonlinear and, in the case of open systems, as irreversible. Chaotic patterns are all around and provide for a view that the physical world is not simply a set of consecutive relations between things, but is a pluralistic network of relationships that exhibit dynamic, creative, complex behaviour that cohere to a set of simple yet non-determining laws. Complexity is thus 'an idea that is part of our everyday experience. We encounter it in extremely diverse contexts throughout our lives, but most commonly we get the feeling that complexity is somehow related to the various manifestations of life' (Nicolis and Prigogine, 1989: 6). Yet for complexity to become known as a 'part of our everyday experience' further shifts had to occur in scientific discourse and understanding - again, away from a mechanistic 'atomistic' paradigm towards notions of a world in flux and unpredictability. This can be largely accredited to the rise and popular appeal of quantum physics.

Quantum Metaphors & Analogies of Complexity

The rise of quantum physics in the early part of the twentieth century pointed towards a less deterministic and linear world whereby a preoccupation with fixed structures was being challenged by a new focus on processes, with metaphors of waves rather than atoms. Suddenly, the new physics was saying that the world, and the universe, was not as previously thought – it was a lot more unstable, complex, and inherently unknowable.[1] Quantum theory views the physical/atomic world as a continuum of interrelated events and not only

[1] See John Gribbin: Gribbin, J. (1984) *In Search of Schrodinger's Cat: Quantum Physics & Reality*. London: Bantam Books,Gribbin, J. (1995) *Schrodinger's Kittens and the Search for Reality*. New York: Little, Brown & Company.

challenges the notion of a mechanical world created out of fundamentally separated objects, but also introduces the notion of the participator as replacing the observer.[2] In this view the universe is observed as an interconnected web of physical and mental relations where the parts are defined through their connections to the whole. Within these terms objects are no longer solid or separate, with definite time-space locations, but are instead, according to bio-physicist Mae-Wan Ho, 'de-localized, indefinite, mutually entangled entities that evolve like organisms' (Ho, 1999). Like the discoveries of quantum physics, complexity theory can also engage with a world that is an interconnected web of physical relations.

One of the facets of quantum theory that postulates the universe as being an undivided whole in which the observer participates is that of non-locality. The understanding of non-locality that quantum physics provides is often presented in the form of the Einstein, Podolsky and Rosen paradox (the EPR paradox). In order to elucidate the phenomenon of non-locality, Einstein, Podolsky and Rosen proposed a 'thought experiment'. Here, the experiment consisted of elementary particles prepared in pairs, which then moved apart in opposite directions. According to quantum theory,

> if we measure a property of one of the pair, such as spin, in which ever direction we choose, the other of the pair would have a correlated property. Say, if the first particle is measured to be spin up, the other would be spin down; if the first is spin left, the second would be spin right and so on. It would be so regardless of which property is measured, and no matter how far apart the particles are (Ho, 1999).

[2] According to quantum theory the act of observation influences the behaviour of the thing observed. This implies that the observer is not objective to the observation but an intrinsic part of it. Therefore, quantum physics sees the observer as a participant.

In 1997, due to advances in technology, this paradox was finally given valid proof by the results from the experiments carried out at the University of Geneva by Nicolus Gisin and his team with their twin-photon experiments (Kafatos and Nadeau, 1999). From this data quantum theorists have concluded that by the act of measuring one particle (which they sometimes refer to as the 'collapse of the wave function'), this action is somehow instantaneously communicated to the other particle; again, regardless of the distance between. In this sense, the particles react as if they are a continuously connected part of an undivided *fabric*, intimately *woven together*, whereby a local effect is instantaneously transmitted globally at that very instant. These analogies may be useful in helping to conceptualise how the phenomenon of complexity is manifesting in the social domain through networks of information communication technologies.

The extent of interconnectivity that has resulted from emerging communication technologies can make for a pertinent similarity to a research area known as holography which is a technology based upon non-Newtonian principles. The concept of holographic phenomena has largely entered quantum physics through the work of David Bohm (Bohm, 1995). However, it is notable that a social theorist, Barbara Adam, has also recognised the hologram as an interesting metaphor. Adam notes that the hologram is

> proving an excellent metaphor for a whole, encoded and implicated in the 'parts', since the information it stores is not located in the individual parts but in their interference pattern. Any one part of a hologram contains, implies, and

> resonates information of the whole. The focus here is not on individual particles in motion, crossing time and space in succession, but on all of the information gathered up simultaneously. (1990: 159)

In what amounts as an appealing engagement, Adam sees several aspects of the hologram metaphor as being of importance for the understanding of social science. Namely, the 'non-sequentiality, its individual-whole relationship, and its multiperspective focus' (1990: 159). What is important here is that a correlation can be made between what Adam sees as aspects of the holograph metaphor taken from its physical characteristics, and particular processes within the complexity sciences. All three aspects that Adam named above – non-sequentiality, individual-whole relationship, and multiperspective focus – are core to some of the processes analysed within the complexity sciences.

By saying this, I am suggesting that there are features within quantum physics, as well as in the natural sciences more generally, that can be useful analogies when using a complexity theory approach to interpret and engage with particular social and cultural phenomena. For example, the compression of time and space that is often associated with global processes can be seen to resonate with metaphors of wholeness, instantaneity, and non-locality as expressed through the discipline of quantum physics. Social science, using the knowledge from the complexity sciences, has yet another tool with which to analyse varied and multiple social, cultural, and global interactions. Yet, on a more sober note, Adam highlights the slow take-up by social science: 'the social sciences who could gain so much from those developments in physics have been virtually untouched by the fundamental shifts in understanding that have taken place during this century' (Adam, 1990: 60). However, a particular intriguing feature of living systems that may be employed in social science as a useful way of viewing the 'lock-in' effect of complex systems is through the concepts of synchrony, or 'sync' as it is commonly referred to.

Are We In Sync? The 'lock-in' of systems

Steven Strogatz, a professor of theoretical and applied mechanics, in his recent *SYNC: The Emerging Science of Spontaneous Order* put forward the possibility that self-organised criticality might be very closely linked to synchronisation in pulse-coupled oscillator systems (Strogatz, 2003). Strogatz goes even further by stating 'life depends on nonlinearity' and that 'in any situation where the whole is not equal to the sum of the parts, where things are co-operating or competing, not just adding up their separate contributions, you can be sure that nonlinearity is present' (Strogatz, 2003:181). For Strogatz the concept of 'sync' is

> grounded in rigorous mathematical ideas; it has passed the test of experiment; and it describes and unifies a remarkably wide range of co-operative behaviour in living and a nonliving matter, at every scale of length from the sub-atomic to the cosmic. Aside from its importance and intrinsic fascination, I believe that sync also provides a crucial first step for what's coming next in the study of complex nonlinear systems, where the oscillators are eventually going to be replaced by genes and cells, companies and people. (Strogatz, 2003: 286-7)

Sync, then, is the phenomena of 'locking-in' of oscillating rhythms to form a resonating field that is 'in step' or coherent, and which may form the basis of self-organisation. Strogatz considers how 'sync' (his abbreviated term for synchrony) can apply to such events as human sleep and circadian rhythms, menstrual synchrony, insect outbreaks, superconductors, lasers, secret codes, and heart arrhythmias, through the spontaneous emergence of order and oscillating coherence out of initial nonlinearity. Using Strogatz's idea of 'sync' it is possible to see how resonating fields of energy/information attempt to lock-in with other fields to create a coherent resonance field. This, Strogatz later considers, may be behind such phenomena as insect swarming. In fact, biophysicist Mae-Wan Ho also considers whether biophoton emission in living systems is a major factor in animal swarming and collective behaviour (Ho, 1998: 153-5).

In the context of my research the concept of a synchronising lock-in may be useful when examining complex social systems and also for notions of decentralisation and self-organisation, which may correlate to such areas as information flows, human agency, and perhaps even traffic flows. Strogatz identifies three levels where his notion of synchrony operates:

> At the lowest, most microscopic level, the cells within a particular organ are mutually synchronised; their chemical and electrical rhythms vary in lockstep. At the next level, sync occurs between the various organs, in the sense that they all keep to the same period, even though the cells have differentiated into disparate types. This kind of sync occurs within the body itself, and so is called internal synchronisation... the third level of synchrony is that between our bodies and the world around us. (Strogatz, 2003: 72)

It is interesting to note that the theory of synchrony can be seen as how open systems operate in an autopoietic relationship with their environment, catering for flows of matter/energy/information. The third level of synchrony, that between 'our bodies and the world around us', may be a lead to investigate further how complex, dynamic systems that are far from equilibrium are able to maintain their systemic coherence and 'wholeness' in the face of myriad and increasingly complex interrelations and interdependencies.

As a way of demonstrating how humans may adjust their behaviour to 'lock-in' with synchronization, the fiasco concerning the opening of the Millennium Bridge in London on June 10th 2000 serves as a colourful example. On the occasion of the bridge's momentous opening, a multitude of people all began to walk across the bridge whereby the bridge began to sway under the feet of the pedestrians. This shock occurrence caused the authorities to close the bridge until further architectural and engineering investigations could locate the cause of the bridge's unsuspected swaying movement. The source of this mysterious swaying was, according to Strogatz, the result of people-sync:

> As the bridge swayed, the pedestrians unconsciously adjusted their pace to walk in time with the lateral movement. This exacerbated the vibration, which impelled more people to lose their balance and simultaneously swing to the same side, reinforcing their synchrony and aggravating the vibration still further. It was this chain reaction - the positive feedback between the people and the bridge - that no one had ever anticipated, and that triggered the wobbling of the Millennium Bridge... it had never occurred to the architects that a crowd of 2000 civic-minded people could inadvertently synchronise their strolling. (Strogatz, 2003:173)

In a similar way Mae-Wan Ho describes how coherent excitations in living systems operate in much the same way as a boat race, where the oars-people must row in step so as to create a ‘phase transition’ (Ho, 1998). This may indicate that there is a tendency in Nature, and in living systems, to resonate together in synchronization as a way of maintaining balance within a dynamic environment, which could be of interest to social scientists in considering how complex systems operate in a social domain. These insightful developments in the natural sciences help to illustrate, by analogy or metaphor, elements of my research. By this I mean in the instances where my research examines how a shift towards new movements and patterns of non-local connections, through technologies of information, is potentially empowering those who participate within such distanced electronic webs. Further, that such networking is allowing a complex dynamic of relations to express both a global integral dynamic whilst maintaining a local individuality. The emerging physical/digital spaces of an increasingly interconnected world will raise new questions on how to view the intricate web being spun.

To summarise, the genealogy of the sciences that was outlined earlier in this chapter has helped to clarify the path that led to the present complexity sciences: a hybrid of cybernetics, autopoiesis, self-organisation, dissipative structures, and systems theory. In this respect, the fields that make use of the complexity sciences make use of these terms also. To accept the notion of complexity means recognising a shift from looking at the world through linear equations to a world where systems behave, not in simple ways, but through nonlinear relationships. As mentioned previously, twentieth-century mathematics developed into mapping the world of strange attractors that create erratic, yet highly organised patterns. As systems manifest progressively more complex processes they display behaviour that shows them to be more vulnerable to change and perturbations in the environment. In other words, they react more noticeably to small external fluctuations, which can lead to system instability. Such instabilities, if not righted, can lead to the breakdown of the system and its eventual collapse.

With the work done by Prigogine et al into dissipative structures, we now have an understanding that this once ‘random’ interconnectivity is in fact related to energy/matter/information flows that an open system utilises in order to remain in a dynamic and far-from-equilibrium state. Complexity theory then is a discourse from which to view dynamic interconnectivities and events, whether local or global, that appear to manifest nonlinear patterns.

What this thesis examines next is the ways in which the complexity sciences are located within other academic fields, especially the social sciences, and how they have been enriched by borrowings, interpretations, and metaphoric overlaps. Chapter Two will explore how the complexity sciences have made an impact, with their understanding of interrelations and interconnectivity, upon various diverse disciplines.

CHAPTER TWO

Locating Complexity: interplays, interpretations, & overlaps

> 'Whether we look at the stars and planets in their courses or examine the miraculous processes of life, we see abundant evidence of faultless organization. Only human affairs seem to be an exception to the general rule'
>
> Edward Russell – 'Design for Destiny'

This chapter examines some of the various fields of study and thought the complexity sciences have influenced. They range from the social sciences such as history, literature, economics, philosophy, civil society and sociology; to military strategies and Gaian thinking. Complexity theory, as has been suggested, has multiple applications within the social sciences, and offers an analysis upon dynamic change, unpredictability, and a shift away from reductionism. The interdisciplinary potential of the complexity sciences may go some way towards what E.O. Wilson refers to as the *Ionian Enchantment* – a belief in the unity of the sciences (Wilson, 1998). Wilson reconfigures this archaic notion into a more modern concept, that of *Consilience*, whereby coherence is advanced under the metaphor of a '"jumping together" of knowledge by the linking of facts and fact-based theory across disciplines to create a common groundwork of explanation' (Wilson, 1998: 6). This conviction, which Wilson argues is beyond that of a mere working proposition, means a drive towards explaining the world as a synergistic manifestation of a small number of natural laws. Despite this looking like reductionism, Wilson's 'consilience' can be seen as a merging of disciplines, a crossing of boundaries, which sees the end of the reductionism of specialisation.

Similarly, physicist Michio Kaku proposes that the 'era of reductionism…is coming to a close' as reductionism has 'in the main, run its course' (Kaku, 1998: 10). The reason for this, Kaku states, is that in the recent advances of scientific knowledge new barriers have arisen that cannot be solved by simple reductionism. Thus, Kaku interprets this as heralding a new era, one of synergy between the three 'fundamental revolutions'; that of the quantum, the bio-molecular, and the computer (Kaku, 1998). And it was the computer revolution, as Kaku refers to it, that played a major role in not only discovering how complex systems operate, but also in helping to bring these insights into social science, especially through simulations and later analysis on technical usage, such as mapping Internet traffic. This chapter begins its exploration of the various locations, interpretations, and overlaps of complexity theory by starting with the importance of the computer and computer simulations to the field of complexity science.

Complexity and Simulation

From the strange attractors of meteorological behaviour – Lorenz's 'butterfly effect' attractor (Gleick, 1998; Mackenzie, 2005) – to simulations of cellular automata (Coveney and Highfield, 1995; Holland, 1996), complex phenomena are being made visible to human observation. The complexity of processes and arrangements that are present in natural systems are beyond the capabilities of the human eye; thus, the rise of the digital computer can be regarded as 'essential for our exploration of universal mathematical principles underpinning complex phenomena' (Coveney and Highfield, 1995: 44). The rise of computing, from Turing and von Neumann models to the present stage, is a well-documented lineage, and there are various sources detailing this (Bardini, 2000; Hobart and Schiffman, 1998). Likewise is the link between computer and brain functioning now well-documented (von Neumann, 1959; Minsky, 1986). Some of these early explorations have branched off into other fields that today are standing within their own reputable research: namely, Artificial Intelligence (Moravec, 1989; 2000), and Artificial Life (Helmreich, 1998; Langton, 1989).

One of the earlier forerunners of simulating complexity was a computer program inspired by the work of von Neumann and proposed by mathematician Stanislaw Ulam, called *cellular automaton*. Cellular automata (plural) comprise 'an abstract array of cells programmed to carry out rules en masse. This collection of cells performing computations in unison could be viewed as an organism, running on pure logic' (Coveney and Highfield, 1995: 91). The state of a cellular automaton at any given moment is influenced by the state of all its neighbouring cells at that instant. Thus, the automation evolves in simulation through a set of simple rules that state how each cell will change from one moment to the next, according to the states of neighbouring cells.

At around the same time frame, in 1963, Edward Lorenz simulated his early equations on weather patterns that showed complex behaviour yet at this time did not relate it to sensitive initial conditions, as he did later with the 'butterfly effect'. Then in 1970 John Conway introduced the 'Game of Life' 2D cellular automaton. Conway had been doing experiments on a PDP-7 computer in 1968 with a variety of different 2D cellular automaton rules and from this had devised a simple set of rules that nonetheless exhibited a range of complex behaviour (Wolfram, 2002). Conway's rules for the 'Game of Life' struck a balance between the two extremes of too many patterns and too few and, as Coveney and Highfield note, 'reflected Conway's fascination with how his combination of a few rules could produce complex global patterns that would expand, change shape, or die out unpredictably' (1995: 94). Although this game soon gained the title of 'The God Game' it began to investigate how computer simulations were able to map complex, self-organising and dynamic processes stimulated from initial conditions set within simple rule parameters.

This conceptual thinking led to the idea of fractals that were popularised by Benoit Mandlebrot in the mid-1970s and which again emphasised the importance of using computer simulations in studying complex forms and behaviour. Mandlebrot coined the term *fractal* in 1975 when he was working at IBM to describe the geometry of regular shapes where he discovered that regardless of how much a fractal object is magnified, it still contained essentially its entire structure (Coveney and Highfield, 1995). It was the mapping and simulations of fractals that helped define the field of chaos theory, or deterministic chaos where complex fractal structures frame notions of the strange attractor. Such simulations, from cellular automata to fractals and attractors, have helped enormously in the understanding and investigation of dynamic, nonlinear systems that have formed the core of the complexity sciences as they are understood today.

In this respect computer science and simulation is a vital element towards an understanding of complex phenomena. Also, computer science has been instrumental in creating shifts and movements between scientific and social discourses and practice (Latour, 1993; Mackenzie, 2002). One notable example is Helmreich's look at the social and simulated worlds of Artificial Life (1998) where new ways of imagining 'life' are examined through self-replicating computer programs, such as computer viruses that act as new forms of living systems. In this way the computer simulation models those very processes of complex living systems in a similar manner to how programs are used to model complex social behaviour and traffic flows. Artificial Life, and the earlier 'Game of Life' programs, thus formed the concept of creating and examining the self-organising properties of simulated 'living systems' in order to gain a better understanding of how complex processes and relationships form and develop. Nowadays network flows and complex systems form a notable core of research into computer digital simulation and modelling (Barabasi, 2003; Bonabeau, Dorigo and Theraulaz, 1999; Dorogovtsev and Mendes, 2003; Huberman, 2001).

Mapping the infrastructures of physical networks, including network attractors and Internet sites, as this thesis will examine, are predicated on a long lineage of computer science development and innovation. Complexity theory, which I argue is a relevant tool for modelling the increasing ubiquitous and pervasive nature of embedded physical-digital networks, owes a great debt to the rise and power of computer simulation. As the title of this chapter suggests I now turn to examine some of the debates around the positioning of complexity theory and its transdisciplinary overlaps.

Sites of Complexity

Investigations into the complexity sciences began in earnest when the Santa Fe Institute was founded in New Mexico in May 1984 by George Cowan (Waldrop, 1994). This was soon followed by Stephan Wolfram's 'Center for Complex Systems' at the University of Illinois in 1986. Both centres based their investigations upon interdisciplinary approaches, making use of mathematicians, biologists, physicists, and social scientists. Since then the term 'complexity' has been employed as a metaphorical, theoretical, and empirical device not only in social science discourse and practices but also in such varied disciplines as architecture, astrophysics, ecology, economics, defence studies, history, literary theory, management, New Age, philosophy, politics, post-structuralism, sociology, and town planning. A range of popular books within the field of complexity science have been appearing in a steady stream over the last two decades, some more explicit in their attachment to complexity than others.

Some significant books in this range include Chaisson's *The Life Era: Cosmic Selection and Conscious Evolution* (1987); Davies's *The Cosmic Blueprint* (1988); Nicolis and Prigogine's *Exploring Complexity* (1989); Stewart's *Does God Play Dice?* (1990); Hayles's *Chaos and Order : complex dynamics in literature and science* (1991) Kauffman's *The Origins of Order: self-*

organization and selection in evolution (1993); Arthur's *Increasing Returns and Path Dependence in the Economy* (1994); Krugman's *The Self-Organizing Economy* (1995); Capra's *The Web of Life* (1996); Holland's *Hidden Order: How Adaptation Builds Complexity* (1996) ; Prigogine's *The End of Certainty* (1997); Rescher's *Complexity: A Philosophical Overview* (1998); Byrne's *Complexity Theory and the Social Sciences* (1998); Cillier's *Complexity and Postmodernism* (1998); Watt's *Small Worlds* (1999); Rycroft and Kash's *The Complexity Challenge* (1999); Gladwell's *The Tipping Point: how little things can make a big difference* (2000); Taylor's *The Moment of Complexity: emerging network culture* (2001); Capra's *The Hidden Connections* (2002); Buchanan's *Nexus: small worlds and the groundbreaking science of networks* (2002); Wolfram's *A New Kind of Science* (2002); Barabasi's *Linked* (2003); Watts's *Six Degrees: The Science of a Connected Age* (2003); Strogatz's *SYNC: The Emerging Science of Spontaneous Order* (2003) Gribbin's *Deep Simplicity: Chaos, Complexity, and the Emergence of Life* (2004); Ball's *Critical Mass: How One Thing Leads to Another* (2004); and Surowiecki's *The Wisdom of Crowds* (2004).

With these titles finding 'popular' appeal on the mass market 'complexity practices can themselves be viewed as a self-organizing global network spreading "complexity" notions around the globe' (Urry, 2005b: 2). To consider the complexity sciences entails an acknowledgement of the presence of multiple and complex sites where complexity theory is produced and consumed as a viable method and/or metaphor. Thrift argues that complexity theory is itself a metaphorical movement, one that is of a particularly rapid kind. He also refers to it as a 'scientific amalgam', as 'an accretion of ideas, a rhetorical hybrid' (Thrift, 1999: 33). In this regard Thrift follows Goodwin (1997) in seeing the idea of this hybrid science as possessing holistic dimensions. In other words, the holistic nature of complexity theory is a recognition of the emergent properties within complex phenomena, and a recognition of the shift within the scientific paradigm that sees parts being replaced by processes, and structure by pattern and relationships. Here there is familiar terminology; an interpretation of complexity theory as an amalgam, a hybrid science, an accretion of various ideas; somewhat similar to the consilience of Wilson. Also, for Thrift, complexity theory exists within the spaces of metaphorical geographies, an 'economy of concepts based around this emergent or self-organizing impulse' (Thrift, 1999: 34), whilst acknowledging that complexity science has travelled through various spaces, or rather sites.

Thrift's argument is that several specific networks have accelerated the emergence of complexity theory and its public exposure, and names the scientific, business, and New Age networks as exemplars. These networks, Thrift shows, are themselves connected and act as nodal points between flows. This reinforces the idea that complexity science, as an umbrella term for a rapidly emerging nonlinear, dynamic perspective, is inclusive of several core concepts. Amongst them, networking, patterns of connectivity, flows and movement, are dominant.

Thrift (1999) also acknowledges that 'complexity', although a newly defined phenomenon, owes a debt to a mixed heritage, a 'complex genealogy'. The gathering contributions from mathematics, computing, evolutionary theory, artificial life, microbiology, et al., can be seen as fostering a need to regard phenomena in terms of newly refined parameters of interpretation. The very fact that these findings have been used as metaphors and models for such subjects as economics (Arthur, Durlauf and Lane, 1997), history (Artigiani, 1987; De Landa, 2003), culture and the arts (Hayles, 1991; Taylor, 2001; Cilliers, 1998), philosophy (Rescher, 1998), and sociology (Byrne, 1998; Eve, Horsfall and Lee, 1997; Khalil and Boulding, 1998; Urry, 2003a), suggests that there are numerous correspondences between physical phenomena and interconnected processes, making the argument for a complexity theory analysis more relevant.

Global events, which by their name imply a transgression of bounded territories, increasingly infer a shift from inclusion towards an ecological paradigm. Here I use the term 'ecological' in the sense of a systemic interrelation whereby linear cause-effect approach is redundant and instead events, actions, agency are bound by a globally related responsibility. Here Clark sees complexity theory in terms of his ex-orbitant globality hypothesis 'that extends the destabilization of regional or national boundedness by social theorists to the perimeters of our planet' (Clark, 2005: 166). Clark regards complex systems at a global scale as implying, and involving, a degree of consideration of what it means to inhabit a planet that is open and not bounded to terrestrial influences alone. Such an unbounded territoriality infers a global system that is open to a cosmic environment of cyclic catastrophe, collisions, and perturbations that 'seems consistent with the general tenor of the study of dynamical systems which social theorists of a complex globality are drawing upon' (Clark, 2005: 177). In this context Clark is highlighting the problematical nature of a global complexity that is not closed to cosmic interventions and interferences. Such sites of complexity then are not necessarily terrestrially bounded but allow for the unpredictability of unforeseen global encounters. The question of global (un)boundedness that complexity theory provokes has pushed sociological thought to recognise that it may operate beyond societies, in a space of flows, fluids, networks, and scapes (Urry, 2000; 2003a). Whilst the metaphors of flows and fluids have entered into social theory (see Urry, 2000) as 'metaphors of the global', they have not yet become substitutes for any kinds of 'law'. They may stand as advocating new ways of pursuing sociological method, yet they are still being sociologically contested (McLennan, 2003).

Complexity theory, as a means of ordering the disorder of flows and scapes, may be more than a metaphor. In this thesis I show that there is a practical side to complexity theory that can be applied to physical phenomena beyond metaphorical analogies. To begin, I examine how the social sciences have made use of the complexity sciences.

Complexity and the Social Sciences

Already in the early 1990s there were published debates over whether complexity theory was just a 'fad' or if indeed it was the future (Ravetz and Sardar, 1994). Yet before the complexity sciences had emerged as a credible social science discipline various analysts of modernity and globalisation were already utilising strikingly similar concepts in their interpretation of social processes. Giddens (1990) had described the modern world as being characterised by irreversible processes with almost nonlinear and unpredictable effects and consequences. Giddens' earlier 'Theory of Structuration' (Giddens, 1986) bears similarity with systems theory with its emphasis on feedback loops, and also with complexity theory in its focus on social practices that become ordered across interdependent relations of space and time. Giddens views social practices, the repetition of acts through individual 'agency', as reproducing the structure, with such structures being neither unbreakable nor permanent. In this manner there are similarities to the dynamic relations often manifested through complex phenomena. Later in these globalisation debates Bauman conceptualises late modernity as a place/space of liquidity and flows, with increased movements of images, money, information, etc. (Bauman, 2000).

Prior to notions of global complexity (Urry, 2003a; 2005a), complexity characteristics were being played out on a global stage in terms of flows rather than solid, territorial structures. One particular domain that was early to undergo a complexity analysis was economic flows. Brian Arthur, who was connected to the Santa Fe Institute during its early years, was one of the first economists to state a direct link between global economic flows and complex phenomena. Arthur noted that 'within the most significant parts of the economy, interacting, non-equilibrium beliefs are unavoidable, and with these so is a world of complexity' (Arthur, 1995). It was the 1980s that first saw 'an intense burst of activity in increasing returns economics' that led to 'positive feedback mechanisms…now central to modern theorizing in international trade theory, the economics of technology, industrial organization, macro-economics, regional economics, growth theory, economic development, and political economy' (Arthur, 1994). Arthur's work was supported by Krugman's analysis of a self-organising economy that examined how economies organize themselves in space over time, citing examples of how cities differentiate themselves into specialized districts; the power-law distribution of city sizes; and business cycles (Krugman, 1995). Complexity theory thus gave a means by which to view these economic flows and cycles within an alternative paradigm/construct.

In this way the complexity sciences facilitated a means of engaging with and interpreting both macro-phenomena and micro-processes, both global and local flows. Further, complexity science arose at a time when overlaps between new socio-cultural shifts were emerging, especially in terms of an interconnected 'network society' (Castells, 1996), as well as cosmopolitanism and trans-nationalism (Beck, 2002). Complexity theory offered new ways at this time to consider some of the traditional issues in social science such as inequalities and social change. Walby states that 'complexity theory offers a new set of conceptual tools to help explain the diversity of and changes in contemporary modernities undergoing globalisation' (Walby, 2004). The emergence of a concern with global processes in the early 1990s called for a post-reductionist critique that complexity theory seemed able to provide. It is here that complexity theory can provide an analysis of change and diversity, whether on the global level that Walby discusses in terms of systems, environments, and path dependence (Walby, 2004), as well as the global microstructures that Knorr Cetina highlights (Knorr Cetina, 2005). Knorr Cetina conceptualises global microstructures as 'structures of connectivity and integration that are global in scope but microsociological in character' (Knorr

Cetina, 2005: 215) and which exemplify decentralised guerrilla mobilisations such as asymmetric terrorist organisations. Here Knorr Cetina views complexity theory as a means of analysing these dynamic interrelations of dispersed coordination, similar to how network-centric warfare has been framed (Arquilla and Ronfeldt, 2001b). Within post-reductionist globalisation debates, complexity theory can offer an alternative framework in which to analyse decentralised flows, and dynamic change, as well as issues of bottom-up and top-down governance (Chesters and Welsh, 2005).

In a similar approach Hardt and Negri have argued for a re-conceptualisation of the concept of 'empire' in which interdependence rotates around pivotal nodes, a system of mobile power, that brings forth 'governance without government' (Hardt and Negri, 2001: 14). In connection with complexity theory, Hardt and Negri, through their work on biopower, construct the major powers – both political and corporate – within a 'fundamental connective fabric' that relates to global spaces (Hardt and Negri, 2001: 31). However, this reading of empire does not fully explain what happens to nation states within this pivotal interpretation of mobile power. Also, Hardt and Negri, I argue, lack an analysis of the flows, processes, and global inconsistencies that otherwise problematise their notion of decentralised governance. If this positioning of a global de-territorializing is less within the contrived '*regime* of the production of identity and difference, or really of homogenization and heterogenization' (Hardt and Negri, 2001: 45) then it may be open to a complexity model that recognises the unpredictability of social bifurcations. As it is, Hardt and Negri describe the connective fabric of 'empire' as one that seeks to manoeuvre itself as a conscious force within an imperial paradigm instead of within a dynamic, open, systemic one. Whilst *Empire* is not explicit in its association with complexity theory, Clark (2005) notes how Hardt and Negri appear to have inherited much of their theorising from the dynamical systems theory that informs the work of Gilles Deleuze. Another theorist who has combined the philosophy of Deleuze with the complexity sciences is Manuel De Landa.

De Landa took the complexity sciences to a more developed level of integration into historical and philosophical processes (De Landa, 2000). De Landa sought to apply complex dynamical systems to subjects such as history, science, and philosophy through geo-physical, as well as economic, interplays of complex systems. De Landa's method is to plot the fluctuations and bifurcations of historical movements to pattern the world as a dynamic and highly interdependent space of adaptive systems of strange attractors and emergent behaviour. In this approach De Landa re-configures the globe to be place/space best to be conceived and modelled through the tools provided by the complexity sciences (De Landa, 2000). In De Landa's analysis the 'global' goes beyond the nation state towards a space comprised of various systems within systems, operating at various levels, with mobile and material systems in complex interconnections with their environments. Similarly, on a more local level, some social theorists have sought to use the complexity sciences to better understand phenomena such as urban growth, policy, and planning (Allen, 1997; Byrne, 1998; and Elliot and Kiel, 1997).

For example, Byrne was an early adopter of integrating complexity theory with empirical data, and affirms in *Complexity Theory and the Social Sciences* that positivism is dead and that the complex is real (Byrne, 1998: 37). Or rather, that 'which we observe in the world is real and that it is the product of complex and contingent causal mechanisms which may not be directly accessible to us' (Byrne, 1998: 37). In this way, Byrne uses complexity theory to 'see' the real in the causal mechanics of the social world, and unapologetically uses a quantitative approach that is itself a tool to model social statistics. Byrne's approach is that quantitative social action is informed by a social engineering that is becoming more based upon complex phenomena. With rational agency, this understanding of complex phenomena may serve to inform the social actors, or agents. In Byrne's work there is a very pragmatic sense that complexity theory is not so much borrowed but rather is here to contribute and inform. The strong point in Byrne's analysis is towards social and urban policy, with these areas the major focus for complexity theory. Also, Byrne takes such terms as bifurcations, emergent properties, and dissipative structures, to show how they may be planted within the processes of neighbourhoods 'flipping', or the shift in urban planning, much in a similar vein to Johnson (2002).

Whereas Byrne is using an amalgam of complexity terms to contribute to social planning, Johnson (2002) looked specifically at the emergent properties of cities in a more holistic manner, and described how segments of a neighbourhood would self-organise into communities specific to such features as ethnicity. Johnson compares this to how historical city neighbourhoods were often divided up according to crafts and skills, as in areas of the city guilds. This self-organised form of complex neighbourhood relations is less planned in comparison to modern complex city management.

Another contribution to urban planning is that of Allen (1997) who has taken self-organising complexity theory as a model for urban growth, and using mathematical models has attempted to simulate how towns, cities, and urban regions may co-evolve through constant interaction and energy-driven growth. Allen's work presents an authoritative interpretation that, unlike Byrne, places his complex mathematical modelling closely in line with Prigogine's work on dissipative structures. Like Byrne, Allen stresses that knowledge of complexity theory should be used to inform social policy and decision making, and urges that 'policies should reflect this uncertainty and always allow diversity, and redundancy in the system to allow for future adaptations to the emerging reality' (Allen, 1997: 258). Whereas Allen remains within urban models, Byrne also examines health and education within complexity theory, stating that

> the significance of the chaos/complexity approach lies precisely in the recognition that whilst there is no inevitable outcome, no linear law, no single answer, we can nonetheless analyse in order to see what the possible set of outcomes might be…we retain a programme of rational agency. (1998: 118)

This appears to veer towards wanting the nonlinear random behaviour of complex processes to be within human bounds of rational agency. Whilst I agree that there are predictive capabilities within complexity theory, Byrne's quantitative approach to complexity-as-analysis avoids some of the more significant elements of geographical spaces in healthcare such as the risks in global viral and epidemiological flows (Van Loon, 2002). As Elliot and Kiel recognise, because 'we live in a highly nonlinear world does not mean that nonlinear dynamics and complexity studies are necessary for all policy studies'

(1997: 70). Elliot and Kiel see a need for nonlinear dynamics and complexity analyses to be complementary rather than exclusionary. Overall, in terms of urban and social planning, it can be seen how complexity theory may be used by public policy, and the social sciences, in order to better understand how elements of change and variability can shape and affect urban growth.

Another field of study that has made use of the complexity sciences is that of the arts and literature (Hayles, 1991; Taylor, 2001). Art has often been an abstract, nonlinear medium for creative expression, yet now many existing art works, including the swirling night-time skies of Van Gogh, can be seen, literally, in a different light. Computer simulation too can be used for digital art using nonlinear algorithms. Also, as Hayles (1991) reminds us, some of the cut-up techniques used by such notables as William S. Burroughs in the 60s and 70s can be seen to employ nonlinear methods to create a narrative within a seemingly disordered and fragmented literature-scape. This idea of language and narrative has been explored further by Cilliers who examines language as a complex system, and Derrida's deconstructions, post-structuralism and semantics as operating within possible open systems of complexity (1998). Cilliers argues that the 'postmodern' world can also acknowledge 'complexity' through a recognition of the shifts and changes within postmodernism 'not as epiphenomena, but as constitutive of complex systems' (Cilliers, 1998: 112). Although I am inclined here not to agree totally with Cilliers who sees a postmodern world requiring complexity, I do consider that a postmodern analysis could benefit from using a complexity theory model. Further, Cilliers notes that it would perhaps be more clarifying to regard the properties of a complex system not as 'emergent' but rather as 'relational properties' (Cilliers, 1998: 143n). In this way, the multiplicity and diversity, and the incredulity towards meta-narratives (Lyotard, 1984) that feature in postmodernism are compatible with the relational nature of the complexity theory model. Cilliers suggests that 'the postmodern approach is inherently sensitive to complexity, that it acknowledges the importance of self-organisation whilst denying a conventional theory of representation' (Cilliers, 1998: 113). It is here perhaps that there could be a compatible overlapping in theories, where complexity theory intermingles and validates the multi-layered textures of a postmodern pluralistic and non-grand unified perception of socio-cultural events. However, I do acknowledge that postmodernism is inherently more varied than what the characteristics of complex systems, in this brief overview, may signify.

Already debates on social complexity have done much to build bridges between the natural sciences and the 'social'. Nowotny argues for such bridges, or 'interfaces', to examine 'complexity' as a scientific and social phenomenon. In this context Nowotny states that complexity science is too significant to be left to scientists alone:

> complex evolving systems are not to be left to science alone, since they are entangled with the complexity of social systems. They involve human agents and things, science and society, in novel configurations (Nowotny, 2005: 28).

This scientific novelty, says Nowotny, requires a social reading in order to be fully appropriated, and that a social interface with complexity theory will help secure its place away from reductionist readings in that

> the race between the increase of complexity and its reduction, the humanities and social sciences have an important task

> ahead. A deeper theoretical understanding of complexity, not as mathematical, but as a social phenomenon is required (Nowotny, 2005: 29).

In a similar way sociologist of science Brian Wynne critiques science as the sole ritual authority in these debates (Wynne, 2005). Wynne argues that complexity scientific thinking 'in relations to genetics, and latterly genomics and post-genomics, has existed and developed within biological science for some time' (Wynne, 2005: 70) yet this should not necessitate a scientific domination. In his strong anti-reductionist argument Wynne states that public culture is already aware of particular forms of complexity within such issues as GM food and similar public risks. Complexity approaches to phenomena then should exist as a force within public policy and not reside exclusively within scientific ritual/reductionist authority. Wynne offers an important contribution to this debate and both shows and develops significant and neglected interrelations between that of science and society (Wynne, 2005).

Complexity approaches within the social sciences have done much not only in forming bridges between particular disciplines but also in breaking down the dichotomies of order **or** chaos, of stasis **or** change, to produce a hybridisation of processes that can exist in both order **and** chaos, with both pattern **and** uncertainty (Prigogine, 1997). Systems of change can be sustained through reflexive positive feedback loops that are not bound by territorial restraints, yet instead are informed through flows of an increasingly global nature. Flows of information, people, goods, money, the material forms of circulation that embody complex social and political mechanisms (Appadurai, 2001) are areas that are open to analysis through complexity science. Similarly, the rise and fall of social revolutions has been viewed through a complexity theory lens (Artigiani, 1987; 1991).

This thesis focuses on revolutions of a different nature: on social re-orderings in space and time, on the electronic proximities opening up through technologies of communication that are re-configuring physical-digital connections; and on the social movements empowered through technologies that connect, communicate, and facilitate forms of networked collaboration. Thus, this thesis will examine how social networking and communications are processes that are better understood through the lens of complexity theory. Although the social sciences are perhaps best positioned to gain from a complexity analysis on such areas as social networking and communications, there are other varied disciplines that can benefit from a complexity theory analysis. Complexity theory is making significant in-roads into business, management and organisational studies, and strategies of warfare.

Complexity Overlaps in Business, Management & War

Features of the complexity sciences have now infiltrated and/or informed many diverse fields of action, thought, and policy, including business organisation and leadership (Axelrod and Cohen, 1999; Griffin, Shaw and Stacey, 2000; Mitleton-Kelly, 2003; Fonseca, 2002); philosophy (Rescher, 1998); and politics and national security (Alberts and Czerwinski, 1997). Insights into natural processes of organisation and growth have, it seems, provided models for social human systems in terms of human and resource management, power hierarchies, group interaction, and variable networking. Researchers Axelrod and Cohen (1999) have ‘harnessed complexity’ in order to transfer its features towards business management and organisation. In particular, the approach to management taken here is based upon the notion of *complex adaptive systems*, as discussed previously. For Axelrod and Cohen, three qualities inherent in such complex adaptive systems are essential to successful business: variation, interaction, and selection. Also, a key element in their analysis is the role of information as both an adaptive and a complexifying agent. In this sense, they regard what they call the ‘Information Revolution’ as reducing the barriers to interaction, thus opening up scope for complex processes to manifest more readily, making information a ‘mediator of interaction’ (Axelrod and Cohen, 1999: 26).

By taking a complexity theory perspective to business management Axelrod and Cohen see fit to pronounce such beneficial transformation in practices as exploration and variety over exploitation, and proximity; social capital over physical-social barriers, re-defining criteria of success, system performance and effective learning, and a visible leadership exercising careful strategies of selection. As a way of summarising, the authors state how a working whole – a ‘coherent framework’ – may be achieved:

> **Agents**, of a **variety** of **types**, use their **strategies**, in patterned **interaction**, with each other and with **artefacts**. **Performance measures** on the resulting events drive the **selection** of agents and/or strategies through processes of error-prone **copying** and **recombination**, thus changing the frequencies of the types within the **system**. (Axelrod and Cohen, 1999: 154 – bold type in original)

In other words, both Axelrod and Cohen here are modelling naturally found complex phenomena onto human models of behaviour; in this instance, business management skills. As the authors state, this is not an extension of the 'evolutionary metaphor' of Social Darwinism to social systems but instead is a mapping of the correspondences between these fields of study.

Similarly a recent edited work by Eve Mitleton-Kelly has brought together complexity theory with evolutionary perspectives on organisations, using

> the logic of complexity to argue for a different approach to managing organisations through the identification, development, and implication of an *enabling infrastructure*, which includes the cultural, social, and technical conditions that facilitate the day-to-day running of an organisation or the creation of a new organisational form. (Mitleton-Kelly, 2003: 46)

One of the approaches suggested by Mitleton-Kelly is to manage organisations as complex evolving systems, co-evolving within a 'social ecosystem', in such a way that self-organisation would be encouraged and emergence would be facilitated. The terminology being used here is identical to those processes outlined in the previous chapter, from the language of the new developments in the complexity sciences: co-evolving; self-organisation; and emergence.

Similar terminology and perspectives is used by Fonseca, who tries to show that the nonlinear dynamics of complexity are needed to break out of the organisational patterns of habit and routine (Fonseca, 2002). Fonseca argues that generally organisations are 'patterns of interaction between participants' that exist in a 'closed self-referential process', whereas real innovation requires 'the possibility of variations in reproduction and the potential for these to be amplified in the nonlinear iterative process of reproduction' (Fonseca, 2002: 80). Here, management organisation is shown to benefit from assimilating the lessons of dissipative structures, for innovation to become a 'complex responsive process', and for the role of misunderstanding to be relevant to the process of bifurcation and creative growth:

> From the complex responsive process perspective I am taking, misunderstanding fuels and is fuelled by the search for meaning and this implies that mainstream thinking is actually a way to stop innovation rather than produce it. (Fonseca, 2002: 87)

In a similar approach Griffin, Shaw and Stacey (2000) have also addressed the complexity notions of stability vs. change, system interaction, dissipative structures, and emergence for management scenarios. Approaches such as this seek to maximise upon change and instabilities in order to foster novelty and creativity, instead of the more common practice of aiming to stifle difference and disruption. Griffin, Shaw and Stacey view the complexity sciences as presenting a challenge to current dominant management discourses (2000). They also view the complexity sciences as offering insights into various business applications in such areas as understanding the growth of organisational processes; self-organising interactions as causes of emergent new directions; organisational relations needing to be dynamic rather than individually competitive; success as a paradox of 'stable instability'; and that difference and diversity should be recognised and embraced (Griffin, Shaw and Stacey, 2000).

What has been highlighted by these new approaches is the move to draw on the characteristics of naturally occurring complex phenomena to help model the behaviour of particular human systems – in this case, business management. That such overlaps appear possible, and potentially beneficial, shows that there is a capacity for using complexity theory to remap social practices. In the light of more recent terrorist events that have dominated the opening years of the twenty-first century, strategic thinking has begun to look seriously into the decentralised manner of people and information networking in order to be prepared to encounter the 'cell' infrastructure of various terrorist networks (Arquilla and Ronfeldt, 2001b). The complexity sciences have not been ignored by military sources; they have, in fact, since the early 1990s been employed as a new approach to solving military problems.

In 1994 the U.S. Marine Corps adopted both the concepts of nonlinear dynamics and complexity theory in order to shed light upon manoeuvre warfare (Alberts and Czerwinski, 1997). Further military interventions into the complexity sciences followed, with the publication in 1996 of MCDP 6-*Command and Control*, which explicitly uses concepts from complexity theory (Alberts and Czerwinski, 1997: xv). Some military strategists see a direct bearing to their own field of that of the complexity sciences:

> The greatest and most direct military implications of complexity theory are likely to be in the area of command and control. Complexity theory is command and control theory:

> both deal with how a widely distributed collection of numerous agents acting individually can nonetheless behave like a single, even purposeful entity. The emerging sciences suggest that war is a radically different type of phenomenon. (Schmitt, 1997: 219-20)

The complexity sciences demonstrate that not only can specific fields be affected by the new understandings that they bring, but also that the perceptions of relationships within the world can be re-figured. That these relationships have nearly always been there, yet are being viewed afresh through the lens of complexity theory, is part of the argument of this thesis. Beaumont states that the chaotic nature of war was noted in military history long before the rise of nonlinearity and the complexity sciences, citing the 1933 edition of the German army's Field Service Regulations, *Truppenfuhrung*, as an example (Beaumont, 1994: 5). As another example, the iconic Prussian general and military strategist Clausewitz (1780-1831), whose ideas on the nature and theory of war have been used and cited extensively by military strategists, describes the military machine in a way that shows similarities to that of a 'vulnerable' complex system:

> The military machine…is basically very simple and therefore seems easy to manage. But we should bear in mind that none of its components is of one piece: each piece is composed of individuals, every one of whom retains his potential of friction…A battalion is made up of individuals, the least important of whom may chance to delay things or somehow make them go wrong. (Schmitt, 1997: 233)

The knowledge provided by the complexity sciences may not be totally new, yet they provide a model through which to interpret patterns, relationships, and outcomes in these various contexts. And there are benefits here for defence strategies, as Beaumont explains:

> if military professionals gained a clearer sense of an order lying beneath apparently random patterns of battle, that would aid the design of deception, or the countering of it, as well as the shaping and arraying of forces, and the timing, phasing, and tempo of manoeuvres. (1994: 11)

As Beaumont infers, a knowledge of chaotic and complex processes may aid tacticians in defence strategy and to gain insight into dynamics that before remained 'hitherto only sensed vaguely, or wholly out of view, and serve as a practical device for ultimately controlling it or preventing it altogether' (Beaumont, 1994: 11).

One of the most visible effects of this interplay in military thought is the prominent rise of 'networks and netwars', which is being hailed as the 'future of terror, crime, and militancy' (Arquilla and Ronfeldt, 2001b). The term 'netwars' is described as

> an emerging mode of conflict (and crime) at societal levels, short of traditional military warfare, in which the protagonists use network forms of organization and related doctrines, strategies, and technologies attuned to the information age. These protagonists are likely to consist of dispersed organizations, small groups, and individuals who communicate, coordinate, and conduct their campaigns in an internetted manner, often without a central command. Thus, netwar differs from modes of conflict and crime in which the protagonists prefer to develop large, formal, stand-alone, hierarchical organizations, doctrines, and strategies as in past efforts (Arquilla and Ronfeldt, 2001a).

This shift in military strategy, and the nature of conflict, is directly influenced by the information revolution in that it strengthens and favours network forms of organisation over those of an hierarchical nature, and also recognises that networks are increasingly mobilising non-state actors (Arquilla and Ronfeldt, 2001b). In the light of their research, Arquilla and Ronfeldt have put forward several policy-oriented propositions based on the increasing role of netwars and complex, decentralised systemic behaviour: i) Hierarchies have a difficult time fighting networks; ii) It takes networks to fight networks; and iii) Whoever masters the network form first and best will gain major advantages , (2001a; 2001b).

As well as military command strategy and 'netwars' appropriating the complexity sciences, the complexity sciences have also been making inroads into defence policy, air power, and national security (Alberts and Czerwinski, 1997). Complex networks do not necessarily require the latest technology – it is a strategy for the low-tech environment much as it is for the high-tech. What appears to be the crucial element is the organisation of decentralised relationships, whether they be between hi-gadget 'cyber' soldiers or peasant rebels using ham radios and local 'runners'. Within this behaviour there is also the capacity for 'swarming', or what is known as a 'seemingly amorphous, but deliberately structured, co-ordinated, strategic way to strike from all directions at a particular point or points' (Arquilla and Ronfeldt, 2001b: 12). This swarming behaviour within complex networks is analogous to what will later be referred to as 'smart mobs', or the collective action of social protest. The idea of empowered and mobilised groups/collectives/systems as having emergent properties has significant implications for both civil strategy and the promises of a global civil society, as well as for military and defence applications.

Complexity & Global Civil Society

The rise in mobile communication technologies in the twentieth-century has had a profound effect upon the ability for individuals to receive, transmit, and organise their own distributed forms of information, abetting civil networks. The form of civil society, both local and global, is 'being transformed by new forms of communication that increase people's autonomy to retrieve their own sources of information and to develop their own communication channels' (Castells, Fernandez-Ardevol, Linchuan Qiu and Sey, 2006: 283). Global civil society itself occupies a place/space within the interrelations of global information flows, and can be seen to operate neatly within the features of a complex system, such as that of self-organisation, non-hierarchical networks, and individual collaborative efforts towards a shared goal. Such notable similarities between global civil society and complexity theory have been analysed (Chesters, 2004; Keane, 2003; Munck, 2002). Within emerging networks of physical-digital connectivity much has been achieved in the way of social campaigning, as the research in this thesis highlights. Later chapters examine these issues in more depth and range, yet here it is appropriate to 'flag' this area as another overlap where complexity theory can be situated. And this is an appropriate positioning for the complexity sciences as recent growth in global civil society organisations has been staggering:

> there are an estimated 5000 world congresses held annually and some 50,000 non-governmental, not-for-profit organisations operating at the global level. The numbers of these international non- governmental organisations have grown rapidly in recent years; helped along by access to money and communications technology, many thousands have come into being since 1985. Nearly 90 per cent of them have been formed since 1970. (Keane, 2003: 5)

Modern civil society, aided by the expansion and rapidity of global communications, is able to operate an integrative policy that sees both multiplicity, diversity, yet unity in their actions; for example, the many and diverse operations of Amnesty International or Greenpeace. At the same time, the actors involved can be said to be more reflexive as they are able to operate and respond to events as close to real time as possible relative to the timing and accuracy of their information. Examples of the now global civil society include

> bodies like Amnesty International, Sony, Falun Gong, Christian Aid, al Jazeera, the Catholic Relief Services, the indigenous and peoples bio-diversity network, FIFA, transparency International, Sufi networks like Qadiriyya and Naqshabandiyya, the International Red Cross, the Global Coral Reef Monitoring Network ...these institutions and actors constitute a vast, interconnected and multi-layered non-governmental space that comprises many hundreds of thousands of more-or-less self--directing ways of life. (Keane, 2003: 9)

Global civil society is dynamic and eclectic in its relationships due to the very nature of the diverse actors, both geographically and psychologically, that constitute its parts. And by the term 'global civil society' this itself is a broad and fuzzy category that although implies networks of social processes provides, within its fringes, the vague spaces where illegal traffickers, arms traders, and terrorists hide/hang out. As Keane explains, the 'spaces of freedom within global civil society also enable individuals and groups to network, in the form of criminal gangs that run World-Wide Industries. An example is the sale and sex trafficking of young girls and boys' (Keane, 2003: 13). Networks within global civil society can be stretched both thinly in certain areas, and again clustered into hubs around the more successful, generally western-funded and publicly known, organisations. Keane understands the dynamics of the global civil society as non-defining its boundaries – 'the "micro" and the "meso" and the "macro" dimensions of this society are both interconnected and co-determinant of each other' – such that any actions and events 'are implicated in loops that produced feedback' (Keane, 2003: 24). Keane further suggests considering the use of complexity theory as a resource:

> the use of ecological similes and themes drawn from complexity theory may be questionable, but they serve the basic purpose of identifying the urgent need to develop theoretical imagery for better imagining global civil society, as it is and as it might become (Keane, 2003: 24).

Highlighted here is the visible overlap between networks and processes of global civil society and the model of complexity theory that offers resources of terminology, analogies, and interpretations of these expanding global networks. Later on this thesis develops these correspondences and analyses their significance in greater depth. What this shows is that complexity theory is a body of knowledge that can be used as a lens for the analysis of social trends. The success of this approach, however, is not certain; this being the very reason it forms the basis of the research undertaken here.

Another overlap between the complexity sciences and other fields of discourse is that of ecological philosophy, especially in the area of Gaian thinking.

Complexity & Gaian Thinking

The 'Gaia Hypothesis', as mentioned in Chapter One, was first put forward in the early 1970s, and fully published in the 1980s by James Lovelock (Lovelock, 1988). This understanding sees the Earth as a whole self-regulating entity whereby its actual physical and chemical composition has been brought into a homeostatic relationship through the aeons of organic life. It is thus described as a complex living system, each part playing a role within the whole, as a complete cybernetic web. This would help explain why a small fluctuation or disturbance in one area of the Earth's ecology could cause a chain of devastating consequences. Lovelock's perceptive theory, coming before the rise of the complexity sciences, acknowledged that the now famous 'butterfly effect' could illuminate the almost unpredictable global consequences of global warming and other climatic disturbances (Lovelock, 2006). Global ecology itself is an intricate web of interdependent processes, all interacting within a self-regulated balance of sustainability and dynamic, yet not stable, equilibrium. In this way it can be said that a broader understanding of the complexity phenomenon may better inform aspects of environmental ecology, and help to understand long-term sustainable interrelations and dependencies.

To some degree this call has been taken up by Fritjof Capra who sketches a scenario where two tangent network webs, that of global capitalism and sustainable ecology, may be on a collision course. By seeking a 'unified framework for the understanding of biological and social phenomena' (Capra, 2002: 3), Capra, a systems theorist, addresses the need to integrate the electronic networks of financial and informational flows with ecological networks of energy and material flows to better formulate a 'Gaian' approach to future global regulation and balance. Capra advocates complexity thinking to further work its way into new understandings of the interconnectedness of bio-socio-eco relationships.

In a somewhat similar vein the concepts inherent to the complexity sciences were touched on much earlier in more spiritual 'Gaian' thinking in the writings of the Jesuit priest Teilhard de Chardin (1959; 1969; 1974). In de Chardin's work he writes that 'the more complex organisms become, the more evident becomes their inherent kinship. …It continues in the similarity of the methods employed by units for collecting together in higher organisms and becoming 'socialised'' (Chardin, 1959: 99-100). This complexity of the socialization of organisms, according to de Chardin, will eventually become a 'mass-formation', or 'planetisation', suggesting that 'peoples and civilisations reached such a degree of either physical communion or economic interdependence of frontier contact that they could no longer develop save by interpenetration of one another' (Chardin, 1959: 252). This envisioning of development through global interpenetration was arrived at under constrained conditions, and as early as the 1920s. Given that de Chardin was writing in isolation (his works were banned by the Catholic Church and he was barred from teaching and posted to China), and that his ideas were the product of thought in the 1920s and 30s, it is remarkable that such insights could be expressed under these times and conditions. The core to de Chardin's work was the creation of a 'noosphere', coined in 1925, that envisioned, in contrast to the biosphere, a global interrelated system of organized thought and consciousness that was 'the specific effect of organized complexity' (Chardin, 1959: 15). Although the term 'complexity' was not used in the same mould as it is being used here, the concept behind its use is still markedly similar. In fact, de Chardin's 'noosphere' can be interpreted as being realized through the rise of global information technology communications, in particular the Internet.

This approach to a complex global systemic world, in an eco-spiritual interpretation, has been growing steadily within particular info-tech circles, with de Chardin's work being carried over into more recent research, such as Russell (1995), as well as being integrated into a cyber-technological approach (Levy, 1999), and cultural theory (De Kerckhove 1998). The correspondences between Gaian thinking and the complexity sciences are many and varied, to which this thesis has only but briefly touched upon here.

This chapter has brought together various strands that have highlighted the interdisciplinary potential of the complexity sciences, both in 'soft' and 'hard' theory. Specifically, it has attempted to examine how aspects of the complexity sciences have deliberately overlapped, and been borrowed by, the social sciences as useful tools and devices with which to bear upon social processes and phenomena. Other interplays and overlaps with complexity theory have been shown to occur in business, management and organisation studies, military strategy, civil society, and Gaian thinking. Such borrowings have often proven fruitful, other times contentious and controversial. Yet it shows that with the rise of the complexity sciences as a prominent ‘mapping’, within the last decade especially, a significant shift has occurred in how processes, patterns, and trends manifesting in the world are viewed. In the next chapter I turn to examine how information forms a central core of complexity theory, and of the various channels in which information drives complex processes. This argument is key to this thesis as I focus upon social information flows as informing technical-social patterns of behaviour and communicative interaction.

CHAPTER THREE

Complexity & Information

> ‘To live effectively is to live with adequate information. Thus, communication and control belong to the essence of man’s inner life, even as they belong to his life in society’
>
> Norbert Wiener

> ‘Everyone takes the limits of his own vision for the limits of the world’
>
> Schopenhauer

As previously stated, the complexity sciences, having arisen from a chemical, physical, and biological knowledge base, can be seen as being part of a shift towards transdisciplinary discourse. Social processes, on both a local and global scale, are also a part of these ongoing discussions. This approach recognises the similarities and benefits from collaborative knowledge. According to a report from the Gulbenkian Commission,

> in a strange way, the shifts in viewpoint in all fields seem to be moving more toward than away from the traditional standpoints of the social sciences. May we then say that the concept of two cultures is in the process of being overcome?(GCRSS, 1996: 69)

The Gulbenkian Commission continues by saying that 'we feel that the principle lesson of recent developments in the natural sciences is rather that the complexity of social dynamics needs to be taken more seriously than ever' (GCRSS, 1996: 78).

This suggests a need to re-examine how the 'social' is interpreted: in particular, how social networking in the age of global electronic communications is re-configuring notions of time, space, agency, and connectivity. This leads to the question of whether, and how, the complexity sciences have a place at the forefront of such social shifts that are occurring in an apparently increasingly globalised world (Bauman, 2000; Beck, 1998; Capra, 2002; Castells, 1996; Robertson, 1992; Tomlinson, 1999; Urry, 2000; 2003a). Part of this re-examining of the place/space complexity occupies within the social sciences, as suggested by the Gulbenkian report, involves making visible how some of the literature around complexity theory discourse has shifted. It is in this respect that I now spend some time in examining models of complexity theory that have been invested in socio-cultural debates, with specific attention to the role of information, accompanied by biological and cultural representations of information. The aim of this chapter is to provide a background to how complex processes have been interpreted within socio-cultural movements and shifts, and to provide an angle whereby information can be viewed as a significant presence in complexity theory, especially in light of the later chapters which consider present social information flows within a complexity framework. I begin with a discussion on how specific socio-cultural debates have incorporated complexity thinking.

Complexity and the Socio-Cultural Model

The idea that the laws governing the natural sciences may be applicable to social systems has a very long history, and has been much discussed since the emergence of Darwinian theory (Jones, 1980). Comte, one of the founding fathers of sociology, claimed that 'the subordination of social science to biology is so evident that nobody denies it in statement' (Jones, 1980: 1). Similarly, the social philosopher Herbert Spencer was renowned for seeing society as an organism, and was instrumental behind such early socio-biological/functionalist thinking when he said

> the analogy of a society to an organism becomes still clearer on learning that every organism of appreciable size is a society; and on further learning that in both, the lives of the units continue for some time if the life of the aggregate is suddenly arrested while if the aggregate is not destroyed by violence, its life greatly exceeds in duration the lives of its units. (Spencer, 1971/1896: 120)

What some of the recent applications of complexity theory now propose is that the same parameters that guide the evolving directionality of matter and life are also the principle guiding game rules for socio-cultural evolution (Artigiani, 1991; Heylighen, 1996; Jantsch, 1975; 1981b; Laszlo, 1986; 1992; Loye, 1991). One commentator has even gone so far as to literally see socio-cultural evolution within 'game rules' and to ascribe evolution to a process known as the non-zero sum game rule, as used in the well-known 'Prisoner's Dilemma' (Wright, 2000). However, caution should be exercised here in that societal evolution follows a complex path that should not be framed within simple reductionist terms. It is all too easy within discourses around complexity theory and complexification to follow a teleological and deterministic path. This can be highly problematic, especially as one of the core features of complexity theory is that is posits unpredictable outcomes and uncertain future(s).

To begin with a broad overview, and by taking Ervin Laszlo's historical perspective (Laszlo, 1986, 1991, 1992, 1996), it can be stated that some human societal structures developed from a nomadic tribal-based grouping, to settled communities with husbandry skills, then to feudal systems of specialised role positions, to the modern complex structures of economic and political states. This directional change has been viewed by Laszlo as driven by the amount of free energy entering the system (1992). As previously discussed, self-organising systems use the flow of free energy to maintain their stability, and make use of available stored energy to increase their overall pattern of complex relationships. In this model, the degree to which open systems have the capacity to fuel their self-organisational processes is thus proportional to the available amount of free energy entering the system from outside. The more free energy that is available to the system the greater the potential complexity as it is the incoming energy, as well as the system's existing stored energy, that can be utilised for further complexification in times of critical instability, according to nonlinear dynamics (Prigogine and Nicolis, 1977).

In the case of the general development of human societies Laszlo argues that 'the factor that enabled societies to access and consume ever more free energy can be identified as 'technology'' (Laszlo, 1992: 245). Laszlo sees technology as that which facilitates greater interaction between humankind and nature, thus allowing greater access to the resources of nature making technology a major agent for stimulating social change. Thus, technology is 'the instrumentality for accessing and using free energies in human societies for human and social purposes' (Laszlo, 1992: 245). Laszlo is cautious to add that the technological impact on society is proportionate to the flexibility of its dominant modes and the ability for the society to adapt to such innovations (Laszlo, 1996). Again oversimplifying, and using Laszlo's summary, it is said a shift occurred from the Palaeolithic Age of kindling and limited use of fire, along with simple hand tools, to the Neolithic era where more sophisticated tools such as saws, hammers, and sickles came into use. Later, when agriculture became the main form of a stabilised community, the progressive development of metallic tools made of copper, bronze, and iron appeared. Except for the transference from iron to steel the 8,000 years from the Neolithic era to the Industrial Revolution saw little in the way of dramatic innovations in basic agricultural tools (Laszlo, 1992).

However, there has been noticeable change in societal organisation during the last 1,000 years as the 'effects of technological innovations have been amplified by rapid means of transportation and communication and exported by dominant economic powers and conquering armies' (Laszlo, 1986: 279). Empires sustained themselves for centuries, especially those along fertile river stretches (Nile, Tigris-Euphrates, Huang-He) yet were also sites of tremendous fluctuations and destabilisations. Technology in the Middle Ages enabled multiple wars, personal and private conquests, and the repositioning of various belief systems through dominant local social structures. In fact, war can be seen as a bifurcatory stimulating influence towards greater social complexity as

> war could help produce information structuring societies. War, like trade, is simply a means for exchanging energy, matter, and information between human groups…But war allows us to see the effects of exchanges more clearly. Any release of matter, energy, and information by one society into another amounts to an observation of it. (Artigiani, 1991: 99)

It has been noted that the increased assimilation of technological innovations within society helped pave the way towards further scientific investigation that ultimately yielded the Enlightenment. This major cultural shift, and later the printing press, the Reformation, and other major cultural transformations recorded by history (Burke and Ornstein, 1995; Hobart and Schiffman, 1998; Wright, 2000) accelerated internal social dynamics. With the advent of steam the Industrial Revolution triggered a radical upheaval in working, living, and production practices that revolutionised modern society. Using an interpretation of complex systems it is possible to see that there is a pattern in these historical processes that can be viewed, according to Laszlo, as technologically driven social change coming on the wave of increased energy consumption:

> With each technological 'revolution', more energies began to be accessed, stored, and used than had been in the preceding epoch…On the whole, technological change is irreversible: whatever the nature of a technological revolution, it is always from the hoe to the plough, and not the other way around…Improvement generally means greater efficiency in the use of energy, materials, or information. It means greater

> speed, less investment of time and money, and operation on a larger scale. (Laszlo, 1986: 280)

This may prompt some to consider Laszlo as a technological determinist, yet Laszlo states his approach not to be a deterministic one but rather that he is highlighting the important factors of the access, consumption, and storing of free energy that drives social systems in a direction of increased structural complexity. In agreeing with Laszlo on this point it is again important to distinguish the difference between seeing technology as a facilitator and viewing it as a determinant agent. In complex systems technology can participate as a catalyst and medium for energy/information flows, yet I am not adopting technological determinism.

In this context, and using Laszlo's argument, technology can be viewed as a facilitator that harnesses energy to influence socio-historical processes. Yet this is not a linear process: not all technologies adopted are the most efficient and may depend upon a variety of environmental factors. A case in point is the adoption of the motor vehicle over steam power. When the Stanley Steamer and the four-cycle Otto engine competed for dominance in the United States, the steam engine was hit by an outbreak of foot and mouth disease that saw all water troughs along public roads removed to halt the spread of the disease. This resulted in the petrol motor engine becoming dominant and being adopted for modern life (Laszlo, 1986). This has also been referred to as the 'lock-in' factor, which is a central feature of complex systems (Waldrop, 1994). This is not to be confused with instrumental rationalism as 'some technological inventions are never adopted, and those that are adopted are not necessarily the most efficient' (Laszlo, 1986: 281).

This brief and simplified explanation cannot give a thorough account of the dynamics of social progress. However, it is able to point out two important factors; first, the complexification of social processes is related to the irreversible flow of increased availability of free energies. Secondly, historical processes manifest long periods of little change interspersed with periods of rapid change (Eldredge, 1985). Such moments of rapid change, or revolutions, can often be as much disruptive as they are progressive, leading to collapse as well as development (Artigiani, 1991). At such times, societies – seen as systems in far-from-equilibrium states – are sensitive to environmental perturbations and liable to socially bifurcate.[3] What social bifurcations help to show is that progress is neither smooth nor inevitable. In short, a consideration of the social sphere through dissipative structures of complex systems is an attempt to offer a model to interpret socio-cultural progress within the framework of complexification and complex phenomena.

The concepts of chaos, nonequilibrium, and dissipative structures are now seen as fundamental to and an integral part of complex open systems. Artigiani has applied Prigogine's dissipative structures model to socio-cultural revolution and evolution:

[3] The varieties of social bifurcations, as outlined in Laszlo's terminology (1991; 1994; 1996), include the results of incorrectly applied technological innovations (T); external conquests or internal socio-political conflicts (C); and collapsing local economic/social order (E).

> Applied to the study of 'revolutions', the Prigogine model leads to a variety of analytical insights that not only vastly improve our understanding of rapid and dramatic social change, but deepen our appreciation of the significance of these events as well. (Artigiani, 1987: 249)

Artigiani sees the Prigogine model of dissipative structures as giving explanation to 'the evolutionary processes governing cultural growth' (Artigiani, 1987: 251). As Artigiani points out, the model of dissipative, complex structures is open to unpredictable fluctuations and environmental disturbances that open the way to multiple futures:

> While it does tie the development of human systems to evolutionary processes determined by the 'arrow of time', its sophisticated use of quantum theory obliges users of the model to recognize that no single developmental path is scientifically determined. Complex structures far from equilibrium have multiple options open to them in the course of their development, and the ones taken are selected by unpredictable local actions and conditions. (Artigiani, 1987: 263)

An important aspect of complexifying systems is that they exhibit irreversible processes, thus adhering to the uni-directional 'arrow of time'. What this tells us, as Artigiani points out, is that such processes are not necessarily deterministic, and that a system is unable to revert back to a previous state. Thus, the system increases in complexity under conditions of instability or, unable to choose an alternative future path, it collapses. Prigogine has stressed repeatedly that the natural systems that compose the world around us are enmeshed within irreversible processes: 'irreversible processes did not cease with the creation of our universe; they still go on today, on all levels including geological and biological evolution…In accepting that the future is not determined, we come to the end of certainty' (Prigogine, 1997: 183). Not only does Prigogine assert that we have come to the end of certainty, but also that our present, not having been determined, is the outcome of bifurcatory causes on a grand scale: 'Our universe has followed a path involving a succession of bifurcations. While other universes may have followed other paths, we are fortunate that ours has led to life, culture, and the arts' (Prigogine, 1997: 72).

The latter half of the 20th Century saw industrial societies shift towards flows of information, such that in recent years energy is often seen in terms of flows rather than in industrial manufacturing contexts. With the advent of the theory of the network society (Castells, 2001), an increasingly interconnected world (Beck, 1998; Capra, 2002; De Kerckhove 1998; Urry, 2000; 2003a) and the dramatically increasing sophistication of information communication technologies, complex patterns of relationships and interconnectedness have become more apparent (Castells, 2002; De Kerckhove, 1998; Urry, 2003). Such degrees of complexification and interrelation require new tools and language for interpretation.

What is today an increasing interconnectedness in social relations is not only due to the implementation of technology but also to the increasing flows, storage, and utilization of information. Information, I argue, is core to the complexification process. Being fully aware that 'information' is itself a contentious and loaded term, I nevertheless position it as a fundamental process. How then is information so central to social complexity?

Complexifying Processes: Social, Cultural and Biological Information Flows

The transition of developed societies in the second half of the twentieth-century has been referred to in such terms as 'Post-Industrial Society' (Bell, 1999/1973); the 'Technetronic Era' (Brzezinski, 1970); the 'Electronic Age' (McLuhan, 1962; McLuhan and Fiore, 1971); the 'Information Age' (Toffler, 1981); and the 'Network Society' (Castells, 1996). Some have even considered this shift towards an informational society as a conspiracy created from vested interests (Roszak, 1994). The relationship between technology and societal practices is one that goes back towards very early beginnings, yet the precise role of information within social development is less clear. The present stage of societal development is inherently imbued not only with information as a commodity, but also with information in terms of production, process, self-regulation, and interdependence. The approach taken here is to view information flows as a central component of the complexification process, and that as a core component it is thus a catalyst for increasing complexity within both organic and non-organic structures. Some theorists in this field (notably Goonatilake, 1991, 1999; Coren, 1998) consider information flows as combining in an additive way. By this it is meant that each new flow combines the previous one, so that the cultural information flow contains the biological. In this way, the overall flow can be seen in terms of a trajectory rather than as hierarchical stages. A macro-version of this information flow can be seen in terms laid out by Coren who notes that 'when information utilisation grew, and/or when information collection became significant...the changes result in the increase of life-form complexity' (Coren, 1998: 145-6). The general information flow in this respect is aligned to information-storage capacity, and storage efficiency is related to information utilization: these changes, according to Coren, result in the 'increase of life-form complexity'. However, before examining 'information' within socio-cultural terms, I will first contextualise informational processes within very early biological beginnings.

Biological evolution on this planet emerged over 3.6 billion years ago with the fossilised remains of early prokaryotic cells, showing their biochemical activity, being dated at 2.3 billion years ago (Laszlo, 1996). Cellular growth is not committed through isolated acts but rather through intra and inter-cellular communication:

> All organismic cells are interconnected through tiny channels in cell membranes or gap junctions. Through these channels, all molecular, chemical, metabolic, and electric communication among cells takes place. These communicative junctions are made of proteins (connexins) that align all cells into one, continuous channel-network: a social system. (Zeleny, 1998: 138)

The genetic information that is coded within the DNA molecule provides the instructions for the manufacture of the required combination of proteins that, in turn, determine the structure and thus the function of that organism. Almost every metabolic process involves a series of reactions with molecules of adenosine triphosphate (ATP) which is itself the final energy-transfer molecule in virtually every cellular process (Morowitz, 2002). However, particular portions of the above molecular combination (namely the adenine molecule) takes no part in the energy process which leads biologist Morowitz

(2002) to wonder that ‘the whole idea seems information-rich…can there be some deep and fundamental, yet hidden, relationship between coding and energy transfer?’ (Morowitz, 2002: 73). The relationship between information and energy appears to be crucially present within the very foundations of the earliest emergence of terrestrial life. In addition, adenine, as well as being a ‘signal for energy transfer’ is also a major component of the genetic code as it is one of the four bases of DNA and RNA.[4] The flow of genetic material was earlier considered to be much more rigid and uni-linear (Goonatilake, 1999). Recent advances in microbiology are providing a new shift in how we see the emergence of complex living systems – a shift that is increasingly incorporating information into its world-view. This may be made clearer by taking a look at what is currently understood concerning the evolution of prokaryotes. This in turn should shed light upon complex processes and information transfer that will become useful models for later in the chapter.

Prokaryotes, such as bacteria, are believed to be the earliest organisms (Morowitz, 2002), and they provide us with what is perhaps the earliest known example of DNA exchange and recombination. Having blanketed the earth some two billion years ago prokaryote bacteria proceeded to use up available resources in such processes as fermentation, photosynthesis and respiration (Margulis, 1993). Within a period of evolutionary time the bacteria changed tactics due to a dwindling of resources and began to invade each other – a phase that Sahtouris (1998) refers to as ‘bacterial imperialism’. This phase ‘led to renewed crisis, because their early attempts at “globalization” into huge colonies were based on competitive exploitation of each other’

[4] The other 3 being cytocine (C), guanine (G), and thymine (T).

(Sahtouris, 1998: 8). The solution, after the extinction of great amounts of bacteria, was to evolve a cooperative division of processes in what we now know to have become the nucleated cell. This formation required each bacterial cell to donate a part of its own DNA to a central collective DNA storage that became central to the nucleated cell's overall functioning (Margulis, 1993). This is what may be referred to as the first experiment in DNA exchange and recombination. This need for cooperation and exchange amongst bacterial cells spurred a creative emergence in information transfer systems. Sahtouris makes an interesting comparison by saying that

> by evolving ways to exchange DNA information among themselves around the world, we can rightly say they invented the first worldwide web of information exchange…information exchange gave bacteria close relationships that facilitated both competition and cooperation in communal living. (Sahtouris, 1999: 3)

Microbiology has shown that networks of information communications and information transfer were essential to early forms of life. What is more, such DNA recombination exhibits traits of autopoietic cognition. According to Sahtouris's research, 'DNA reorganizes itself intelligently when organisms are environmentally stressed' and that 'errors known to occur in DNA during reproduction and by cosmic radiation and other accidents, are recognised at the molecular level and fixed by repair genes' (Sahtouris, 1999). Genetic researcher Eshel Ben-Jacob, of the 'Bacterial Cybernetics Group', sees the genome as 'not merely a storage device, but a sophisticated cybernetic entity well beyond a universal Turing machine' (Ben-Jacob, 1998: 58). The cybernetic gene works in cooperation with other similar genes to ensure regulation of the cell, and as a network, such genes can 'produce changes in the genome's activity and structure that modify the individual cells in a manner beneficial to the colony as a whole' (Ben-Jacob, 1998: 65).

The term *adaptive mutagenesis* refers to genomic mutations appearing under selective pressure and in response to external pressure, such as bacteria undergoing corrective mutation in genomic make-up in order to digest specific food (Shapiro, 1984; Cairns et al., 1988; quoted in Ben-Jacob, 1998). The conclusion drawn from Ben-Jacob's research was that mutations were adaptive in accordance with pressure being externally applied. More recent experiments by Galitski and Radicella - (see Ben-Jacob; 1998) - confirm Ben-Jacob's hypothesis that 'in order to perform adaptive mutations (and other non-random mutations) the bacteria employ cybernetic agents' such that 'a picture of problem-solving bacteria capable of adapting their genome to problems posed by the environment might be emerging' (Ben-Jacob, 1998: 63). This cybernetic capacity, which is a form of internal feedback, Ben-Jacob informs us, also serves to regulate information transfer and interaction.

What Ben-Jacob is describing is the genome as a dynamic entity, and as such it 'implies that the genome is capable of self-reference, has self-information and, most crucially, has self-awareness' (Ben-Jacob; 1998: 67). However, care needs to be taken in distinguishing between the concept of 'self-awareness' and that of 'self-consciousness'. Self-awareness in this context refers to a system's internal creative response in regard to the impact of external fluctuations upon its operating processes. In order to function as a multicelled organism bacteria trades DNA in a series of complex interactions much like, as Sahtouris observed earlier, the World Wide Web (www). Ben-Jacob prefers to refer to this web-like microbiotic networking as a *genomic web*, where bacteria produce a number of gene 'agents' that act as cybernetic regulators that oversee adaptive self-organisational mutations. Complexification, for Ben-Jacob, is seen through a 'genomic leap' towards more complex genomic webs:

> The web, being more complex than the individual genome, can design and construct a new and more advanced genome relative to the original ones, i.e. perform a vertical genomic leap. Such a leap is best described as a cooperative self-improvement or cooperative evolution. (Ben-Jacob, 1998: 71)

This appears to confirm what Lynn Margulis referred to in her pioneering work *Symbiosis in Cell Evolution* (1993) where bacteria and their genetic material had to create cooperative symbiotic networks in order to evolve into more complex cell structures. This body of research provides an understanding, albeit still tentative at this stage, that at a genetic level of life there are complex processes being performed in a self-organising (neg)entropic manner that operate an efficient web-like transfer of information, matter, and energy. These findings seem to correlate with the view of *paninformationism*: the recognition that information, along with matter and energy, forms the three fundamental characteristics of the universe (Jdanko, 1994). An informative, though controversial, conclusion to be drawn from this body of research is that progressive complexification in Nature is not so heavily weighted towards a Darwinian accumulation of random mutations but rather 'that of a cooperative evolution based on the formation of creative webs' (Ben-Jacob, 1998: 73). The research of this thesis will apply these models to explore the possible implications of such cooperative 'creative webs' in the social world, with information flows as being crucial to (neg)entropic growth. In order to clarify what is actually involved in the dynamic cybernetic processes of genomic webs, it is necessary to refer back to the concepts of autopoiesis and self-organisation.

By way of a brief reminder, the theory of autopoiesis (Maturana and Varela, 1980; 1998), requires that a system processes the information received about its environment. In other words, autopoiesis is the *behaviour of relevant self-maintenance in accordance with information*. This pre-patterned informational process has a 'cognitive' ability to absorb environmental perturbations. In this way, diversity is created through drives towards greater complexity through (neg)entropic processes. By spending some time discussing the biological role and function of information flows I have attempted to provide some background in which to view information flows in a socio-cultural context. In this sense, information can be seen as being ubiquitous to all organic, living systems, which includes also aspects of the social sphere.

Before studying the role of information in a socio-cultural context, I examine the relationship between information and entropy, as this will be significant when considering modern social 'complexity'.

Information and Entropy

In the study of living systems it is becoming generally accepted that incoming matter/energy dissipates and catalyses the system into growth and away from decay (Haken, 2000; Morowitz, 1969). This process has been stated by Erwin Schrödinger as the very essence of life (1962). Thus, the Second Law of Thermodynamics, whereby energy moves from a useable to a less-useable state, is bypassed by those systems that maintain a dynamic order in a far-from-equilibrium state. In 1894 Boltzmann remarked that entropy is related to "missing information", thus creating perhaps the first stated relationship between the increase of entropy and the decrease of information (Campbell, 1984). Thus, a state of increased information (low entropy) therefore means that there is greater structure and cohesion within the system despite it being still far from equilibrium. This leads to viewing information as a structuring/organizing enabler.

The biologist Hermann Haken notes that a system 'in thermal equilibrium cannot even *store* information' (Haken, 2000: 23), and concludes that storage requires an open system and that the operation of such a system produces information that can be called *synergetic information* (Haken, 2000). This further suggests that information, whether in cyclic-flows or in storage, appears to be linked to processes of organization. This is in contrast to entropy which is noted for its directionality towards decay, and thus disorder, or disorganization. Haken notes this relationship in his conclusion:

> It is tempting to conclude that in systems far from thermal equilibrium or even in nonphysical systems, (Shannon) information plays the same role as entropy in systems in thermal equilibrium or close to it, namely as the cause of processes (2000: 209)

In dynamic far-from-equilibrium states Haken is tempted to see information as the catalyst towards a direction away from decay; i.e. towards growth, and as an organizing principle. Brooks and Wiley (1986) also identify information as specifying structure. In this light, information can be seen as a negentropic entity and/or process.

Similarly, Goonatilake sees a state of maximum entropy (disorder) as related to a minimum of information. Thus, the greater the information, the more organised is the internal structure and the capacity for increased complexity and growth: 'the creation of information is thus linked to the creation of structure' (Goonatilake, 1991: 142). The information that is available to a given system is crucial to how that system manages its dynamic state, and stored energy (information) is the means by which a living system is able to absorb and adapt to environmental disturbances. Likewise, if we take the analogy of a social disturbance, such as a disease entering a particular social group, then the knowledge (information) that that particular group holds will determine the degree to which it is able to adapt and develop from the infection, or be broken down from it. In both biological and social systems information flows are core to the system's organization and growth.

By examining these various analyses it can be summarised that they tend to agree that complex systems, including living systems, share common features of information, as characterised through its storage, flow, and utilization. Further, that these processes and analogies of information can be useful for social analysis. I turn now to examine cultural information in this context.

Cultural Information

Cultural information, according to Goonatilake (1991), is able to be passed down through the generations so that each successive generation is potentially able to benefit from what has passed. In this way 'human historical evolution consists of a series of interventions with the environment' (Goonatilake, 1991: 45); where the environment refers to both the physical and the cultural. Hobart and Schiffman (1998) see information as coming between orality and literacy and have categorized its development into three distinct phases: the Classical Age, the Modern Age, and the Contemporary Age. Whilst this is accurate in a relatively modern survey of historical processes, it ignores the origins of earlier forms of information transmission, such as Asiatic pictographic languages.

By going further into the origins of the ancestral human, it has been noted by Goonatilake how 'rudimentary external information systems used by humans probably go back to very early human ancestors...The earliest memory aids were probably notched sticks and knotted cords' (1991: 85). The externalization of the inner world of the human can be evidenced in the late period of *Homo erectus* during the transition to *Homo sapiens* - circa

300,000 years ago. This was succeeded by Cro-Magnon man who replaced Neanderthal man with a culture that was rich in complex symbols and imagery. Late Palaeolithic man showed ability through realistic paintings of animals to externalise and represent the world around: in other words to project information that was in their minds. The 'Neolithic revolution' finally occurred with the domestication of agriculture around the world and, according to Goonatilake, gave rise 'to a new stage in the externalisation of information storage' (Goonatilake, 1991: 87). And since the earliest tool technology the possession of such knowledge acted as a catalyst for the emergence of a language system and a means of culturally preserving such innovative information (Burke and Ornstein, 1995). Here information is related with technology and as such was crucial in the developing complexification of social systems.

The earliest known examples of recorded writing are called 'proto-cuneiform' as it precedes cuneiform (from Latin *cuneus* - wedge). The oldest examples are dated between 3200-3100 BC at the site of the great temple in the Sumerian city of Uruk: they mix pictographs, symbols, emblematic signs and are perhaps the earliest known example of human society storing and coding information (Hobart and Schiffman, 1998). Returning to the three Ages previously mentioned, the first of these – the Classical Age – is said by Hobart and Schiffman to begin with the creation of the Greek Alphabet as it constituted the 'first form of writing capable of capturing the nuances of speech' (Hobart and Schiffman, 1998: 1). Whilst these classifications may be controversial to some, they provide a useful framework in which to position major developments in information structures, and will be used here to highlight such emergences rather than as a validation of their historical accuracy. The alphabet was undoubtedly a major step in the codification of information and opened up a means for the transmission and reflexivity of human thought.

The Modern Age, using Hobart and Schiffman's classification, coincides with the Renaissance and the rise of printing. The Gutenberg printing press was a dramatic revolution in socio-cultural terms and contributed towards an increase in social complexity as information flows accelerated within the public domain. Marshall McLuhan, who has written extensively on the emergence of print culture, cites informational technologies as having a direct influence upon the physical body of man:

> if a technology is introduced either from within or from without a culture, and if it gives new stress or ascendancy to one or another of our senses, the ratio among all of our senses is altered...The result is a break in the ratio among the senses, a kind of loss of identity. (1962: 24).

Thus, in terms of print, information began to be visually perceived in a linear format due to syntax and left-to-right sentence structure.[5] Information became rationalized, in terms of left-brain hemispheric organization.[6] The sudden increase in a reading public put emphasis upon the need for greater social organization as print 'created national uniformity and government centralism, but also individualism and opposition to government as such' (McLuhan, 1962: 235).

[5] This left-right structure indicates a Latinised format and does not take into account other scripts such as Arabic that use a right-left sequence.
[6] The left hand side of the brain is known to be involved in linear thought rather than abstract and intuitive thought which is processed in the right hemisphere.

This rise in the analytic projection, transmittance, and rationalization of information can be seen as a contributing factor in the prominence of the analytical method towards mapping the world that emerged in the late 17th century to mid-18th century. Hobart and Schiffman see the new analytic techniques of modern, relational mathematics devised by Descartes and Fermat as 'the first, fully symbolized and abstract language capable of storing, organizing, and manipulating information' (Hobart and Schiffman, 1998: 133). As they explain, the cultural flow of information created a world-view that was mathematical – the clockwork universe:

> With his techniques of co-ordinate geometry, science of a universal mathematics, and philosophical exposition of clear and distinct ideas, Descartes formulated a wholly novel way of shaping the contents of our exchanges with the outer world, a new technology for managing information. This was the analytical vision, whose means of storing and processing information were found in the mathematical language of abstract operational symbols. (Hobart and Schiffman, 1998: 133)

Although information flows had increased dramatically over this time period, the overall world-view of an orderly universe fed back into a vision of information as storing universal laws. However, another dramatic shift was required for this world-view of an orderly universe to be challenged sufficiently; and this came in the early decades of twentieth century science, as described in Chapter One. The twentieth century also saw the arrival of what has been called the Contemporary Age[7] (Hobart and Schiffman, 1998), and the later appellation of the Information Age (Toffler, 1981; Castells, 1996).

[7] Another term to be used here is 'modernism'.

One of the prominent features of the twentieth century is the technological capacity to store and transmit information faster, and with more power, than in previous epochs. Not only did the mid-twentieth century see the emergence of the computer but also information, alongside cybernetics, as being recognized as a non-biological organising medium in its own right. With this the focus turned towards the need for ever-increasing domains for the external storage of information.

Let me reiterate that entropy, the thermodynamic law towards decay, can be counter-acted by flows of energy/matter/information, and that these open systems that defy entropic decay can be viewed as the driving force behind evolving structures of increasing complexity and organization. In fact, Goonatilake views the various information-sharing systems to be interlinked:

> The evolution of information on earth gave rise to the sequence of information cores which emerged corresponding to these different environmental stages. In the first core, the struggle with the environment is coded in DNA. Later, outer flow cores are 'externalised' from this inner core of DNA, corresponding to the cultural flow lines running through brains. Still later, exosomatic information flow lines are externalised out from the biological packages...thus, human social groups adapt to the environment much faster through their culture than through their gene pools... the process of externalisation of the information envelopes is such that given sufficient evolutionary time, and suitable environmental pressure, externalising of the genetic to the neural flow line and from there to the non-biological must occur...the tendency towards further elaboration and evolution of information is therefore but a necessary outcome of an almost inevitable phylogenetic process. (Goonatilake, 1991: 132)

The externalising of information can be seen as a continuation of the outward information flow from the genetic to the neural. Just as genetic information processes have helped to organize biological life, and neural/cultural assimilated information has assisted in the growth of human societies, so too, it has been argued, will externally stored information aid in the future development of a complex, informational society (Goonatilake, 1991).

One way to view information then is as a set of instructions that provide ways of dealing with the environment:

> Information in this sense of a set of instructions to deal with the environment is coded in the biological realm in the genes. Such information also exists in human culture as a set of proclivities and instructions on how to interact with the environment. Similar information also exists in the new computer-based information artefacts. (Goonatilake, 1999: 6)

Information as a set of instructions on how to adapt and deal with the environment, whether genetically, culturally, or in artefacts, enables a system to increase in complexity in line with dynamic and changing external events. The more information is available, stored and processed, the more capable is that system for growth and survival.

Now that the present period is one of increasing informational exposure, the usage and rate of transmission of information can be a measure of how complex a system may become. What is significant about the present era is that it may very well be operating upon unprecedented macro flows of information. In other words, it may be a culmination of all previously stored informational sub-systems, and moving towards a converged hyper-cycle: a globally complex network. This increase of information-complexity is a model upon which can be viewed modern mobile decentralized practices of communication via physical-digital scapes through the mobile phone and the Internet.

This chapter has argued that informational flows are a central component of the complexification process, and that as a core component it is thus a catalyst for increasing complex processes within both organic and non-organic structures. However, the complexity of a system is not solely its information content, as being a system it also forms around processes and flows. I have attempted to show that information entering a system acts as a catalyst for the increasing complexity of the processes of that system, much the same as autopoietic cognition of environmental factors influences the self-maintenance of a living system.

The future, as complexity theory informs, cannot be wholly predicted but may depend largely upon how global interconnectedness develops, is fostered, and sustained. The influences that are allowed to manifest today have the potential to become the influences for a more complexly integrated future, and global information communication technologies have an important role to play in this. Modern technologies, information communications especially, have fostered a trend towards ever-greater levels of complex social interconnectivities. Global spaces, increasingly connected by communication technologies, are inherently more complex in their connectivity and relationships through presence ‘at a distance’. Now, I turn to look at how the concept of networking has emerged into contemporary social science for it is through the interconnectivity of network structures that information flows and ‘complexity phenomena’ have manifested in social spaces.

CHAPTER FOUR

Networks, Clusters & Collectives

> 'The size of the computer market cannot be very large, since five computers can serve the needs of the U.S. and two should be sufficient for the United Kingdom'
>
> Thomas J. Watson, Sr. – Chairman of IBM

> 'I link, therefore I am' William J. Mitchell

In this chapter I examine networks, network theory, and the physical and behavioural connections and infrastructures that preceded complexity theory and facilitated the increase in informational flows. Previously I discussed specific growth patterns of complex systems, and metaphors and analogies that re-conceptualised systemic connectivity. I also examined similarities between concepts in the complexity sciences with quantum theory and synchronisation. In the previous chapter I discussed the relationship between complexity and information through an examination of biological complexity and bacterial information flows as a means of approaching socio-cultural complexification. In this chapter I turn to examine networks, and how the concept of networking has emerged into contemporary social science, and how it is being worked into sociology through a physical and pragmatic sense of a 'network society', as Manuel Castells (1996; 1997; 1998) has termed it.

The infrastructures of networks and network theory are important to the investigation of complexity theory as it underlies a practical, theoretical, and perceptual understanding of how networks operate, thus leading to a clearer conception of complex systems. By this it is meant that the history of social and technical infrastructures, from the telegraph to the telephone or the railways to radar, shows the growth in communicative structures that have built upon each other – or piggybacked – to greatly enhance a global communications potential. It has also been noted that networks were the skeletal pattern that complexity theory built upon (Barabasi, 2003). Concepts of path dependency, attractors, and nodes, are all features that characterise networking behaviour, and as such operate within complex systems also. What networks and networking lack is the degree of complexity in the relationships and processes between the nodes, and the concept of emergence that affects the properties of the whole. Yet physical networks were crucial in establishing a physical communications infrastructure that was the progenitor to later digital technologies.

With the rapid growth in global interdependencies over the past several decades came the theoretical perspective of network theory, largely popularised by Castells (1996; 1997; 1998). Castell's work has been important in giving attention to quantitative expressions of connectivity and global interrelations and, importantly, has opened up sociological discourse into newer domains. Network theory is now finding sympathy with similar research in the natural sciences as quantitative physical investigations are helping to bring understanding to how networks operate in terms of clustering and laws of attraction. Again, this has been significant to this thesis as it sheds light onto Internet topology and electronic network behaviour, as this chapter describes. Finally, with such research into networks and network theory gaining more prominence, it has enhanced a cultural perception of networks that existed previously in lesser degrees. Even young users of technology, without the technical comprehension of networks, are likely to be able to grasp the concepts of network connectivity through popular usage of mobile media as well as familiarity with the Internet and the World Wide Web. For these reasons - practical, theoretical, and perceptual – the concepts of network infrastructures and network theory are significant to this present discussion on complexity theory and how complex systems may operate on the social level.

This chapter examines both older, and then more modern, instances of networks and how such networks have impacted upon understandings of time and space. This leads to a discussion on the behaviour of networks, and their inherent fallibilities, and will focus upon network communication and its implications upon an increasing socially interdependent global society. To conclude, this chapter examines the concept of collective intelligence, which is becoming more prominent in discussions on how mobile social movements, blogging, and other non-physical interconnectivity and 'meetingness', are forming complex systemic relations of communication, information and resource sharing (Levy, 1999; 2001). First, I examine the historical context of networks.

Is Networking New?

It is a fallacy to think that older, more ancient civilisations were isolated and disconnected from the social communities around them. Instead, the issue concerns the degree, medium, and frequency of connectivity. Ancient trade routes, from the Silk Road to the King's Highway; from the Incense Route to the infamous slave trade routes, existed long before modern technology compressed notions of time and space into today's global terms. Migration, nomadic drifts, and trading routes, up until the most recent imperial expansions, have involved a physical traversing, founding, and conquering of new spaces. All these movements have left trails, indelible marks that have carved out the paths of physical networks: it is these connections that can be said to be the forerunner to what is now understood to be modern networking. Yet what is meant by the notion of networking? A standard definition would consider a 'network' as 'an interconnected group or system' or 'a system of intersecting lines, roads, veins, etc' (Collins English Dictionary). This definition can be applied to varied systems of interconnected components networked together, including transport connections, pipelines, electronic and digital circuits, and social and business interconnections. The etymological root of network comes from an extended sense of 'any complex, interlocking system', from 1839, in original reference to transport by rivers, canals, and railways (Online Etymology Dictionary).

Early attempts at laying drainage channels, pipelines, and city grids were models of networking, which places networks alongside architectural spaces and urban planning. Mitchell describes this urban planning in terms of how:

> meeting places and other communal facilities were concentrated at the centre, and a network of paths and roads extended out into the hinterland... in the 20th century, then, rural electrification and telephone systems have done a great deal to improve the conditions of life outside the city limits. Digital telecommunications infrastructure is now beginning to follow the old electric and telephone wires, and in some cases to piggyback on the existing copper. (Mitchell, 1999: 24)

Here, the digital network is following on from, or 'piggybacking', on either earlier technologies or earlier connective spaces. To emphasise this Mitchell sees a progression of technology that builds upon and establishes the network infrastructure:

> by putting in a sophisticated water supply and sewer networks, for example, ancient Roman engineers succeeded in creating densely packed systems of (relatively) sanitary places. When the Industrial Revolution brought gas and electric networks, cities everywhere became collections of illuminated places and could extend their activities around the clock-liberating themselves from the ancient bondage of the diurnal cycle. Furnaces, pipes for hot water and steam, and the ducts for air enabled creation of centrally warmed places, and made urban life far more comfortable in cold climates. By contrast, air-conditioners plugged into the power grid allowed cities like Phoenix to develop as far-flung constructions of cooled places - among which people shuttled in their chilled vehicles. And Alexander Graham Bell opened out the way to a world of connected places. (Mitchell, 1999: 67)

Mitchell recognises how such epochs as the Industrial Revolution led to an improvement in street grids to enable greater volume in road and haulage transport; waterways for transporting resources and goods; the construction of water and sanitation systems; leading to the pipes that finally delivered gas and electricity. Later communication networks thus followed on the heels of these networked channels that connected urban living into industrial, and then post-industrial times. The end result, according to Mitchell, is that 'digital data distribution systems will soon become as ubiquitous within cities as electrical and telephone networks, they will carry many different kinds of information, and there they will ultimately (if not immediately) provide high capacity at low-cost' (Mitchell, 1999: 23). Yet the timeline for networking infrastructures is not a smooth transitional process. The emergences of technological innovations are themselves often a consequence of complex processes, involving accidents, situational contexts, and accumulated efforts. Rarely are such social contributions either the gift of a solo 'innovator' or the result of straightforward implementation (Burke and Ornstein, 1995; Burke, 1999; 2003).

As previously stated, complex networking had been present in the earliest stages of biological growth, and that biological webs, formed through bacterial exchange of DNA, can be viewed as the first organic examples of networking. Elisabet Sahtouris, an evolutionary biologist, makes an interesting comparison by saying that 'by evolving ways to exchange DNA information among themselves around the world, we can rightly say they invented the first worldwide web of information exchange' (Sahtouris, 1999: 3). Ben-Jacob (1998) prefers to refer to this web-like microbiotic networking as a *genomic web* and in his experiments has gathered results that seem to validate genomes as cognitive entities that creatively form a complex super genomic web. In furthering this recognition of biological networks the distinguished evolutionary biologist Niles Eldredge attempted to stress that 'social systems indeed arise from a complex commingling of reproductive and economic organismic activity' (Eldredge, 1998: 97) and concluded by suggesting that social networks are biotic systems. In an argument of a similar vein J.M. Epstein states that 'macro social behaviours such as war, revolution, arms races, and the spread of drugs may conform well to equations of mathematical biology' (Epstein, 1997: 7). According to Dorogovtsev and Mendes, the concept of the 'network' may 'turn out to be a central notion in our time...As a rule, these networks are not static but evolving objects' (Dorogovtsev and Mendes, 2003: v). However, networking is examined here within the domains of social information use and communication flows.

In order to contextualise complex global interdependencies it is first necessary to frame how networked infrastructures developed in order to lay the groundwork for later technologies that, in the words of Mitchell, 'piggybacked' onto earlier existing infrastructures. Similar to how the latter half of the twentieth-century exploded in terms of modern computational technologies, the mid-latter half of the nineteenth-century also witnessed similar significant innovative bursts in communicative networks, noticeably in the 1840s.

New Age(s) in Temporal and Spatial Networks

The sense of the 'present', of the here-and-now, the simultaneity that modern communications brings is not a unique experience. Another, older generation went through a similar experiential curve with the introduction of World Standard Time. With the rise of the telegraph, railway networks, and general mass travel, the issue of shared time became a crucial need. The rise of the telegraph in the early nineteenth-century has been interestingly referred to as the 'Victorian Internet' (Standage, 1998). The forerunner to the present-day Internet can be said to have been born on May 24th 1844 when wired telegraphy was given its perhaps largest public exposure when Samuel Morse sent his first telegraph message "What hath God wrought?" between the Supreme Court chamber of the Capitol building in Washington to the Railroad Depot station in Baltimore. And the telegraph can be said to have finally become 'international' at the St. Petersburg Conference of 1875 which established the standard procedures for international telegraphic communication (Kern, 2000/1983).

The 1840s not only saw the rise of the 'Morse code' but also the unification of the British postal system, the expansion of travel, and the concept of mass travel. The adhesive postage stamp and the uniform postage rate were devised in Great Britain by James Chalmers around 1834.[8] Chalmers' ideas were finally adopted by Parliament in August, 1839 and the next year, 1840, saw the General Post Office launching the now famous 'Penny Post' service. The much sought-after stamp known as the 'Penny Black' was issued three months later, with the profile of Queen Victoria famously printed on it. The postal system, observes Mitchell, was a precursor to today's modern telecommunication systems. As nation-states emerged they

> established national mail systems as government monopolies or near-monopolies, and entered into treaties for international exchange of mail. The resultant global network was the first of many such large-scale information distribution systems that were to follow. And, though it was many orders

[8] See http://en.wikipedia.org

> of magnitude slower than today's digital telecommunications systems, it possessed many of their essential structural features. (Mitchell, 1999: 132)

Another contributor to the modern age was that of early mass travel. Mass travel became a possibility when both improvements in communications facilitated the transport of large numbers of people as well as people having the leisure time to indulge. Thomas Cook is generally regarded as the 'father' of mass tourism as he organised the first package tour on 5th July 1841 by chartering a train to take a crowd of campaigners from Leicester to a rally in nearby Loughborough, a journey of some twenty miles.[9] This significant beginning was dependent upon the railways that were springing up in the 'railway mania' of the 1840s. Although the Great Western Railway was set-up in 1833, Isambard Kingdom Brunel's engineering feat did not see the first train to run along its completed track, from London to Bridgewater, until 14th June 1841, reaching Bristol in an astonishing four hours. The railway network in Britain saw a flurry of activity with 5,000 miles of track having been built by 1846, doubling to 10,000 miles by 1860, and quadrupled to 20,000 by 1890.[10]

However, the railroad companies were notoriously affected by the lack of a standard time. For example, in around 1870, if a rail traveller heading from Washington to San Francisco set his/her watch in every town they passed through, they would have to set it over two hundred times (Kern, 2000/1983). So the US railroads imposed a uniform time on November 18th, 1883, yet it

[9] See http://en.wikipedia.org
[10] See http://www.swuklink.com

was not until a year later, in 1884, that the representatives of 25 countries met at the Prime Meridian Conference in Washington. It was here that Greenwich was proposed as the standard by which to measure the universal day, and the International Conference on Time, hosted in Paris in 1912, established a uniform method of maintaining precise time signals and broadcasting them around the world by the use of the wireless telegraph. This culminated in the first time signal being transmitted around the world at 10 o'clock on July 1st 1913 from the Eiffel Tower, Paris. The telegraph, railroads, wireless telegraph, maritime travel, and later the telephone, all contributed to the desperate need for coordinating time within an ever increasing connectivity of networks.

Such extensive travel networks were not limited to the ground either. The side-wheel paddle steamer *SS Great Western* was the first purpose-built steamship to begin regular trans-Atlantic crossings, starting in 1838. This shrinkage of trans-Atlantic crossing time, from months into weeks, was one of the significant contributors to the mass immigration to the 'New World' of the United States in the nineteenth-century. In fact it was Brunel's sister ship, the *SS Great Eastern*, launched in 1858, that proved to be the only working ship with the size capacity needed to lay the 5000 tons of one-inch reinforced transatlantic telegraph cable in its attempts of 1865-6 (Standage, 1998). Physical communication networks – the railways, steamships, telegraph cables – were not only in place but being utilised to compress late nineteenth-century global space and time in traversable and knowable regions. Jules Verne's hero Phileas Fogg in his now classic *Around the World in Eighty Days* (1873) established the time precedent to beat, which was duly done by

George Train who managed the global endeavour in sixty days in 1892. As Stephen Kern rightly notes on this:

> with improvements in travel, scheduling facilitated by the introduction of World Standard Time, and the invention of the telephone and wireless, the time required to circumnavigate the globe was progressively reduced, and by the turn of the century the hope was to cut Fogg's time in half. (Kern, 2000/1983: 213)

As Kern says, it was the invention of the telephone and the wireless that really reduced the globe for nineteenth-century travellers. The invention of the telephone in 1876 began not with the apocalyptic tone of Morse's '*What hath God wrought?*' but, on 10th March 1876, with the more playful '*Mr Watson – come here – I want to see you!*' as Alexander Graham Bell spoke to his assistant in the next room. By 1880 a concert in Zurich was broadcast over the telephone wires to the town of Basel fifty miles away; and in 1880 the London *Times* installed a direct telephone line to the House of Commons (Kern, 2000/1983: 115). Yet it was not long after such physical communication networks had been established that the nineteenth-century went wireless.

The Italian inventor Guglielmo Marconi[11] sent and received his first radio signal in Italy in 1895. The first wireless signal was broadcast across the English Channel in 1899, and the first successful transatlantic wireless radiotelegraph message – between England and Newfoundland – was sent in 1902. This proved especially important for maritime use and soon oceanic

[11] Nikola Tesla is now credited with having invented the modern radio as in 1943 the Supreme Court overturned Marconi's patent in favour of Tesla's.

vessels were equipped with wireless receiving and sending equipment. By 1912 the 'wireless was an essential part of international communication linking land stations and ships at sea in an instantaneous, worldwide network' (Kern, 2000/1983: 69). And Newfoundland was to play an important role in another sending/receiving of messages – in the early hours of April 15th 1912.

It was the wireless station in Newfoundland that informed the world, at 01.20 hours, of the sinking of the Titanic. The distress call, first put out by the captain of the Titanic at 12.15 am, was picked up immediately by those ships at closer range. Ironically though, the ship closest to the Titanic, the *Californian*, which was approximately 19 miles away, and thus near enough to have saved a majority of the stricken passengers, was not in wireless contact and had gone 'offline' about ten minutes before the Titanic's first wireless distress signal (Kern, 2000/1983). As ever, it pays to be, not so much 'wired', but connected: or rather, networked. And further, it pays to know about time.

The introduction of World Standard Time helped to establish a greater uniformity of shared public time. This new sense of sharing time expanded spatially to create 'the vast, shared experience of simultaneity... In the cultural sphere no unifying concept for the new sense of the past or future could rival the coherence and the popularity of the concept of simultaneity' (Kern, 2000/1983: 314). Time, Kern tells us, is the measurement upon how life is to be known as 'Man cannot know the world "as it really is", if he cannot know what time it really is' (Kern, 2000/1983: 314). And the rhythm of social life, it was being noted, was becoming increasingly faster. In 1881 the psychiatrist George Beard (who also introduced the concept of 'nervous exhaustion' into psychiatric parlance) published his work titled *American Nervousness*, which blamed clocks and the invention of watches for causing general social nervousness. For, Beard noted, 'a delay of a few moments might destroy the hopes of a lifetime' (cited in Kern, 2000/1983: 15). And, of course, the world has rapidly become a whole lot faster (Gleick, 1999). It has also become a whole lot more networked.

Chart 1 below gives a time-line representation in the expansion in data-communication transmitting devices, thus developing networking functionality.

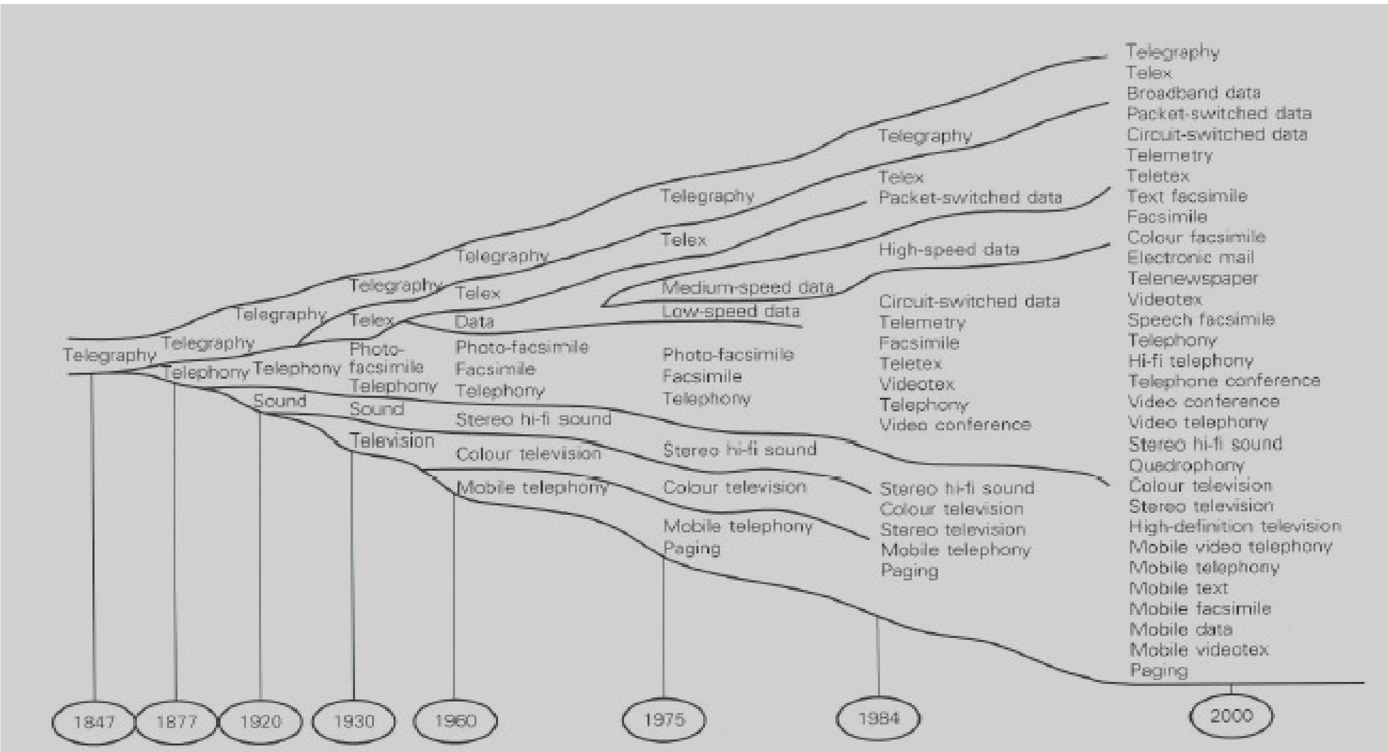

CHART 1 Innovations in transmission of tele-, data and mass communications *Source: Dijk, 1999*

Although the above time-line chart suffers from a reductionism of the transition and growth of these technologies, it does conveniently express the dramatic expansion in such technologies and their devices. Further, many of the functions listed in the final ‘2000’ category can be applied to a single device, thus demonstrating how there has been a trend in the commercial market place to converge multiple applications within shared mediums. Here it is possible to see how there is a move towards enabling particular devices, technological ‘hubs’, to have greater links and networking capacity. An example would be the mobile phone which now serves for receiving/transmitting text, email, photos; as voice recorder; calculator; currency exchange; PDA (personal digital assistant); MP3 (music files); and Internet smart-phone, as well as the usual mobile telephony. Increasingly, access to networks is being enabled through fewer material devices, as is a feature of network clustering.

Network Topology & Clusters

Networking phenomena has grown exponentially in modern technological societies and networking, in one form or another, now permeates much of the modern world. In the words of network researcher Albert-Laszlo Barabasi, ‘networks are the prerequisite for describing any complex system, indicating that complexity theory must inevitably stand on the shoulders of network theory’ (Barabasi, 2003: 238). In Barabasi’s approach, complex interconnectivity is itself a consequence of networking. The dynamic relationships that are formed between the links and nodes of a network are the flesh of emerging complexification:

> the goal before us is to understand complexity. To achieve that, we must move beyond structure and topology and start focusing on the dynamics that take place between the links. Networks are only the skeleton of complexity, the highways for the various processes that make our world hum. To describe society we must dress the links of the social network with actual dynamical interactions between people. (Barabasi, 2003: 225)

Barabasi believes that not only does the interconnected world indicate that the new century will be dominated by networks, but also that 'they will drive the fundamental questions that form our view of the world in the coming era' (Barabasi, 2003:7). This view is also shared by network researchers Dorogovtsev and Mendes who claim that the network will become a 'central notion of our time' and that

> the world of networks is our inevitable future, for better or worse...the progress is so immediate and astounding that we actually face a new science based on a new concept, and, one may even say, on a new philosophy: the natural philosophy of a small world. (Dorogovtsev and Mendes, 2003: 219)

This idea of the 'small world philosophy' has been picked up recently and become popularised by such events as the Kevin Bacon Game that was set up in 1997 by two college graduates to test the theory of close-tie linkages – the now well-known 'six degrees of separation' (Watts, 2003). The 'science of networks' has now also been investigated, and popularised, under the banner of the *small worlds* phenomena, and has produced some quite substantial literature (Barabasi, 2003; Buchanan, 2002; Urry, 2003b; Watts, 2003). In this context I turn again to Barabasi who is interested not in the type of network – which can be social, economic, digital, biological, or physical/chemical – but rather its structure and organisation.

In Barabasi's research he found that networks start off with an array of nodes that facilitate links between them. However, after a critical number of links, particular nodes will often become stronger attractors; that is, attracting more links to them than other nodes. This will in turn transform those specific nodes into hubs, or clusters. These clusters then attract further links and strengthen their own attraction, and other nodes connect out from these cluster-hubs to form the network. As Barabasi describes, such nodes with an anonymously large number of links are 'present in a wide range of complex systems, ranging from the economy to the cell' (Barabasi, 2003: 56). Bernado Huberman, an Internet researcher at Palo Alto, has found a similar pattern emerging, such as is demonstrated on the World Wide Web in terms of user traffic, and cites such sites as Amazon, Google, and E-Bay as cluster-hubs (Huberman, 2001). Huberman has found that underlying regularities occur within the World Wide Web between the links of users and that these regularities can often be predicted by statistical mechanics. However, since the 'parts that make up the Web – sites, links added to them, or pages - can display complex nonlinear dynamics' then 'the only predictions that can be made about their behaviour are probabilistic in nature' (Huberman, 2001: 21). That is, although the system displays a certain degree of statistical order it is also, as a nonlinear system, open to fluctuations of a chaotic nature. Saying this, Huberman has been able to use statistical mechanics to adequately describe the distribution between 'the number of pages per site, and also the number of links emanating from a site or coming to it. It is a robust empirical regularity found in all studies of the Web' (Huberman, 2001: 25).

This surprising finding gives a degree of order to the surfing patterns of World Wide Web users. Huberman explains that users self-organise their linkage to and from sites according to the busyness of the traffic; much like a car driver would take an alternative route during rush-hour traffic. This organisation of behaviour is not server-directed (i.e. technology-induced directionality) but appears to be a pattern of genuine non-random user-response. Further, as a Web site becomes more popular it adds on more links, and 'the more links a site has, the more visible it becomes and the more new links it will get' (Huberman, 2001: 30), such that a site will self-organise its growth through its connectivity with other linked sites. Huberman's research bears remarkable similarity to Barabasi's findings yet Barabasi chooses to call it a 'phase transition':

> the theory of phase transitions told us loud and clear that the road from disorder to order is maintained by the powerful forces of self-organisation and is paved by power laws... they are the patent signatures of self-organisation in complex systems...they learned that near the critical point, just when order emerges from disorder, ordered quantities of interest follow power laws characterised by critical exponents...Why do hubs appear in networks of all kinds, ranging from actors to the Web? Why are they described by power laws? Are there fundamental laws forcing different networks to take up the same universal form and shape? How does nature spin its webs? (Barabasi, 2003: 77-8)

There seems to be a distinct similarity between what was said earlier in terms of bifurcatory shifts in complex systems, and the phase transition that

Barabasi sees in networks, as a phase transition represents a shift to a different order of networking. Thus, bifurcations and phase transitions are both characteristics occurring at different scales within the same system. A complex system incorporates, and contains, networks; and the level of complexity of a system is tied to the number, degree, and clustering, of links within and between the nodes and hubs within a complex system's networks. Networks then are not random in that new nodes connect to anywhere in a network but instead networks are 'scale-free', meaning that preference is given to where new nodes become connected. In scale-free networks some of the nodes act as stronger attractors and become more highly connected so that the network is no longer randomly connected but influenced by specific attractor nodes that form more densely connected hubs:

> The scale-free topology is a natural consequence of the ever-expanding nature of real networks. Starting from two connected nodes...a new node is added to the network. When deciding where to link, new nodes prefer to attach to the more connected nodes. Thanks to growth and preferential attachment, a few highly connected hubs emerge. (Barabasi, 2003: 87)

Attraction then is the key, whether it is in everyday social networks or digital networks. When the clustering or links around a node becomes critical, a hub forms. A dramatic increase in the number of hubs in any system may be one of the factors that cause the system to complexify on a greater scale in order to maintain dynamic equilibrium. An example that can be used here, albeit a simplified one, is that when nation-states in a particular geographical region increase the number of their links with other nation-states, the critical number of flows/links between such nation-states may force a bifurcation whereby the complex system of geographical regions shifts into an overtly more simplified system, whilst being inwardly more diversified - such as the European Union. This in turn will guarantee a greater degree of security, for 'most systems displaying a high degree of tolerance against failures share a common feature: their functionality is guaranteed by a highly interconnected complex system' (Barabasi, 2003: 111). In opposition to this, however, it should be noted that networks are also vulnerable to catastrophic breakdowns due to the very nature of their interconnected structures, as will be examined later.

Are We Living In A Network Society?

The idea that growth and development is not smooth and steady, but rather a series of uneventful stable states 'punctuated' by revolutionary shifts at rare moments (Eldredge, 1985), is shared by Castells. Castells views the end of the 20th Century as being one of these rare moments: 'an interval characterized by the transformation of our "material culture" by the works of a new technological paradigm organized around information technologies' (Castells, 1996: 28). The last two decades of the 20th Century is where Castells sees the major technological breakthroughs occurring: in materials, energy, medicine, transportation, and communication. Importantly Castells, like Laszlo, considers the storage and use of information to be primary:

> Furthermore, the current process of technological transformation expands exponentially because of its ability to create an interface between technological fields through

> common digital language in which information is generated, stored, retrieved, processed, and transmitted…unlike any other revolution, the core of the transformation we are experiencing in the current revolution refers to *technologies of information processing and communication.* (Castells, 1996: 29-30 -italics in original)

Castells continues by affirming that information is a primary mode of energy and that information technologies are a transformation from earlier technologies in that they enable a functional interface, or involvement/participation, with the user. As such, 'the feedback loop between introducing new technology, using it, and developing it into new realms becomes much faster under the new technological paradigm' (Castells, 1996: 31). In this way Castells views the new information technologies not merely as tools but rather as processes, such that computers, programming, and communication systems become more like 'amplifiers and extensions of the human mind' (Castells, 1996: 31). The rapid advancement in technology that occurred in the twentieth-century marked a shift from technologies based on the inputs of fuel energy (e.g. electricity) to ones based upon the input and flows of information (not neglecting of course that computers need electricity for their power supply). Nicolas Negroponte, founding chairman of the MIT Media Laboratory, has referred to this as the shift 'from atoms to bits' (Negroponte, 1995). However, caution is needed here with using such vocabulary, as the 'atoms to bits' image can suggest an evolutionary drive, or transcendence, that has elements of both technological determinism and post/trans-humanism.

Castells, who has spent a considerable time tracing, investigating, and writing about social/global networks, argues that society is undergoing a transformation in connectivity. He sees that a major trait of the present 'information age' is the spread of networks linking people, institutions and countries. This, Castells recognizes, can lead to both an integration of global processes as well as an increase in the fragmentations inherent within (Castells, 1996). Although Castells was an early investigator, and one of the first sociologists, to take on board the importance of social networks, he also stands in a lineage of other commentators who since the 1970s have been espousing the rise of networking within social relations, albeit in a less academic environment. Marilyn Ferguson, who conducted a survey in the US in the 1970s upon the change in people's lifestyles and attitudes, reported that:

> anyone who discovers the rapid proliferation of networks and understands their strength can see the impetus for worldwide transformation. The network is the institution of our time: an open system, a dissipative structure so richly coherent that it is in constant flux, poised for reordering, capable of endless transformation (Ferguson, 1981: 213).

Likewise, John Naisbitt - former Assistant Secretary of Education to President Kennedy - first published his *Megatrends* predictions in 1982 saying that

> networks exist to foster self-help, to exchange information, to change society, to improve the productivity and work life, and to share resources. They are structured to transmit information in a way that is quicker, more high touch, and more energy-efficient than any other process we know…although sharing information and contacts is their main purpose, networks can go beyond the mere transfer of data to the creation and exchange of knowledge. As each person in a network takes in new information, he or she synthesises it and comes up with other, new ideas. Networks

> share these newly forged thoughts and ideas. (Naisbitt, 1984: 193-4)

Society as a 'network' has, indeed, fast become a central metaphor of our age (Castells, 1996; 1997; 1998). Castells traces the roots of today's network society to the 1970s, and especially to the capitalist crisis, and the subsequent restructuring that followed. For Castells, capitalism now exists globally in real time and Castells argues that the rise of the networks does not constitute the death of the nation-state: although perhaps weakened, he sees the state as being drawn further onto the global stage by participating through networks. In this sense, access to such networks is more important than the issue of content.

The beginnings, rise, and growth of the Internet, from the early days of the Advanced Research Projects Agency (ARPA) in September 1969, to the free release of Tim Berners-Lee's web browser 'WWW' in 1993 has been well documented elsewhere (Berners-Lee, 1999; Castells, 2002; Hafner and Lyon, 1996; Rheingold, 2003b). The initial concept, however, was to construct a decentralized, flexible communication network to serve as a military communications system able to survive a nuclear attack (Castells, 2002). The dramatic rise and use of the Internet has fostered the shift towards time compression in the global network society and thus ushers forth notions of 'timeless time' (Castells, 1996).

Castells has characterised several features that constitute this shift to what he terms as the 'timeless time' of the network society. The first feature is that information is the raw material for the new technologies – '*these are technologies to act on information*'. The second feature referred to is the '*pervasiveness of effects of new technologies'*, as human activity is itself based in information. The third feature refers to the '*networking logic'* of the new ICTs as the increasing complexity of relationships and patterns in information require a move to network processes for efficiency. A fourth feature is the flexibility inherent in the new ICTs, and their capacity for rapid adaptation. Not only can processes be reversible, but they can be modified, altered, and rearranged to the configuration of the new 'technological paradigm'. This ability to re-configure is what Castells sees as being a decisive feature of the network society. The fifth feature then is the growing '*convergence of specific technologies into a highly integrated system*…in terms of technological system, one element cannot be imagined without the other' (Castells, 1996: 70-2: italics in original). These features pointed out by Castells demonstrate that a 'networking logic' follows the systemic thinking whereby processes and relationships take over from structure and parts.

Along similar lines Jan van Dijk sees the most important catalyst of a network society as being 'the integration of telecommunications, data communications and mass communications in a single medium' (Dijk, 1999: 9). It is this process of convergence, Dijk states, that has been enabled by two revolutionary techniques: first, the complete digitalisation of transmittable information in equipment that works on micro-electronics; and secondly, broadband transmission through fibre-optic cables, satellite with microwave transmission and new optical techniques, including lasers (Dijk, 1999: 9). Chart 1 (shown earlier) visualised how the growth of data transmission, from the telegraph to present day technologies, is converging applications into multi-functional devices. This developing infrastructure of connectivity is allowing for a plurality of interaction between people, in new spatial and temporal proximities, thus enabling an increased degree of feedback and reflexivity. A network society is, I argue, not only its infrastructure but also, importantly, the individuals, groups, organisations, and other such social formations that form the nodes and hubs that stimulate and utilise the links of the network. Similarly, Dijk sees a network society as being defined as a form of society 'increasingly organising its relationships in media networks which are gradually replacing or complementing the social networks of face-to-face communication' (Dijk, 1999: 220). Dijk also states that he sees social and media networks as forming the principal, and most important, modes of organisation and structure of modern society.

One of the potential consequences of this is that there can be a shift away from the traditional, ritualistic groupings such as the family, neighbourhood, workers, and life associations, towards patterns of ritual and communality that are diffused, connective over new spatial and temporal arrangements, and more flexible, mobile, and dynamic. Examples here can be seen in the upsurge towards online communities, MUDs (Multi-User Dungeons), chat rooms, social movements, and now social networking websites (Castells, 2002; Rheingold, 2003b). There are also now online neighbourhoods – *I-*

Neighbors – where local neighbourhoods are encouraged to register online so as to create a space where, according to their homepage, neighbours can:

> Meet and communicate with your neighbors.
> Find neighbors with similar interests.
> Share information on local companies and services.
> Organize and advertise local events.
> Vocalize local concerns and ideas. (http://www.i-neighbors.org/)

This new space where the physicality of neighbourhoods begins to blur with virtual online meeting *cyber-neighbourhoods* can be argued to be a re-configuring of the concept of social 'meetingness'.

It seems that infrastructural networks of electronic-mediated communication are increasing the importance of space and time through their very contraction of these zones (Dijk, 1999). Commentators on the Internet and society, such as James Slevin (2000), see these networks as allowing individuals to participate more fully in the formation of opinion and decision-making processes, and relates this to features of late modernity, as espoused by Anthony Giddens (1990). Giddens is noted as seeing the radicalisation of modernity as resulting from the intensification of globalisation processes, the rise of post-traditional forms of organisation, and the emergence of increased forms of social reflexivity (Giddens, 1990). What Giddens refers to as the 'circularity of social knowledge' suggests that the social domain is increasingly dynamic and 'cyclic', as opposed to a stable environment, as new information is continually being fed into it. This implies that not only is change more likely, but also that individuals are increasingly entering into patterns of social connectivity that are becoming markedly more reflexive and pluralistic: i.e. social communication is being fed by continual feedback as it is no longer only one-on-one but one-to-many-to-many-to-one. This, as I show later, is precisely what is happening in such forms as ‘smartmobbing’, and the new blogging communities.

Also, as this research has stressed throughout, the feeding of new information is one of the processes that fuels the growth of complex systems. It is thus possible to see in Giddens’s comments upon the radicalisation of modernity that he considers increased flows of information through ever more varied channels, or networks, as re-configuring patterns of spatial and temporal interconnectivity. Slevin, in a similar fashion, notes that

> under conditions of reflexive modernisation, all forms of organisation lack fixed horizons of action. Organisational communication and the context in which information is produced and received are therefore involved in a process of substantial reorganisation. Uncertainty can no longer be confronted by the routine exertions of centralised authorities or be contained within spaces made up of a relatively fixed temporal-spatial co-ordinates. (Slevin, 2000: 126)

Such processes of ‘substantial reorganisation’ that Slevin emphasises might also be equated with the reflexive modernisation concept of *detraditionalisation* (Beck, Giddens and Lash, 1994).

This view is reinforced by Dijk who views networks of mass communication as leading to ‘mass on a global scale’. A mass that is less anonymous; less passive because of the opportunities for ‘selection, feedback and interaction offered in the new media’; forms ‘new types of communities’ that appear ‘largely or partly based on mediated communications'; and a mass that is less and less detached as 'the traditional boundaries between interpersonal communication, communication within and between organisations, and mass communication are disappearing' (Dijk, 1999: 169). This is a state that, as Dijk emphasises, is at once more integrated and more differentiated which, after all, is a 'feature of rising complexity in society' (Dijk, 1999: 221).

The concept of 'mass on a global scale' does not take into account issues of equality of access in less technically advanced global regions. Current statistics place the world population at 6,499,697,060; the current number of registered Internet users worldwide is 1,086,250,903 which makes a user percentage of 16.7%.[12] 'Civil access' to the Internet can at present still be regarded as access for the privileged. Also, in countries like China and Iran Internet usage is strictly monitored and access to many sites blocked from the user. Networks then may be flexible and dynamic yet they are still vulnerable to breakages, blockages and hierarchical control.

Network Breakages, Blockages, and Fallibilities

A network, as experienced in rush hour, is only as efficient as the flows that maintain it. An increase along major pathways may cause a network to re-route some of those flows onto lesser routes, leading to extra pressures building up on weaker routes. The question remains as to what would happen if some of the major hubs that serve various routes became disabled. Perhaps more importantly, network flows and routes may themselves become the very

[12] These figures were accessed and updated on 23/11/06 from http://www.internetworldstats.com

carriers of their own destruction, containing their own Trojan Horse. Examples of the above scenarios are numerous and can be found in the instances of disruptions to energy grids, financial markets, transport networks, as well as bio-health flows, and to almost all networks. According to William Mitchell,

> In large, high-speed networks, such as modern power grids and the internet, patterns of overload propagation and progressive failure are potentially very complex, hard to predict, and frustratingly difficult to control. Once they get started, even in a small way, there is an ever-present danger that they will grow explosively to produce a large scale, long term damage. (Mitchell, 2003: 172)

Recent media-covered events include the North American electrical grid failure, where huge numbers of people experienced blackouts as 'with thousands of generators, millions of miles of lines, and over a billion loads, this huge electric animal is now so interconnected and sensitive that a single disturbance can be detected thousands of miles away' (Barabasi, 2003: 110). Also financial networks can accrue huge losses within the interdependency of the global economy. Barabasi notes that

> the aggregate market value loss between March 2000 and March 2001 of the 12 major companies that adopted out sourcing - Cisco, Dell, Compaq, Gateway, Apple, IBM, Lucent, Hewlett-Packard, Motorola, Ericsson, Nokia, and Nortel - exceeded 1.2 trillion dollars... (Barabasi, 2003: 212-3)

Financial markets are notoriously sensitive to any vibrations or disturbances in their international networks, as have been reported post-September 11th. A year after the September 11th attacks on New York the President's Critical Infrastructure Protection Board reported:

> Our economy and national security are fully dependent upon information technology and the information infrastructure. A network of networks directly supports the operation of all sectors of our economy - energy (electric power, oil and gas), transportation (Rail, Air, Merchant Marine), finance and banking, information and telecommunications, public health, emergency services, water, chemical, defence industrial base, food, agriculture, and postal and shipping. The reach of these computer networks exceeds the bounds of cyberspace. They also control physical objects such as electrical transformers, trains, pipeline pumps, chemical vats, radars, and stock markets. (cited in Mitchell, 2003: 10-11)

The fallout from the September 11th attacks on the World Trade Centre affected more than just the financial networks. In September 2001 Manhattan had, under its streets, more fibre optic cable than in all Africa; also, its two main telephone switches in the financial district had more lines than many European nations, and placed on top of the World Trade Centre north tower were more than 1500 antenna structures (Mitchell, 2003). The collapse of the buildings also delivered a huge blow to the telecommunications infrastructure, resulting in a severe overload and partial loss of service, as well as disruption to the financial data networks, and storage networks. Data networks also have other factors to be concerned with, such as viruses, worms, hackers, and cyber-espionage; and networks of water, air, and transport are routinely vulnerable to physical contagion (Adam, Beck and Loon (eds) 2000; Beck, 1992; Perrow, 1984; Van Loon, 2002). As an example of this, networks of trade flows were seen as responsible for the spread of the recent Foot-and-Mouth epidemic as

> the specific strain that came to Britain in 2001 appeared in central India, in 1990. By 1995 it had spread across much of India, and by 1998 it had inserted itself into the international trade in animals and meat products and was moving much more quickly (Law, 2004b: 4).

The end of the twentieth century witnessed the weaving together of complex webs to the point where the global world is now deeply and heavily embedded within networks of interdependence and shared consequences, albeit unequally. In today's complex world 'the cave in Afghanistan threatens the skyscraper in New York. If an outbreak of SARS is not controlled in Hong Kong, the consequences are immediately felt in Toronto', which tells us unequivocally that 'our circles of interaction and mutual obligation cannot be limited to our campsites, immediate neighbourhoods, cities, nation states, or even networks of international trading partners; they are truly and inescapably global' (Mitchell, 2003: 207).

Even the networks surrounding the maintenance of global brands such as McDonalds, which was once seen as a tightly coupled network with 'enduring and predictable connections between peoples, objects and technologies that stretch across multiple and distant spaces and times' (Urry, 2004: 8), are now open to the unpredictability of negative customer feedback and media coverage in the wake of recent obesity speculation. Networks then are as dynamic as they are vulnerable - a caveat to a globality of increasing interrelations and dependencies, as well as increasing splinterings, inequalities, and dissatisfactions (Graham and Marvin, 2001). This raises the point that global relations, based on complex flows, from energy, data, branding, to viruses, people, and power, are obliterating boundaries. The question now is whether physical boundaries are becoming overly coerced and artificial, in the sense that their maintenance requires greater effort than ever before to maintain their validity, their *sovereignty*. As the world becomes increasingly interconnected the issue of boundaries, of bounded space, becomes ever-more contentious and contended. And this issue forms a central feature of the complexity sciences in that growth in complex systems require those very systems to remain open, and exposed to external stimuli.

To conclude here, alongside the fragility of networks that 'splinter' are networks that use technology to inform, empower, and attract. Such networks have the capacity to become a major dynamic force behind social change. According to Dorogovtsev and Mendes, we are taking 'a step towards understanding one of the few fundamental objects of the Universe: *a network*' (Dorogovtsev and Mendes, 2003: 220).

Informationally Informed Collectives

Thus far I have dealt largely with physical networks, although partly dealing with network patterns, scale-free networks, and hub formations/attractors, in reference to Internet research (Barabasi, 2003; Dorogovtsev and Mendes, 2003; Huberman, 2001). The infrastructures of physical networks, of which the Internet can be viewed as a particular cumulative result, are integral to the discussion of complex interrelations. In short, networks are fundamental to facilitating and enabling complex flows and processes of information and people, as this thesis addresses, as well as being the backbone to technological communication infrastructures. Networks, both physically and digitally, are conducive to complex social self-organising. I finish this chapter by looking at how networks of computer mediated communications are establishing what is being hypothesised as 'collective intelligence'. It is this concept of collective intelligence which is becoming a focus for discussions on how mobile social movements, blogging, and non-physical interconnectivity, are forming complex, yet dynamic, systems of information and resource sharing.

Citizen self-organised protests, disaster relief response and NGO activities have all made increasing use of technically mediated networks of communication. As security analyst Ronald Deibert notes, citizen networks are 'intensifying their linkages, burrowing deeper into the Internet to develop transnational webs of communication and organization…citizen networks have employed the Internet to augment their intelligence capacity in a variety of innovative ways' (Deibert, 2003: 189). Deibert refers to the strategic uses of technological networks as network intelligence, and he foresees them as being crucial to how bottom-up, distributed non-hierarchical social organising will increasingly emerge. Deibert also notes how network intelligence is aiding two different social forces, that of social activists/NGO groups, and computer hackers (Deibert, 2003). These two 'social' groups can be seen at times to be similar in the way that mobile technologies are increasingly involved in global civil society:

> the trajectories that they have respectively taken, separate until recently, have now begun to converge. Through symbiosis, they have complemented and reinforced each other, each bringing strengths that the other has traditionally lacked (Deibert, 2003: 176).

Computationally, technologically, physically and socially, networks are an important resource to complexity theory and thus form an intrinsic part of this thesis. I show later how mobile communication networks inform complex self-organised collectives, for both social protest and disaster relief. The Internet, as a prime model of network infrastructure, is well placed to serve as a crucial element in complex mobilities. Also, networks of resource sharing are integral to the daily functioning of the Internet. Distributed networking is on the increase when it comes to allocation of resources, specifically the use of rapidly growing file-sharing resource communities, referred to as 'Peer-to-Peer' computing (p2p), or 'distributed processing' (Rheingold, 2003). Although it was the music file-sharing Napster program that became the focus of public scrutiny in late 2000, due to major lawsuits brought against it by the recording industry, the sharing of computer memory by fellow users has been underway for a number of years. Here, users share space on their central processing unit (CPU) with others so as to enable more people to pool and exchange data and have increased resource power. Recently, this CPU sharing, or distributed processing, has evolved into a more complex form.

As one example, the National Foundation for Cancer Research and the University of Oxford used a similar technique whereby they asked for volunteers to offer their free CPU space to evaluate Oxford's database of 250 million candidate molecules for potential leukaemia medicine. With the assistance of 1.35 million online users the complete dataset was evaluated in just four weeks rather than several years (Rheingold, 2003). Recently the World Community Grid (WCG) enlisted thousands of privately owned computers to lend their resource capacity towards solving health and social problems.[13] Sharing resources through networking is a feature of what sociologist Pierre Levy views as a part of forming collective intelligence. For Levy, a definition of collective intelligence is

> the enhancement, optimal use, and fusion of skill, imagination, and intellectual energy, regardless of their qualitative diversity. This idea of collective intelligence obviously involves the sharing of memory, imagination, and experience through the widespread exchange of knowledge, new forms of flexible organisation and co-ordination in real time. Although new communications technologies enable human groups to function as intelligent collectives, they do not automatically determine them. (Levy, 2001: 147)

The forms of interconnectivity realised through modern ICTs are enabling the individual to better confront informational chaos, according to Levy, which in turn will be 'accompanied by previously unknown forms of understanding, new participants in its production and management, and new criteria of evaluation in the orientation of knowledge' (Levy, 2001: 148). Further, Levy sees an expanding interconnection of the global communications system, which he sees as being both collective and interactive, as not an infrastructure. Instead it is

> not a conventional territorial and industrial infrastructure but a self-organizing technosocial process, finalised in the short term by a categorical imperative for connectivity that strives to award an idea of collective intelligence, which has, to a large extent, already been implemented. (Levy, 2001: 174-5)

[13] According to a BBC broadcast - http://news.bbc.co.uk/1/hi/sci/tech/4270241.stm

The reaping of these benefits is being seen, as Levy informs, by those who are exploiting existing infrastructures to create an engagement with social processes of collective intelligence.

The infrastructures of ICT networking provides the capacity to go beyond previous spatial and temporal barriers to foster greater coordination in events of shared knowledge, resources, and goals. One such potential of a shared commons is the capacity to call into play individual nodes/agents/people into active service. This move towards distributed agency in the social sphere has been most recently demonstrated by rapid, often spontaneously, organised protests and street marches coordinated through mobile communications. What was once seen as disorganised, unstable mobs are now being re-configured – or *re-actualised* – into complex collectives of dynamic yet coordinated networks of individuals. Such groupings can be used equally effective towards either protests or charitable assistance, as will be shown in the next two chapters.

What this thesis will show is that such networks, in the form of Internet *bloggers*, and mobile social movements, are forming new collectives that are sharing intelligence, resources, and influence, to a degree that is having marked effect upon social patterns of connectivity and action. And it is these newly emerging and expanding forms of collective networking that may be better equipped to handling the type of society that is rapidly appropriating new technologies as part of the 'social'. The new questions that emerge to frame these networking social patterns will be around issues of information, access, sharing, responsibility, transparency and cooperation rather than centralization, codification, and hierarchy.

In order to start exploring such questions, this thesis turns to examine the behaviour of 'smart mob' social movements using an understanding of complexity theory to research how distributed individuals self-organise themselves into effective bottom-up networks of resistance.

CHAPTER FIVE

Performing Complexity 1: Smart-Mobs & Bloggers

> 'Never doubt that a small group of thoughtful, concerned citizens can change the world. Indeed, it is the only thing that ever has'
>
> Margaret Mead

> 'Social disorganisation is seen not as a breakdown of existing structure but as an inability to mobilise action effectively in the face of a given situation'
>
> Herbert Blumer

> 'No man is an Iland, intire of it selfe; every man is a peece of the Continent, a part of the maine; if a Clod bee washed away by the Sea, Europe is the lesse, as well as if a Promontorie were, as well as if a Mannor of thy friends or of thine owne were; any mans death diminishes me, because I am involved in Mankinde; And therefore never send to know for whom the bell tolls; It tolls for thee'
>
> John Donne (Meditation XVII – Devotions)

Information flows have often been closely connected to, and incorporated into, revolutionary social changes. Social critic Andrew Shapiro wonders whether we are in an age where 'terms like *communications* revolution and *information* revolution actually don't go far enough in explaining the transition at hand' (Shapiro, 1999: 10 – italics in original). This is where the current thesis positions itself: researching and examining transitions, shifts in socio-techno practices that are informing new understandings of how social, mobile practices are formed. Yet with modern technologies and social movements merging and influencing each other, questions are arising as to whether this is leading to states of 'absent presence' (Gergen, 2002) in which qualities of the present are being sacrificed for distant relations; or whether we are seeing the appearance of a 'control revolution' (Shapiro, 1999). And what has complexity to do with all of this?

This chapter engages with, and argues against Gergen's 'absent presence', and describes how distributed technologies of communication are facilitating connections 'on the move' and contributing to a shift in social dynamics of presence and action. The focus will be on both mobile and Internet-based technologies – the mobile phone, and blogging in particular. I draw from specific characteristics of the complexity sciences discussed previously, whilst building on the theory of networks and network clusters. I show how social information-sharing, non-localised formations/movements are beginning to infringe, influence, and change the behaviours of social practice. I ask whether these shifts will have any impact upon a 'fragile reordering of the social landscape' (Shapiro, 1999: 10). In this context the complexity sciences are able, I show, to offer a perspective and understanding that is better aligned to these non-localised physical-digital formations than other social theories which examine networks, collectives, and individualism from often separate focus. Complexity theory combines the unpredictability of dynamic flows and interconnectivity with understandings on the collective whole as well as individual participation and networking behaviour.

In this sense complexity theory can be used to counteract criticisms of advocating conformity in the 'whole' as it doesn't describe blind crowd behaviour; rather it characterises participation of individual agents through reflexivity and feedback loops, thus bringing the observer into the system observed. This, as I will show, allows cooperative traits and behaviour to be analysed. As such, complexity theory goes some way in allowing increased reflexive individualism within a larger system thereby negating conformity and passivity. A complex system remains dynamic and in constant contact with incoming flows of information. In these times of increased convergences in temporal-spatial relations, complexity theory is in a position to offer a model of analysis that is open, systemic and holistic, whilst at the same time being grounded in contemporary natural science.

I begin by examining how emerging technologies of mobile phone communications are shaping, and being shaped by, social protest movements. The position taken is that social practices and technologies influence and impact upon each other as a set of processes, not as separate entities. This chapter researches how technologies of communication are appropriated and adapted into social practices of mobility and complex groupings. My research examines several empirical events as case studies to show how new technologies are enmeshed within increasing social/civil practices in a way that raises questions as to whether mobilities rather than societies are to be the core of a new 'reconstituted sociology' (Urry, 2000). As Urry has noted, some of the most important developments in sociology have indirectly stemmed from social movements with emancipatory interests, and that practices of new social movements are reconstituting public space and developing, partially, a kind of globalising civil society (Urry, 2000: 211). This forces the question, as Urry asks, whether such cumulative efforts are in fact facilitating the emergence of a newly constructed global civil society. But first, why the analysis through the complexity sciences?

From Mobilities to Complexity

The approach taken in this thesis is to view information flows as a central component of the complexification process, as stated previously, and that as a core component information is thus a catalyst for increasing complexity. This view correlates with that of *paninformationism*: the recognition that information, along with matter and energy, forms the three fundamental characteristics of the universe (Jdanko, 1994). As empirical research has shown (Laszlo, 1991; Prigogine and Nicolis, 1977) open systems exposed to constant energy flow can become more structured and complex as the system is able to organise and structure itself by making use of, and storing, the increasing quantities of free energy rather than seeing the energy lost through entropy. Thus, complex, open systems allow energy to flow through, and to be stored, and use the energy in their environment to inform, and sustain, their complexity. This approach was used in Chapter Three to model the patterns of socio-cultural complexification.

It was noted earlier how complexity theorist Ervin Laszlo viewed technology as being a major agent for stimulating social change; technology being 'the instrumentality for accessing and using free energies in human societies for human and social purposes' (Laszlo, 1992: 245). By this it is claimed that three of the important underlying factors that drive social systems in a direction of increased structural complexity are the access, consumption, and storing of free energy. In previous chapters I addressed issues relating to processes of complexity, and applied this to macro-processes in the form of historical and cultural shifts. The intention was to position the complexity sciences as based upon core flows of information that are both stored and utilized. This relates to modern technologies that facilitate both micro and macro flows of information. That is, with more mobile and ubiquitous information technologies, communication flows are informing both localized groupings (immediate social networks) as well as more dispersed, non-localised collectives (global social movements).

By looking at the practices of mobile communication through mobile phones and blogging (personal websites), I examine how social collectives of information-sharing individuals both form, and disband, collective groupings in a way that transcends the more traditional local affinities, in order to respond to immediate external events. I examine such phenomena through the lens of complexity theory as a way of interpreting emerging patterns of social behaviour. By doing this I show that an understanding of the complexity sciences can help to illuminate some of the emerging trends of non-localised civil movements that are forming in relation to mobile information technologies. I now turn to examine how the recent rise in mobile phone text messaging has contributed to these trends of complex social behaviour.

Mobilisation through Mobile Messaging: Smartmobbing

In contrast to what Gergen (2002) sees as mobile phoning contributing to a negative 'absent presence' I would support the view that mobile communication networks are encouraging, and realising, an increased sense of individualised communication within mass society. Although this is a somewhat vague term, I refer back to network theorist Dijk (1999) who saw mass communications as leading to 'mass on a global scale'. Previously I stated that networks of communications are leading to a mass that is less anonymous; less passive because of the opportunities for 'selection, feedback and interaction offered in the new media'; that forms 'new types of communities' that appear 'largely or partly based on mediated communications'; and a mass that is less and less detached as 'the traditional boundaries between interpersonal communication, communication within and between organisations, and mass communication are disappearing' (Dijk, 1999: 169). This is a state that, as Dijk tells us, is at once more integrated and more differentiated, which is itself a feature of rising complexity in society (Dijk, 1999: 221).

This thesis takes the view that social groupings fostered by pervasive communications are not leading to a loss of individualism, as Maffesoli (1996) would claim, but rather a heightened sense of individual agency, as well as a sense of participation. Barry Wellman in his NetLab project at the University of Toronto calls this 'local involvement and global reach' *glocalisation*, a term that seems to be both welcomed and loathed in equal measure, and first coined in the early nineties by Roland Robertson (1992). Yet this feature is also present within complex systems, in that a 'part' of the system has relations with the behaviour of the whole. Such systemic behaviour, in the complexity sciences, exhibits features of non-locality whereby behaviour/participation of the parts affect, or are acknowledged by, the whole. This acknowledgment can lead to both greater coordination and organisation, as I demonstrate, and also to a sense of participation of the 'local' individual within the wider 'global' or 'whole' domain.

With mobile communications, to be local is also to be effective. What Gergen (2002) does not emphasise is that mobile communications can empower an individual in more than just a local sense. This is reinforced by recent research undertaken into mobile phone use that is helping to shape an understanding of emerging social practices that demonstrate this increased participation and activity. New research is indicating that some of the fastest developing markets for mobile phones are in the African states as mobile phone operators are producing cheap or recycled units. A recent study by the Centre for Economic Policy Research stated that

> mobile phones had enabled developing countries to 'leapfrog' old technologies. The result is explosive growth - 5,000% in Africa between 1998 and 2003…This research provides the first empirical evidence of a link between social and economic development and the establishment of mobile phone networks (BBC, 2005c).

The wealth of research into mobile phone use and social practices has increased dramatically, with lifestyle and health surveys being carried out by various research centres.[14] However, my research specifically focuses on those uses of mobile phone technology that are informing complex collectives of information-sharing individuals that constitute episodes of dynamic social movements. I examine whether such social phenomenon forms what Rheingold terms 'self-organized, citizen-centric movements' (Rheingold, 2003a). An important feature of such behaviour is that unlike some properties of mobile communications, these movements utilise physical-digital spaces, avoiding what I have already touched upon as 'absent presence' (Gergen, 2002). In this regard, wireless communication devices can foster social engagement and local action, in contrast to such areas as gaming and chat-rooms, where physical contact is usually lacking. Mobilisation through mobile messaging is not a one-off phenomenon but becoming an established means of bottom-up organisation. In this instance it is seen that the political realm is a major attractor for these movements. In order to examine the uses of mobile communication technologies within social environments I now turn to a discussion of what has been termed as 'smart mobs'.

The term 'smart mobs' was coined by Howard Rheingold (2003) to refer to mobile social networks that organize activities and communicate via mobile phone devices. In this chapter I refer heavily to the work of Howard Rheingold and the significance of 'smart mobs' in regards to informationally-driven social collectives. According to Rheingold, these mobile networks are the new 'social revolution' in that they are shifting social practices which connect like-minded people together into collective action at such short notice. Such

[14] For example, see 'Mobile Interaction & Pervasive Social Devices' at LSE; 'RIS:OME - Regulation, Information and the Self: Ownership in Mobile Environments' at University of Surrey.

networks are constantly on the move, constantly communicating, and forever able to 'swarm' within a matter of minutes if physically able. As a case in point, SMS text messaging in Manila, the Philippines, was a major contributor in ending the presidency of incumbent Joseph Estrada. A text message of "Go 2EDSA, Wear blck" was sent around and within the first hour tens of thousands of Filipinos descended upon Epifanio de los Santas Avenue (known as Edsa). Over a four-day period more than a million people showed up in an effort to oust Estrada (Rheingold, 2003b). And the action proved successful.

On examining the situation in Manila more closely, historian Vincente Rafael notes that liberal trade policies in the Philippines 'shares the paradox of being awash with the latest communication technologies, like the cell phone, while being mired in deteriorating infrastructures' (Rafael, 2003: 402). According to World Bank figures the private sector, between 1993 and 2003, invested $230 billion in telecommunications infrastructure in the developing world (Economist, 2005). Added to this development, the United Nations launched a 'Digital Solidarity Fund' on March 14th, 2005 to finance projects that address 'the uneven distribution and use of new information and communication technologies' and 'enable excluded people and countries to enter the new era of the information society' (Economist, 2005). And though the UN has announced that it wants to reach a goal of 50% access by 2015, a recent report from the World Bank states that 77% of the world's population already lives within range of a mobile network (Economist, 2005). Rafael makes note of a local Philippine who shouted that 'the phone is our weapon now', whilst a college student remarked that 'the power of our cell phones and computers were amongst the things which lit the fuse which set off the second uprising, or People Power Revolution II' (Rafael, 2003: 402) . Rafael writes how a technological 'thing' thus became idealised as an agent of change.

Despite protestors and commentators idealising the mobile phone, such a device has enabled a portion of the un-voiced to become active, participatory and, in degrees, noticed. In this context it has enabled 'each user becoming his or her own broadcasting station: a node in a wider network of communication that the state could not possibly monitor, much less control' (Rafael, 2003: 403). Local accounts put the Edsa four-day protest at over a million people, with texting 'credited with converting the crowd into the concerted movement of an aggrieved people' (Rafael, 2003: 412). Yet it is not only in developing economies that such spontaneous movements have occurred. Both in North America as well as in Europe there have been instances of ad-hoc social movements becoming mobilised, coordinated and organised through communication on the move.

The well-known anti-WTO protests in Seattle 1999 – often referred to as 'The Battle of Seattle' - coordinated crowds through phones, laptop emails, and texting. These 'anti-WTO protest movements…explicitly modelled themselves after the distributed, cellular structures of self-organizing systems' (Johnson, 2002: 225). Smaller affinity groups had been called up through emailing on the Web, and their arrival, in vast numbers, in Seattle astonished even the authorities (Klein, 2000). Although their interests varied within the overall movement, they came together in their protests to create action greater than the sum of their parts, despite diversity. This is an example of how mobile social networking - Direct Action Network - can form into more inclusive complex systems that are maintained through a constant flow of information, are decentralised, and far from equilibrium. Citing another example, in Madrid after the train bombings of March 2004 there occurred what has been dubbed a '21st century protest' or 'the night of the mobile telephone' (Losowsky, 2004) whereby tens of thousands of angered Spaniards spontaneously protested against what they considered as a deliberate government cover-up over the bombings. The incumbent Spanish government had quickly blamed ETA for the bombings in a move that was seen by many as an attempt to manipulate Spanish voters towards a pro-government stance only days before a general election. The result was a text-based people-protest:

> Pass it on. It spread first across the city and then the country, multiplying itself through mobile phones, emails and the internet. You have one new message. "Today at 6pm, Genova Street, to find out the truth. Pass it on"...And they did, in their thousands. The message stretched far beyond Madrid. By that evening, PP [People's Party] branches all over Spain were being harangued on the night before the general election by demonstrators not allied to any political party. In Spain, the PP appeared on television to denounce the demos; the number of protestors subsequently soared. There were 7,000 protesters in Barcelona, 1,500 in Galicia and hundreds more in city centres across the country. Most remarkable of all, the protests were organised in just a few hours, via text message and email, by a disillusioned electorate that had decided to take matters into their own hands. It was a political extension of the phenomenon nicknamed "smart mobs"...The day after suffering their own impromptu smart mobs, the Spanish government was defeated at the polls. (Losowsky, 2004)

Again, such causes cannot be simplified to a single effect or action. Other factors contributed to the defeat of the incumbent government, such as the mobilisation of left-wing voters many of whom would probably not have voted; the TV appearance of Rajoy, PP presidential candidate, 'sending the demonstrators home', and the broadcast on State TV of a documentary film about ETA murders, which had also been showed by Madrid's regional TV, both controlled by Partido Popular (PP), the government's ruling party (SmartMobs, 2004). This demonstrates how the 'smart mob' ad-hoc groupings are using mobile communication technologies to bypass traditional boundaries of news/information sharing, once the bastion of the established media, at a grassroots level. An issue that became a bone of contention in the case of Madrid was whether the protests were indeed spontaneous or rather the work of opposing political parties. Jose Cervera, a journalist and self-confessed multiblogger living in Madrid, wrote an account of the events surrounding the SMS mobile messaging as he experienced it:

> I have in my cell phone what I believe is one of the first wave of SMSs that were all over Madrid that fateful day (13/03/2004). Is dated 13:41 pm, and simply states that the government is withdrawing information. At 14:12, another one from other source, same text. The first one calling for a demonstration in front of the Partido Popular office has a date 16:58 pm. The text states that the government is lying, a journalist notorious for his pro-government ways is working, and you should do something. It adds: without parties, for truth, pass it on. I was very worried and opposed the actions, thinking that the demonstrations could harden the will of the government supporters. But I personally re-sent those SMSs to my friends that day. That is the way I think it started: people spamming their cell phone books. People started to send messages, venting their frustration with the official information. Then they became aware of the possibilities, and added the call for a demonstration. I really don't believe there is any political organization in Spain sophisticated enough for pulling such a stunt. And the sources of my messages are people I know personally, ideologically motivated; not a message center. I sincerely believe it was self-organized. (SmartMobs, 2004)

Rheingold recognises how people dissatisfied with the reports of the main institutionalised media used mobile messaging and the many-to-many communication capability of the Internet to create, form, and mobilise a complex grouping of self-organising individuals in order to mould a collective, or voice, against what was considered to be a great affront. Although the individual participants had particular aims, the overall emergent effects appeared beyond all expectations. Rheingold notes how

> People who had a strong reason to act found that they had a new means of gaining information, publishing, organizing, and creating...We are seeing the first steps toward new means of organizing people socially and culturally as well as politically. Wireless, peer-to-peer, ad-hoc, mesh networks of telephones, computers, and people add up to capabilities – for good and for ill – on the scale of those unleashed by the printing press or the alphabet. I can guarantee that not all future political demonstrations organized via the Internet and mobile phone will be peaceful or democratic. The most pragmatic cause for hope is that the new techno-social regime – the media, the way people use them, the institutions that emerge and collapse as a result – is still young. (Rheingold, 2005b)

Rheingold admits that this phenomenon of ad-hoc mobile networking is still young and that it may not necessarily be either wise or kind. Yet in these case studies there is a degree of spontaneity in the complex groupings that form through communication networking. Yet does spontaneity necessarily manifest order?

In complex systems dynamic states are maintained by flows of matter, energy, and information, which are some of the requirements for a complex system to maintain itself in the face of apparent instability. With new technologies of communication it is seen how individuals relate with, adapt, and use information flows. This relationship with information flows increasingly puts an emphasis upon mobility and movement, spontaneity, and more dynamic forms of social relations. These information flows are no longer the one-to-one type of earlier telegraphs and traditional telephones; nor the few-to-many variety of established print media and broadcast but rather the many-to-many (increasingly referred to as 'peer-to-peer') that invests the user(s) with an increased sense of autonomy in terms of what information is received, used, and transmitted on. This new format provides opportunities and electronic proximities for grassroots activism in such areas as 'gathering and disseminating alternative and more democratic news; creating virtual public spheres where citizens debate the issues that concern democratic societies; and organizing collective political action' (Rheingold, 2003a). What appear to be materialising are pockets, or rather subsets, of systemic behaviour, coordinated by mobile information communications. Also, they do not necessarily need to be coordinated throughout, if the initial stimulus is sufficient to sustain a continued flow of information and messaging.

As was demonstrated in the Spanish protests, these were seen to be self-organising, and relatively spontaneous. The mass of participants were engaged within the aim of the whole, whilst maintaining an active role as an individual. I argue here that complex systemic behaviour as manifested within the complexity sciences can, and does, have a place when modelling these features of emerging mobilised crowds and informationally-activated individuals.

This social action is a relatively recent phenomenon as only recently have political activists been employing distributed media to mobilize large-scale collective action such as street demonstrations and protests. Due to such phenomena being relatively recent there are few social critics who have done research on these issues, hence I refer often to the writings of Howard Rheingold who has studied these social movements in depth. Also at this time it should be remembered that the World Wide Web was still an immature phenomenon, approximately a decade in existence, and still in its infancy in terms of potential development and capacity. Similarly, the new-generation phones that sync with the Internet and perform multi-tasks are still in their stages of ongoing development. Users who are aware and clued into using a combination of emerging technologies are the early-users that are forming and participating in these sub-groups of complex, information-rich systems that manifest individuals as active agents. What the future of this phenomenon will be is still undecided. Rheingold notes that in the next few years, what is termed as peer-to-peer (many-to-many), self-organized, citizen-centric movements enabled by smart mob media, will 'either demonstrate real political influence…or recede as a utopian myth of days gone by' (2003a). I now turn to study some further cases where such 'citizen-centric movements' have influenced political events.

Mobile Protesting in the Political Arena

The last US election campaign of 2004 was unique in that it employed and actively encouraged the mobilisation of emerging technologies of mobile communications, from a bottom-up grassroots level, to promote and spread propaganda. Democratic candidate Howard Dean was first to utilise the self-organising capacity of online communities with his site 'Howard Dean for America'.[15] This soon spurred other candidates to wake-up to the capabilities and potential of attracting the support of the online community with regular daily updates. Supporters of the Dean campaign were encouraged to send text messages to friends in order to mobilise the vast market of potential yet apathetic voters. On day one of the Democratic National Convention graduate students and others active in mobile reportage were allowed access to post pictures, news, audio and video streaming to their online sites via a new Democratic-sponsored site powered by 'Textamerica'.[16] This site featured audio and visual reporting sent in via mobile phones directly to the website.

This emerging use of mobile phone technology spurred the rise of websites that served to utilise such mobile communications for more active campaigns. TxtMob was initially developed by the Institute for Applied Autonomy[17] an art and engineering association that develops technologies specifically for political dissent. TxtMob is an application for SMS services that enables collectives/social groups to quickly network through shared text messages similar to an email message-board system. Also, like email groups, a user is able to sign up in order to receive and send text messages from particular groups arranged according to topic. The first groups to use the service were protest organisers who used the service to provide activists with up-to-the minute information about gatherings, direct action, and police movements.

[15] See http://www.deanforamerica.com/
[16] See http://www.textamerica.com/
[17] See http://www.appliedautonomy.com/

The service was developed to be used by protesters at both the recent 2004 Democratic National Convention in Boston and the Republican National Convention in New York. Also, both medical and legal support groups have used TxtMob to dispatch personnel and resources in response to changing and dynamic situations. There are currently three types of TxtMob groups that a person can register with: i) Public: a public group is one which any TxtMob member can join; ii) Private: membership in a private group is restricted by the group's administrators; and iii) Secret: secret groups are similar to private groups in that membership is restricted by the group's administrators. However, membership in secret groups is by invitation only; secret groups do not appear in group directories and uninvited members are unable to sign up. Thus, 'TxtMobbers' – as they are called - can only send to groups of which they are members (http://www.txtmob.com/). The service is free and is currently managed by Tad Hirsch who is a researcher at MIT's Computing Culture Group.

TxtMob was recently put into practice by the organisers of 'Turn Your Back on Bush', a protest coordinated against the US president on the day of his inauguration. As the presidential motorcade travels down Pennsylvania Avenue on route to the White House protesters planned to line the route and turn their backs at the appropriate time. As the Washington Post noted,

> Turn Your Back on Bush plans to use TxtMob to provide "updates on the action" as well as more practical advice such as which security checkpoints people should avoid because they are too crowded...using TxtMob to send the same message to multiple recipients at once is an effective tool for protesters -- giving people the ability to read, respond,

> converge and disperse at a moment's notice. (MacMillan, 2005)

The dynamic flow of information between message senders and receivers creates a network of participants that 'converge and disperse' within moments, almost swarm-like in their movements. In these moments the group of active and coordinated members act as a complex system, maintained in dynamic order by adaptive behaviour in relation to the information flows, with the emergent property of this sub-system as greater than the behaviour of each single individual – such as the sudden coordinated turning of protesters' backs. Relations between individuals are becoming increasingly more complex as networks are being formed that exist beyond traditional bonds of grouping. Systems of individuals are being created out of shared ideology/goals, held together temporarily for a momentary purpose and disbanded when the goal has been reached.

In some circumstances, however, a collective identity can help to bond mobile coordinated movements, as demonstrated recently in Kiev and Kuwait. Rola Dashti, head of the NGO 'Kuwaiti Economic Committee' (KEC), is key organiser and leader of demonstrations calling for women's voting rights in Kuwait. A recently staged protest was largely, and quickly, organised discreetly through mobile phone messaging. In Kuwait demonstrators used text messaging to mobilize followers, dodge authorities and swarm quickly to protest sites. Coll (2005) notes how candidates organizing for the region's limited elections use text services to call supporters to the polls or slyly circulate candidate slates in countries that supposedly ban political groupings.

As a recent report in the Washington Post indicates, dissidence is going digital and 'Text messaging is only the latest in a wave of border-hopping communication technologies to rewire patterns of Arab dissent' (Coll, 2005). Such groupings are usually beyond normal physical ties of presence and the networked relations amongst participants often exist solely through shared text messages. This develops an arrangement that may appear as complex as it is unstable, yet it exists only for a purpose that is time-limited. After this the participants disperse.

In politically sensitive regions as this where formal political parties are banned but loose political societies are often tolerated,

> text messaging allows organizers to build unofficial membership lists, spread news about detained activists, encourage voter turnout, schedule meetings and rallies, and develop new issue campaigns - all while avoiding government-censored newspapers, television stations and Web sites. (Coll, 2005)

A new dynamic of relations and contact is being forged, with flows of information being a core feature. Such groupings of individuals formed through text messaging can be said to show traits of complexity as they are not in equilibrium yet they are dynamic and an individual's 'membership' to the group is also limited to the cause of that moment which forms an acknowledged 'system' of allegiance. Also, the participants are held in coordination through information flows – via mobile texting - and not only do they respond and adapt to outside environmental influence but they are also open in the sense that they can be infiltrated, physically, and if their dynamic coordination/order is broken down, can bifurcate into a state of disorder.

The recent social uprising in the Ukraine, as a response to the alleged political election rigging, made use of TxtMob when organising its Orange-clad supporters in the streets of Kiev (MacMillan, 2005). Here, the Ukrainian protesters were also supported, and coordinated, through an online site called 'Pora' dedicated to protesting against the alleged politically corrupt election.[18] This site became a central news source for those wishing to either follow or participate in the dramatic events unfolding in Kiev. Now that the Ukrainian election dispute is largely resolved Pora has moved onto appealing for social reform in other similarly restricted countries. The latest message on its website reads:

> PORA Appeal to the Presidents of the Countries with a Weak Democracy
>
> to the President
> of Azerbaijan
> Mr. Ilkhan Geydarovitch Aliyev
>
> Respected Mr. President,
>
> PORA Civic Campaign pays its respects to you and people of Azerbaijan.
>
> We consider that our duty is to draw your attention to the low level of (sic) following the generally recognized democratic rights and freedoms in Azerbaijan. Unfortunately, we have to establish the facts of serious limitations of the freedom of Mass Media, the insufficient possibilities of access to Mass Media by the opposition representatives, defeating the freedom of expression the citizens' political views and the pressure exerting on the opposition from the law machinery.

http://pora.org.ua/en/

As this shows, the central issue is the access to mass media, i.e. information flows. This access is crucial, especially in terms of access to the Internet if the mobilisation of goal-orientated systemic behaviour of individuals is to be activated. For this reason, regimes such as China and Iran both restrict Internet access and actively incarcerate individuals from the online dissident

[18] See http://pora.org.ua/en/

community. This was recently highlighted by the case of two online writers – bloggers - being imprisoned in Iran for maintaining blog news sites. There is now a global online committee that serves to protect bloggers' rights[19] that established an online day of solidarity amongst the blogging community to support the release of Arash Sigarchi and Mojtaba Saminejad: 22nd February became the 'Free Mojtaba and Arash Day' (BBC, 2005b).[20]

Although it could be argued that these analogies are tentative, speculative, or contrived, I suggest that in an age of increased networks of communication, where relations are forming beyond traditional bonds, and information is by-passing established channels, such models are useful in order to gain insight into trends of emerging behaviour in these times of re-configured electronic proximities. In order to further examine these claims and to provide a more diverse range of examples it is appropriate that I now turn to aspects of blogging, and the blogging community.

Rise of the Blogosphere

There's no escaping the blog. Fortune Magazine placed it as one of the Top 10 Tech Trends for 2004.[21] The term 'weblog' was coined by Jorn Barger in December 1997. In 2003 a Finnish group of Internet web designers and programmers named Aula held a meeting in Helsinki with respected Internet

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[19] To be found at: http://committeetoprotectbloggers.blogspot.com/
[20] Arash Sigarchi, who was sentenced to 14 years in jail, has now been released on bail, according to blogging sources.
[21] 'Why There's No Escaping the Blog' – December 27th, 2004

entrepreneurs and users to discuss media, copyright, and privacy. They defined blogs as follows:

> Weblogs, also known as blogs, are regularly updated websites or parts of websites, with entries, or posts, in chronological order. Blogs require very little technical skill to maintain, and companies such as Blogger and LiveJournal offer simple tools for hosting weblogs. A person who keeps a weblog is called a blogger. Weblog posts usually link to news articles, other weblogs, or other websites, and are accompanied by the blogger's commentary, which can include personal opinions, factual corrections, and anything in between. (Ahtisaari, Engestrom and Nieminen, 2003: 127)

The first weblog was in effect the first website to be posted - http://info.cern.ch/- the site built by Tim Berners-Lee at CERN. From this page Berners-Lee pointed to all the new sites as they came online. Although there were a few weblog sites in the mid-nineties, widespread usage did not appear until the end of the millennium when the term 'blog', shortened by Peter Merholz in early 1999,[22] coincided with the arrival of what has become one of the most well-known and used web-hosting tools - 'Blogger'. Blogger was launched by Evan Williams and Meg Hourihan's company 'Pyra Labs', and was subsequently bought by Google in 2004. Other weblog tools and software packages enabling instant blogging soon followed, such as the popular TypePad, Xanga, and Movable Type. Anyone can start a weblog; it doesn't require any tech-knowledge or sophistication as it comes as a ready-

[22] The history of the lead-up to blogging can be found at http://en.wikipedia.org/wiki/Blogging

made template. Once a person registers[23] they are able to start publishing straight away: web-publishing at one's fingertips.

The term 'to blog' has now become a part of normalised Internet speech, as a verb meaning 'to edit one's weblog or a post to one's weblog' as the following words were added to the Oxford English Dictionary on March 13th 2003: blog, *n.*; blog, *v.*; blogger, *n.*; blogging, *n.*. Blogging has become rapidly popular in such a short time, as

> weblogs differ from the homepages of the early days in that they have a standard (sort of) interface and its easy to find things to read by following the links from somebody's weblog to another web site. Weblogs also share many of the same qualities that have made the computer-based media tools so popular. Blogging is easy, it's cheap, and it's available to anybody who can access a network-connected computer…for the first time ever, the audience is in control. (Ahtisaari, Engestrom and Nieminen, 2003: 50)

Noted website producer Tom Coates has called this a shift towards mass amateurisation. He notes how weblogs are becoming 'enterprise solutions', in an area that he terms 'nano-publishing'. Coates describes how across the world,

> faster and more randomly than anyone has yet been able to track and collate, webloggers are linking, posting, trackbacking, commenting, aggregating, and moblogging their ways through the first days of the 21st Century. The world finally seems to be changing, and weblogging is part of that process (2003: 53).

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[23] This is usually for free, although some companies are now charging a minimal fee for upkeep and support.

This shift towards mass amateurisation began with the access to more sophisticated computer hardware/software at cheaper prices, combined with the dramatic increase in information supplied by the Internet. This was accelerated, says Coates, by the easy access to distributed material through Internet pathways and networks: ‘for the written word the Internet has already been the easiest, cheapest, and potentially most targeted distribution channel for a good few years’ (Coates, 2003: 55). What makes the weblog more dynamic and durable than the homepage is its fluidity: it is updated almost daily (sometimes several times daily); it is easily modified as it uses a downloadable template; and it adapts to the newly arriving information like a conversation. The weblog can be described as ‘the homepage that we wear’ (Coates, 2003: 56), and blogging also allows users to link, trackback, and forge connections easily by use of *syndication*.

A technology known as RSS has transformed how people can customise Internet content. Initially RSS stood for RDF Site Summary, or Rich Site Summary. Now it is more generally known as Really Simple Syndication. Again, with reference to the Aula gathering:

> It is a format used to syndicate web content of news sites, community sites, and personal weblogs. It can be thought of as a way of subscribing to websites. RSS makes it easier to keep up with favourite sites, and at the same time it is a convenient way of ensuring that others can keep up with one’s own site. The RSS feed contains headlines, a link to the actual item, and optionally a description or summary of the update. (Ahtisaari, Engestrom and Nieminen, 2003: 127)

What RSS allows is for the user to customise the delivery of their Internet content. It is a syndication ability that allows readers of blogs, websites, news sites, and other pages in which they have an interest, to enable their computers to retrieve the latest updates from these pages and deliver them to the reader in the form of an indexed content-cataloguing. Thus, on one page a reader can see the latest headlines, or tag words, to a hundred or more of the Internet pages to which that reader regularly follows. From there the reader can see a brief summary of the updated page, and has a link that takes them directly to it if they so wish. The growth of this tool has been largely down to the bloggers and blog community who wanted more effectively to follow other people's blogs and what they were saying. Journalist and technology writer Dan Gillmor sees it as

> spawning a content revolution that is only now beginning to be understood and appreciated. It could well become the next mainstream method of distributing, collecting, and receiving various kinds of information. If the Web is a content warehouse, the blogging world is a conversation – and RSS may be the best way to follow the conversation (Gillmor, 2004: 38-9).

The information content the user requires, instead of being amidst redundant information, is brought directly to the user. In this way many bloggers are subscribing to other bloggers' RSS feeds, as well as linking to them from their own sites. Control of information flow is being shifted over to the user/reader: this is a shift away from the norms of traditional media. Again, as Gillmor admits, 'I don't need to go surfing all over the Web to keep an eye on what all the people I'm interested in are writing. It comes to me' (Gillmor, 2004: 40).

Examples of popular RSS tools are FeedDemon, and NetNewsWire. In a similar way the site Technorati was set-up by San Francisco technologist Dave Sifry to fulfil a personal need in wanting to know which other bloggers were specifically talking about him: 'I wanted to know what people were talking about, and what they were saying about me, and about the people I cared about' (Sifry cited in Gillmor, 2004: 42). The Technorati site not only crawls the World Wide Web searching out conversations, it also lists those blogsites that are most linked to. In all, what are emerging here are dynamic circuits of blog knowledge and awareness, operating in real-time feedback. With the proliferation of rapid linking between blogsites, coupled with the conversational search engines such as Technorati, as well as the customised RSS content feeds, information is spreading, being networked, stored, and utilised, at unprecedented speed and complexity.

This interconnected infrastructure of information differentiates the blogosphere from the more commercial and 'traditional' sphere of the Web. As will be examined, these emerging complex pathways of information sharing are causing the mainstream media more than a little concern, resulting in high-profile resignations and high-revenue compensations. As in complex systems the blogosphere relies on internal reflexive feedback through a myriad of interlinked, intercommunicating sites that are often looking out for one another against corporate 'bullying'. In some ways, the top-down hierarchical executive *does* have something to be concerned about.

It is significant to note that the rise to prominence of the bloggers came principally after 9/11 and the subsequent 'War on Terror' when many people were critically divided. By 2002 many of the well-known bloggers were supporting the US-led strategies to confront Iraq and the WMD controversy, largely because they came from prominent politically-right orientated sites such as ‘Instapundit’. The term then used – ‘war bloggers’ – was broadened to include all those bloggers whose main focus at the time was the war in Iraq, irrespective of their political position. By the spring of 2003, *Forbes Magazine* used ‘war blogger’ in this larger sense when listing the ‘best warblogs’.[24] Since that time blogging, or the blogosphere, has become a mix of debates, issues, and bloggers, which are distributed amongst all political, racial, religious, and ethnic positions. By the end of 2003 many of the top rated blogs, such as Instapundit, Daily Kos, and Atrios, were receiving over 75,000 unique visitors per day.[25] This phenomenon was also being tracked by Wikipedia, which is itself an example of distributed self-organisation, similar to blogging, and is a prominent hub/node of the blogging community.

To offer clarification, the term *wiki* refers to a collaborative website, which can be edited and authored by anyone. The name *wiki* comes from the Hawaiian word for ‘quick’ and anyone can contribute to a wiki page by adding information, editing content, or even deleting information (Ahtisaari, Engestrom and Nieminen, 2003). Thus, it is a form of open-source information which is a product of the collectivity of users. It is amended, updated, and edited constantly, making it a dynamic source that represents flows of information at the grassroots level of online users.[26] The Wiki

[24] See Wikipedia entry http://en.wikipedia.org/wiki/Blogging
[25] According to blog search engine Technorati - http://www.technorati.com/index.html
[26] In February of 2004 Wikipedia published it’s 500,000th article Gillmor, D. (2004) *We the media*. Sebastopol, CA: O'Reilly..

phenomenon is a self-organising, dynamic distributed network of information maintained through the ongoing contributions of countless participants, some of whom are regular volunteers, others transitory users. In these systems of information-sharing collectives, there is no top-down hierarchy. It is the goodwill of the collective, morphing and transforming in adaptive growth that sustains the whole against the seemingly disparate actions of the 'parts'. The Wiki phenomenon, such as the Wikipedia online encyclopaedia, may not be 'authoritative' in terms of the old traditional media, yet it represents the latest awareness and knowledge from the constantly updated Internet community. In this sense it is an example of how fast information-feedback loops can operate, as all content remains open to continuous upgrading, much like blogsites. The concept of self-reflexivity, and feedback monitoring, is almost second-nature to regular bloggers, and also to others who deal in peer-to-peer information sharing. By comparison traditional mainstream media channels are static and dull; literally, they just can't keep up. Nothing stays still, just as social knowledge, news, trends, and fads are in endless transformation.

Likewise, Weblogs demonstrate the speed of information-feedback loops and are nowadays noted for being amongst the first to cite, break, disseminate, and cover or criticise, the latest news. Some of the more famous blogs that cover the Iraqi situation are 'The Baghdad Blogger'[27]; 'Baghdad Burning'[28] and 'Back to Iraq'.[29] There are literally thousands of blogs covering such issues as the Iraqi Invasion, so it would be beyond the scope here to go into such detailed lists. For a comprehensive guide to topics and sites of the blogosphere

[27] See http://raedinthemiddle.blogspot.com/
[28] See http://riverbendblog.blogspot.com/
[29] See http://www.back-to-iraq.com/

Technorati offers links to all postings and sites by watchwords and directory. A recent request for blogs posting on the Iraqi situation brought up a list of 1,115,406 recently updated Iraqi blog-posts (accessed 13/06/06). Technorati is currently watching 44.2 million blogs, and tracking 2.5 billion links.[30] Already these figures are out of date. The blogosphere moves fast, and so does its news. In an eighteenth-month period, March 2003 – October 2004, Technorati experienced a dramatic rise in the number of published weblogs, with significant doublings around every six months. The latest update to these figures, posted by Technorati's CEO David Sifry in the 'State of the Blogosphere, April 2006' report, can be seen in the chart below:

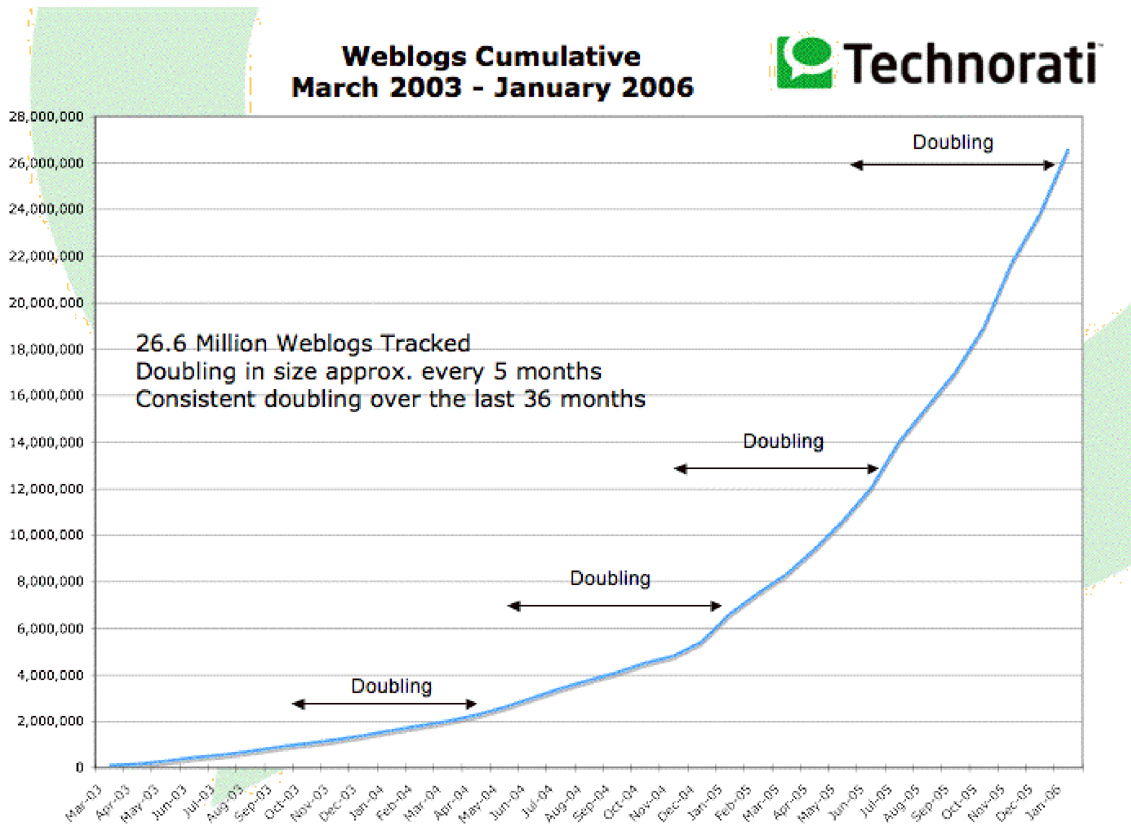

Chart 2 – Weblogs March 2003 – January 2006 (http://www.sifry.com/alerts/archives/000432.html)

[30] http://www.technorati.com/ - accessed 13/06/06

These updated figures show a dramatic rise from October 2004 to January 2006, a period of 16 months, the number of blogsites jumped from a little over 4 million to 26.6 million weblog sites – an increase of 650%. This means that the blogosphere has been doubling in size every 5 months. And blogging is also attracting some notable figures in the academic community. Noted cultural and media critic Doug Kellner, at the University of California, Los Angeles, has established, with several colleagues, his own blog entitled 'Blog Left: Critical Interventions'[31] which demonstrates, as the title indicates, a blog of politically left content. Another notable example is that of James Moore who wrote a paper which explored how distributed citizens worldwide might join together through the use of communications technology, engage international institutions, and thus become a transnational 'second superpower' that could form a dialogue with governments and help set global policy. Immediately Moore was encouraged by fellow Harvard colleague and Internet notable Dave Winer to publish it on the World Wide Web in the form of a blog. Dave Winer had, at this time, recently launched Harvard's first free blogging service. Thus, Moore's blog was formed – now titled as 'Jim Moore's Journal: reporting on systems evolving'[32] - and the paper 'The Second Superpower' became a blog-hit with around 50, 000 downloads in the first five days.[33] As Kellner notes, 'bloggers have demonstrated themselves as technoactivists favouring not only democratic self-expression and networking, but also global media critique and journalistic sociopolitical intervention' (Kahn and Kellner, 2004: 91).

[31] http://www.gseis.ucla.edu/courses/ed253a/blogger.php
[32] http://blogs.law.harvard.edu/jim/
[33] This paper can be read at: http://cyber.law.harvard.edu/people/jmoore/secondsuperpower.html

Bloggers can be formed from all levels and social strata as the act of blogging itself, and the access to self-publishing blogging tools, is largely democratized. And this democratization of information is not only central to a dynamic and complex interrelated blogosphere, it is also a step further in the development of the Web:

> If the world-wide web was about forming a global network of interlocking, informative websites, blogs make the idea of a dynamic network of ongoing debate, dialogue, and commentary central and so emphasize the interpretation and dissemination of alternative information to a heightened degree. (Kahn and Kellner, 2004: 91)

And these ongoing debates have also infiltrated the corporate world. A few corporate techies got wind of the idea that transparency can equal honesty. Public relations pro Tom Murphy wrote on his *PR Opinions* blog that 'Blogging is an opportunity for Public Relations, not a threat…Blogging provides a unique means of providing your audience with the human face of your organization. Your customers can read the actual thoughts and opinion of your staff'.[34] Murphy thus sees the blogosphere as appealing to both the commercial and non-commercial positions. Murphy's links to other PR blogs on his site is both exhaustive and indicative of the trend; and Murphy's '2005 PR Opinions Survey' lists the number one trend in PR as the growth in 'direct communication'.

[34] Taken from the website - http://natterjackpr.com/

Similarly, CEO of *Groove Networks*, Ray Ozzie, used his own blog as a channel to alert his readers to what he felt was a major security lapse in wireless computing.[35] Journalist Dan Gillmor noted that when Groove Networks Ray Ozzie explains something on his blog, the reader 'is gaining insight into the CEO's way of thinking...it illustrates how one executive used this channel to talk about an important issue in today's computing world' (Gillmor, 2004: 72). Gillmor continues by reiterating that 'CEO blogs are useful. Even better, in many cases, are blogs and other materials from people down the ranks' (Gillmor, 2004: 74). The case of blogs from 'people down the ranks' has been increasingly taken up as more and more corporate employees post blogs. One of the more open companies in this respect is Microsoft who have a range of community blogs, one of the more popular ones being 'Channel 9',[36] which at any one time has thousands of guests popping in to see what Microsoft employees are chatting about.[37] One of the more prolific of the Microsoft bloggers, Robert Scoble, has created a well-known blogsite called the *Scobleizer Blog*[38] that currently enjoys 15,444 links from 5,630 sources.[39] In 2003 Scoble posted a manifesto for corporate bloggers on his blogsite with his number one article as: 'Tell the truth**.** The whole truth. Nothing but the truth. If your competitor has a product that's better than yours, link to it. You might as well. We'll find it anyway'.[40] It seems that the blogosphere is walking its own talk – a non-hierarchical, bottom-up information distribution network. Since blog posts rely heavily upon referencing and linking to other

[35] See http://www.ozzie.net/blog/
[36] See http://channel9.msdn.com/
[37] At time of writing (13.14 - 20/5/05) there were 12,069 guests looking in on the Channel 9 site.
[38] See http://scoble.weblogs.com/ - Robert Scoble announced his departure from Microsoft in June 2006 – however, he continues to blog.
[39] Latest statistics from: http://www.technorati.com/live/top100.html
[40] Taken from: http://radio.weblogs.com/0001011/2003/02/26.html

sites, news, and feeds, much of what previously may have slipped through theInternetis being dredged, found and claimed. In going from strength-to-strength the blog format has given rise to some unexpected revelations.

The blogosphere has been behind some of the more recent prime-time news scandals. One of the most famous cases was when the words 'Newsweek Kills Story on White House Intern: 23-Year-Old, Sex Relationship with President' appeared as a Saturday-night headline on the now infamous independent news-blog called the 'Drudge Report'. The author of the blogsite – Matt Drudge – learnt that Newsweek reporter Michael Isikoff had been following the potential scandal only to have his story frozen by bosses at Newsweek. On Saturday 17th January 1998 the Drudge Report published the story to the World Wide Web plus, according to his own calculation, his more than 85,000 subscribers: 'by the early hours of Sunday, the news had hit Internet news groups. It moved from alt.current-events.clinton.whitewater to alt.impeach.clinton and then to the more mainstream political discussion groups'.[41] Three days later, on the Wednesday, the mainstream news channels finally ran the story. The rest is impeachment history. Two more recent cases involve what has become known as 'Rathergate' involving long-standing CBS anchorman Dan Rather.

CBS flagship news program '60 Minutes' ran a story from reporter Dan Rather that used military documents criticizing President George W. Bush's military service in the Texas Air National Guard during the Vietnam invasion. Questions over authenticity were highlighted on politically-right blogs until

[41] According to a BBC News Online post on Sunday January 25th

CBS had to declare an internal investigation.[42] Dan Rather was forced into resignation after nearly 24-years as top CBS anchorman; and the blogosphere, despite doubts over its longevity, became accepted by the mass media as a source of news. According to online source Wikipedia this case also showed how blogs could keep the pressure on an established news source – 'Blogging is also used now to break consumer complaints and vulnerabilities of products, in the way that Usenet and email lists once were'.[43]

One such example of the power of blogging was demonstrated by the discovered vulnerability of Kryptonite 2000 locks. The Kryptonite Lock, developed in 1972, has become a brand name in the world of security locks. The Kryptonite Evolution 2000 U-Lock was supposed to be one of the best for 'toughest bicycle security in moderate to high crime areas', according to the manufacturers. On September 12th 2004 an Internet discussion group user with the *non de plume* 'unaesthetic' posted a strange observation they had encountered with the lock: that it could easily be picked with a Bic ballpoint pen. Two days later the observation was circulating within the blogosphere (Kirkpatrick and Roth, 2004). On September 14th 2004 well-known consumer electronics blog 'Engadget' posted a video showing how the Bic pen unlocked the Kryptonite in a matter of seconds.[44] Technorati, the blogosphere's watch-site, estimated that as of September 19th, just one week after the anonymous discussion post, about 1.8 million people had linked to, downloaded, or read postings about the Kryptonite lock (Kirkpatrick and Roth, 2004). Three days later, on September 22nd, Kryptonite announced it would exchange any

[42] Details to be found at: http://en.wikipedia.org/wiki/Rathergate
[43] Details to be found at: http://en.wikipedia.org/wiki/Blogging
[44] The video can be seen at http://www.engadget.com/entry/7796925370303347/

affected lock for free. In effect, a recall; estimated at around 100,000 locks. Marketing director for Kryptonite was quoted as saying 'It's been – I don't necessarily want to use the word 'devastating' – but it's been serious from a business perspective' (Kirkpatrick and Roth, 2004). In all, the incident cost an estimated $10 million in 10 days. That's the power of the blogosphere. So who is using the blogosphere, and what are the implications of this for complex dynamic groupings within emerging electronic proximities? In order to examine these issues a researched navigation of the blogosphere is required.

Navigating the Blogosphere

Jason McCabe Calacanis, founder of Weblogs Inc., former editor-in-chief of the 'Silicon Alley Reporter', calculates that there are only 200 blogs with a monthly traffic of 1 million page views per month. Only 20 of those receive over 10 million page views per month (McGann, 2004). In terms of viewing numbers 'the Pew Internet & American Life Project' estimates about 11 percent (approximately 50 million) of Internet users are regular blog readers. Active bloggers, meanwhile, update their blogs regularly, to the tune of more than 275,000 posts daily, or about 11,000 updates an hour' in 2004 (McGann, 2004). However, these figures have risen significantly since 2004. According to David Sifry,

> The blogosphere is over 60 times bigger than it was only 3 years ago. New blog creation continues to grow. Technorati currently tracks over 75,000 new weblogs created every day, which means that on average, a new weblog is created every second of every day - and 19.4 million bloggers (55%) are still posting 3 months after their blogs are created. That's an

increase both absolute and relative terms over just 3 months ago, when only 50.5% or 13.7 million blogs were active...In addition to that, about 3.9 million bloggers update their blogs at least weekly.[45]

These figures are shown below in Chart 3:

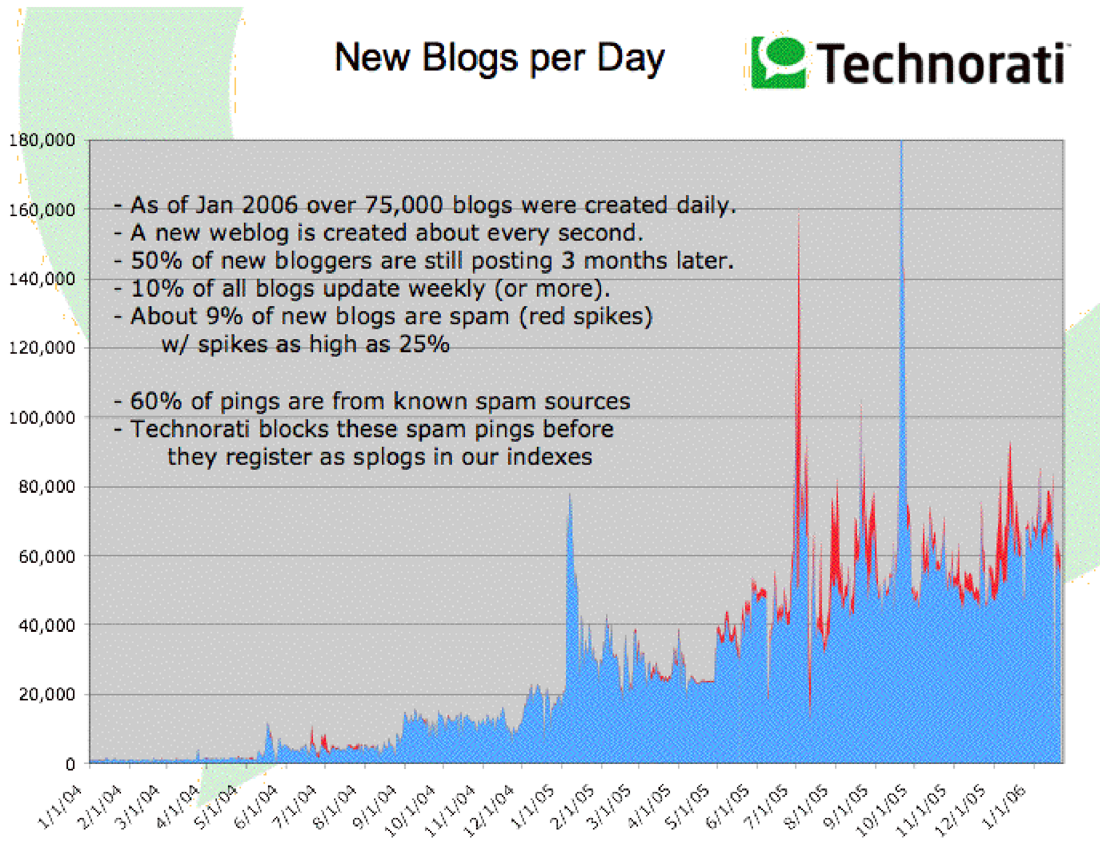

Chart 3 – New Blogs per Day (/www.sifry.com/alerts/archives/000432.html)

Chart 3 graphically shows the number of new blogs per day – an average of 75, 000 – with particular emphasis upon specific days. On certain days there

[45] Given during a post at: http://www.sifry.com/alerts/archives/000432.html

are peaks in new blog activation which, I suspect, have some relation to social events and increased stimuli for people wishing to comment. It is also a known feature that blog-traffic increases sharply when certain Internet news-events occur, as in the scandals mentioned above or during heightened political events. The chart below (chart 4) shows a Technorati survey done during several recent key events. For example, the Kryptonite lock controversy in September 2004; the Indian Ocean tsunami in December 2004; the London bombings in July 2005; and Katrina in September 2005. Although the chart shows a greater number of daily blog posts for 'Deepthroat Revealed' than it does for the Indian Ocean tsunami this is due to the number of activated blogsites which would have increased in the interim.

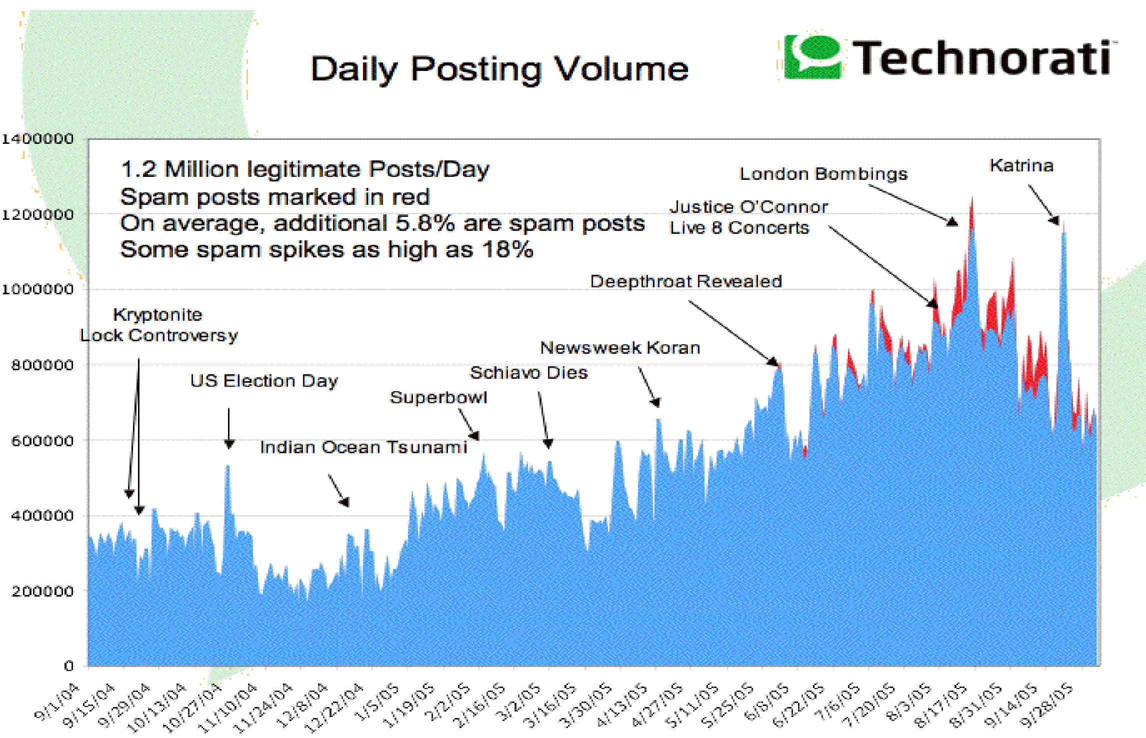

Chart 4 - Daily Posting Volume

(http://www.sifry.com/alerts/archives/000432.html_

Not only do blog-sites peak at particular newsworthy events, they also cluster around the more well-known or prestigious sites; what can be called the blog-attractors. This is a feature that has been discussed previously in relation to the nature of networks. As mentioned, Barabasi considers networks to be the precursor to any complex system (Barabasi, 2003). In the research that Barabasi undertook he found that networks start off with an array of nodes that facilitate links between them. However, after a 'critical number of links', particular nodes will become stronger attractors; that is, attracting many more links to them than other nodes, thus, not resembling a normal distribution. This will in turn transform those specific nodes into hubs, or clusters. These clusters then attract further links which then strengthen their own attraction. Barabasi states that such 'connectors-nodes with an anonymously large number of links-are present in very diverse complex systems, ranging from the economy to the cell' (Barabasi, 2003: 56).

Bernado Huberman, an Internet researcher at Palo Alto, finds similar patterns emerging in terms of Internet user traffic, and cites such sites as Amazon, Google, and E-Bay as such cluster-hubs (Huberman, 2001). Huberman's research, as outlined previously, found that underlying regularities occur within the World Wide Web between the links of users and that these regularities can often be predicted by statistical mechanics. That is, although the system displays a certain degree of statistical order it is also, as a nonlinear system, open to fluctuations of a chaotic nature. From what appears to be a pattern of genuine non-random user-response a web site becomes initially more popular and then begins to add on more links, such that a site will self-organise its growth through its connectivity with other linked sites. This bears remarkable similarity to Barabasi's findings, as explained in Chapter Four. However, whereas previously I spoke of such sites as Amazon and Ebay as becoming nodes, or clusters, the bottom-up geography displayed by emerging social Internet movements are moving towards clusters of blog-sites. Technorati, the blogger's watch-site, regularly updates its Top 100 of 'most authoritative blogs' ranked by the number of other sites that link to it – as in Barabasi's network-nodes. At present (22/06/06) the Top 5 ranking blog-sites are

1. Boing Boing: A Directory of Wonderful Things – 66, 219 links from 20, 223 sites
2. Engadget – 93, 994 links from 15, 817 sites
3. ITMedia News – 44, 031 links from 13, 096 sites
4. PostSecret – 17, 103 links from 11, 798 sites
5. Flickrblog – 21, 880 links from 11, 451 sites

(http://www.technorati.com/pop/blogs/ - accessed 22/06/06)

The top ranking site Boing Boing, which has long been a favourite of the blogging community, and is the brainchild of Internet techie-geek-sci-fi author Cory Doctorow, is linked from 20,223 sites thus making it the strongest blog-attractor and thus a leading node in the blogosphere network. The consumer electronics blog 'Engadget' – which leaked the Kryptonite 2000 U-lock fiasco – is ranked No 2 with 93,994 links from 15,817 sites. As was noted earlier, Jason McCabe Calacanis, former editor-in-chief of the 'Silicon Alley Reporter', calculates that there are only 200 blogs with a monthly traffic of 1 million page views per month, and only 20 of those receive over 10 million page views per month (McGann, 2004). According to Technorati CEO David

Sifry's State of the Blogosphere, April 2006 report, the number of links around blog clusters looked like the following as of early 2006:

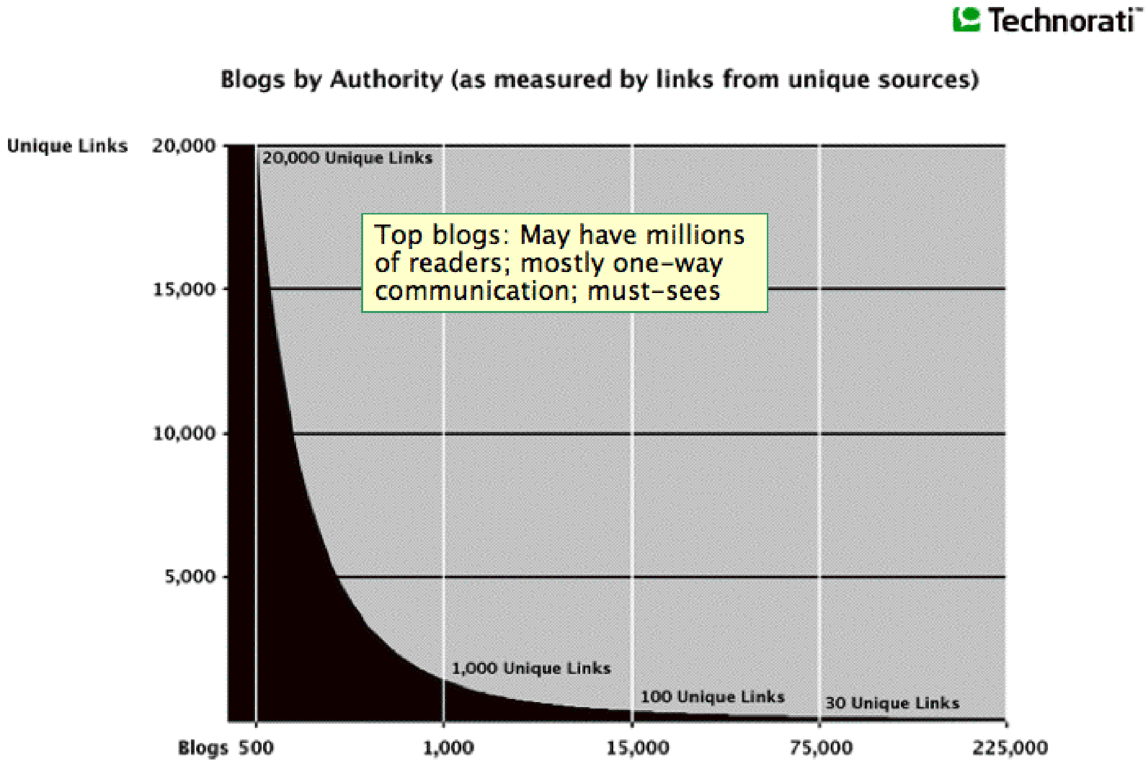

Chart 5 – Blog Attractors (http://www.sifry.com/alerts/archives/000432.html)

The above graph highlights the nature of blog-attractors. These major blog-attractors demonstrate that the blogosphere, like the Internet generally, and similar to other complex systems such as the economy and the cell, work within a network topology that is the basis upon which complex systems operate. Further, in reference to the functioning of the nonlinear dynamics of complex systems regarding thermodynamic entropy, the blogosphere maintains its own far from equilibrium and dynamic random order through the constant open flow of information. The network of the information flows that facilitate a complex system of interacting blog-users, readers, information gatherers, are networking within these emerging spaces of personal hubs of electronic contact. And blog-sites are created around informality and availability. The new electronic spaces are based on being personal, approachable, and within a community of contact. In this respect the space of the Internet is facilitating not the isolated distances of bedroom-mongering but rather fostering opportunities for connectivity. I turn now to examine some of the latest research on blog-demographics.

Who Be Blogging? Blog Demographics

With so many blog-sites and users – both temporary and more permanent – it is difficult to gain reliable analysis into blog-authorship, and user age. Thus, the demographics of blog authorship are somewhat disputed, and shifting, yet the bulk of bloggers generally appear to be within the under-30 demographic. According to a Perseus study 'over 90 percent of blogs are authored by people between the ages of 13 and 29, with 51.5 percent between the ages of 13 and 19' (McGann, 2004). The results of this survey are shown below, in Chart 6:

Blog Demographics		
Age Range	Blogs Created by Age	Percent
10-12	55,500	1.3%
13-19	2,120,000	51.5%
20-29	1,630,000	39.6%
30-39	241,000	5.8%
40-49	41,700	1.0%
50-59	18,500	0.4%
60-69	13,900	0.3%
Total	4,120,000	100%
Source: Perseus Development Corp.		

Chart 6– Blog Demographics (http://www.clickz.com/stats/sectors/traffic_patterns/article.php/3438891)

Chart 6 suggests that the younger generation (early adopters) are taking to new technologies so much more rapidly with each new emergence. However, in terms of those sites that may be considered as blog-attractors, and that carry influence in terms of news and event-coverage, rather than the 'personal pages' of the younger users, the authorship is more likely to lie between the 20-39 age range. This still makes for a considerable 45.4%, nearly half of all bloggers tracked by this survey: 1,871,000. However, these demographic figures give numbers and quantity, yet do not show more precise details such as gender, ethnicity, or length of time blogging.

Often it is the case that bloggers do not continue updating their sites after the initial few months, highlighting the phenomena of becoming dead-weight. That is, 'by the end of 2004, there will be 10 million blogs, the vast majority already dead' (McGann, 2004). A question that arises here is: why do so many blogs die? One response could be to say they starve to death. Literally, they require continual information flows for their sustenance. As in living systems, and also non-living complex systems, entropy increases in proportion to the decrease in flows of energy/matter/information. Like tendrils that dry and wither, and drop off; or, to use another biological analogy, like neurons that do not form connections in the early stages of the human brain, such nodal points become obsolete. In the blogosphere then, as in networks, the pattern follows that of the scale-free network. Here, particular nodes will become stronger attractors; that is, attracting more links to them than other nodes. This will in turn transform those specific nodes into hubs, or clusters. These clusters then attract further links which strengthen their own attraction, with such networks being termed as 'scale-free' networks. As lesser blogsites lose their continual informational updates and as the information flows to those sites dry up - which could be through a variety of reasons such as the person failing to regularly maintain the site and create new links - the blog atrophies and becomes, in terms of the blogosphere, a dead weight.

These trends validate, not diminish, the model of seeing mobile technologically-orientated communications as emerging systems based upon the features of the complexity sciences. I have argued that what keeps complex systems dynamic, and in a state far from equilibrium, are flows of information within open systems. What is being suggested here is that blogging, and blogsites, are open systems with their linkage and RSS feeds that form collectives of people, which are sustained upon continual information flows. In this respect, social aggregations and movements, both democratic and grassroots, require both information transparency (flows) and information access (open systems) in order to sustain, and maintain, complex interconnectivity within an increasingly merging physical-digital environment. As the dramatic increase in mobile phone SMS messaging shows, especially in the rise of handsets in less developed countries, people are seeing, and utilising, the potential in forming relationships, bonds, and collectives through increased mobility without the need for a computer terminal. And with the advent of wireless Internet connectivity this trend shows signs of growing significantly.

Another important aspect would be concerning the demographics – where the bloggers are located physically. An initial answer to this would be almost *everywhere*. However, Internet access, though widespread, is still a luxury. Amidst this the blogosphere is seeing a rapid increase in the number of bloggers from regions with otherwise restrictive Internet access, specifically China and several Middle Eastern countries.

China, well-known for its restriction of media, is undergoing an Internet boom. In 2000 China was estimated to have 22.5 million Internet users. By 2006 this had risen to 123 million users – a use growth of 446.7%.[46] By any terms, this is phenomenal growth. In 2002 Isaac Mao and Zheng Yunsheng published China's first online discussion forum about blogging technology 'CNBlog.org' (Qiang, 2004). China is reputed to have around half a million bloggers, which is still relatively small in comparison to its number of Internet users, yet is a significant number when one considers that the Chinese

[46] Latest statistics from: http://www.internetworldstats.com – accessed 16/11/06

authorities are constantly engaged in Internet crackdown, with the closures of hundreds of websites, Internet cafes, and the arrests of those online commentators disapproved of. According to Reporters Sans Frontières, at least 63 bloggers have been arrested, and most of those are publishing articles outside of the country (BBC, 2005a). David Reid, author of the BBC report, sees how some authoritative regimes might regard blogging as a threat because it is ‘so virulent…In the same way that spammers can reach millions of people in an easy way, ideas deemed dangerously democratic by many regimes can spread faster than bacteria on a petri-dish’ (BBC, 2005a). In the same report, Julien Pain, of Reporters Sans Frontières, says: ‘These are people who are really resisting government oppression…Blogging is a very, very important tool in terms of freedom of expression…That's why it is so interesting. It is a kind of a revolution now’ (BBC, 2005a).

In China, being a blogger can have serious consequences, especially when the main content under discussion is news. The official China Internet Network Information Centre in Beijing estimates that 62% of Internet users go online primarily to read news. Since 2000 China’s police force has set-up Internet departments in more than 700 cities and provinces (Qiang, 2004). The Chinese authorities are aware of the power inherent in the masses, and an online blogosphere can manifest potentially significant consequences in terms of social activist organisation. In January 2003 the Chinese authorities blocked all access to *Blogger* which is one of the most popular blog hosts on the Net. Within a short time three small blogging servers were offering a new gateway into the blogosphere: Blogcn.com; Blogdriver.com; and Blogbus.com. All blog-hosting services were based within China, and by people who had first gathered on Mao and Yunsheng's CNBlog.org. The term *bo ke* has come to mean 'blogger' in China. The blog revolution, if one is to call it that, is sweeping through China, with blog-hosts popping up constantly. Xiao Qiang, director of the China Internet Project at the University of California at Berkeley, and host of China Digital Times, has followed this blogosphere explosion. Qiang notes how by the end of October 2004 China had more than 45 large blog-hosting providers and that 'a Google search for *bo ke* will return more than two million results, from blogs for football fans to blogs for Christians' and that 'blogs play an important role in republishing and spreading information as quickly as it is banned from official websites' (2004). A newer application for blogging is moblogging: moblogging being a combination of mobile and blog, with posts sent mainly by mobile phone, using SMS or MMS messages. Users of China's 300 million mobile phones are beginning to find that their service providers are now offering 'moblogging' services whereby both text and photos can be sent directly from their phones to their blogs. As Qiang notes, 'for now, most blogs are personal, but their potential for building networks or people and disseminating news cannot be underestimated' (Qiang, 2004).

The blogosphere is awash with many questions, speculations, and 'what ifs'. One question that repeatedly crops up, in one form or another, is whether complex systemic networks of mobile people can really be the start of a new revolution. It is by using a complexity analysis that possible future(s) can be envisioned through emergent phenomena yet, as complexity infers, such future states are unpredictable. As Howard Rheingold is quoted as saying in a recent interview: 'These are just people flexing their abilities to self-organise...Whether it's political action or frivolous entertainment, they're practicing. Imagine the skills they'll have to organise political action 10 or 15 years from now?' (Turney, 2004). An issue that needs to be addressed here is whether increases in distributed information flows are really so influential upon contemporary forms of mobility, especially in the light of complex social behaviour.

Information & Mobility: The Distance that makes No Difference

Global interconnections, from ancient trade routes to the rise and fall of Empires, up to more recent networks of flows and communication, do not always take into account the rise of 'grassroots' or bottom-up networks of self-organisation. I have argued that modern networks are achieved through newer spaces of proximity, of presence and action. Informational meaning that was once ascribed to the 'difference that makes a difference' (Bateson, 1985) is being transformed into the 'distance that makes no difference', as information connects, flows, and is distributed beyond physical proximities. Emerging electronic proximities are fostering social networks and presence at a distance, as electronic proximities are increasingly operating non-locally, informing local citizens into social action. The citizen is becoming the mover: 'OhmyNews.com' is a South Korean online newspaper, founded by Oh Yeon Ho on February 22nd, 2000 with the motto "Every Citizen is a Reporter". 'Ohmynews' remains a landmark site as

> It was the first of its kind in the world to accept, edit and publish articles from its readers, in an open source of news reporting. About 20% of the site's content is written by the 41-

> person staff while the majority of articles are written by other freelance contributors who are mostly ordinary citizens. OhmyNews was influential in determining the outcome of the South Korean presidential elections in December 2002 with the election of Roh Moo Hyun. Roh granted his first interview after being elected to OhmyNews. The OhmyNews International page features "citizen reporter" articles written in English from all over the globe.[47]

With the potential for everyone to be a 'citizen reporter', or a node in a network of information, both connectivity and complexity increases. As technology journalist Drew Turney remarks,

> The person-to-person connectivity enacted in a smart mob holds the key to transforming information into action. Your friend sends you an SMS about something of interest to you, you send it to three of your friends you know will be interested, they in turn send it to three friends, and suddenly you and your social network are their own broadcast media with 100% target accuracy…But those who are active or aware – not just of political issues but the power of information in the palm of your hand - will drive the future of communications. (Turney, 2004)

At present, with these social movements springing up in diverse geographical regions, they represent self-organising complex systems based upon networks of mediated mobile information. Whether they pop up in Manila, Kiev, Seoul, or Seattle, these 'smart mobs' are self-organising, dynamic, far from equilibrium, and maintain themselves through information flows, thus exhibiting characteristics that can ally them with the complex systems of the complexity sciences. What are emerging here are complex collectives of information-mediated human agents within spaces of presence and action. Such tools as text messaging (SMS), and blogging, help to create this *presence*

[47] Online description at: http://en.wikipedia.org/wiki/Ohmynews

at a distance. In this environment the notion of time becomes more adaptable and flexible as time schedules can be arranged 'on-the-move' and negotiated in-transit.

A sense of punctuality that is emerging in these new mobilities is shifting from a *place* to a *space* situation as meetings/conversations can take place not only on the move but across continents and national borders: punctuality can be viewed as being 'present' in space when required, more so than being present 'in place' on demand. The static notion of punctuality to *be somewhere* at a designated moment is being replaced by the notion of perpetual movement. The concept of 'clock time' as once being a sign of the 'synchronized measure of life first across national territories and later across the globe' (Lash and Urry, 1994: 229) is becoming transformed into digital time, a satellite monitored time more suitable for mobile connected lives. Here, the synchronization occurs in mobile space and is concerned less with clock time, which seeks to regulate, but instead with nodes of access, that transcend regular time[48], which seeks to connect. Such technologies of communication are informing a new space of mobility and time (Green, 2002) that readdress the issue, or problem, of 'distance'; and contributes to the changing relations of presence and time in urban spaces (Green, 2002: 283).

In these emerging complex interrelations the 'self', as a part of a larger interconnected network of information-sharing participants, becomes the *self-on-the-move*. Information flows are forming a distributed intelligence where

[48] We may remember here the stories we hear of people sleeping with their mobile phones open, or of mobile wireless devices that facilitate Internet access whilst on the move.

mobility is not only about where **you are** but also where you are in relation to other mobile bodies around you. Issues of mobility are not only about one's relation to 'other' static places or destinations but rather where other mobile 'bodies/nodes' are in relation to one's own movement. Also, these electronic proximities are both virtual/digital and physical, in that they often lead to action and group relations if only for a brief, or goal-orientated, task. The 'distance that makes no difference' is one that is seemingly both local and non-local. It is the flow, flux, and feeds of information that are fuelling the increased practices of mobility.

To conclude, information flows facilitate networks, and network clusters/attractors that can lead to possible physical groupings that appear to manifest complex, systemic behaviour. As technology journalist Dan Gillmor states, 'blogs and other modern media are feedback systems. They work in something close to real time...Now, for the first time in history, the feedback system can be global and nearly instantaneous' (Gillmor, 2004: 237). Such bottom-up distributed information flows, like open systems, are responsive to feedback loops that maintain their dynamic, almost 'shapeless' structure. As in complex systems, the structure here is in the processes and relationships between the information 'carriers'. Information feeds the relationships such that digital networks demonstrate that the whole is greater than the sum of its parts. In this manner, communications are moving towards a mesh: a convergence that includes such technologies as the World Wide Web (blogging, websites, newsgroups, chat-boards); mobile phones (SMS messaging, audio blogs, calling); and Wi-Fi (PDAs, wireless laptops and handhelds).

Convergence is now one of the hot buzzwords in the technology market, especially from a corporate perspective. However, these developments go some way in forming novel, creative, dynamically interconnected, feedback responsive, complex collectives that can perform both locally and globally, both physically and virtually. So far, these trends are only emerging in pockets, in smaller complex groupings. Yet as this phenomenon develops Gillmor notes that 'it's hard to keep secrets and harder to stonewall effectively... more transparency is almost always better' (Gillmor, 2004: 238).

This chapter examined several sub-sets of complex collectives that used technologies of information and communication sharing to organise their social dynamics. In this analysis I drew from specific characteristics of the complexity sciences whilst building on the theory of networks and network clusters. From the approach of complexity theory I examined how rapidly increasing informational flows, through emerging digital technologies, can facilitate, and inform, recent mobile decentralized practices, such as 'smart mobs', social protests, and social cooperation. Central to this argument is the concept that information flows within socio-cultural interactions facilitate the formation of complex systems. The view this research takes is that increased growth of such interactions will be based around forms of non-traditional ties that utilise shared information in physical-digital networks and relationships. This form of social complexity, with increased interconnectivity and communication, is one that lends itself to a complexity theory model.

The question remains how transparent and effective such complex networks can be. The next chapter explores this issue, and examines how such socially complex networks have recently mediated distributed communications in response to a major event.

CHAPTER SIX

Performing Complexity 2: Tsunami & Disaster Relief

'An ounce of action is worth a ton of theory'

Friedrich Engels

'The multiple...here's a set undefined by elements or boundaries. Locally, it is not individuated; globally, it is not summed up. So it's neither a flock, nor a school, nor a heap, nor a swarm, nor a herd, nor a pack. It is not an aggregate; it is not discrete...I have no idea, or am only dimly aware, where its individual sites may be, I've no notion of its points, very little idea of its bearings. I have only the feeblest conception of its internal interactions, the lengthiness and entanglement of its connections and relations, only the vaguest idea of its environment...Am I immersed in this multiple, am I, or am I not a part of it?'

Michel Serres – 'Genesis'

The previous chapter discussed the emerging practices of mobile and web-based distributed social communications based upon increased information flows, storage, transmission, and usage. I also discussed how peer-to-peer information sharing networks can lead to electronic swarming, often around attractor-nodes (central weblogs or leading texters), that can lead to physical groupings that appear to manifest complex, systemic behaviour. It was stated that such bottom-up distributed information flows, like open systems, are responsive to feedback loops that maintain their dynamic, nonequilibrium, fluid state. Such systemic communication that combines the technologies of the World Wide Web as well as that of mobile devices is forming creative, and dynamic, interconnected, feedback responsive, complex interrelations that can perform both locally and globally, both physically and digitally.

This chapter continues to examine the 'performance of complexity'. I address how mobile collectives can be formed in both local and global groupings, both physical and digital, in order to work together, with individual participation, to respond to environmental and/or external event/stimulus. This demonstration of a *complex collective* is researched here in the response to the recent December 2004 Indian Ocean tsunami disaster. I examine how mobile communication devices, as well as the Internet, were used, both individually and in clusters, in order to bring safety, survival, and relief to many affected people. Using complexity theory in this context highlights not only the effectiveness of bottom-up, decentralised self-organised processes but also demonstrates how both individualised participation and collective emergent behaviour are facilitated through complexity characteristics. Complexity theory is a model that can theorise how both localised and more global participation are incorporated into interrelated systems. In examining the response to the Indian Ocean tsunami from the perspective of both on-the-ground mobile phone users and local bloggers, as well as blogging communities more globally, I show how sub-sets – or 'hot-spots' – of complex systems can develop and collaborate within a larger context. Complexity theory does not argue for the operation of one global complex system; instead it explains how smaller complex groupings operate and form interrelations within a global environment. These complex sub-sets may then overlap with one another with the potential to form ever more complex ties and connections. However, for the purpose of this present study I have focused on the formations of collaborations between mobile phone users and Internet bloggers specifically.

Complexity theory when applied to the social can demonstrate dynamic connection between individuals and shows how civil society can be active, communicative, and collaborative, rather than excluded and isolated. In this context social networks that facilitate collaboration and cooperation can become a form of social capital in that people can foster relations that provide resources. This position places itself in opposition to Robert Putnam's work on social capital that claims active civil engagement has been in decline, principally in the US, since the 1950s (Putnam, 1995). In his argument Putnam cites the technological transformation of leisure as being partly responsible for this democratic malaise in civil society:

> There is reason to believe that deep-seated technological trends are radically 'privatizing' or 'individualizing' our use of leisure time and thus disrupting many opportunities for social-capital formation...in the language of economics, electronic technology enables individual tastes to be satisfied more fully, but at the cost of the positive social externalities associated with more primitive forms of entertainment...The new 'virtual reality' helmets that we will soon don to be entertained in total isolation are merely the latest extension of this trend. Is technology thus driving a wedge between our individual interests and our collective interests? (Putnam, 1995: 75)

Although Putnam has analysed social trends with case studies and huge amounts of data, his knowledge of online networks, technologically-mediated forms of mobile communications, and physical-digital networks is limited. Also, Putnam is too ready to establish the 1950s, his era of healthy social capital, as a Golden Age of community, and is too ready to accept a US-centric stance. The antiquated vision of donning 'virtual reality' helmets that Putnam embellishes as a modern phenomenon is not a part of what bottom-up self-organising complex mobilities are about. What complex mobilities do point to is a restructuring, in varying degrees, of social connectivity, communication, and civil contribution, and the formation of new ties. The face-to-face talk that Putnam sees in decline has to some degree shifted into systems of physical-digital networking that have been successful in varying areas of global civil engagement, as this chapter will demonstrate.

The first part of this chapter looks at some of the issues being discussed on the traits and benefits of collectives – the 'wisdom of the crowd' scenario. Secondly, I research and examine the Indian Ocean tsunami disaster in order to elicit working examples of these practices in action, and as a way to illustrate the benefits and functionality of such emerging practices of complex, mobile connectivity and information flows. Thirdly, I present some research that shows how some of the practices outlined in the previous section are being implemented as policy, and what this implies for the future of global informational networks in terms of both security and social connectivity. First, I turn to some of the present literature that attempts to illustrate and elucidate the nature of 'collective intelligence'.

Intelligence of the Collective?

The term 'collective intelligence' can mean many things. It has been used to denote - in no particular order - bacterial, hive or insect intelligence (Bonabeau, Dorigo and Theraulaz, 1999; Wilson, 1975; Sahtouris, 1998); artificial intelligence (Bonabeau, Dorigo and Theraulaz, 1999; Langton, 1989); military strategy (Arquilla and Ronfeldt, 2001b); cyberspace connectivity (Levy, 1999; 2001); the spiritual 'noosphere' (Chardin, 1959; 1969; 1974); the 'global mind' (Bloom, 2000; Minsky, 1986; Russell, 1995; Stock, 1993); ecology (Lovelock, 1988; Margulis, 2001); and political governance (Levy, 1999; Atlee, 2003). Swarm intelligence, whereby a group of individuals function akin to a singular organism, is also a term, and strategy, in vogue with both computer programmers and developers of artificial intelligence and military planners in terms of net-warfare. What binds all these diverse fields in commonality is that they share a central core feature – that of information sharing. Whether in biological, computational, strategic, or social terms, the capacity for what is defined as 'collective intelligence' involves the ability to transmit, receive, utilize, and ultimately share, flows of information. This does not claim that social forms of collective intelligence are derivatives, or formed from, biological roots; rather it points to the similarities within various forms of operation and function.

Aspects of social phenomena that may be designated as 'collective intelligence' appear to be emerging from the complex interrelations of communications. In this way the concept of 'complexity' can be viewed as being tied to forms of collective intelligence as such functioning can only emerge when levels of complexity between participating agents/nodes are sufficiently high. When the information sharing and interactions within a complex system of participants becomes sufficiently dynamic yet coordinated, properties that may be deemed 'smart' or 'intelligent', and which show capacities beyond that of the individual components can emerge.

It is possible to conceive of this as positive 'groupthink' in action, made manifest by mediated forms of technological communication. Yet because the people/agents involved are not in constant physical contact with each other they are less susceptible to the traditional groupthink caveat – that of homogenous peer-pressure thinking. The complex collective of information sharing networks over physical distance – distributed intelligence – eschew the group dependencies that have been known to form in more restricted physical spaces, such as offices and boardrooms. James Surowiecki noted this in his study of 'wise crowds' in his look at why the many are often smarter than the few (Surowiecki, 2004). Surowiecki showed that the more personal contact they have with each other, the 'less likely it is that the group's decisions will be wise ones. The more influence we exert on each other, the more likely it is that we will believe the same things and make the same mistakes' (Surowiecki, 2004: 42). Thus, individual goals distort the collective result. Yet Surowiecki noted that if you could connect together a diverse group of people who possess varying scales of knowledge and potential then such a grouping would be more liable to come up with 'smart' decisions; further, that 'technology is now making a global collaboration not just possible but easy and productive' (Surowiecki, 2004: 163). For Surowiecki then, crowds can be 'wise', yet they need to be diverse and beyond physical homogeneity in order to be so. Decentralized crowds make for 'wise crowds' according to Surowiecki. This seems to suggest that there are degrees of 'intelligence' to be found in collectives that are distributed, diverse, heterogeneous, yet connected enough to share affiliations to similar information flows.

Such shifts toward smarter collectives of information-sharing individuals are, using sociologist Pierre Levy's words, an 'attempt to make human groups *as conscious as possible of what they are doing together* and provide them with practical means of coordination' (Levy, 2001: 177 – italics in original). As touched upon at the end of Chapter Four, in the work of Pierre Levy there is a conviction that technological infrastructures will combine with materiality to create a virtual space – an *agora* – where collective and smart formations can manifest. Levy explains that 'My hypothesis is that it is both possible and desirable to construct technical, social, and semiotic means that will effectively incarnate and materialise collective intelligence' (Levy, 1999: 105). Levy goes on to articulate the meanings within what he terms collective intelligence: 'What is collective intelligence? It is a form of universally distributed intelligence, constantly enhanced, co-ordinated in real time, and resulting in the effective mobilisation of skills' (Levy, 1999: 13). Levy's work on collective intelligence is useful in this context to examine how complex systems can involve collective participation, although I feel that caution should be exercised when dealing with vaguer notions of collective 'intelligence'.

However, phenomena in this category, such as spontaneous protest movements, and other ad-hoc street demonstrations spurred on by mobile communication and messaging, have a more sporadic, temporary, and chaotic element to them. This growth in communicative aggregations, complex informational networking, and intelligent cooperation seems to be leading towards a complex system that combines both Net-structure and physical practices, digital networks of communication as well as material actions, to form more responsive collectives of individuals that are thus more aware and reflexive to global, local, contemporary, and future needs. And since communications technologies are allowing almost instantaneous connectivity, such collectives operate in real-time, regardless of their relative positions within either digital or material space.

What is suggested here is that the embedded networks and technological infrastructure that inform almost all cultural practices, whether it be telephone cables, the railway and other transport networks, satellites, radio and various wireless spectrums, in local and global space, is already a systemic 'mesh' that binds and coordinates social presence and action. Levy's 'agora' then is not so much the physical space of the ancient Athenian public square, nor the consumerist spaces of shopping and leisure centres or urban parks. Neither is it to be found purely in the electronic spaces of television or the digital Net. This new agora is informed through a synchronization of material physicality in coordination with communicative and digital technologies. Levy prefers to call this the 'virtual agora', yet I feel that this emphasises too heavily non-physical presence. Levy researched much of the material for his book *Cyberculture* in the early 90s, when the Internet was still in its early commercial stages, so in this respect Levy's work can be seen as prescient, and can be understood for having so much emphasis upon the notion of a ‘cyberspace’ – a term that is less used these days, along with ‘virtual reality’. Yet it can be seen that Levy’s thoughts have dramatic import and relevance:

> the essential point is that cyberspace, involving the interconnection of computers around the world and a communications system that is simultaneously collective and interactive, is not an infrastructure: it is a certain way of using existing infrastructures and exploiting resources and is based on an incessant distributed inventiveness that is indissolubly technical and social...the key element of cyberspace isn't the consumption of information or interactive services but participation in a social process of collective intelligence. (Levy, 2001: 174-5)

For Levy then, this cyberspace is a combination of virtual and material practices that utilise techno-social infrastructures to inform greater participation in social processes towards a form of shared, collective intelligence. This is similar to what is described in this research as collectives, or networks, of agent-sharing information that are beginning to show signs of collectively getting smarter.

The increasing emergence of ‘smarter’ aggregates of individuals, in dynamic relationships to their embedded technologies of communication, show the capacity to inform smaller complex systems of shared goals in response to specific environmental stimuli. However, this does not always pre-suppose ‘smartness’, as Jaron Lanier notes recently in ‘Digital Maoism’ (2006), where ‘the strange allure of anonymous collectivism’, of collective fetishism and the herd mentality implicit in the hive mind, may intrude upon innovative thinking. And it may not only be online that ‘the collective rises around us in multifarious ways', as Lanier notes, but also in our social encounters, in our movements in and through our daily routines. In daily negotiations with people – strangers, colleagues, associates, friends – the notion of collective influence may erode the capacity for 'smart' collective intelligence.[49] Much of the literatures on social grassroots protests, street demonstrations, blogging projects and citizen journalism, and other forms as outlined previously, neglect to consider the detrimental possibilities inherent in the 'hive mind' and instead focus upon the benefits only.

One of the major benefits discussed in terms of distributed communications is the potential ability to become aware of problematic events/situations much sooner, and to articulate a response to such problems, using a combination of both digital and physical presence, and through socio-techno communication systems - in other words, to be able to form networked connections to provide a 'practical means of coordination' in a self-reflexive manner. To see the beginnings of this, and in order to be better positioned to envisage where this may lead in future scenarios, I take the recent Indian Ocean tsunami disaster of December 26th 2004 as a case study. Research into the response to this catastrophic event will elucidate the social practices of complex collectives and show the possible future benefits of communication-mediated coordinated responses from such dynamic informational networks.

[49] See essay online at http://www.edge.org/3rd_culture/lanier06/lanier06_index.html

The Indian Ocean Tsunami Disaster: the Human Cost of Communication Failures

The 2004 Indian Ocean earthquake, referred to by the scientific community as the ‘Sumatra-Andaman’ earthquake, was an undersea earthquake that occurred at 00:58:53 UTC on December 26, 2004. The subsequent tsunami generated by the earthquake, which is the event in the popular public imagination, killed approximately 275,000 people, making it one of the deadliest disasters in modern history.[50] Authoritative estimates now put the tsunami at a magnitude of 9.15.

Such a magnitude cannot be underestimated, for when combined with a time-span that lasted nearly ten minutes, when most major earthquakes last no more than a few seconds, it caused reverberations on a global scale.[51] It has now been verified that the earthquake originated in the Indian Ocean just north of Simeulue Island, off the western coast of northern Sumatra, Indonesia. The resulting tsunami had an incredible impact causing devastation and destruction upon the shoreline communities of, specifically, Indonesia, Sri Lanka, South India, and Thailand, with waves up to 30 m (100 ft). At present, the furthest recorded death due to the tsunami has been recognised at Port Elizabeth in South Africa, 5,000 miles (8,000 km) away from the earthquake epicentre. In total up to 500, 000 people were injured

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[50] http://en.wikipedia.org/wiki/2004_Indian_Ocean_earthquake

[51] Reports state that it caused the entire planet to vibrate at least a few centimeters (CNN), whilst other observers noted that it also triggered earthquakes elsewhere, as far away as Alaska (Science).

from the effects of the tsunami, and 'between three and five million people are without access to basic resources such as clean water, shelter, food, sanitation and healthcare' (Bhattacharya, 2005). Why so many deaths? Over a quarter of a million deaths, and half a million injured, in an age of almost instant communications?

Despite there being a time lag of up to several hours between the earthquake and the impact of the tsunami, it appears that nearly all of the victims were taken completely by surprise. The reason for this is that there were no warning systems in the Indian Ocean to detect tsunamis, or to warn those persons living around the impacted areas close to the shoreline. It has been stated that tsunami detection is not easy because while a tsunami is in deep water it has a very low height and a network of sensors is needed to detect it; and that setting up the communications infrastructure to issue those all-important warnings is an even bigger problem (Knight, 2005). A New Scientist article a few days after the tsunami hit, reported that

> A sensor network capable of detecting an oceanic earthquake and an impending tsunami in the Indian Ocean is feasible, say experts, but will be useless unless backed by improved communications infrastructure in the countries in greatest peril. (Knight, 2005)

The article also notes how an 'early warning system for tsunamis is already in operation in the Pacific Ocean and consists of a network of seismograph and tidal gauges linked via satellite to monitoring centres based in Alaska, US, and Hawaii' (Knight, 2005). Some of the policy responses to the Indian Ocean tsunami in terms of communication infrastructures will be looked at later in this chapter.

Not only was there a failure in the absence of an early warning system, there was also a lack in the transmission of normalised communications:

> The Indian Ocean tsunami of December 2004 highlighted the human cost of communications breakdowns during disasters. While seismic monitoring stations throughout the world detected the massive sub-sea earthquake that triggered the tsunami, a lack of procedures for communicating these warnings to governments and inadequate infrastructure in the regions at risk delayed the transmission of warnings. Yet, based on the successful evacuation of the handful of communities that did receive adequate warning through unofficial channels, it is clear that better communications could have saved tens or hundreds of thousands of lives. (Townsend and Moss, 2005: 3)

The breakdown of essential communications is apparently one of the most widely shared features of all disasters (Townsend and Moss, 2005). Despite the advancement in recent information communications technologies it seems that communications failures remain a serious threat to disaster recovery. This may be because of over-reliance upon hierarchical forms of vertical communication networks that are centralised and command operational, rather than self-organised from the bottom-up around distributed individuals, whilst at the 'society, community, or organizational levels, the vertical and hierarchical flows of information, are normally very complicated and difficult' (Quarantelli, 1998: 11).

Townsend and Moss also note that crises generate 'intense human need for communication…Historically, major disasters are the most intense generators of telecommunications traffic, and the resulting surge of demand can clog even the most well-managed networks' (2005: 12). However, recent communication networks, such as the Internet, were designed to be more resilient and effective against physical destruction and infrastructure attack.[52] Also, the *Short Message Service* (SMS) provided by mobile phones has allowed communications without the same clogging of networks that would occur through voice conversation. In such disaster scenarios it has been noted how 'high rates of personal ownership of computers and mobile phones telecommunications has been a powerful tool in helping rapidly resume normal social and economic activities' (Townsend and Moss, 2005: 21). Anthony Townsend and Mitchell Moss, of the Centre for Catastrophe Preparedness & Response (CCPR), based at New York University in partnership with the Department of Homeland Security and its Office for Domestic Preparedness, compiled a report after the 2004 tsunami titled 'Telecommunications Infrastructure in Disasters: Preparing Cities for Crisis Communications'. The main emphasis of their research was focused on which communications worked, and which failed. Their conclusions noted the inadequacy of traditional communication infrastructures, such as landlines and governmental warning systems, whilst recognising the impact of newer, more distributed communication networks that form self-organised collectives of self-reflexive and adaptive individuals:

> Mobile phones have become increasingly important in post-disaster resumption of normal life. Used in peacetime to organize complex daily activity patterns across sprawling cities, mobile phones provided a flexibility and feeling of security and connectedness vital to survival in unpredictable post-disaster urban landscapes. (Townsend and Moss, 2005: 21)

[52] This, after all, was the initial design imperative behind the Pentagon/DARPA construction of the Internet – to withstand a nuclear attack and communications blackout.

On a similar point Rheingold notes that communication infrastructures fail in disaster because ‘damage to centralized, non-redundant, switching stations causes systemic damage, because sudden network congestion swamps surviving systems, because of physical damage to landlines, antennae and cables’ (Rheingold, 2005d). Rheingold goes on to say that ‘deploying VOIP capability, multiplying wireless Internet support and providing many-to-many SMS capability for early responders and relief workers would all pay for themselves many times over in case of a future disaster’ (Rheingold, 2005d). These responses demonstrate how the converging technologies of computerised and networked communications, as well as the meshing of global informational scapes and flows, are beginning to have an influential effect upon disaster planning and response.

My research focuses on how information flows through mobile and Internet communications, via individuals, emerged as crucial links in a complex web that self-organised into collectives of cooperation. I argue here that an understanding of the complexity sciences can be brought to bear upon highlighting some of the mechanisms behind social-mobile behaviour. That is, the need to respond to incoming information – be it chaotic and disturbing – is counteracted by a systemic reorganisation into complex information sharing within collectives of participating nodes/individuals for the greater good of resource sharing.

It was during the Indian Ocean tsunami disaster relief that self-organising mediated information flows, forming cooperative collectives of resource sharing, came into being as a palpable force and presence. In this light it demonstrated how effective such a medium could be, and outstripped traditional forms of media when it came to getting the messages, and photos, out to a global audience on the true impact of the disaster. The phenomena of 'Smartmobbing' became one of the first lines of response to the tsunami, as described by Rheingold who stated a few weeks after:

> I wasn't surprised when people used sms, blogs, cameraphones and wikis to organize relief efforts during the first hours after the tsunami of 2004. If you can smartmob political demonstrations, elections and performance art, you can smartmob disaster relief. I observed two of my friends on opposite sides of the world doing just that. (Rheingold, 2005c)

On examining the emergence of response initiatives arising within the ad-hoc mobile communications sphere it appears that the response was two-fold. On the one hand citizen-journalists and bloggers used their blogsites to publish photographs, lists of missing people, and calls for assistance and resources. Yet they also tapped into streams of mobile voice and text messaging in order not only to receive live reports directly from disaster sites but also to locate individuals. Rheingold has accurately noted how

> the Internet's worldwide, multimedia, many-to-many information broadcasting capabilities and power to link strangers who share interests, joined to the ubiquity and instantaneous communications of mobile phones, enables people to organize collective action in new ways, with new populations and in new places. Those capabilities have been growing for years, although tsunami relief brought them into public visibility. The tsunami was the first disaster of global scale that called for the kind of onsite-to-global-and-back-

> again powers that such ad-hoc networks can provide. (Rheingold, 2005c)

Indeed, such a tragic event facilitated the public visibility of self-organising 'almost instantaneous' complex systems of information, collectivised under the emergent aim of resource sharing and aid. It appears that those same technologies which have sometimes been used for protest-mobbing and flash-mobbing can have great influence in the midst of greater crises and disasters. Such a dynamic, interconnected, feedback responsive complex system, that can perform both locally and globally, both physically and virtually, can have an impact in dealing with the nonlinear, often unpredictable and chaotic events such as natural and deliberate disasters. Again, in reference to Rheingold, it is worth noting that

> from Manhattan on 9-11 to Asia after the 2005 tsunami, self-organized responses by both official responders and citizens using mobile telephones and Internet communications have proved to be highly useful. At the same time, communication infrastructure failures after earthquakes and terrorist attacks multiplied the lethality of the triggering events. Yet neither incumbent private communications providers nor government agencies appear to have heeded key advice of expert panels that were set up in the wake of the disasters. (Rheingold, 2005d)

This emphasises how communication during disasters is hampered by inherent failures in established network infrastructures, as they often rely upon centralised control. The importance of civilian mobile phone use is that it is spontaneous, mostly self-organised, and has the ability to adapt to changing circumstances on the ground, as was the case during the Indian

Ocean tsunami disaster response. By way of demonstrating these claims I now turn attention towards the use of the mobile phone in both organising a response to the tsunami disaster as well as becoming a valuable tool for those persons caught in the midst of the disaster to reach out and connect with aid networks.

The Role of Mobile Phones in Disaster Response

Text messaging (SMS) came to the fore during the wake of the Indian Ocean tsunami due to the effectiveness of sending messages over jammed networks as text can get through when the line is too weak to sustain or transmit a voice conversation. Thus, the phone can be used as a valuable tool in such emergency circumstances. Sanjaya Senanayake works for Sri Lankan television and was one of the first on the scene after Sri Lankan coastal regions were hit, and to realise that landlines were unreliable and mobile phone networks weak (Boyd, 2005). According to official sources the landline network was badly affected 'after the tidal wave submerged and severely damaged most coastal towns and fishing villages in the North, East and South of Sri Lanka' with 'fixed line phone services in Tangalle, Hambantota and Matara…completely disrupted after the weekend tidal wave' (lankabusinessonline, 2004a). Senanayake's immediate reaction was to send out text messages telling others of what was needed on the ground, and where. Blogging friends took Senanayake's messages and posted them on blogs to spread the news of what was needed. Many of Senanayake's texts were sent to Rohit Gupta, a blogger in Bombay, who posted the messages to the blogsite that he organises - the now well-known *The South-East Asia*

Earthquake and Tsunami Blog (tsunamihelp.blogspot.com), and an associated wiki, which are some of the leading Net-hubs for immediate tsunami-related information. Senanayake is quoted as saying that 'because I've been running around a lot, I don't have time to sit down and write anything. When I am driving around in the car, and when I have two free minutes, I send a message to Gupta and he blogs it' (Wagner, 2004).

In the disaster areas Senanayake found that landlines were down, and mobile phone voice networks were jammed, but SMS was working without problems. This allowed a group of 'about a half-dozen young journalists to file stories with their media organizations (apparently knowing those stories would be censored), and then to use SMS to get the real information out' (Wagner, 2004). On December 30th Senanayake is quoted as saying, in a phone interview, that 'I think I have sent over 4,000 messages in the past four days. My keypad has just about stopped working—it's been giving me trouble this afternoon' (Wagner, 2004). Wagner goes on to quote Senanayake as saying that

> The biggest relief-providing infrastructure is done by small groups, neighborhoods collecting everything, putting it into a vehicle, and driving it out to an affected area and distributing it…That relief aid, from small, spontaneous relief groups, is much better and more important than what the government and U.N. and everyone else is doing. (Wagner, 2004)

People on the ground were becoming frustrated with the various competing news organizations as Senanayake complained that the Sri Lankan government media was primarily focused on making itself look good in media reports, claiming that aid was getting through universally, which it was not, claims Senanayake. On the other side, anti-government media, who were bent on discrediting the government during this crisis, made claims that the aid was completely blocked, which, according to Senanayake's reports, were equally untrue. Senanayake noted that 'as word got out, people started putting pressure on the government to stop lying and get things done' (Wagner, 2004). In this context it can be seen how spontaneous relief efforts from individuals on the ground, using their mobile technologies to connect with other networks of flows, such as the blog-attractors, proved to be perhaps more important in getting aid out than the government or relief agencies, or at least the information that triggered aid responses. And SMS proved vital here in getting word back to the neighbourhoods providing relief as SMS networks are able to cope with much more traffic than the mobile phone call, or even the standard land line call. Also, as Senanayake succinctly points out, 'in every rural community, there's at least one person who has access to a mobile phone, or has a mobile phone, and can receive messages' (Boyd, 2005).

What is demonstrated here is the complex interconnectedness of mobile information flows that are able to access, and feed information/energy, into differing complex systems. On the one hand the messages are flowing to a central blog-attractor, in this case *The South-East Asia Earthquake and Tsunami Blog* (which has already received over 2.5 million visitors), and also to single individuals who are perhaps the sole owner of a mobile phone in their rural village. Each flow enters an open system and stimulates further self-organising as the system adapts to incoming information. And these complex networks influence other nodes within the communication flows to combine the technologies of theInternetas well as that of mobile devices.

Senanayake's messages were being read by many who were to be mobilized into action by them. On such person, Taran Rampersad, knew the importance of ground communication from his military background, and began to devise how there might be a way to automatically centralize text messages so that they could then be distributed and sent on to agencies and other helpers (Boyd, 2005). In a BBC World Service interview Rampersad is quoted as saying,

> Imagine if an aid worker in the field spotted a need for water purification tablets, and had a central place to send a text message to that effect...He can message the server, so the server can send out an e-mail message and human or machine moderators can e-mail aid agencies and get it out in the field...Or, send it at the same time to other people who are using SMS in the region, and they might have an excess of it, and be able to shift supplies to the right places. (Boyd, 2005)

Paul Saffo, director at the Institute for the Future,[53] responded to this idea by remarking that 'this is a classic smart mobs situation where you have people self-organizing into a larger enterprise to do things that benefit other people' (Boyd, 2005). Rampersad is now currently working on open-source software that can link such networks for disaster response; he is calling it the *Alert Retrieval Cache*. This is just one of the post-tsunami responses to ad-hoc mobile networks that are addressed in the latter part of this chapter. What

[53] Also a board member on the Stanford Advisory Council on Science, Technology and Society, and who used to serve as an advisor and Forum Fellow to the World Economic Forum (which in the late 1990s named him as one of its '100 Global Leaders For Tomorrow')

needs further examination at this point is how mobile information flows aided in locating and retrieving survivors of the tsunami disaster. Again, I turn to events in Sri Lanka.

Mobile phone technology also allows for the user to be known and, in some instances, located. This was exactly the case as happened to numerous survivors in Sri Lanka as thirty-six stranded British tourists were rescued as one of them carried a mobile phone with user-location technology. The Britons were reported to have been picked up ‘from the southern beach resort of Hikkaduwa where they were stranded after the tsunami lashed three-quarters of the island's coastline, killing nearly 13,000 people’ (lankabusinessonline, 2004b). This was a result of a private initiative involving all phone companies in Sri Lanka who began to monitor mobile phones with international roaming and then traced the call patterns to find the location of the phone users. According to Chris Dharmakirti, who heads the Tidal Wave Rescue Centre,

> there were 10,252 international roaming phones working on Sri Lankan networks at the time of the tragedy...We sent everyone an sms and got responses from 2,321...He said 5,983 roaming phones had gone dead since the disaster while 4,269 phones had been used to make at least one call after the tragedy...Whenever anyone used the phone, we could track where the person was and restrict our search to affected areas of the country...If a phone is dead it could be that the unit is lost or the person is affected by the tragedy...But, we are keeping a track on these numbers. (lankabusinessonline, 2004b)

As another case amplifies, 35 Hong Kong based employees of the Morgan Stanley investment group were tracked and found because their international roaming phones remained switched on. Dharmakirti notes how ‘this is the first time in Sri Lanka that we have used high tech call tracking for a rescue mission’ (lankabusinessonline, 2004b). Further examples are to be found such as the Czech government which sought the help of the country's three mobile phone companies to send text messages to the phones of about 90 Czech tourists who remain unaccounted for: ‘the operators were establishing whether the phones were active when the wave struck, and whether they have since been reactivated elsewhere’ (Lostcoders, 2005).

There are now numerous reports available that catalogue how mobile phones and SMS were used in the wake of the tsunami disaster to mobilize help, spread information about the event and highlight the need for resources, and to guide both aid workers and survivors into safe areas. For example, SMS messages in Malaysia warned road users not to use the Penang Bridge due to safety concerns (Turettini, 2004). Officials in the disaster management division of the home ministry in the Indian government at New Delhi were awoken at 7am with SMS messages informing them of a quake in the Indonesian region. Later that day two ships had been dispatched with aid to the Indian stricken area of Colombo and the President had made offers of assistance to Thailand, the Maldives, and Indonesia (Calcutta-Telegraph, 2004).

A first-hand account comes from Alison Gray, editor of *The Scotsman Magazine*, who was on holiday in Sri Lanka at the time. She described, in her article of Monday December 27th, how she was able to use her phone SMS to get word out to her family letting them know she was safe. Like others, Alison found that 'the Foreign Office hotline either jammed or not recognised: text messaging has been the only reliable communication' (Gray, 2004). In the light of these revelations phone companies worldwide came to assist by offering such things as free SMS messaging to and from the tsunami affected areas. Some overseas operators even made all mobile calls free on their network for the tsunami-hit regions. Emily Turettini's blog *textually.org*[54] became another blog-attractor that helped to self-organise resources and activity via SMS messages. This influential blog became the space where to send SMS messages in what became a form of bulletin board (later emulated by such sites in the wake of hurricanes Katrina and Rita). *Textually.org* then posted an updated site on 'A round up of operators and companies around the world offering free or rebated phone calls and text messaging to and from the tsunami devastated countries'.[55]

What this showed was that the infrastructure responded to the actions, calls, and the self-organisation of its users. It is to be seriously doubted if such corporate actions would have been taken if it were not for the obvious benefits of the mobile devices being highlighted by the users on the ground. Before governments or even both local and international media could respond, self-organising behaviour was adapting itself to the new situation and the information flows required. It was chaotic, it was extremely complex; yet complexity theory here models not the general complexity of the disaster, as

[54] http://www.textually.org/
[55] http://www.textually.org/textually/archives/2005/01/006592.htm

would be appreciated in layman terms, but the new formations and relationships of the information flows that formed systems of aid, warning, calls for resource, and bulletin boards for survivors' messages. The complex mesh of phone/SMS networking proved of significant use again when it was used as a means for charity relief raising campaigns globally and for being attractors for financial donations.

Again, *textually.org* became a central node for distributing information on charity networks and campaigns: it listed a roundup of tsunami relief SMS fund raising campaigns around the world. Examples are:

- UK: SMS tsunami donations reach 1m

- Boost Mobile Ringtones for Tsunami Relief

- Tsunami 2005: Greece - SMS donations

- Bell Canada offers ringtones for Tsunami Relief

- Australia. Pledges to the tune of $15m

- Spanish Tsunami SMS Campaign raises $5.9 million in 2 days

- Netherlands raises 2.2 million in Tsunami SMS campaign

- Korean Mobile Carriers Raise Fund for Tsunami

- SMS donation campaign mainly for orphans and children

- SMS message VAT revenues could go to tsunami-hit Asia

- UK Relief tasks for text messaging

- Swiss and Brussels Airline miles now given in SMS text messages
- Czech charity ADRA raises 500,000
- French and Malaysian fund raising campaigns by SMS

- Ericsson using SMS Technology to aid Donations

- Mobile Bridges sets up SMS to donate

- SMS The Singapore Red Cross

(http://www.textually.org/textually/archives/2005/01/006593.htm0)

Examples here abound. In the UK, by 25th January 2005, customers of the UK's major mobile phone networks raised over one million pounds for the Disasters Emergency Committee (DEC) tsunami appeal fund (Mobile, 2005). Similarly, in Italy, operators made a single number available for donations and sent text or voice messages to their customers appealing to them to send one euro (Lostcoders, 2005). Anna Fraschetti, who is a spokeswoman for public Italian radio and television network RAI, commented that ‘A euro is not very much, that's true, but people are responding enthusiastically…It also enables young people to participate…If all the 50 million people who own a portable phone in Italy sent one euro, that would add up to a nice sum’ (Lostcoders, 2005). Small cash payments made by mobile phones, via SMS, are quicker, more spontaneous and less costly than a bank transfer. The ‘one euro’ campaign in Italy raised 14 million euros in the first five days after the disaster - the power of the collective and the wisdom of crowds? Or, as Christian Crumlish, author of *The Power of Many: How the Living Web is Transforming Politics, Business, and Everyday Life*, puts it:

> The urge to get involved, to help people, or to make a difference in some way can be a strong enough motivation to move someone away from their computer screen and out onto the street. This is true whether the goal is to raise money to help combat a deadly disease, or to head to a Red Cross centre to donate blood to help those at risk from disasters and other emergencies. (Crumlish, 2004: 65)

Mobile interconnectivity, whether through the Net, or through phone networks and SMS, is engaging individuals into action. This can be seen as a form of physical/digital presence, where electronic proximities are informing physical systemic/collective behaviour. In this way, the complex interrelations of communication technologies are forming a creative, and dynamic, interconnected, feedback responsive, complex network that can function both locally and globally.

Complexity theory is able to analyse dynamic webs as part of self-organising systems that facilitate the flow of information. Complex feedback-responsive systems work on positive feedback which means that they react to environmental stimuli not by counter-acting it in order to regain balance and equilibrium, but the opposite. Positive feedback systems respond actively to adapt to new stimuli and to amplify the original system that is being impacted. In this case creative connections were formed not to *shrink away* from the environmental perturbation but rather to move towards it and to make new pathways of connectivity to deal with it. Examples of these pathways are perhaps more noticeable on the Internet and the World Wide Web, specifically with the phenomenon of the blogosphere. How such a complex mesh of personalised Internet sites responded to the Indian Ocean tsunami disaster is both revealing and informative for future networks of surveillance and information gathering. I now turn to examine how the blogosphere responded to the tsunami.

Blogging Disaster Relief: Web Complexities of Action

The latest trends in World Wide Web activities and architecture point towards user-generated and collaborative tools. This was in evidence from the user self-organised response to the Indian Ocean tsunami. Many news-hungry people didn't wait for the traditional media to source news reports to be edited and broadcast, or for the day-after newspaper printing – they turned to the immediacy of the Net. And within hours

> witness accounts, photos and video were available on hundreds, if not thousands of blogs...the "blogosphere" began organising to help aid efforts...They were also an important conduit for many people looking for news and information about missing friends and relatives (Martin, 2005).

Such comments come from the mainstream media itself and show how they recognised such ad-hoc formations of organised information flows. So much so that many traditional media outlets now regularly employ in-house bloggers, as well as buying stories and photos from the 'blogosphere'. A development of blogging – video blogging (known as 'vlogging') – whereby amateurs use their digital video cameras to shoot footage began appearing on blogsites almost instantly. Amateur video shot by tourists at such disaster sites as Phuket and Patong in Thailand, Penang in Malaysia, and areas in Sri Lanka, and Aceh, started appearing on blogs (Martin, 2005). Another example of a blog-attractor site was from Geoffrey Huntley whose blog *Waveofdestruction.org* was created on December 28th and which stated that his blog was 'to serve as a central location for videos/photos related to the tsunami' (Martin, 2005)[56]. Immediately his site went up to 39,000 webpage visitors, to then climb to a staggering 3 million plus in less than 48 hours (Borton, 2005). Although a large number of these visitors would have been only observing the videos passively, their linking to the site increased the density of connections and gave the site prominence. This is similar to the phenomena of tipping points that push systems towards emergent properties (Gladwell, 2000). Ultimately many of these vlogs were transferred over into mainstream media reportage.

Such actions of the bloggers, and Web citizen journalism, offer a more instantaneous source of information that can be disseminated and distributed through their linking networks to potentially large numbers of readers. Such a medium is indisputably a valuable means for collaborative organisation. One of the main advantages here is the speed of information in the blogosphere, and the anonymous spirit of cooperation that appears to infuse such

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[56] As a side note, Ebay sellers have been offering DVD titles of amateur footage of the tsunami for sale under such titles as 'TSUNAMI DVD THAILAND PHUKET WAVE OF DESTRUCTION' (listing checked on 15/10/05).

networking. However, this is no guarantee of the accuracy and legitimacy of the information.

Further media responses included Guardian journalist Bobbie Johnson who wrote that ‘the web's most important contribution was to inform people about what was happening - to organise people, and point them in the direction to raise funds’ (Johnson, 2005). Rheingold again reiterated that existing systems found themselves inadequate to respond with a disaster on such a scale, adding ‘I think this was a wake-up call for grassroots disaster relief…The instances that were blogged…will inevitably lead people to come up with better solutions in the future’ (Johnson, 2005). One such website, mentioned earlier - *The South-East Asia Earthquake and Tsunami Blog* (Sea-Eat) – within a week came up on a Google search as third ranking for ‘tsunami’ on the Web. According to another Internet commentator, Jeff Jarvis, president of Advance.net, this ‘demonstrates the power and speed of the mob through its links. People immediately spread the word and gave this new site ‘authority’ as we now measure it online - they gave it links’ (Johnson, 2005). And links, as previously discussed, are what create both a blog-attractor, and an organizing influence within complex systems. The Sea-Eat blogsite thus became a model within the self-organising complex collective.

Mumbai-based blogger Dina Mehta, one of the main bloggers and principle contributors behind Sea-Eat,[57] has said that ‘I think we are a working model for the future - not just restricted to disasters and relief programs, but

[57] Dina Mehta is also one of the founding bloggers for the more recent aid blogsites ‘Katrina Help’ (http://katrinahelp.blogspot.com/), and ‘Rita Help’ (http://ritahelp.blogspot.com/).

designed to change the way people communicate, collaborate and organize for work or play. Across corporations and media. And they are listening' (Borton, 2005). The Sea-Eat blogsite was set-up on the Monday, just one day after the tsunami hit. In the first five days the site received over 450,000 visitors, a great deal of press, over 60 contributors, and many more volunteers (Borton, 2005). Mehta explains how this expanded into more complex links:

> We have also linked to a Sea-Eat wiki for easy search on resources, and to another wiki for volunteers. The wikis are works in progress ... It's nice to see lots of learning on social software over the last two years implemented here; linking blog to wiki and wiki to blog, working with the limitations of using Blogger, using blogrolling to enable links to wiki pages, putting up a Flickr Zeitgest on missing persons. We still need a button/logo. We still need cross-referencing between blog posts and wiki pages. We still need easy migration of data from blog to wiki. (Borton, 2005)

As discussed, a wiki is software that allows users to freely create and edit webpage content using any web browser. The most well-known and used example is the online encyclopaedia Wikipedia. A wiki site supports hyperlinks and syntax for creating new pages and for enabling cross linking. It is, in effect, a model of complexity behaviour where each node can connect – hyperlink – to another node that forms a system based not on linear structure but on shared meaning. Wikis thus facilitate strong group systemic communication as it allows for the self-organisation of both contributors and content. Also, the Sea-Eat site had linked to Flickr, an image/photo hosting site, in order to link postings with 'missing persons' photos.[58]

The Sea-Eat site acted as a hub not only to coordinate relief operations amongst volunteers on the ground but also as one of the first point of calls for those people in the disaster zone to get word to friends and family back home. Sea-Eat is thus a 'marvellous demonstration of the collective intelligence of humanitarian smart mobs' (Borton, 2005) as fellow blogger Rohit Gupta, who along with Mehta helped start Sea-Eat, had noted. As of October 28th 2005 the Sea-Eat site has logged 2,576,904 visitors, and continues to grow daily, although not at its earlier exponential rate. Most of the early postings to Sea-Eat were on the issue of asking for and coordinating aid on the ground. As examples of such posts, below are shown some of the actual posts retrieved from the site's archives:[59]

URGENT Sri Lanka: Immediate Aid Needed in Koralawella, Moratuwa

There is a shortage of food at the Camp operating in the Sunanda Upananda Temple in Koralawella, Moratuwa. Approx. 680 families are living there right now. They say the have sorted out ways of cooking the food and can help themselves if given dry rations. An aid worker there estimates a minimum need of 100 Kgs of rice and 30 Kgs of Dal per meal for all the families for the next 2 days.

Because of the proximity to Colombo, the people of Koralawella have been virtually ignored and left to fend for themselves. This need is urgent.

[58] The Flickr 'Southeast Asia Tsunami-MISSING PERSONS' site hosts all the photos of the missing people with posted messages from friends. See: http://www.flickr.com/groups/tsunami_help_missing/

[59] I have deliberately erased the phone numbers of individuals for the postings here. Corporate numbers remain.

Please contact Kelly on +94 777 XXXXXX for more information and for directions on how to get there.

The most important thing needed in Chennai.
KEROSENE.

They need Kerosene to burn the dead. No one seems to have supplied that as yet.

PUNE UPDATE - 1ST JAN.: INFORMATION FOR VOLUNEERS
MAITRI (PUNE):
Contact us at vinitat@vsnl.com or jayuanil@vsnl.net. Vinita: 094225 XXXXX or Jayashree 098231 XXXXXX

LOCAL RED CROSS (PUNE): O20-26130031

AID HELPLINE (CHENNAI): 044-28350403 / 044-55615629

VOLUNTEERS FOR RESCUE WORK (TAMIL NADU):04635-242999

The National Christian Council in Sri Lanka has been using their network of churches in the affected areas of the island for relief distribution and coordination work. They need your support. Niroshini Nayagam National Christian Council, Sri Lanka - +94 112 810502 +94 777 847550

(http://tsunamihelp.blogspot.com/2004_12_26_tsunamihelp_archive.html)

Although some have dubbed these examples of mobile coordinated action as 'tribal digital networks' I argue against the use of 'tribal' since it suggests a particular ethnic or cultural identification in precedence over those deemed to be 'outside' of the assigned tribe/clan. I view these examples as collective digital networks that are forming complex systems of relations and processes.

Again, it must be stressed that such phenomena as demonstrated here through the mobile and online networks are not universal. It would be more accurate to see them as several smaller complex systems behaving in adaptation to external events. Such sites as Sea-Eat act as node-attractors that link to other sites, such as wikis and photo-hosting sites, as well as numerous other aid sites. And the list of examples here are literally too long to cite all. Some examples of actors within the blogosphere network include the Finnish site *www.sukellus.fi*. This site was maintained by a group of Finnish scuba-diving enthusiasts and instructors, who were in the disaster area, while the central figure and site administrator at the Finnish end was Alex Nieminen, a former journalist and management consultant. This made the information posted more reliable, since the information was being put together by people on the ground with strong local knowledge and even skills in the local language. This Finnish website, which would normally receive around a daily quota of 300 hits a day, had, by December 29th, received more than a quarter of a million registered hits. As in the case of most blogs, the site was the work of a few dedicated people who had self-organised on voluntary terms (Helsingin-Sanomat, 2005). Other sites also became central nodes in the rapidly expanding blogosphere news network, noticeably *Worldchanging.com*.[60] The premise or mission statement for *Worldchanging* is

> that the tools, models and ideas for building a better future lie all around us. That plenty of people are working on tools for change, but the fields in which they work remain

[60] http://www.worldchanging.com/

> unconnected. That the motive, means and opportunity for profound positive change are already present. That another world is not just possible, it's here. We only need to put the pieces together. (http://www.worldchanging.com/aboutus/)

To form efficient networks in this context requires connecting them through each site in the network linking, RSS feeding, and hypertexting to numerous other sites it feels sympathetic to. In this way it can be seen how an interconnected system of like-minded individuals can form and emerge into a reflexive community.

As described by the complexity sciences, the parts make the whole in shared resources and engagement with the energy/information flows, yet each part still retains its individuality and diversity. In a complex system wholeness incorporates, and requires, diversity. In a similar way a major blog-attractor will foster its diversity of links to guarantee that flows of information/energy will also be passed on, thus operating as an open system rather than as a closed one. Examples of blog-attractors include *Boing Boing*[61] which functions as a node that directs readers/bloggers to other more specialised sites.[62] Another popular site that coordinates for volunteers and aid for NGOs is *Be The Change* which states its intention as being 'to enable inspired people to contribute in meaningful ways to the Tsunami related efforts'.[63]

What I show emerging here are complex networks that link together, whether through hypertext, RSS feeds, written URL addresses, or posted information,

[61] http://www.boingboing.net/
[62] The Boing Boing post on Tsunami links can be found at: http://www.boingboing.net/2004/12/27/bloggers_in_se_asia_.html
[63] See http://www.bethechange.org/

that share resources and information in order to coordinate, or establish, responsive groups that react in real-time to an actual physical event, in this case a geophysical disaster. Sea-Eat blogger Mehta's response, in an interview with Rheingold, is that 'we have now gathered a tremendous resource on aid, relief, donations and volunteers for the disaster. That works to bridge those who are suffering with those that can help' (Rheingold, 2005c). More importantly perhaps, as Rheingold reflects, is that 'people are beginning to think about how to prepare for the next mobilization, learn from their mistakes and take advantage of the capabilities that the online response to tsunami relief have provided' (Rheingold, 2005c). Howard Rheingold, a long-time commentator on technically-mediated networks, was one of the few aware voices to be heard immediately in the aftermath of the disaster expounding the importance and critical usefulness of bottom-up, distributed participant collaborations. For this reason I have made extended use of his critiques and commentary; as likewise I did with the research on smart-mobs.

Another significant point to be addressed is that despite what some blog-watchers and online researchers have referred to as 'blog triumphalism' (Garfunkel, 2004), there is a recognition that these forms of complex, collective networks are still in their infancy in comparison to what can be achieved in the future if the present trajectory and capabilities are developed further without atrophy (as is common in both complex systems, networks, and the blogosphere in general). The blogosphere response to the tsunami disaster can be criticized, as can all forms of communication to some degree, and the blogosphere more so because it is an incomplete, unfinished technology that is still largely untested to its fuller functioning capacity.

However, by seeing how the mobile ad-hoc networks of both the blogosphere, and the mobile phone networks, formed/swarmed in response to environmental stimuli shows, it is argued here that such forms of distributed communication/information systems have a significant role to play in a global, reflexive society – a society that is both increasingly transnational in terms of information flows, as well as increasingly mobile in both physical and digital movements.

Complexity theory then is a model that allows correspondences and interrelations between the physical and digital domains, as action in one often leads to effect in the other. As this thesis demonstrates, physical and digital interconnectivity is converging into a more comprehensive complex system. Now I turn to a brief examination on how an increasingly interrelated communication-mobile society might take advantage of the capabilities that a complexity response to disaster relief could provide.

Performing Preparations for a Collective Response

A recent report published several months after the Indian Ocean tsunami, from the Center for Catastrophe Preparedness and Response at NYU, asked the question: 'How does the growing body of research on social network structures, and the way new communications pathways are forming on the Internet, inform the design of future emergency communications systems?' (Townsend and Moss, 2005: 39). The authors of the report, Anthony Townsend and Mitchell Moss, recognized the leading role that electronic mobile social networks could play in such a distributed system:

> Some of the greatest success stories from recent disasters have come from the ways in which new technologies have been applied in unanticipated ways to solve timeless challenges of emergency communications….One model for how this might be done can be found in the Internet Society's recent Public Warning Challenge. Seeking to harness the power of the Internet and "smart mob" electronic social networks, this challenge will spur development of distributed, bottom-up early warning systems…For example, the widespread use of mobile text messaging (SMS) and email before, during, and after the 2004 tsunami suggests that there are unexploited opportunities lying within the capabilities of our existing telecommunications systems. (Townsend and Moss, 2005: 37)

The Internet Society's 'Public Warning Challenge' referred to above called for collaborative action in order to make public warning systems a reality. Such action requires a standards-based public warning strategy. The Internet Society state that

> When public warning is necessary, emergency managers need to get timely and appropriate alerts to everyone who needs them, and to only those who need them. Authoritative alert messages should transmit on all available communications media as appropriate, including broadcast or individual targeting. Alerts should be converted automatically and securely into forms suitable for each technology: Internet messages, news feeds, text captions on television, messages on highway signs, voice on radio and telephones, signals for sirens, etc. (The-Internet-Society, 2005)

Whilst this seems to cover the broad spectrum of communication technologies, including the top-down traditional media, Townsend and Moss's report veers towards strengthening the networks of more bottom-up collaborative communication. Its final recommendations are for increased research in the following six policy and technology areas of emergency and disaster communications:

1. Preparing the Private Sector and NGOs for Disaster Communications

2. Improving the Reliability of Public Networks

3. Leveraging New Communication Technologies and Practices

4. Risk Management, Telecommunications and Urban Decentralization

5. Rethinking Public Warning Systems

6. Modernizing the Amateur Radio Service

(Townsend and Moss, 2005: 33)

As suggested, leveraging 'new communication technologies and practices' recognises the nature of spontaneous self-organised networks that used mobile phones, SMS, and blogs in the wake of the Indian Ocean tsunami as a low-cost, adaptable, and resilient infrastructure to provide human emergency response. Rheingold also notes how the authors of the above report are asking specific questions about the role of fluid, mobile networks of communication, such as:

> How are ad hoc communications structures developed in disasters? What can they teach us about improving design for official systems? How does the growing body of research on social network structures, and the way new communications pathways are forming on the Internet, inform the design of future emergency communications systems? How do new communications technologies perform in comparison to older, more established ones during disasters? What can be done to improve their resiliency? (Rheingold, 2005d)

As would be expected within the blogosphere and mobile communities this question is now under serious debate and many see such complex, self-organising networks, and systems of distributed response, as being a major function of how new mobile communications networks are proving more adaptable to shifting global geophysical events.

Security analyst W. David Stephenson, who maintains an influential blog titled *Stephenson Strategies*[64] has subsequently devised a '10-point "smart mobs for homeland security" strategy' which includes such recommendations as: 'Work with existing groups, but also facilitate ad-hoc ones'; 'Capitalize on new location-based communications'; and 'Make it interactive' (Stephenson, 2004). Here can be seen signs that strategists are beginning to realise, and capitalise upon, the benefits of complex, nonlinear communication flows for active response. The focus appears to be upon how information can be best gathered and disseminated, and whether the new communication technologies, which use mobile connectivity, and linked networks of associations and feeds, have an advantage over pre-existing forms of communication.

In the latter part of the twentieth-century human technology saw a dramatic rise in mapping tools: from satellite monitoring of public spaces, to sea-bed scanning, to remote sensors being placed in many geophysical regions, and now the rapid development of digital mapping. With this technical toolkit the ability to forecast potential environmental disruptions has increased in

[64] See http://www.stephensonstrategies.com/

accuracy. However, such widespread monitoring is incomplete without an efficient information-dissemination program. As mentioned, there is a tsunami-warning system already established in the Pacific, and now there are developments currently underway to set-up a similar system for the Indian Ocean. However, the fact still remains that a tsunami warning system that relies upon centralised infrastructures will be less effective than one distributed by a mobilised population. Where complex processes of informational networks have their strength is in nonlinear distribution of such information in a pattern that, as has been shown, can become exponential when participants become active in the web of transmission.

There are now suggestions being raised concerning the use of SMS as a medium for sending disaster alerts (Agence-France-Presse, 2005; Boyd, 2005; Cascio, 2004; Charny, 2005; Tae-gyu, 2005). At the present time one of the disadvantages of this system is still that it would require a centralised authority to initiate the alert. Yet once out, such a message would be spread through mobile networks in a nonlinear and exponential fashion; each recipient passes it on to their list of contacts: assuming, of course, that such action would only concern those in affected regions and phone carriers could ensure greater bandwidth for disaster zones to cope with increased traffic. Active blog commentator and principal voice at *Worldchanging*, Jamais Cascio, has been discussing this subject for some time:

> Imagine a site which collects storm/earthquake/tsunami/disease outbreak/etc. alerts and announcements, making information available by region. You can then register your SMS number or email address with the site, and give it your current location -- changeable as you

> travel, of course -- so the site can send you updates and alerts. RSS might also work, although one would want the RSS reader to check for updates far more frequently than is typical; a half-hour delay receiving a tsunami alert (for example) could prove fatal. The system could flag those events of particular import, and even provide short safety notices for responding to the particular danger (e.g., "seek higher ground" or "avoid contact with birds"). Imagine how many people could have survived this week's tsunami if a small number had received warnings on their mobile phones and told those around them. (Cascio, 2004)

One such move to enable greater flows of information is the recent ‘Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations’ that came into force on 8th January 2005, following ratification by 30 countries (Cellular-News, 2005).

Before this time the trans-border use of telecommunication equipment by humanitarian organizations ‘was often impeded by regulatory barriers that make it extremely difficult to import and rapidly deploy telecommunications equipment for emergencies’ (Cellular-News, 2005). The seventeen-article, legally binding international treaty which was, according to reports, first unanimously adopted on 18th June 1998 by the delegates of the 75 countries that attended the Intergovernmental Conference on Emergency Telecommunications (ICET-98), hosted by Finland in Tampere, had since been requiring 30 ratifications in order for the Treaty to come into effect. The tsunami, it seemed, had proven to be a wake-up call for the final ratifications to occur. The Tampere Convention

> covers both the installation and operation of reliable, flexible telecommunication services. Regulatory barriers that impede

> the use of telecommunication resources for disasters are waived. These barriers include the licensing requirements to use allocated frequencies, restrictions on the import of telecommunication equipment as well as limitations on the movement of humanitarian teams. (Cellular-News, 2005)

From a top-down hierarchical perspective there are shifts occurring to allow the lifting of impediments on the flow of trans-national communication.

This thesis has looked at complex phenomena in terms of bottom-up and nonlinear mobilisations of information flows, through the role of distributed, and complex, networks of mobile communications. Also to be noted is the shift, in both practice and discourse, from top-down hierarchical architecture, as in the way mainstream media and relief operations have traditionally worked. This thesis has also shown the operations of distributed networks and how efficiency is maintained through collaborative relations. Historically, social organisation was considered to be most efficient through a strict top-down hierarchical structure (Pattee, 1973) whereas discourse is now recognising the power, influence, and efficiency of distributed networks (Deibert, 2003).

Cascio, of *Worldchanging*, has written on the potential of distributed communication networks and interrelations of information flows for disaster alert in relation to the *Common Alerting Protocol* (or CAP). CAP is ‘an open, standardized alert information format usable to collect and disseminate warnings and reports of hazards and disasters, natural or otherwise; it's XMLbased, so it's usable on a wide assortment of devices and media' (Cascio, 2005).[65] According to its specifications CAP

> addresses the concerns about compatibility and operational complexity that have been stifling development…the sender can activate multiple warning systems with a single input…A single input message also provides consistency in the information delivered over multiple systems. People receive exact corroboration of the warning through multiple channels. This is very important, as research has found that people do not typically act on the first warning signal but begin looking for confirmation. Only when convinced that the warning is not a false alarm, do they act on it. (Cascio, 2005)

CAP is thus designed to be compatible with multiple public and private information/data networks, and so is essentially a 'content standard' in that it can be applied to all variations of alerts and information distribution. Yet CAP is still in its early stages of global recognition as diverse state and commercial bodies engage in their own research to provide telecommunication coverage and regional mapping. Security analyst W. David Stephenson advocates a communication application known as *Roaming Messenger* that can be integrated into the CAP standards and be used as the delivery system for such networked alert messages.

Stephenson believes that it solves the most pressing problems for distributed emergency communications. According to Stephenson, *Roaming Messenger* should play a critical role 'in overcoming interoperability problems. More important, by linking individuals via location-based, real-time information, it

[65] The April, 2005, draft of the v.1.1 protocol is available online (PDF) at: http://www.oasis-open.org/committees/download.php/12649/CAPv1-1.pdf

provides exactly the kind of flexible, ad hoc teambuilding required in chaotic natural disasters or terror attacks' (Stephenson, 2005). Also, the *Roaming Messenger* can locate persons even when they are not logged on at the time. Amongst other things it

> Delivers information in a variety of formats, e.g., text, voice, photos, diagrams, GPS data, etc.; Lets user interact with key information and initiate action from mobile device; Retrieves GPS data from users and can execute commands based on their location; Captures data and interactive responses from users in the field as well as remote systems (Stephenson, 2005).

In this way, a central standard, such as CAP, could provide the channels through which such an application as *Roaming Messenger* would then provide the means to contact individuals through various devices, or at least to locate them if their device is inoperable, or switched off, so long as they have been registered.

Such developments and reflexivity, especially after catastrophic events, offer profound insights into an increasingly mobilised society that is gaining improved access to information, whether through traditional or decentralised mediums. And with the increased mobility in tourism, and globe-trotting, such geophysical vulnerable regions that were once seldom visited other than by local or near-local peoples, are seeing greater numbers of foreign visitors that not only add to the population, and thus the numbers of potential casualties in a disaster, but also leads to greater foreign state involvement in disaster recovery and responsibility. The question of how to reach such people in a crisis, and how to receive information back from such individuals, becomes ever more a significant issue.

What my research highlights is not any finished model on how ad-hoc 'smart-mobs' can resolve this issue, but how, in the wake of the 2004 Indian Ocean tsunami, people did their best to deal with the situation in a self-organised, bottom-up fashion, using what they had and what they knew. This involved the use of mobile phones, SMS text messaging, and the Internet with its blogosphere, to act as a nonlinear network of information retrieval, storage, and dissemination, in order to coordinate, as best as possible, a chaotic situation. In this sense, such communicative relations of interconnectivity attempted to bring order into a very complex and chaotic environmental situation. The systems of communication and coordination that subsequently emerged were beneficial in not only initially spreading the news faster than the traditional news networks, but were more efficient in locating survivors and highlighting those areas most in need of specific aid. Complexity theory is an insightful and valid model in which to view and analyse these emerging trends.

To conclude, the complexity sciences offer a perspective that allows for the presence of dynamic change. Complexity theory caters for, and explains, disturbances, perturbations, and bifurcations in a system; how small disturbances/impacts can lead to greater instabilities, and how a system re-arranges itself to accommodate these changes. Complexity theory as a sociological tool provides a way of understanding constant adaptation. In an age where disturbances and fracturings are likely to occur increasingly within global socio-economic systems, whether through natural catastrophes such as the Indian Ocean tsunami or deliberate 'terrorist' interventions, the capacity to adapt within systems is crucial. Also, the complexity theory model allows a perspective on the effects of crowd behaviour (Crumlish, 2004; Surowiecki, 2004). This thesis suggests that positive contributions are to be found in collectives that are distributed, diverse, heterogeneous, yet connected enough to share affiliations to similar information flows. Again, such observations are compatible with what has been discussed here through complex mobilities of information and resource-sharing. This thesis offers findings that differ from the claim that active civil engagement is in decline in the US (Putnam, 1995).

This claim of civil collaboration amplified through complex systemic mobilities is further addressed in the next chapter which examines technologies of cooperation, ad-hoc citizen journalism, amateur and decentralised media, and the facilitation of shared knowledge. I argue that these are emerging shifts in the way an increasing number of individuals are investing in information-access, increased mobility, knowledge-sharing, and immersion in multiple networks of participation, contribution, and content-creation. These shifts are not resulting in a decline in social capital, as Putnam states, but are instead facilitating increased social engagement, especially in the domain of global civil society. I turn now to examine how complexity theory can 'perform' in various social strategies.

CHAPTER SEVEN

Performing Complexity 3: Civil Strategies

> 'When we communicate and reflect among ourselves as citizens—publicly learning about and affirming our shared sentiments as an extended community—then we "know that we know." In our dangerous and difficult time of global transition, it is not sufficient for civilizations to be wise; we must become "doubly wise" through social communication that clearly reveals our collective knowing to ourselves. Once there is a capacity for sustained and authentic social reflection, we will then have the means to achieve a shared understanding and a working consensus regarding appropriate actions for a positive future. Actions can then come quickly and voluntarily. We can mobilize ourselves purposefully, and each person can contribute his or her unique talents to building a life-affirming future'

Duane Elgin – 'The Promise Ahead'

> 'A society's fitness is determined by its social cognitive map'

Robert Artigiani

In previous chapters I discussed how complex interrelations that are distributed, diverse, heterogeneous, and yet connected, can be effective in performing bottom-up self-organised response. I also stated that such interconnections need to function through civil participation. This is supported by behaviour emerging from an increasingly content-led development of the Internet which involves knowledge webs and knowledge sharing through such digital social networks and collaborative tools as *Wikipedia*. This has been initially hailed as the Web 2.0, although this term is still controversial. The research presented in this thesis points to a noticeable growth in the spread of what has been termed 'mass amateurisation': such as blogging, podcasting, and text activism, which all move towards increased decentralisation by contrast to more corporate mainstream forms.

This chapter further examines how complexity theory performs, and is the third study in the 'performing of complexity'. Cilliers has correctly recognised that complexity, as well as containing its own contradictions, also 'acknowledges that some form of performative tension is inevitable…and this requires a certain "performative reflexivity"' (Cilliers, 2005: 261). By this Cilliers means that complex systems respond to their own manifestations (performance), which can lead to tension as complex systems are vulnerable to their own unstable dynamics. Cilliers also notes that a complex world cannot be understood clearly, and to profess otherwise would be a major contradiction. Complexity theory, as a tool to model social relations and processes is favourable precisely for these reasons: a complexity approach emphasises inherent instabilities, dynamic nonlinear pathways, reflexive feedback mechanisms, and contradictions albeit not complete randomness. Complexity theory is a way of re-configuring sociological positions such that change is not viewed as a linear outcome from individual actions but rather as individual actions contributing to change through overall emergent effects which are both beyond the individual yet at the same time dependent upon processes and relationships maintained between individuals in complex dynamic networks. These interrelations between individuals may be maintained deliberately, as I discuss in this chapter, yet this does not fix an outcome. In complex systems any deliberate strategy, whether one of cooperation or contestation, cannot guarantee a future path lock-in.

In this chapter I discuss technologies and strategies of cooperation as deliberate social actions from individuals, whilst many of the cooperative effects are emergent properties that could not have been foreseen by any one individual or actor. Also, I address how the new interrelations of complex flows of connectivity and information are contributing to a more bottom-up, and distributed forms of civil participation. In this context, aspects of global civil society are analysed through the lens of complex systems. I argue that complexity theory offers an understanding of increased strategies of civil participation and cooperation in the global social sphere that incorporates and allows for dynamic adaptability and change. Drawing on previous research into blogging and mobile phone ad-hoc networking, I argue that these practices are the forerunner to a more significant global civil society that is increasingly showing signs of distributed activity. Importantly, I suggest that complexity theory is a useful lens in which to view, analyse, and comment upon these social practices. In this context I discuss 'technologies of cooperation' whereby an increasing number of people who are investing in information-access, increased mobility, and knowledge-sharing contribute to multiple networks of co-participation and cooperation.

I begin by addressing the new scapes of mobility and social connectivity largely driven by user-created applications. First to be discussed are some of the elements that are fostering a potential social restructuring; namely, the rise of what can be called 'amplified shared knowledge' through shifting patterns in technological applications and user participation. Secondly, I discuss how global civil society can be analysed and interpreted within a model of complexity theory and complex systems. Thirdly, several developing projects - 'social tapestries' of interconnectivity and mapping – will be focused on as cases in point that demonstrate increasing technically-mediated forms of civil participation, again examined through the lens of complexity theory. Fourthly, this chapter examines how communication-mediated forms of civil participation in China are being hampered, sabotaged, and banned by the hierarchical top-down state structure of the Chinese authorities, and how this contrasts with the more open-access models presented in this thesis. Finally, the chapter addresses the implications of this research in terms of complexity and future possible directions.

An Open Manifesto: where users add value

The Internet has shifted through various phases since the early appearances of web browsers in the 1990s and its initial commercial popularism. It has also fundamentally altered the way people can, and do, interrelate, communicate, think, link, and act. As the Internet increasingly becomes a space where people are becoming the creators, co-designers, and feedback mechanisms, of many-to-many software applications, a new form of complex interconnectivity is forming. Some note this to be the Web 2.0, although there is still much debate about just what the term Web 2.0 means with some critics viewing it as a meaningless marketing buzzword, and others accepting it as the next step in online innovation (O'Reilly, 2005). Tim O'Reilly, founder and CEO of O'Reilly Media, Inc., views one of the key lessons of the Web 2.0 era as being 'Users add value' (O'Reilly, 2005). In this sense links within interconnections are being ascribed meaning; and information is being seen as needing to be meaningful in order to sustain the connectivity. Links and processes that fail to maintain meanings are disconnected, discontinued, and decay. This is not dissimilar to the way in which neuronal pathways in the human brain are developed through habitual use and function, and which atrophy when consistently unused. In this sense, complex interconnectivity, as dynamic processes, require meaningful connections, and this mirrors the shift occurring in how people are increasingly interacting, and developing, with technologies of communication. The World Wide Web is displaying a shift from professional webpages to amateur blogsites; from photo-hosting software to open-source web image hosting (such as 'Flickr'); from the Britannica Online to Wikipedia; from web directories to tagging; from email lists to syndication.

O'Reilly sees this shift as practices and principles forming around the following 7 key areas: i) The web as platform; ii) Harnessing collective intelligence; iii) Data is the next intel inside; iv) End of the software release cycle; v) Lightweight programming models; vi) Software above the level of a single device; and vii) Rich user experiences (O'Reilly, 2005). However, it needs to be noted that these principles offer a pro-computer user bias as O'Reilly, having a corporate interest in content-led user development, sees such applications to be the way forward for the World Wide Web. Although O'Reilly's focus is deliberately corporate I still consider his insights to be appropriate for framing particular technically-mediated networks. In order to strengthen my argument of a complexity theory approach to web-related user activity it is important to take O'Reilly's core principles and to examine them from an understanding of complexity science.

The first point, the web as platform, moves towards open-source software which develops in accordance with user feedback: thus it acts as a platform for innovation rather than as set stage. This type of development can be seen in terms of positive feedback, which is a key characteristic of complex systems.

The second point – harnessing collective intelligence - is highlighted by O'Reilly as a core principle, and notes that 'hyperlinking is the foundation of the web…with associations becoming stronger through repetition or intensity, the web of connections grows organically as an output of the collective activity of all web users' (O'Reilly, 2005). This covers areas such as the success of Amazon, eBay, and Google – as attractor nodes – with applications such as *Wiki, Flickr, and folksonomy,*[66] adding to the network of associations bolstered now through the blogosphere and syndication (RSS). Such linking capacity facilitates involvement and interactivity for the user, and shifts passive reader into active navigator. Also, hyperlinks make it possible for almost anyone to annotate, amend, and improve any map embedded in the Web. With what has been said previously, this connects with network topology, and hyperlinking as complex systemic interrelations.

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[66] **Folksonomy –** 'a portmanteau word combining "folk" and "taxonomy," refers to the collaborative but unsophisticated way in which information is being categorised on the web. Instead of using a centralised form of classification, users are encouraged to assign freely chosen keywords (called tags) to pieces of information or data, a process known as tagging'. (http://en.wikipedia.org/wiki/Folksonomy)

The third point – 'Data as the next intel inside' – sees database management as a core feature of online processes. This refers to the need, and capacity, to store and utilise information, such as location, identity, identifiers (tags), text, video, photos, etc. Applications that currently provide these ordering principles are such as *delicious*, *Flickr*, *MapQuest*, and *Google Earth*. This information management relates to what has been said about the storage and utilisation of information as a prime feature of complex systems; i.e. the negentropic behaviour of creating order out of chaos.

Fourthly - the end of the software release cycle - sees new Internet software as being delivered as a service rather than as a finalised product, thus seeming dynamic. Complex systems, whether complex adaptive systems (*cas*), or autopoiesis, are able to function dynamically, and be regularly updated, in accordance with external circumstances. Complex systems undergo constant adaptations from positive feedback, and are never a 'final product'.

The fifth principle, according to O'Reilly, is lightweight programming models. This indicates easily modified customised content, through such models as syndication. This capacity to intervene, to remix and innovate, is not dissimilar to how nodes within complex systems are adaptable to environmental conditions and stimuli, and as such they appear to remodel behaviour according to system needs.

Feature six - software above the level of a single device – envisions more and more devices being connected to the distributed communications of the Web platform. This feature recognises the shift that is facilitating multiple-way flows where devices, such as our phones and cars, are not only consuming data but reporting it back. This type of feedback behaviour can be related to such phenomena as flash mobs, smart mobs, citizen journalism, and real time traffic monitoring, although this was most likely not part of O'Reilly's agenda. As described elsewhere during this research, such 'smart mob' displays can be modelled very effectively through the lens of the complexity sciences.

Finally, the seventh principle - rich user experiences – concerns the enhancement of the experience of the user/participant through combined interactions facilitated through such integrated communications as the World Wide Web with the mobile phone, text and Instant Messenger (IM), combined with Voice over Internet Protocol (VoIP). Kevin Kelly, author of *New Rules for the New Economy : 10 radical strategies for a connected world*, has stated that 'this impulse for participation has upended the economy and is steadily turning the sphere of social networking - smart mobs, hive minds, and collaborative action - into the main event' (Kelly, 2005). As demonstrated by this brief mapping of complexity theory onto Web 2.0 developments, there is a clear and identifiable relationship between features, characteristics, and behaviour. This is significant for it points the way towards the suitability of complexity to map emerging social practices of user-led civil engagements and participation.

The shift towards digital social networks, and amplified knowledge sharing, is a move in the direction of an open innovation commons (Rheingold, 2005a). Like the tragedy of the commons where resources become depleted through misuse, exploitation and abuse, this is also the case for systems of technologically-mediated communication. Research into early forms of biological complex systems (Capra, 1996; Margulis, 1993; 2001; Sahtouris, 1999) shows that competition between the parts of a system eventually turned into cooperation and resource sharing: a form of symbiosis in some circumstances. A similar model can be seen for information-sharing systems. As I will clarify, cooperation is a major contribution to complex systems, and its contestations with competition form part of the dynamic far from equilibrium nature of the system that pushes it towards increased complexity. It is also a factor in how complex collectives remain dynamic: constant adaptation towards collaborative action within a fitness landscape of unpredictability and possible bifurcations. Further, such practices of cooperation versus competition lay the playing field of a global civil society which struggles for presence and greater participation in the social domain.

The Internet is also a space for the ongoing wrangle between the corporate and civil sectors, especially in the area of access-facilitating communication technologies. Just as corporate interests are attempting to control access to the Internet, and to charge for bandwidth use, grassroots users are increasing their networks of home DIY inexpensive, high speed wi-fi connections. And just as freelance Internet programmers are developing social bookmarking sites such as *delicious* and *Flickr*, as previously mentioned, they are being bought out by corporate giants trying to get a foot in the next dot.com boom. Both *delicious* and *Flickr* were bought by Yahoo, and MySpace was recently bought by Rupert Murdoch's News Corp for $580 million[67] with the intention of influencing Internet traffic towards its own mainstream sites.

Whilst there may be an increasing number of interconnections and interrelations between and within such systems, this shows that contestations between systems are much in evidence. And while cooperative strategies within complex systems are a major player, they are never allowed a free space. This is where technologically-mediated forms of communication are gaining an increased presence, and more so within the global civil society movements (Castells, Fernandez-Ardevol, Linchuan Qiu and Sey, 2006; Chesters, 2004; Glasius, Kaldor and Anheier, 2006). Whilst acknowledging that many of these developments are being led by a minority of tech-enabled programmers and users, their take-up rate is increasing. Yet what is significant here is not so much the early numbers of users/adopters but rather what such applications signify for social practices so as to leapfrog from these initial trials and gestations. I turn now to re-examine global civil society in terms of complex participant relations.

Social Tapestries: weaving civil participation

A global civil society can be many things. Increasingly though it is being recognised less as the older concept of a well-governed, ordered way of civil life (Keane, 2003) and more of a 'sphere of ideas, values, institutions, organizations, networks, and individuals located between the family, the state,

[67] Details can be found at: http://www.thenewstribune.com/news/nationworld/story/5952997p-5240913c.html

and the market and operating *beyond* the confines of national societies, polities, and economies' (Taylor, 2002: 341). I have dealt with definitions and characteristics of the global civil society earlier in the thesis, so here I focus on those aspects that relate and correspond with complex systemic relations. The sudden rise in global NGOs, from around 6000 in 1990 to 25, 540 in 2002 (Taylor, 2002) incorporates a vast interconnected web that comprises of 'INGOs, voluntary groups, businesses, civic initiatives, social movements, protest organisations, whole nations, ethnic and linguistic clusters, pyramids and networks' (Keane, 2003: 18). In this way it is seen that the global civil domain is a constellation of institutions, associations, and actors/agencies, which are interrelated through webs of communication, interdependence, and cooperation. They connect through flows of information and action, both physical and digital. The International Campaign to Ban Landmines, for example, linked 1,000 NGOs in around 60 countries without ever using either a bank account or a street address (Taylor, 2002). The term 'swarms', earlier used to designate the characteristic of ad-hoc protest organization – the so-called 'smart mobs' – is now being used to refer to NGOs: 'The label NGO "swarm" has been used to refer to new horizontal forms of organization that are decentralized, fluid, and multidriven clusters of NGOs, linked and mobilized through the Internet, that swarm in on a target with dramatic effect' (Taylor, 2002:345). Taylor, in his article 'Interpreting Global Civil Society' (2002), sees the increasing interconnectedness and synergy of the global civil society as being in a constant state of becoming.

In a similar manner Keane (2003) considers global civil society to stand, somewhat precariously, between the boundaries of order and disorder at the edge of chaos. It is perhaps no coincidence that the terminology of the complexity sciences is trickling into descriptions of the global civil sphere. As this research has shown, user-driven forms of mobile communication technology are significantly influencing, and aiding and facilitating, social capacity for collective action. Such emerging networks of technologically-mediated communications are enabling dispersed and distributed users to engage and participate in complex social webs of presence and action, as previously described.

One of the forms that this complex sociality is taking is that of civil participation: what can be called a social tapestry of justice. Beth Simone Noveck sees technology as creating the conditions and boundaries for collective action. And the technology she comments upon is that which facilitates collaborative group action:

> The Internet is the locus for social action and activism. But it facilitates not only exclusively online interaction. These new tools can enable groups to wield “real” power, namely the power to take action, make decisions, solve problems. The underlying technological preconditions to collective action and activism are changing. As a result, groups and webs of groups can become more effective legal actors than they have in the past. (Noveck, 2005)

Noveck sees the emerging phenomenon of complex social grouping as promoting collective action in economic, civic and cultural arenas: in her words, the practice of democracy with a small ‘d’. An example of this would be citizen juries. Whilst this issue is still perhaps not a general feasible option, it does hold promise and potential. Noveck asks us to imagine individuals earning bonus points for civic participation; a participation that can take place from the courthouse but also from home via the Internet or 'in interstitial spaces, such as bus stops or subways platforms, using networked kiosks to join and visualize the jury, connect with other members, view information about an ongoing proposal and provide feedback: the so–called "deliberative bus stop"' (Noveck, 2005). In a similar manner to Noveck's call for greater civil participation, James F. Moore posted an essay on the Internet, via his webpage, on March 31st 2003 entitled 'The Second Superpower Rears Its Beautiful Head'.[68] The term 'the second superpower' has often been used in conjunction with global civil society (GCS) and the alternative globalisation movement (AGM); however, the term is now more narrowly used, especially within the blogosphere, to refer to collective, and connected, individuals working towards an emergent democracy that can influence both the mainstream media and government policy. The main ideas expressed in Moore's paper encourage blogging and other communication-mediated technologies to link together a global community that can influence 'first superpower institutions' such as international corporate bodies and international law. Moore's paper also encourages participants to foster ties of a personal reflective nature in order to maintain bottom-up communality. As previously discussed, the paper received around 50, 000 downloads in the first five days, and has remained an active discussion issue since. This links in with the growth, mostly after Moore's paper, of another form of civil participation: that of citizen journalism, in the form of individual and group weblogs, as was discussed in Chapter Five.

[68] http://cyber.law.harvard.edu/people/jmoore/secondsuperpower.html

Former mainstream and now active citizen journalist and blogger Dan Gillmor commented that this 'is a golden opportunity for citizen activists to get involved, to help inform others who do care about specific topics. Maybe the masses don't care about all the issues, but individuals care about some of them' (Gillmor, 2004: 103). Likewise, Gillmor recognized the value of decentralizing people and data at a time when information flows are beginning to circulate in more complex pathways than can be tapped by central operations alone. In this Gillmor stated that 'we need to find ways to bring the nation's collective energy and brain power to bear on the threat... tapping the power of every one is the best approach' (Gillmor, 2004: 107). Without wishing to restate some of what was written earlier about citizen journalism, at this juncture it is important to recognise the growing convergence between the professional and amateur realms of reportage, as was mapped out by the recent Demos report 'The Pro-Am Revolution: How enthusiasts are changing our economy and society' (Leadbeater and Miller, 2005).

The signs of a growing civil society are visible through the technologies used to receive, organise, and utilise the information flows. As mentioned these include folksonomy (tagging), Wikis (such as the popular encyclopaedia Wikipedia), blogging, podcasting (a form of audio-post blogging), and now vlogging (video blogging). As the name suggests *folksonomy* is for 'the people', and is a form of tagging individual information posts (whether it be textual, visual, or audio) in a way that allows other users to search for items by related taglines. It is a collective way of organising massive amounts of information. A popular site that utilises this system is *del.icio.us* (http://del.icio.us/) whereby users can publish their bookmarked sites on the World Wide Web to share with other online users. According to the site's own description,

> del.icio.us is a social bookmarks manager. It allows you to easily add sites you like to your personal collection of links, to categorize those sites with keywords, and to share your collection not only between your own browsers and machines, but also with others (http://del.icio.us/).

Each posted site is then given tagged words with which to define the entry. In this way people can have access to, and share, a multitude of websites that other people have deemed useful, and have organised according to key words. And the same has been done with people posting pictures and images onto the Web, via such sites as the popular photo-hosting site *Flickr* (http://www.flickr.com). Such bookmarking sites are collaborative tools designed to augment human intelligence by allowing, and making visible, storage of data designated to be meaningful, i.e. transparent to other users in order to share links and information. Such linkages are also expressed by the social website *Panarchy.com* which claims to promote the discussion of Panarchy: 'complexity and networked governance in the information age, including economics, sociology, culture, political science, commons, etc.' (http://panarchy.com/).

The term 'panarchy' plays on the forms of *pan*, meaning *all* (global), and *anarchy*, meaning either chaotic patterns of relationships or the absence of dominant top-down hierarchies. There is also another meaning inherent here, as PAN is also an acronym for *Personal Area Network*. A personal area network is 'the interconnection of information technology devices within the range of an individual person, usually by wireless. PAN's make possible a truly decentralized and global citizenry' (http://panarchy.com/). This highlights one of the issues of this chapter: the ability to form and create personal area networks that interconnect and facilitate locatedness in mobile local environments. This can also inform practices of cooperation on the move.

Although many online innovations and applications are bought out by corporate interests eager to gain a foothold in the burgeoning digital domain, this should not be taken to infer that those applications immediately lose their relevance and capacity. The continual hustle and jostling between uses and users is part and parcel of the interplay that feeds and informs social practices. There is, as complexity continues to reveal, the element of unpredictability in most systems and networks of interrelations.

Today collaborative tools are constantly being created that facilitate a move to a more mobile civil participation and mapping of presence and action. In order for complex systems of information-sharing individuals to become effective and efficient, they need to have more precise knowledge about their presence and participation within the whole. In this way individuals within complex networks of information-sharing are not solely nodes, acting as information hubs, but are shifting towards becoming embedded, or enmeshed, agents. One example of creative innovation in this area has been developed by social research centre Proboscis, which has an emphasis upon what it calls public authoring. For them this term implies using communication technologies to author and share information rather than solely to consume. In this context Proboscis researched software 'for annotating geographic places with content (text, images, sounds) and making relationships between places' (Lane, 2004). They named this software *Urban Tapestries* (http://urbantapestries.net/); the prototypes developed allowed mobile users (PDAs; phones) to map and share local knowledge 'in situ' – whilst on the move. The intention behind this software is to provide better understanding of the relationships between people, places, and things. It also provides data on urban social interactions and communications. The latest project coming from the Proboscis research team is a 2-year research programme in collaboration with the London School of Economics Media and Communications Dept., titled *Social Tapestries*.[69] The project aims to positively exploit the social benefits of local knowledge sharing that has been opened up through new mobile technologies of communication:

> How do we map and make sense of the social tapestries which make up the warp and weft of our daily lives, interweaving with others belonging to the people we share our environment with?...The Social Tapestries experiments aim to explore how users might engage with mobile location-specific content in the context of 'civil society''. (Lane, 2004)

Social relations have been impacted upon by mobile and wireless technologies, as well as by online networks, in the way that information is dealt with. It is becoming increasingly participatory, with smart-mobbing, the blogosphere, and now social tapestries of local mapping. Using network technologies to 'gather, create, and share knowledge at grassroots – no matter

[69] Proboscis is also in partnership with Ordinance Survey, Creative Partnerships Hull and Kingswood School, and The Public, for this project.

how informal – offers the possibility of profound changes to the way in which we engage with our environment and the people who inhabit it' (Lane, 2004).

If content is becoming the prime resource, as Web 2.0 discourse advocates, then local geographical knowledge is perhaps best served by distributed individuals who have, and are, experiencing it rather than through centralised means. This shows that individuals are deliberately contributing to cooperation through mobile information flows, as in the Indian Ocean Tsunami case study. Further, that these social actions are being enacted through local geographical spaces. Resource sharing, in a complex system of any size, is a feature that is required in order to stave off the tragedy of the commons.[70]

Another striking example of how individuals are contributing to creating dynamic physical-digital social networks is through what is being termed *citizen cartography*. Here, the deliberate strategy is to create an online map of a specific local area, using mobile phone and GPS technology, so that the resultant map can be posted online at an open-source destination[71] and thus be available for creative and dynamic additions, uploads, and sharing. Most Internet maps are protected by strict copyright laws that forbid creative utilisations by users. Citizen cartography is a means whereby users 'on the ground' reclaim the digital representations of their local geographical spaces for network-sharing and for negotiating complex relationships of social behaviour and 'meetingness'. One such recent project was that of 'Mapchester'

[70] This phrase – 'tragedy of the commons' - is used to refer to a set of events/circumstances that involves a conflict for resources between individual interests and the common good.
[71] In this case the open-source destination was OpenStreetMap at http://www.openstreetmap.org/

when on Saturday 13th and Sunday 14th May, 2006 over 40 individuals used a GPS receiver to log local streets in Manchester, most of them on foot. The organisers see this event as a collaborative, community exercise:

> Mapchester is an experiment in 'citizen cartography' that we hope will make a significant contribution to wider efforts in so-called 'open-source' mapping. This is an emerging and rapidly growing cartographic activity, driven in part by technology (cheap GPS equipment and online collaboration tools, like OpenStreetMap.org), but also by a very different ethos to knowledge production. Under open-source models the rights of authorship are de-centred and the ownership of knowledge is seen as a common resource that can be distributed and re-used without restriction or license. As such 'opening' up mapmaking has real potential to empower people to create their own knowledge and encourages re-use of cartographic resources in novel, creative ways. (http://10.futuresonic.com/mapchester.html)

As the above examples of the *Urban Tapestries* and *Mapchester* projects show, these are explorations into using mobile location-specific content in order to facilitate people, organisations, and other actors, within the global civil society. Keane considers that

> we are being drawn into the first genuinely bottom-up transnational order, a global civil society, in which millions of people come to realise, in effect, that they are incarnations of World-Wide Webs of interdependence, whose complexity is so riddled with opportunity, as well as danger (Keane, 2003: 17).

Again, this links complex interdependencies with risks and contestations. Keane suggests that global civil society is the most complex society in the history of the human species, and as such requires new metaphors in which to 'picture and understand': 'it is better to liken this society to the tens and hundreds of thousands of "nested systems within nested systems" described in certain versions of complexity theory. Certainly, this global society is both integrated and de-centred' (Keane, 2003: 19). The striking connections and correspondences between complexity theory and global civil society have also been developed by other theorists (Castells, Fernandez-Ardevol, Linchuan Qiu and Sey, 2006; Chesters, 2004; Chesters and Welsh, 2005; Munck, 2002). Munck writes that:

> A complexity approach to GCS would stress the way in which multiple and contingent causation mechanisms are combined. Complexity explanations are meant to be foundationalist but never reductionist…They recognise that general meta-narratives have generally failed to capture the complexity of social (as other) processes. Complexity theory rejects teleological explanations and accepts that processes could always turn out otherwise. So we need to go beyond theories of GCS based on simple unilinear projections…to embrace contingency and complexity in terms of causation and future projects. (2002: 356)

The self-organised networks of communication, through mobile phones/texting, blogging, or mobile location-specific software, are informing a global civil society that, as Taylor says, being in a constant state of 'becoming', it shows increased correspondences with the features of complexity theory. It is these very interconnections, both near and at a distance, that are informing the new complexities: the re-configuring of patterns of connectivity, communication, and collaboration that are the central focus of the research in this thesis.

The very antagonisms that inform global civil society, the network processes between state and non-state actors, whether individuals or corporate bodies, in regional, national, global clusters, are similar to the dynamic instabilities inherent in complex systems as they vie for a niche in the fitness landscape, as they contest within and between systems, on the threshold of chaos and order, in dynamic far-from-equilibrium states. This again highlights the clash of opposing systems, between one that is top-down hierarchical and the other bottom-up and distributed. Although there are multiple links and processes between state and non-state actors, rather than there being a clear divide, in large part it still manifests a conflict that outlines disparities between hierarchical and complex, networked strategies. In this understanding, global civil society is ‘connected into global affinity structures maintained by computer mediated communications and reconfigured during intense periods of social interaction around specific protest events or reflexive gatherings' (Chesters, 2004: 330). Chesters and Welsh go further than Keane and Munck on the correspondences between complexity theory and global civil society, and see this relation as being more than metaphoric:

> complexity theory offers not only a metaphoric resource vital to theory building, but also a means of engaging with the dynamics of a global movement typified by increasing internal complexity derived from its multi-linear social evolution. (Chesters and Welsh, 2005: 190)

Chesters and Welsh write that ‘within both the natural and social sciences, metaphor becomes a crucial resource in forging new theory, a process that explains the attraction of complexity theory’ (Chesters and Welsh, 2005: 192). The metaphors of complexity are useful in analyzing social practices yet, like Chesters and Welsh, I take complexity to be more than a metaphoric resource;

it can be a way of understanding the increasingly technologically-mediated social practices that exist in flows, processes, networks, systems - in dynamic, uncertain, states that are far from equilibrium. Such dynamic communication-mediated mobile movements, that emerge sporadically and then are gone, and which contest with existing systems/movements, are also recognized by Melucci when he says that in complex societies social movements develop only in limited areas and for limited periods of time: 'when movements mobilize they reveal the other, complementary face of the submerged networks. The hidden networks become visible whenever collective actors confront or come into conflict with a public policy' (Melucci, 1989: 70). Such movements are enmeshed in communication flows and contested meanings, feedback upon themselves, and manifest a self-reflexive capacity as demonstrated in complex systems. Melucci also recognizes this when he writes that

> What is new about contemporary movements is first of all that information resources are at the centre of collective conflicts. Conflicts shift to the codes, to the formal frameworks of knowledge, and this shift is made possible by the self-reflexive capacity of complex systems. (Melucci, 1989: 74)

This description of a global civil society is described by Melucci as a planetary action system, as a 'system whose complexity increases through systemic feedback facilitated by the assimilation of computer-mediated communications in all aspects of social life and historically unprecedented levels of mobility' (cited in Chesters and Welsh, 2005: 191).

The new complexities this thesis outlines are composed of these very factors: systemic feedback; computer-mediated communications; and ‘unprecedented levels of mobility’. My research shows how ad-hoc mobilizations of people – ‘smart mobs’ – and bloggers coordinating in the blogosphere, are part of an emerging civil society of participation, communication, and collaboration. These are bottom-up collectives, engaged in flows of unpredictable yet dynamic connectivity. Such behaviour corresponds to what has been termed either the global civil society or the alternative globalization movement (AGM). On this point Chesters states that:

> what the AGM seems to demonstrate is a set of *emergent* properties that are the outcome of complex adaptive behaviour occurring through participative self-organization from the bottom up. This organizational form and the behaviour that structures it leads to the emergence of a collective intelligence that in turn drives forward the same processes in feedback loops leading to substantial increases in agency and potential. (Chesters, 2004: 334-5)

In terms of social movements there is a decline in the importance of fixed locations in favour of relationships that are formed, re-formed, and continuously reconstructed in relation with shifting and dynamic environments. It is important then for these shifts to be recognised as social patterns and that the sociology of contemporary social practices ‘distinguishes between the abstract and conceptual Cartesian division of location into the grid of longitude and latitude, and the subjective, negotiated social spaces of lived experience’ (Lane, 2004).

With the shift towards negotiated social spaces this reaffirms what has been said previously about how physical/digital spaces can serve to foster ties, linkages, and networks of relations over physical and linear restrictions of location. In this way complex systems are formed that leave traces along networks of connection: one such form of traces is what has been discussed as tagging/folksonomy – or *social bookmarking*. In this, the system being traversed or connected is being endowed with a form of cognitive capacity as the tagging technique is leaving informed tracking signs. As the next, and final, chapter will discuss, the rise of tagging, tracking, and tracing will dominate online development in the next few years. Increased complexity, as the complexity sciences state, deals with creating increased order within spaces of increasing dynamism, in systems far from equilibrium.

What this thesis shows is that informational-mediated forms of social practices are becoming increasingly informed through technologies of connectivity and communication that are showing signs of merging physical and digital/virtual spaces. This enables informed people to act as cognitive participants in socially complex networks and systems. Such technologies are enabling users to 'weave our own structures of narrative and creation…as designers of new conduits for navigating urban experience' (Lane, 2004). Physical/digital presence thus begins to treat connections as conduits of conversation, as patterns of information-sharing that manifest complex systemic behaviour: order through sustainable dynamic relations. In such habitable spaces, and inhabited flows, that encourage both presence and action, both agency and authorship, self-organising cognitive networks are shifting towards relationships of collaboration and resource sharing. The collaborative strategies of complex systems can be expressed in the social domain through the mediated functioning of technological devices and human appropriation. This collaborative mixture of informed creativity not only facilitates interaction with an increasingly fluid environment, it also allows for an expanded understanding of complex, interdependent dynamics. In this context, cooperation can be viewed as a functional and practical tool. It is towards newly emerging forms of socio-technical networks of cooperation that I now turn.

Technologies of Cooperation

Cooperation has been an integral part of relationships in many forms; some of these were noted in the beginning chapters in terms of symbiosis and genomic complexity. The implications suggested in this research deals with the new opportunities for developing complex cooperative strategies through emerging technologies of communication, specifically digital technologies. The specific emphasis here is on deliberate strategies of cooperation, rather than suggesting that cooperative relationships are naturally inherent in complex systems. This perspective would be misleading and erroneous since complex systems have no pre-determined trajectory, and are not 'social' by definition; what they demonstrate is sensitivity towards environmental impacts and inputs. In order to sustain cooperation, complex interrelations between individuals and their technically-mediated communications must of necessity be deliberate and intentional strategies. Another point to add here is that although there are deliberate intentions on the part of the individuals involved, this does not guarantee a prescribed outcome, for complex systems produce effects that are emergent, beyond the scope of single individuals, and often unintended and beyond control. It would be more appropriate to view cooperative strategies as 'steering mechanisms'. Just as cybernetics (a feedback property of complex systems) is named from the Greek *kybernetes* meaning, amongst other things, 'steersman', so too can collaborative strategies be seen as attempts to steer social networks towards emergent cooperation.

A recent report published by The Institute for the Future (IFTF), which is an independent non-profit research group based in California's Silicon Valley, outlines digital technologies of cooperation. Their report 'Technologies of Cooperation' (published January 2005) opens with the declaration

> When social communication media grow in capability, pace, scope, or scale, people use these media to construct more complex social arrangements – that is, they use communication tools and techniques to increase their capacity to *cooperate* at larger and larger scales. Human history is a story of the co-evolution of tools and social practices to support ever more complex forms of cooperative society (Rheingold, Saveri and Vian, 2005: 3)

The report recognises that as devices 'become technologically networked – as they themselves are organized into increasingly complex societies of cooperating devices – the value of the technical network multiplies' (Rheingold, Saveri and Vian, 2005: 4). As explained previously, this network growth through industrialisation and human innovation catalysed the ability to organise collective and complex groupings and relations of networks at almost exponential rates. Yet it needs to be stated that the growth and development as presented in this research exists on 'the border between deliberate design and unpredictable emergence' as only sometimes are such human-artefact relationships intentional, and 'often they are the emergent result of aggregating a large number of individual interactions. And occasionally they are both' (Rheingold, Saveri and Vian, 2005: 5). In this way there is the capacity for technological lock-in, a feature of complex systems whereby a device, such as the automobile, influences the way a system develops, whether the locked-in object is initially the most efficient or not. As analysed in the distributed bottom-up response to the Indian Ocean tsunami, no-one could predict in what manner, or to what extent, the mobile technologies of communication would respond or inform individual action. As I demonstrate there are deliberate efforts to map the emerging strategies of cooperative technologies into a working infrastructure, whilst the outcome remains dynamic and nonlinear. Such systems of relations and processes, as informed mobile networks, are always on the move, and meshing in continuously updated arrangements. The IFTF report on cooperative technologies cites eight key clusters, to which I now turn.

The key clusters identified in the IFTF report as comprising significant areas in cooperative technology are: self-organising mesh networks; community computing grids; peer production networks; social mobile networks; group-forming networks; social software; social accounting tools; and knowledge collectives. I argue that these key clusters can also be understood through the lens of the complexity sciences and as such demonstrates that collaboration is a capacity of complex systems. Recent studies into biology have shown that cooperation is central to biological evolution (Augros and Stanciu, 1987).

Whilst cooperation in the biological realms of complexity studies has been acknowledged (Axelrod, 1990; Ben-Jacob, 1998; Goodwin, 1997; Goerner, 1999; Margulis, 2001; Sahtouris, 1999), little has yet been said about complexity in the social sphere in terms of cooperative strategies. Axelrod has produced some significant work in the fields of complexity theory and game theory, as well as some revealing research on cooperation. His book *The Evolution of Cooperation* (1990) drew on the analysis of a situation known as Prisoner's Dilemma (a game devised in the 1950s by researchers at Rand to analyse game theory), to examine conflicts and encounters within biology, business, society, and international affairs. Axelrod's observations include such comments as 'the most direct way to encourage cooperation is to make the interactions more durable...Another way...is to make the interactions more frequent' (Axelrod, 1990: 129); and 'an excellent way to promote cooperation in a society is to teach people to care about the welfare of others' (Axelrod, 1990: 134). The emphasis here being upon the need to build connections, strengthen and sustain those connections, and to bring reflexivity, or feedback, into the system. Axelrod also notes that 'the ability to recognise the other player from past interactions, and to remember the relevant features of those interactions, is necessary to sustain cooperation' (Axelrod, 1990: 139) – here suggesting that ties are reinforced through increased familiarity and trust. Such observations are close to what has been discussed in terms of social networks and complex collectives.

Cooperation, as a whole, relies upon the increasing complex interrelations and performances of the parts, and is an emergent effect. Axelrod's later research used agent-based models of collaboration, referencing the work of John

Holland and his Complex Adaptive Systems (*cas*), published as *The Complexity of Cooperatio*n (1997). Here, Axelrod again examines how processes of cooperation and complexity can lead to changes in the behaviour of actors that are nonlinear. Social cooperation has also been studied in terms of the 'commons' and collective action (Kollock, 1998). Cooperation can be viewed through the lens of complexity as an emergent effect that leads a system away from a negative bifurcation (breakdown), and is sustained through creating and sustaining linkages – a network of interactions – that is fostered through increased familiarity. Taking this as a framework, I argue that the same view can be used to approach social strategies of cooperation through mobile technologies of communication. Social complexification, mediated through technology, can benefit from strategies of cooperation in order to navigate away from negative bifurcations in order to form stability within increased forms of distributed functioning. This is not stating that cooperation is a certainty in complex systems: cooperative strategies also have to negotiate their place within the fitness landscape of competing strategies. This can be seen when a dynamic system wavers on the cusp of breakthrough or breakdown. Again, I address those key clusters as put forward by the IFTF report.

Cluster one – self-organising mesh networks – are 'constellations of devices that can serve as both transceivers and relays or routers, with built-in intelligence to recognise compatible devices and configure themselves as a node in the network' (Rheingold, Saveri and Vian, 2005: 12). Systems that comprise of intelligent nodes can be self-adaptive, thus relinquishing the need for centralised governance. The burden of responsibility for maintaining such networks becomes a shared one as nodes become active participants – they become 'smart'. This is the behaviour that has been described previously in terms of actors within a communications network; this notion of a 'smart' meshwork is a step towards a more ubiquitous, connected social environment. This type of mesh architecture can be applied to other areas such as governance, commercial, and energy organisation.

Community computing grids, the second key cluster, refers to the sharing of CPU resource power so that distributed processing, often called 'peer-to-peer' computing, facilitates the sharing of information between individual computers within a network in order to provide an overall increased computational resource. Such examples are the SETI program where hundreds of thousands of computer users worldwide have signed up for their computers to download code from a central server that is scanning for signs of radio signals in space. With so many hands on the job, the task is made that much easier – many hands make light work, as the saying goes. This is a form of computer swarming that is not unlike that of social swarms whereby social networks and mobile communications can form emergent effects. Complexity research provides the means to understand how such emergent properties are formed through interacting parts engaged in positive feedback. With technically mediated flows not only can millions of people link their social networks through mobile communication devices, but 'the computing chips inside those mobile devices will soon be capable of communicating with radio-linked chips embedded in the environment' (Rheingold, Saveri and Vian, 2005: 15). Such multiple flows between people, their devices, and the environment may produce the ultimate complex system that includes this myriad network of nodes – human, technical, and social.

Key cluster three – peer production networks – refers to spontaneously formed networks of individual actors who come together to participate cooperatively in a distributed manner, for the creation of a common good. Such self-organised systems form around resource sharing and also involve positive feedback. A technical example of this is open software which is distributed on the Internet for free and is open for continuing upgrade and modification by its users. In this domain Linux is a striking example. In the social sphere this would describe the ad-hoc response to the tsunami disaster in terms of social networks of cooperation to share knowledge and resources about how best to provide aid.

To reiterate what was previously said about complex systems, both resource sharing and processes of cooperation and collaboration are features of these systems. Complex systems that must maintain themselves in states of nonequilibrium are dynamic in terms of their processes rather than of structure; these processes rely on communication and collaboration, using positive feedback, rather than hierarchy and centralisation. Thus, when Beth Noveck discusses citizen juries she is referring to these peer production networks. The caveat here is not to automatically assume that since complex systems use collaborative strategies that this implies future social formations will necessarily be cooperative and peaceful. The physical domain, with its evolutionary strategies, is also about competition, survival, and selfishness. What is being argued is that as the social domain forms stronger ties with technologically mediated networks, and as more distributed and interconnected relationships are formed, more apparent similarities with complex systems emerge and, as such, the need to see complexifying trends and bifurcations become increasingly important. For this reason I have already discussed the phenomenon of smart mobs, which comes under key cluster number four – social mobile computing.

The IFTF report sees group-forming networks, cluster five, in terms of Reed's Law, which states that networks grow exponentially with increases in the number of nodes. This is also similar to Barabasi's notion of scale-free networks whereby nodes in a system attract further nodes towards them thus forming clusters within networks and expanding the network. However, the emphasis in the IFTF report is upon a combination of human social and technical networks – a socio-techno hybrid. An example of this would be those human groups who depend upon technical systems to support them: this could be people who use Ebay for their commerce, and financial institutions that rely continuously upon computer-mediated financial flows. This area is developing into a shared knowledge base, such as Wikipedia, collaborative news gathering, and online communities. This bears similarity to the research and vision of biologist and computer scientist Joel de Rosnay.

De Rosnay, a graduate of MIT and Director of Research Applications at the Pasteur Institute in Paris, examines the future organisation of life as a techno-environmental hybrid, a symbiotic network. De Rosnay, also a complexity theorist, sees the need to form a unified theory based on the study of complex organised forms in which he proposes to unify the self-organization and dynamics of complex systems: 'I would propose the term symbionomics...the study of the emergence of complex systems through self-organization, self-selection, coevolution, and symbiosis' (de Rosnay, 2000: 31). Such group-forming networks, in de Rosnay's vision, are helping to establish a form of social/human macro regulation of flows, both material, economic, and energy, that form to stabilise such organization as traffic flows, air traffic, financial, and social (de Rosnay, 2000). Collaboration and positive feedback within such group networks are necessary to sustain interrelations across disciplines and fields; a merger that both de Rosnay and the IFTF report deem crucial.

Clusters six and seven – social software and social accounting systems respectively – are software and mechanisms/tools that enable social systems to emerge that facilitate transaction and trust. Examples here of social networking include blogging, social bookmarking, social communities online, the use of RSS syndication for ease of transactions, and the reputation system for signalling trust. Again, these features have been dealt with previously in varying degrees of detail and there is no need for further repetition.

The final eighth cluster is knowledge collectives. Here, the ability for systems to hunt and gather information in order to provide common resource pools of knowledge is emphasised. In other words, a decentralised, distributed complex network of information flows with open access and participation. Earlier I referred to folksonomies and social bookmarking as providing means of ordering information in the emerging Web 2.0. As in a complex system, the push is to form a common resource pool as an emergent phenomenon. Just as Google's mission statement is 'to organize the world's information and make it universally accessible and useful'[72] so too are the emerging social networks striving through collaboration to facilitate participation and access to collective resources. So it is that new social formations are manifesting new complexities, and the similarities between socio-techno networks and the behaviour of complex systems in the natural sciences are becoming more marked (Goerner, 1999; Goonatilake, 1991; Kelly, 1994; de Rosnay, 2000; Sahtouris, 2000; Stock, 1993; Stock and Campbell, 1998).

Although it is difficult to assess empirically, the signs are that such collaborations are on the increase, especially if the social sphere is required to maintain and develop its complex arrangements. As Derrick de Kerckhove, Director of the McLuhan Program at the University of Toronto, has noted:

> The increase in human interactions - personal, social, and institutional - through integrated networks is concentrating and multiplying human mental energy…consequently, the degree of collaboration among individual people's minds is about to become vastly increased. (De Kerckhove 1998: 143)

Again, the question to ask is whether cooperation is necessarily an emergent property of complex systems. I have argued that this is so, and that biologically complex systems have born this out in that resource sharing and cooperation form complex arrangements both within the cell and within the genomic web (Ben-Jacob, 1998; Margulis, 1993; 2001). Also, cooperation between the component parts of a complex system often facilitate a positive bifurcation outcome; that is, a shift towards an increased level of complexity

[72] Available at: www.google.com/intl/en/corporate/

with denser interconnections. In the examples presented, looking at social tapestries and technological strategies of mobile communications, it has been shown that the path of cooperation is a functional step in facilitating coordination amongst a denser array of distributed participants in ever increasing socio-technical networks. Yet cooperation is not a certainty: although an emergent property inherent within the capacity of complex systems, this is no guarantee it will manifest.

Social researcher Robert Wright, however, considers cooperation as a definitive characteristic of complex systems. In his book *Nonzero: The Logic of Human Destiny* (2000) Wright argues that biological and cultural evolution moves towards broader and increasing complexity, using the logic of the non-zero sum. That is, evolution and progress works from mutual need and cooperation rather than competition and the win-lose scenario. Like Axelrod (1990, 1997) Wright also made use of the Prisoner's Dilemma to show how the option of cooperation, the choice of non-zero sum, has been a decisive factor in the evolutionary growth of complex systems:

> The successful playing of a non-zero-sum game typically amounts to a growth of social complexity. The players must co-ordinate their behaviour, so people who might otherwise be off in their own orbits come together and form a single solar system, a large and synchronised whole. And typically there is division of labour within the whole. (Wright, 2000:21)

For Wright, such complex cooperation 'explains why biological evolution, given enough time, was very likely to create highly intelligent life- life smart enough to generate technology and other forms of culture' to the point where, somewhat controversially, he states that ‘Globalization, it seems to me, has been in the cards and not just since the invention of the Telegraph or the steamship, or even the written word or the wheel, but since the invention of life’ (Wright, 2000:7).

In response to Wright’s comments I consider it to be narrow and somewhat short-sighted to see evolution as being only a path of cooperation, and to deny features of competition and struggle, yet it is still a pertinent point to emphasize here that strategies of complexification require, at particular moments, technologies of cooperation in order to facilitate their systemic development and maintain their dynamic states. Inherent within the complexity sciences literature is a tendency to view increasing complexification as a teleological drive; a tendency that I consider too easy a view to fall into. Yet a significant question to be raised is whether such new complexities of the social are more amenable to strategies of cooperation at this time, and how the socio-technical meshwork of interrelations and processes might facilitate this relationship. The habitation of information flows may require such collaboration and resource sharing. Wright believes so, for he writes that ‘Indeed, it is hardly an exaggeration to say that non-zero-sum dynamics are the reason information gets transmitted in the first place’ (Wright, 2000:98).

However, what needs to be taken into account is when the non-zero-sum game is not played, and information does not always get successfully transmitted. In other words, when collaborative processes are deliberately blocked, hampered, and firewalled. I now turn to a brief discussion of performances of non-cooperation.

Technologies of Non-Cooperation

For the most part this thesis has engaged with socio-technical systems as a facilitating force and/or commodity for furthering social ties and fostering complex spatial-temporal relations, whilst also recognising the presence of contestation and antagonisms inherent in far-from-equilibrium systems. Antagonisms have also been recognised as present within the various competing networks of presence and action, such as between open-source innovations and users, and corporate bodies that aim for profit; between bloggers and the mainstream media; between ad-hoc mobilisations of people for protest and aid, and traditional forms of civil structure. As a general rule technology, like most other systems, inherently contains both positive and negative implications and/or consequences. I turn now to discuss instances where cooperation is being hampered, and manipulated, by hierarchical top-down control use of technology.

Tampering with connectivity, complex flows, and cooperation, requires an understanding and practical knowledge of these technologies. It requires, to varying degrees, a working knowledge of such issues as: regulation of the Internet; open-source software and democratic innovation; dynamics of complex connectivity, networking, and online communities (including blogging); the interpersonal and social effects of mobile technology; digital and physical spaces and the propensity for civil protest; and access to bandwidth (including Wi-Fi). This list is not exhaustive. Whilst there are numerous organisations available to defend cooperative strategies, such as the Electronic Frontier Foundation,[73] there are severe restrictions within digital territories governed by such state authorities as China, Iran and North Korea, for example. Recent events have focused to a large degree upon the restrictions placed upon citizen access, and freedom of speech and movement, within Chinese controlled territories. This is in part a contradiction to China's expansion of its telecommunications industry over the last two decades as part of their modernisation program. Since 1993 China has been laying fibre optic cables in a grid-like network across the country so that '80% of China's communications backbone and 40% of its urban networks now use fiber-optic cables' (Deibert, 2002: 146). Alongside internal modernization Chinese Internet start-ups and portals have received significantly increasing overseas financial investments. In contrast to how global Internet access is promoted Chinese authorities are territorializing Internet traffic by funnelling network connections first via their localised intranet, thus leading to what has been dubbed as 'The Great Firewall'. These macro measures are counter-balanced by aggressive micro-measures of control and surveillance within the Chinese Internet and blogosphere.

A recent, and highly publicised, restriction placed upon the Google search engine operating inside China forced Google to accept the condition of creating a self-censored search site. Its previous search engine for China's fast-growing market was subject to government blocks. The new site - Google.cn -

[73] This is a non-profit organisation that works on behalf of citizens' rights online.

censors itself to satisfy Beijing (BBC-News, 2006). China's euphemistically titled 'Great Firewall' restricts the BBC news site and, for example, if a search were to be done on Google.cn for the controversial Falun Gong spiritual movement the user would be directed to a list of critical and anti-Falun Gong articles. Yet Google is not alone: both Yahoo and Microsoft utilize their own forms of censorship in order to comply with the Chinese authorities. And it seems that this 'Great Firewall' is not only preventing access to 'unacceptable information', it is also restricting strategies of cooperation. Chinese authorities, it seems, are anxious over connections that lead to civil spaces and/or meetings; and they have good reason. Chinese authorities are becoming worried that social unrest is reaching 'alarming levels':

> Not long ago, the mainland's top cop, Zhou Yongkang, said that 74, 000 major protests took place last year, up from 58, 000 in 2003. More than 3.7 million people took to the streets in 2004 – angry about such issues as official corruption, health problems, environmental degradation, mistreatment by employers, and home evictions. (Liu, 2005b)

It does not require much imagination to conceive of how the tension of this situation could be increased through the use of 'smart mob' technologies, blogging, and other connective strategies aimed towards dissent. Because of this such lines of communication – networks of strategies – are being closely monitored and interfered with behind the 'Great Firewall'. Networks of cooperation rely, to some degree, upon notions of trust and reputation. In some corners of online space this is a cause for concern, especially when shared presence cannot distinguish between user and official state abuser. In this respect, China is perhaps at the forefront of such technologically deceptive strategies of online misrepresentation. According to recent estimates there are between 30,000 to 40,000 Chinese e-police who constantly surf online chat communities and lead a double-life as noted online contributors (Liu, 2005a). The job of the e-police is to block and/or delete undesirable content, and to locate and detain those users deemed 'troublemakers'. Also, to

> proactively influence web content in ways beneficial to the regime – and pre-empt people from organizing politically. The aim is not simply to stifle dissent or to control the free flow of information, but increasingly to shape public opinion in cyberspace. In fact, Chinese propagandists worry less about the Web as an information source than as a tool for mobilizing mass movements. (Liu, 2005a)

The Chinese authorities are concerned more with the issue of social organisation, on how the information is used, rather than the information itself. In late 2005 the Chinese authorities released a new set of 'web-rules'; in these, two new categories forbade content: one bans 'inciting illegal assemblies, associations, marches, demonstrations or gatherings that disturb social order'; whilst the second 'forbids conducting activities in the name of an "illegal civil organization"' (Liu, 2005a). The authorities have hired thousands of covert e-police to act as 'moles' to infiltrate popular chat-rooms and to pose as grassroots activists, as well as prominent bloggers. In this way the authorities are attempting to place a top-down hierarchical control structure over bottom-up distributed systems. In these instances there are deliberate attempts to sabotage complex interrelations from creating emergent social phenomena.

According to Xiao Quing, head of the China Internet Project at the University of California, Berkeley,[74] roughly one tenth of all sites accessed through Chinese cyberspace are set-up and run by the state authorities. Also, according to Paris-based *Reporters Without Borders*, in their annual report, at least 64 known online 'dissidents' are serving long jail sentences[75] with the authorities having closed 12,575 Internet cafes within a 3-month period in late 2005 (Liu, 2005a). In the first worldwide index of press freedom, published by *Reporters Without Borders*[76] out of a list of 139 countries (ranging from 1-139 in decreasing order of press freedom) China came in at 138, beaten only by North Korea. At the same time China is recognised as one of the fastest growing technologically developing nations. Such figures may appear contradictory, yet somehow fail to surprise. According to OpenNet Initiative, a project that involves researchers from Cambridge, Harvard, and Toronto universities, 'China operates the most extensive, technologically sophisticated, and broad-reaching system of Internet filtering in the world. The implications of this distorted on-line information environment for China's users are profound, and disturbing'.[77]

It was only recently that anti-Japanese sentiment, which was promoted by the Chinese authorities by online bulletin-board postings and SMS messages, induced thousands of Chinese people into physical rioting, catching the

[74] Whose mission statement is 'To explore interactive digital media and communication technologies in order to advance the world's understanding of China, and to promote the knowledge, culture and social practices of those technologies which will facilitate China's democratic transition' - http://journalism.berkeley.edu/program/china-internet/
[75] Details at: http://www.rsf.org/article.php3?id_article=13426&var_recherche=china
[76] http://www.rsf.org/article.php3?id_article=4116
[77] Source at: http://www.opennetinitiative.net/studies/china/

authorities somewhat off-guard by the ferocity of the event. In an attempt to stem and quell the protests, the authorities engaged in overt SMS messages this time 'warning residents to avoid illegal demonstrations and to focus their patriotism on their studies and jobs' (Liu, 2005a). The capacity of smartmobbing within mainland China is significant, especially when considering that there are, at latest estimates, almost 120 million Internet users[78] and, according to the Chinese Ministry of Information Industry (as reported by China Daily)[79] an expected rise to 440 million mobile phone subscribers by the end of 2006. With such colossal numbers, complex strategies of cooperation and mobile networking are something the Chinese authorities do not wish for.

Against the civil push for blogging, online networking, and strategies for complex interrelations, there is a similar push for building up firewalls that actively seek to form strategies of non-cooperation, where trust is invalidated through e-police 'moles', and information is either eradicated or actively swapped for influential misinformation. In such an environment complex collectives are barred from forming; networks are not distributed evenly but tied to top-down hierarchies of control and containment. This arrangement displays characteristics of the typical conflict between hierarchical and network architectures, as has been suggested in this research. Information flows are restricted and centralized by the Chinese authorities, with access becoming secretive and compartmentalized, as is the structure of top-down

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[78] According to China Daily (http://www.chinadaily.com.cn/english/doc/2006-01/09/content_510623.htm) – accessed 3/2/06
[79] 'Mobile phone subscribers to hit 440m in 2006' - http://www.chinadaily.com.cn/english/doc/2006-02/02/content_516771.htm - accessed 3/2/06

control (Deibert, 2003). Another example of Chinese state control mechanisms is the ban on Chinese individuals or companies from using foreign encryption software, placed in 1999 by the State Encryption Management Commission (Deibert, 2002). This regulation forces all those wishing to use encryption software to apply to use only that which is provided by the state, thus also enabling all encrypted software to be unlocked by state authorities if they wish to survey. On the other hand Chinese bloggers are attempting to form bypass networks of information dissemination that are unfiltered and open, thus causing consternation with the state authorities. Security analyst Deibert notes how, paradoxically

> the more that citizen networks are targeted by traditional state intelligence agencies the more the security of their information flows will harden, pushing citizen networks deeper into the subterranean layers of the Internet...There is a contradiction, in other words, between the operating procedures and the object of state intelligence – in this case, of citizen networks. Together these two constraints will make the job of monitoring citizen networks by state intelligence agencies an increasingly formidable task. (Deibert, 2003: 188)

Again this highlights the difficulty in hierarchical structures trying to maintain control over distributed actors. As in complex systems, when a route or pathway becomes blocked, other linkages are formed, emphasizing the process-orientated feature of complexity's interrelations.

An example of this is that a significant number of Chinese bloggers and Internet users are sidestepping imposed firewalls by use of proxy servers that reconnect users to sites that have been banned:

> A good example is the proxy servers that are maintained by a news site, *China News Digest*, which each day provides a list of thousands of different proxy servers that are available to Internet users in mainland China as well as detailed instructions on how to sidestep China's firewall technology. (Deibert, 2002: 11)

This example of the contestations erupting between the clash of different systems coming together – that of distributed bottom-up networks that constitute complex processes and top-down hierarchical control architecture – is at present part of the core infractions being played out between the Chinese authorities and the rapidly increasing number of bloggers and mobile-communication users in China. It is a clash that has been fuelled by China's recent policies toward increased investment in telecommunications and technological modernization. In contrast to China's industrial modernization program the state authorities have shown only tentative movements towards accepting, and allowing, a burgeoning civil society to manifest and develop.

According to Dr. Wang Yizhou, Deputy Director of the Institute of World Economics and Politics at the Chinese Academy of Social Sciences in Beijing, civil society 'in People's Republic of China (PRC) is a rather new phenomenon, both as an concept and as a reality, especially comparing with modern Western world' (Yizhou, 2005). Yizhou states that national departmentalism and totalitarianism has set the limitations for the existing social structure over a long period of time, with the result being that what remains of civil society today is extremely weak, and that the contemporary intellectual and political elite in China today mostly rely upon the influence and support of the state.

Thus, Yizhou concludes, many of the social organizations operating close to the state share these similar features. However, the situation is not without movement. Zhang Ye, Country Director of the Asia Foundation in Beijing, recently reported to the Brookings Institution in the US that

> China's drive toward economic reform and modernization in the past 25 years has created new opportunities for citizen participation. The Chinese people are seeking ways to organize their own institutions to respond to social needs and convey grievances and concerns in a way which influences the policy-making process. One of the significant developments of Chinese society in the past two decades is the emergence of non-governmental organizations. (Ye, 2003)

In a survey report of the NGO Centre of Tsinghua University in 2000, a wide array of emerging NGO activities were seen as operating, including environmental protection, poverty alleviation, and academic protection (Ye, 2003). Ye refers to this shift as the 'quiet revolution'. However, the survey does not detail the degree of activity, or to what depth of engagement, these emerging NGOs are allowed. Where perhaps the real 'quiet revolution' is occurring is in the spaces behind the Great Firewall, where strategies of connectivity are being sabotaged by state e-police and chat-room moles. In these networks, quiet connectivity produces longevity, and open communication and collaboration comes at a price. Yet with an estimated blogging culture of more than 30 million bloggers,[80] the future of such a silent mass remains uncertain: uncertain and indeed complex.

[80] A radio podcast titled 'In China, Blogs Are Revolutionary Tool of Opinion' - http://www.npr.org/templates/story/story.php?storyId=5250144

To conclude, these situations are not associated with China alone. As listed on the *Reporters Without Borders* index of press freedom, networks of information are being hampered, blocked, and sabotaged by state and hierarchical interference. In this chapter I discussed technologies and strategies of cooperation, as deliberate social actions from individuals, yet many of the cooperative effects – as in the blogging response to the Indian Ocean tsunami – are emergent properties that could not have been foreseen by any one individual or actor. This again emphasises the nature of complex systems in that they have the capacity to produce effects greater than anticipated, yet in a nonlinear manner, often through what appears to be chaotic processes. The complexity sciences, and the shifts in discourse this thesis has discussed, suggest that social relations produce outcomes that are much more varied, unpredictable, and collaborative than earlier theories such as Durkheim's organic solidarity allowed for (Durkheim, 1984/1893). Complexity theory allows social science to view social processes as dynamic, emergent, whilst also containing inherent instabilities and tipping points. As Urry notes, complexity theory would have been a suitable model in which to view the contestations and continual dialectical processes as put forward by Marx in the nonlinear emergence of a revolutionary proletariat class (2005a).

Complexity theory emphasises the fact that global systems are more sensitive to fluctuations, impacts, and perturbations than recognised in some global literature (Beck, 1998; Giddens, 1990; Robertson, 1992). Complexity theory in social discourse is better positioned to account for nonlinearity, instabilities, adaptations, fluidity, and sudden, perhaps radical, shifts. Also, as I have shown, cooperation is one strategy of engaging with these processes;

although outcomes can never be guaranteed. Cooperation is also liable to result in conflict, as discussed in global civil society literature (Keane, 2003; Munck, 2002; Taylor, 2002). This contradiction sits comfortably with complexity notions, and is part of what Cilliers calls the 'performative tension' within the contradictions of complexity (Cilliers, 2005).

In this chapter I also discussed the contestation between complex systems that are bottom-up and distributed as opposed to hierarchical top-down architectures of control. This was highlighted in reference to Chinese bloggers and state authorities. It was also inferred within the discussion on the complex features of some NGOs and global civil society. Such contestations are continual, yet the success and expansion of NGOs and civil society actions imply that complex behaviour, as I show them to manifest, are more adaptable to the present global fitness landscape. A recent shift in social science discourse towards complexity, and the recognition of complex processes and interdependencies, suggests also that as a theoretical model it works as a means for analysing ever increasing global scapes and flows. Sociological discourse has recently taken to viewing such complex arrangements of relations and increased interconnections as steering towards the *hyper-complex* (Qvortrup, 2003). Whether there is an emergence of the hyper-complex, or rather a shift towards increasingly complex mobilities - the 'new complexities' of this thesis – I turn to address these issues in the next chapter when examining the emerging spatial landscapes and geographies of mapping, of geospatial information integration technologies, and the hybrid connectivity of things.

CHAPTER EIGHT

Hyper-Complexities: emerging geographies of connectivity and communication

'Far away in the heavenly abode of the great god Indra, there is a wonderful net that has been hung by some cunning artificer in such a manner that it stretches out infinitely in all directions. In accordance with the extravagant tastes of deities, the artificer has hung a single glittering jewel in each "eye" of the net, and since the net itself is infinite in all dimensions, the jewels are infinite in number. There hang the jewels, glittering like stars of the first magnitude, a wonderful sight to behold. If we now arbitrarily select one of these jewels for inspection and look closely at it, we will discover that in its polished surface there are reflected all the other jewels in the net, infinite in number. Not only that, but each of the jewels reflected in this one jewel is also reflecting all the other jewels, so that there is an infinite reflecting process occurring...it symbolizes a cosmos where there is an infinitely repeated interrelationship among all the members of the cosmos. This relationship is said to be one of simultaneous mutual identity and mutual intercausality'

Francis Cook – 'Hua-yen Buddhism'

'Every man who had ever lived became a contributor to the evolution of the earth, since his observations were a part of its growth. The world was thus a place entirely constructed from thought, ever changing, constantly renewing itself through the process of mankind's pondering its reality for themselves...No continent or people have turned out to exist except in relation to themselves. Their geographic location has also proved to be deceptive. The inescapable conclusion is that the true location of the world, of its countries, mountains, rivers, and cities, happens to lie in the eye of the beholder'

James Cowan – 'A Mapmaker's Dream'

The previous chapter concluded by suggesting a shift towards new complexities that are being informed through emerging spatial landscapes and geographies of mapping, of geospatial information integration technologies, and the hybrid connectivity of things. This can be seen as constituting a new *hyper*-complexity. This chapter examines emerging trends and upcoming scenarios in terms of informational connectivity, as seen through the lens of complexity theory. I discuss both benign and surreptitious uses of complex networks of informational connectivity, both civil and military, in order to gauge possible futures of such socio-technical capacities. By discussing various sites of complexity I again emphasise that there can be an overlapping of various sub-sets of complex systems. Not only theoretically, as examined in Chapter Two, but also physically as military, civil, and commercial technologies of communication can create a myriad of diverse sub-sets of complex systems as opposed to imagining one global system. However, as I discuss in this chapter, with a technological development moving towards ubiquitous 'everywhere' computing and the rise of the 'Internet of Things', there is a tendency to conceive of a future place/space where complex interrelations and interdependencies between person-object-environment will form a more pervasive complex system. First, I begin with a brief look at the concept of hyper-complexity, with reference to time.

Time and Hyper-Complexity

Mobile socio-technically embedded networks inherently have the capacity to produce both cooperative effort and increased conflict; both as a means of sustaining complex arrangements. Norwegian researcher Rich Ling calls this mode 'hyper-coordination' (Rheingold, 2003b). Similarly, Finnish researcher Pasi Maenpaa, from the University of Helsinki, sees how this trend is leading towards a 'hyper-informed' pace of living:

> In the mobile culture one lives with the other foot permanently planted in the future, using the mobile to administer and manage his or her future meetings and affairs. Places and times are not planned in advance…This makes life less bound…The mobile blurs the previously organised everyday structure and shifts it to a more flexible direction… The future is no longer conceived as something consisting of exact moments as much as of approximate places-in-time which are open to negotiation according to the situation. (Maenpaa 2001: 107)

Importantly this points towards a social presence that is 'open to negotiation'; that changes, adapts, and fills according to the situation, much like a fluid that flows to fill the spaces of a mould. Social networks become *interruptible*: spaces which facilitate availability, in-flows of relationships and habitation. Distant proximities, spaces that once could be used to hide, excuse, or shield, are being replaced by electronic proximities that open-up, include, track and survey, as well as allowing shared participation in complex webs of moments, events, and involvements.

These emerging electronic proximities, the spaces of presence and action, are emphasised by the increasing incidents of cooperation and coordination between people/parts/nodes within a complex network of multiple arrangements. Here there is a shift towards 'confronting a growing level of complexity, and that social complexity in fact represents the basic problem and challenge of our current society' (Qvortrup, 2003: 3). Danish sociologist Lars Qvortrup believes that society has entered a stage of hypercomplexity:

> according to the theory of the hypercomplex society, we are developing toward a society with a large number of functionally differentiated centres, i.e. a polycentric society, in which the stabilising factor is not a central guiding body of social ideology, but communication-based processes of coordination. Stability is then not the outcome of order and centralisation, but of a higher level of complexity and decentralisation. Here, information and communication technologies are not understood as determining factors, but as socially shaped technologies formed by the need for decentered processes of mutual observation and co-ordination among social sub-centres. (Qvortrup, 2003: 4)

Qvortrup sees hypercomplexity as a form of second order complexity: 'as an example, hypercomplexity is the result of one observer's description of another observer's descriptions of complexity, or it is the result of a complex observer's description of its own complexity' (Qvortrup, 2003: 6). This appears to emphasise reflexivity and feedback on the part of the observer/participator. This can be seen in such manifestations of the blogosphere whereby individual bloggers are linking and commenting upon each other, knowing that some issues have the potential for larger effects within the blogosphere. Significantly, the notion of hypercomplexity also involves how one researches complex phenomena, and thus must also include this author. By attempting to maintain both a distanced and critical position towards the research material, as well as being more closely involved in tracking and following the online conversations and information networks, one's position becomes a type of 'second-order complexity'. Such reflection upon the reflexive nature and behaviour of participants within complex systems is what Qvortrup regards as hypercomplex. By taking this line of argument it can be stated that my research, this thesis, is itself a hyper-complex body of work. In this way it is almost impossible to conceive of any position *outside of a complex system* as such a position may only be from *a different order of complexity*. Such a perspective throws light upon what has been said at various points throughout the thesis about how complex systems involve the participation of individual agents through reflexivity and feedback loops, thus bringing the observer into the system observed.

Further, Qvortrup argues that in a hypercomplex society not only is stability sustained by decentralization rather than central order, but also that the stabilising factor is 'communication-based processes of coordination'. Through such communication, and coordination, both human and organisational bodies have access to modes of social actions on a global basis, according to Qvortrup. I find Qvortrup's argument a lucid and persuasive way of framing the hybrid relationship between human, the social, the technical, and the environmental, which is also somewhat akin to de Rosnay's vision of an organisationally complex cybiont (de Rosnay, 2000). Here, both Qvortrup and de Rosnay use complexity as their theoretical base.

This thesis shows that new complexities are emerging that facilitate more diverse patterns of coordination; also, that these denser networks of coordinated interrelations can be sustained by forms of social cooperation. In contrast, however, coordinated interrelations can also function for disruptive ends, as in both local and global terrorist networks. Yet some theorists argue that the way forward towards social complexification, if a catastrophic negative social bifurcation is to be avoided, requires relationships of mutual cooperation (Goerner, 1999; Laszlo, 1991; 1994; 2001; Wright, 2000). My argument here is that complexity theory not only underlines the patterns that are forming social networks and global mobilities, but that complexity theory can also be taken as a tool, a lens, in which to approach and examine these emerging socio-tech mediated trends of connectivity and communication.

The technologies of cooperation I have researched demonstrate a possible social restructuring in the way that each society adapts and merges with an increasing number of individuals who are investing in information-access, increased mobility, knowledge-sharing, and immersion in multiple networks of participation, contribution, and reflexive creativity. These newly emerging scapes of complex mobilities are steps toward a more ubiquitous connectivity with the environment. In this scenario processes and patterns of complexity have taken the social domain towards an environment where mapping – social, ecological, military, etc – becomes the operational mode of ubiquitous computing and sentient artefacts. That is, a social sphere that sees converging technologies and networked information forming the new infrastructure for spatial geographies.

These emerging social patterns are part of the new complexities that are embedding themselves within increased global interconnectivity where not only is intelligence increase fostered through greater access to information/knowledge flows, but also the whole becomes increasingly aware of its parts through geospatial information in location-aware applications. This degree of complexity, which may also be referred to as the hypercomplex, is incorporating increased awareness, reflexivity, creativity, and degrees of inclusion. It also impacts upon existing notions of space and time as well as location. Temporal and spatial considerations have become intimately enfolded within the increasingly networked infrastructures, methods, and procedures of communication, as part of the shift towards increased nonlinearity, complexity, and unpredictability.

Shifts toward moments of simultaneity and physical/digital presence lead to a more dynamic, and inherently nonlinear, interconnected world and 'shared time'. The inheritance of classical Newtonian physics, as well as deeply ingrained industrial time (Adam, 1990; 1998), has inflicted a linear and sequential understanding and lived experience of time. In a world where initial conditions have diverse and unpredictable outcomes, as modelled by the complexity sciences, and where minor fluctuations may result in major and widespread consequences, then this linear, sequential notion of time must necessarily come under scrutiny and deserves re-evaluation. Thrift argues that the 'metaphors of complexity theory make it easier to think about *time* in new ways…and especially the structure of the future as open, as full of possibility and potentiality, even as pliant' (Thrift, 1999:56). This is a significant observation and highlights an important aspect of the complexity sciences. It also recognises that complex processes are often connected with a '*future*': that is, dynamic states far from equilibrium that shift towards order can also be said to be moving in a directionality that supposes a future state. Since this future state is never predictable, it levers open the door to possible futures. Thrift's angle on this is to see time as being constructed around three principle 'registers': that of personhood, things, and possible worlds. Personhood referring to persons as ‘a set of complex, multivalent and more open subject positions’ (1999: 56); things as an increased capacity to interact with the ecology of things as nodes; and possible worlds that suggest future potentialities. Whilst not in disagreement with Thrift’s points I argue that they do not go far enough in emphasising the potentialities of possible future(s).

Concepts of complexity recognise the reconfiguring of time that embodies the notion of possible unpredictable future(s); the flows of change, dynamism, and diversity within webs of relationships and patterns of (re)forming order. Complexity also allows for path dependencies that lock-in the unpredictable and reinforces these interdependencies into escalating patterns of connectivity. Thus, for complexity, events are often nonlinear and relationships form within shifting contexts that are irreversible. The latest investments are in innovative technologies that can self-organise their software and reprogram themselves according to adaptive need. Many of these developments are in the area of nanotechnology/molecular engineering (Drexler, 1990; Jones, 2004; Mulhall, 2002), and bio-mimicry[81] (Benyus, 2002), and envision possible artificially engineered future(s) based around biology. This scenario forecasts how communication systems will slowly become embedded within living molecular networks. Biological time, seen in terms of inner circadian[82] rhythms (Adam, 1990; Loye, 2000), might also form a part of the technological environment. It has already been hypothesised that time is accelerating towards a technological singularity

[81] Also known as ‘bionics’, biomimicry is the application of systems and methods that are found in nature to the study and design of modern technological systems.
[82] **Circadian:** adj. of or relating to biological processes that occur regularly at about 24-hour intervals, even in the absence of periodicity in the environment. (Collins English Dictionary).

(Kurzweil, 2003; Vinge, 1993), characterised by smarter-than-human intelligences and accelerating machine networks. Emerging insights into biological, physical, and chemical processes have brought a new bearing onto how social theory must deal with time (Adam, 1990; 1995; 1998).

Urry sees time-space as being compressed and folded into 'roaming hybrids' such as nanosecond instantaneity and commodified futures, as well as fragmented through automobility (2003a: 72). Also, such an interconnected world brings forth questions of presence. Marshall McLuhan, who saw modern technologies as bringing about 'an implosion in which everybody is involved with everybody' saw early on how the forthcoming 'age of co-presence of all individuals is the age of communication - the age of instant humans' (McLuhan, 1970: 35). A question that arises from this is how such networks, complexities of information and global flows are re-configuring such concepts as 'present/presence'. The new global heartbeat, Mitchell tells us, is speeding up:

> electronic vibrations subdivide seconds into billions of parts... calibrate GPS navigation systems, regulate power distribution and telephone systems, measure and commodify both human and machine work, and precisely construct the accelerating tempos and rhythms of the digital era - coordinated, where necessary, by a central atomic clock... seconds, milliseconds, microseconds, nanoseconds, picoseconds: the electronic global heartbeat keeps quickening and gathering power. (Mitchell, 2003: 12)

Global positions, or rather positioning within the global, are now entwined with spatial and temporal considerations in a very real and heightened sense;

this is especially so since the commercial use of satellite technology. As telecommunications guru Joseph Pelton writes:

> already, satellite systems such as Orbcomm, INMARSAT, American mobile, Telesat mobile, Globalstar, and Satellife provide a global internet interconnectivity to mobile or semi mobile terminals. Within the next five years the number of mobile satellite systems allowing Internet links will mushroom tremendously (2000: 32).

Although satellites are generally perceived of in terms of telephone/television broadcasting (or for clandestine operations) a recent military-to-commercial cross-over of significant social interest is the Global Positioning System (GPS).

GPS was completed in its original form by the US Department of Defence, in 1994, for the purposes of providing the military with potentially the most sophisticated infrastructure for wireless location, for both surveillance and navigation. Location, and thus distance, is calculated using radio signals that travel between the satellite transmitters and their ground-based receivers. In this way time, space, and location can become synchronised, compressed, and commodified into useable data. GPS thus

> allows time synchronisation to better than a millionth of a second, which is useful for co-ordinating bank transfers and other financial transactions. The Global Positioning System consists of 24 satellites orbiting about 11,000 miles above the Earth, arrayed so that any spot on the planet is visible to at least six of the satellites at any time. Each satellite carries four atomic clocks on board, synchronised within a billionth of a second of one another by the master super-clock in Boulder. (Strogatz, 2003: 119)

The clock, as a physical representation of time, has been a metaphor of order, regularity, and authority within modern Europe for several centuries (Adam, 1990). Industrial urban life was so structured around the punctuality of clock-time that Simmel notes how 'if all the watches in Berlin suddenly went wrong in different ways even only as much as an hour, its entire economic and commercial life would be derailed for some time' (Simmel, 1997: 72). Also, as sociologist Norbert Elias notes:

> By the use of a clock, a group of people, in a sense, transmits a message to each of its individual members. The physical device is so arranged that it can function as a transmitter of messages and thereby as a means of regulating behaviour within a group (cited in Mackenzie, 2002: 93).

As Elias stresses here, the clock is more than a time-device; it functions to regulate group behaviour. In this manner, the clock/watch can be seen to frame the social customs of those wearers, much like a modern RFID (Radio Frequency Identity) tag. In like manner, hearing or seeing a clock 'has become less important than the clock's often invisible and silent infrastructural role in directly regulating and synchronizing other technical elements, and indirectly coordinating disparate elements of a collective' (Mackenzie, 2002: 109).

Time is now becoming more concerned with the *where* rather than the *what* – 'The watch does not tell you the *time*; it tells you *where* you are…globalization of location' (Virilio cited in Mackenzie, 2002: 91) – and has the potential to become an increasingly indirect influence upon 'elements of a collective'. The atomic clock of GPS 'affords an image of completion of globalisation' (Mackenzie, 2002 :91) which, according to Virilio, leads to a 'globalization of location'. Developments in temporal synchronisations have been made possible through the increasing role of satellites in civil communications.

In 1994 telecommunications entrepreneur Craig McCaw joined forces with Bill Gates of Microsoft to fund McCaw's vision of what he saw as the 'Internet-in-the-Sky' – known as 'Teledesic'. In 1994 Teledesic applied for an FCC license to build, launch, and operate a range of 844 satellites in Low Earth Orbit (LEO) to 'reinvent networking, global access, and even the global telecommunications infrastructure' (Pelton, 2000: 77). Through the infrastructure of these 844 satellites the company envisioned linking all possible homes to the Internet, to transmit the majority of business video conferencing, as well as doubling as a phone operator in such underdeveloped areas where there were no existing phone facilities. Its objective was to provide affordable access to global network connections, especially to those regions that would not otherwise have the capacity to. As previously noted, the splintering of urban regions through privileged networks (Graham and Marvin, 2001) is becoming a major barrier to equality of access and fuelling the infamous 'digital divide'. As Daniel Kohn, spokesperson for the Teledesic Corporation, states: 'In most of the world, fiber deployment will never likely happen' (Kohn, 1996). Similar to the 'piggybacking' on old technologies the telecommunications industry recognizes that

> to the extent the digital revolution is tied to wires, it is just an extension of the industrial age paradigm. Like the highways and the railways before that, wires are rigidly dedicated to particular locations. If you live along side the main line you prosper. If you live a few miles distant, you are left behind (Kohn, 1996).

In the new structure of satellite broadband Kohn tells us that access is 'indifferent to location', making this a more egalitarian technology. And since the technology aims to cover the entire globe, it will automatically provide access-location to developing regions by providing it to the developed ones: 'It is a form of cross-subsidy from the advanced markets to the developing world, but one that does not have to be enforced by regulation but rather is inherent in the technology' (Kohn, 1996). Teledesic promotes itself as a local service that is provided through a global network to create 'the vision of a Global Information Infrastructure to all the world's citizens' (Kohn, 1996). Such a 21st century global broadband satellite system proposes a new perspective upon a networked future.

Now that Teledesic has combined with other key players in this area to form what has been dubbed the "Dream Team" of satellite communications - Motorola, Boeing, Matra Marconi Space, and Teledesic – the project has increased its investment package and reduced the number of required LEO satellites to 288. Other major players, such as Spaceway; Cyberstar; Astrolink (Lockheed Martin), and Skybridge (Alcatel), are attempting to get in on the act, potentially turning the skies into congested space(s) with hundreds of Low Earth Orbit satellites vying for consumer connectivity. Space, time, and location are notions no longer tied to fixed frames of reference; they are becoming fluid, flexible, adaptable, and thus open to re-configurings. Space is being transformed into co-space, to be shared in time if not in practicality: and it is a space that can be tracked, located, and guided. The 'global information infrastructure' has the potential to enable regions once obscured to become known; or individual places to be co-visited. Yet the tracking of complex interrelations of information flows can be as much a restrictive, malignant coverage as it can be benign. As was mentioned briefly in Chapter Two, military research into complexity studies is beginning to inform operational strategies.

Clandestine Complexities

In 2002 the US Pentagon's DARPA (Defense Advanced Research Project Agency) responded to the lack of intelligence data after the September 11th attacks by establishing the 'Total Information Awareness' office, commandeered by John Poindexter (the ex-retired Navy Admiral, and one-time National Security Advisor to President Reagan). According to Poindexter's own words,

> We must be able to detect, classify, identify, and track…This is a high level, visionary, functional view of the world-wide system…The mission here is to take the competing hypotheses from the analytical environment and estimate a range of plausible futures. The objective is to identify common nodes, representing situations that could occur, and to explore the probable impact of various actions or interventions that authorities might make in response to these situations. (Poindexter, 2002)

The latest program in this project is the *Space Based Infrared System* (called SBIRS High) that aims to track all global infra-red signatures as well as, what is termed, 'counterspace situational awareness' (Dinerman, 2004). The 80s 'Star Wars' missile defence project of Reaganite US security policy has been craftily converted into intercepting the enemy of today: not missile flows, but networked information. The US military also has in operation the IKONOS remote sensing satellite, which travels at 17, 000 mph 423 miles into space, circumnavigating the globe every 98 minutes, with a 3-foot resolution capacity. Such satellites belong to the private company Space Imaging Inc, who work for the military due to US law that restricts the US government operating upon their own soil (Brzezinski, 2004). Also, the US military RADARSAT satellite uses radar to see through clouds, smoke and dust. The US National Security Agency (NSA) utilizes top of the range KEYHOLE-11 satellites that have a 10-inch resolution, which means headlines can be read from someone sitting on a bench in Iran, although this resolution remains officially unacknowledged (Brzezinski, 2004).

As an example of more distributed and networked surveillance, many bridges within North America have acoustic sensors and underwater sonar devices anchored to the base of the bridges to check for the presence of divers, to prevent anyone from placing explosives on the riverbed. These devices are then linked to a central hub for monitoring information feedback. Such post 9-11 fears have led to the setting up of USHomeGuard, a private company established by Jay Walker (founder of Priceline.com), which utilises over a million webcams to watch over 47,000 pieces of critical infrastructure across the US, eg; pipelines, chemical plants, bridges, dams. These webcams are monitored continuously by observers working from home (Brzezinski, 2004). Crandall sees this as a part of the emerging 'contemporary regime of spectacle…machine-aided process of disciplinary attentiveness, embodied in practice, that is bound up within the demands of a new production and security regime' (Crandall, 2005). This operational practice, as Crandall sees it, confirms a 'codification of movement' and 'manoeuvres of strategic possibility', and leading to a 'resurgence in temporal and locational specificity' (Crandall, 2005), with this being related directly with the US military construction towards a network of complete coverage: in their terms, 'full spectrum dominance'.[83] In 1997 the Chief of Staff of the US Air Force predicted that within three years 'we shall be capable of finding, tracking, and targeting virtually in real time any significant element moving on the face of the earth' (cited in Crandall, 2005).

In this ironic twist on the nature of complex systems, it appears that the US industrial-military machine is attempting to enclose the global open system; to transform it and enmesh it within a closed system of total information awareness; to cover, track, and gaze omnisciently over all flows, mobilities, and transactions. It is a move towards a total system, an attempt to gain some degree of mastery over the unpredictability and bifurcatory nature of complex systems, through the core component of dominating the flows of information. It can also be seen as a move from complexity to hierarchy. The US military are currently establishing a linkage of satellites into what has been dubbed the military 'Internet in the sky', which will form part of their secure informational network named as the Global Information Grid, or GIG (Weiner, 2004). First conceived in 1998, and now in construction, $200 billion has already been estimated as a cost for both the hardware and software (Weiner, 2004). This war-net, as the military also term it, forms the core of the US military's move towards network-centric warfare (Arquilla and

[83] 'Full Spectrum Dominance' is a key term used in the Joint Vision 2020 report – a document outlining future visions for the US Department of Defense. See http://www.defenselink.mil/news/Jun2000/n06022000_20006025.html

Ronfeldt, 2001a; Arquilla and Ronfeldt, 2001b; Dickey, 2004; Weiner, 2004). The chief information officer at the US Defense Department was noted for saying that 'net-centric principles were becoming "the centre of gravity" for war planners' (Weiner, 2004). Some of the names of the military contractors involved in this project include Boeing; Cisco Systems, Hewlett-Packard; IBM; Lockheed Martin; Microsoft; Raytheon; and Sun Microsystems (Weiner, 2004). As part of this complete coverage – or 'full spectrum dominance' – the US military hopes to be able to communicate and control an increasing arsenal of unmanned air vehicles (UAVs) and unmanned ground vehicles (UGVs), integrated into what they are calling the 'Multimedia Intelligent Network of Unattended Mobile Agents' (Minuteman). This in turn is part of a larger military project on Intelligent Autonomous Agent Systems (Science-Daily, 2002).

This shift in military affairs involves re-strategizing informational systems toward what the military see as a 'transformational communications architecture' to 'help create a nimbler, more lethal military force to which information is as vital as water and ammunition' (Dickey, 2004). Brig. Gen. Robert Lennox, deputy chief of the Army Space and Missile Defense Command, describes the military vision as 'one seamless battlefield, which is linked without the bounds of time or space, to knowledge centres, and deployment bases throughout the world' (Dickey, 2004). Beginning in 2008 the US Navy plans to replace its Ultra High Frequency Follow-On satellite network with a Mobile User Objective System which will provide voice and data communications through wireless hand-held receivers as part of the Global Information Grid (GIG). The 'Internet in the Sky' that will form part of the GIG will consist of both AEHF and TSAT satellite programs (Dickey, 2004). Each AEHF satellite has the capacity to serve as many as 4,000 networks and 6,000 users at once; and the proposed TSAT satellites are claimed to be ten times more powerful than the AEHF. These proposals are currently underway as part of the US's 'revolution in military affairs' to develop not only a superior battlefield information network but also to 'extend the information grid to deploy mobile users around the globe, creating a new capability for combat communications on the move' (Dickey, 2004). The complexity of security communications and sensitive information is being targeted within military strategy in an effort to enclose all; to survey the full spectrum of an open system in a bid to collect and contain. In short, to transform the unknown into a known closed system: the containment of complexity. This also can be seen within the security of complexity, circulation, and contingency.

Dillon sees circulation as a term that emphasises the situation/problems put forward by complex interdependencies and flows in a world of global in-securities. This 'global security problematic' is concerned with the circulation of everything, Dillon states, as 'in a systemically interdependent world everything is connected or, in principle, is able to be connected, to everything else' (Dillon, 2005). For Dillon, circulation shifts the new global security problematic 'from a "geo-strategic" into an "ecological" problem characterised by the escalatory dynamics of complex interdependencies' (Dillon, 2005). In Dillon's world, complex systems are socio-technical systems, hybrids of the interface between the human and the technical so that security on a global level necessarily must shift to view this alliance as a problematic whole. And the more complex these interdependencies become, the more contingent becomes their operation, according to Dillon. The challenge of global security in this context lies in the contingency between calculability and doubt. Dillon further sees this as being behind the trend in US military affairs towards the complexity sciences: 'the fascination of military-strategic science in the United States especially with complexity, chaos, nonlinearity and the new science of life introduced by the digital and molecular revolutions has proclaimed as much since the early 1990s' (Dillon, 2003).

Security and power relations transcend traditional boundaries in such a geo-spatial environment of complex informational interrelations and circulations. Relations of sensitive informational networks are being 'enacted between living things – of life as the fluid dynamic, co-evolutionary and miscegenating, power of contingent (complex adaptive) systems' (Dillon, 2003). Security is both socio-technical and biometric: complexity operates at contingencies of the human level as well as at the level of complex biological informational systems. The security problematic is becoming increasingly virtual and codified, ordered with attempted control of disorder (Dillon, 2003), and thus the new complexities of the social are marking novel cartographic domains. The militarization of complexity has serious implications for issues of civil liberty, and notions of the surveillance state. Although not specifically dealt with in the research here, the presence of such military manoeuvrings remains consistently a concern.

Such domains of complex interdependencies are radicalising, in a militaristic sense, information, communication, command, control, and surveillance

(Dillon, 2003). The internal/external circulation and flows characteristic of complex, open systems are under interrogation from Western hegemonic, specifically US, military strategies in an attempt to close them down, plug-up the pores of flows and to blanket-coverage all potential contingencies. These are the operations of clandestine complexities: the effort to contain the unpredictability of complex systems into mapped cartographies of control. However, this is an impossible task. The uncertainty and dynamism of complex systems cannot be contained or denied. Information informs flows: this is a central feature of complex negentropic systems. Information within systems is not static or permanently quarantined: it is received, stored, and utilised. The global social system, as a complex entity emphasised here, cannot be totally known since it contains its own inherent doubts and multiple path(s).

However, the decentralised and de-localised nature of complex information communications are being recognised as leading to mobile manoeuvring, or what Crandall (2005) sees as manoeuvres of strategic positionality. US Military strategist Libicki sees emerging networks as being ‘the silicon equivalent of conversations between intelligent agents’ (Libicki, 2004), whereby future nets will form a mesh of interrelated communications between multiple devices on the move. Such locationing technologies present a world where ‘every object and human is tagged with information specifications including history and position – a world of information overlays that is no longer virtual but wedded to objects, places, and positions’ (Crandall, 2005). Such meshing of the physical and the digital through the medium of sentient communicators is what is foreseen here as steering discourse towards the new complexities, or the hyper-complex. And military strategies/technologies are the forerunner towards appropriation with civil technologies. For example, by 2003 a quarter of all rental vehicles at US agencies used some form of GPS tracking: not only for driver-location but also for the rental agency to know where the car has travelled, and its speed. Also, cars with speakerphones can be enabled from remote devices in order to listen in and eavesdrop on occupants in a car under surveillance, as has been utilized by police forces in the US (Brzezinski, 2004). This 'un-wiring' of the world can have serious implications upon increasingly surveyed, tracked, and mapped social practices. For this reason the complexity sciences offer a timely and relevant model in which to understand the increasing moves towards an informationally pervasive and networked environment.

The new complexities of systemic interrelations of connectivity and communication are merging into a world where everyday objects are being networked, such that a recent UN report predicts the likely future scenario to be prompted by an 'Internet of things' (Biddlecombe, 2005). It is to emerging spatial landscapes and geographies of mapping, of geospatial information integration technologies, and the 'Internet of things', that this thesis now turns.

Complex Cartographies

Visions of an interconnected future are on the rise, from serious media reports that sees ubiquitous connectivity as coming through cheap sensors proving feedback flows of digital data (Adam, 2004b); to computerising the body. In the summer of 2004 US computer software giant Microsoft was awarded a patent[84] that gave Microsoft exclusive rights to a technology that uses the electrical capacity of the human body to act as a computer network (Adam, 2004a). In this scenario the 'technology could combine with chips and sensors fitted around our bodies and clothes to sense and react to the changing circumstances of our everyday lives' (Adam, 2004a), which supports what Bill Gates himself has said about the computer finally disappearing into the environment and world around us that we inhabit (Gibson, 2005). Gate's vision is for computers to become almost invisible as they are integrated into daily activities. This vision is being accelerated by such developments as the so-called 'Specknet' which are grain-sized semiconductors, combining sensing, computer processing and wireless communication, to form a network that can literally be 'one day be sprayed onto surfaces like paint onto walls to give computers access to places previously out of reach...to link the physical and digital world in a kind of computational aura' (Staedter, 2005). Information flows of access and identification characterise the new cartographies of complex socio-technical systemic interrelations and interdependencies.

Emerging geographies and spatial landscapes that are sensored and networked can also serve to reaffirm space and place. As Crandall states, it is 'about a semiotics of mobility, yet is also **a fundamental reassertion of temporal and locational specificity**' (Crandall, 2005 - bold in original). Significant cartographies are emerging as part of the new infrastructures of a

[84] US patent 6, 754, 472 – 'Method and apparatus for transmitting power and data using the human body'

physical-digital landscape linking place and space into a systemic relationship. An augmented social landscape that registers the environment and interacts with it informationally is being envisioned as the next stage in ubiquitous computing. The 2004 report ‘Infrastructure for the New Geography’ from the Institute for the Future (IFTF) outlines a physical landscape that will be a likely possibility within the next decade:

> Wireless location-aware devices, new geospatial software, global location services, and online geodata repositories are all eroding the limitations to human perception, making accessible a rich spectrum of digital information in real time and in real place. The physical landscape we move in will become “deep” with vast amounts of digital information – in text, images, and other sensory forms. (Liebhold, 2004: 2)

The relationships, processes, and flows between people, physical objects and the environment will make implicit information explicit, engagement between the physical and the digital will become more commonplace, and perhaps in time, an accepted interface. These are the scenarios presented by emerging applications of location-specific, informationally-augmented objects. The miniaturisation of technology will create sensors able to be embedded into physical environments that will mesh with existing systemic interrelations, thus expanding the complexity of social-technical engagements, and leading to what has been termed the ‘new geospatial web’ (Liebhold, 2004). According to the IFTF report the key elements in this geospatial web are:

- Location-sensing techniques
- Geocoded data and information

- Geospatial information integration technologies
- Comprehensive geodata search
- Location-aware applications
- Location-based services
- Geospatial standards
- Geospatial polices (Liebhold, 2004: 5)

Many of these issues are based upon location-sensing technology which forms part of the geo-positional satellite (GPS) infrastructure now being put in place and in orbit. This technology has already, and will increasingly be, placed into commercial/civil devices, from car navigation, to handheld PDAs, and phones, as well as within items of clothing and physical structures. This trend will continue as it incorporates Radio Frequency Identification tagging (RFID) and sensor technology in its move over from military and commercial tracking[85] into civil technologies of convenience and benefit.

Digital geocoded data and information is replacing traditional cartographic methods of landscape mapping through layering simulations of geophysical data obtained through satellite imaging, and physical environmental sensors. Cartographic hypermedia is also being provided by the sudden rise in online mapping merging with locational devices. I return to both these topics in more detail later. Yet what these shifts indicate is the physical world is undergoing increased ordering through informational feedback systems and

[85] For a number of years both the US military and such corporate entities such as UPS have been using RFID technology to track the movement of their goods.

tracking. Such ordering is being integrated into the vastly expanded capabilities of search programs:

> A comprehensive geodata search must ultimately include the ability to retrieve all the attributes of a place – descriptions of its features, maps, aerial and satellite images, plus narrative information about the place. In short, it's a way for users to discover the full digital richness of any place on earth. (Liebhold, 2004: 14)

These developments accelerate the need, and demand, for location-aware applications to be both embedded in physical environments, as interfaces and/or receivers/transmitters, as well as in mobile devices.

The development of sentient networked environments will go some way towards creating a physical-digital environment operating in real-time. Computer scientist Vernor Vinge suggests a possible future where

> in the social, human layers of the Internet, we need to devise and experiment with large-scale architectures for collaboration. We need linguists and artificial-intelligence researchers to extend the capabilities of search engines and social networks to produce services that can bridge barriers created by technical jargon and forge links between unrelated specialties. (Vinge, 2006: 411)

A new geospatial literacy will need to inform social practices in the scenario that Vinge suggests; a literacy that is common tongue rather than specialised and tech-elite in order to better navigate the emerging relations of processes and interactions between the physical and the digital. The formation of a systemic relationship of interconnections and interdependencies between humans, objects/machines, and the environment has led some commentators to speak of an emerging cybernomadic landscape (Saveri, 2004). Here, the emphasis is on an embedded sensory world that will influence and fundamentally alter social practices. Such a cybernomadic landscape is described, in a recent IFTF report, as 'the distributed and interconnected physical, digital and human network of places, spaces, relationships, and reputations' (Saveri, 2004: 2), defined by three primary forces of physical-digital fusion; the augmented self; and digitally catalysed masses.

There are an increasing number of voices who predict that, in the coming decade, sensing devices 'will have the most profound effect yet, as they bring information, awareness, and responsiveness to the objects, places, and people around us' (Saveri, 2004: 5) that will unfold new forms of social connectivity and communication. A sensor-based socially augmented sentient environment will accelerate both the perceptions of the individual as well as their responsiveness, as is characteristic of feedback-responsive complex systems. Only this time the social will have become enmeshed within the hypercomplexity of real-time systemic participation. De Rosnay sees this future as a form of symbiotic humanity: 'each person functions as a node in this hypernetwork. Symbiotic humanity is both the totality of the network and one of its elements; it exists through the network and the network exists only through it' (de Rosnay, 2000: 143). De Rosnay envisions this symbiosis as leading to a 'copiloting of complexity' in which he reveals that

> the new culture of complexity includes the values of symbiosis. It promotes the integration of differences and respect for diversity. It connects the natural and the artificial in a broad vision of nature and civilisation. The cybiont and symbiotic humanity are the thought models for this synthesis. (de Rosnay, 2000: 240)

Whilst De Rosnay terms this systemic interdependency the 'cybiont', others see it as an 'Internet of things' (Biddlecombe, 2005; IFTF, 2004; Saveri, 2004), and also somewhat less computer-savvy as 'digital Gaia' (Vinge, 2006). In all cases it involves the networking with, utilizing, and interacting with objects, something which futurist and author Bruce Sterling terms as 'shaping things' (Sterling, 2005). Sterling refers to a society of shaped things as a synchronic society:

> A SYNCHRONIC SOCIETY generates trillions of catalogable, searchable, trackable trajectories: patterns of design, manufacturing, distribution and recycling…Embedded in a monitored space and time and wrapped in a haze of process, no object stands alone; it is not a static thing, but a shaping-thing. (Sterling, 2005: 50)

And a 'shaped-thing' may in the future rely upon more efficient and ubiquitous radio frequency identification (RFID) tags, now often euphemistically termed as *arphids*. These RFID tags can be networked into a global system of positioning and identification:

> Your arphid monitors are hooked into the satellite based Global Positioning System. Then your network becomes a mobile system of interlinked objects that are traceable across the planet's surface, from outer space, with one-meter accuracy, around the clock, from pole to pole. (Sterling, 2005: 92)

A physical-digital augmented environment interlinked with objects is, as Sterling states, based upon identification. Objects, as well as individuals, need to be identified, both in their object-self identity as well as in their positions. An object which becomes embedded into a socio-technical environment is, for Sterling, termed a SPIME. Sterling, not coy to name a term, considers the development of SPIMES in 3 stages:

> - First, we have the capacity for identity - the code - which is modestly pasted onto the object
> - In the second stage, a much thicker and more capable identity is embedded into the object, and that identity is historically traced
> - In the third stage, the means of production are re-engineered around the capacity for identity. The object becomes an instantiation of identity. It's named, and it broadcasts its name, and then it can be tracked. That's a SPIME. (Sterling, 2005: 104)

Julian Bleecker, Research fellow at the Annenberg Center for Communication, in a recent paper titled 'A Manifesto for Networked Objects — Cohabiting with Pigeons, Arphids and Aibos in the Internet of Things' refers to networked objects as 'blogjects':

> To distinguish the instrumental character of "things" connected to the Internet from "things" participating within the Internet of social networks, I use the neologism "Blogject" — 'objects that blog.' "Blogject" is a neologism that's meant to focus attention on the participation of "objects" and "things" in the sphere of networked social discourse...The Blogject is a kind of early ancestor to the Spime, Bruce Sterling's resonant, single-syllable noun for things that are searchable, track their location, usage histories and discourse with the other things around them. (Bleecker, 2005: 2)

In a similar manner to Sterling's SPIMES, these blogjects leave deliberate digital traces and actively participate within the feedback-responsive network of which they are a part:

- Blogjects track and trace where they are and where they've been
- Blogjects have self-contained (embedded) histories of their encounters and experiences
- Blogjects always have some form of agency — they can foment action and participate; they have an assertive voice within the social web

(Bleecker, 2005: 6)

These developments as outlined in the 'Internet of Things' can be modelled using complexity theory as networked devices of mobile communication flows that merge with digitised data into active, complex systemic physical-digital spaces and environments that are informing new geophysical relationships. Further, such an emerging geoweb of sentient artefacts is sustained and fed through increased information flows, as in complex systems. One of the rapid growth areas of the physical-digital online web is through online mapping, and the phenomenon of mash-ups.

Mapping a New Geography

Mobility not only deals with movements through a physical landscape; new mobilities incorporate a capacity to merge, and move between, both physical and digital geographies, through relations of connectivity, communication, and information. Mobility is increasingly about being in a mesh of data –

enmeshed in a developing sensored environment. Such a landscape involves accelerated complexities of networks and systems, of collective collaboration and information-sharing nodes and artefacts. Emerging trends envision a gradual dissolving of the material and cognitive barriers between human, machine/artefact, and environment. As such, newer territories require newer maps.

Baudrillard, a quarter of a century previously, had talked of the simulation as no longer representing the territory (Baudrillard, 1994). For Baudrillard the successive generation of models had replaced 'the real' by the hyperreal: 'the territory no longer precedes the map, nor does it survive it. It is nevertheless the map that precedes the territory' (Baudrillard, 1994: 1). In Baudrillard's approach he overturned the logic of general semantics to invert the map and the territory. Lord Alfred Korzybski's study of non-Aristotelean systems and general semantics considered humankind's relationship to the world in view of fluid meanings and contexts. Korzybski's seminal phrase was '*The map is not the territory*'.[86] In this sense, humankind is free to make all kinds of possible maps and models to represent the world, yet the result is to do no more than to approximate actual physical phenomena.

According to Korzybski's 'General Semantics', reality cannot be known since humans are linguistically tied to structures of representation that in turn affect our senses and neuro-linguistic programming. Like Baudrillard, however, we are consistently updating our maps to the extent that they may replace all semblance of the territory forever. In this context, Baudrillard

[86] For more information see http://en.wikipedia.org/wiki/Alfred_Korzybski

(1994) makes reference to Jorge Luis Borges whose fable *Viajes de varones prudentes* talks of a great Empire that created a map that was so detailed it was as large as the Empire itself. The actual map itself grew and decayed as the Empire itself conquered or lost territory. When the Empire finally crumbled, all that remained was the map:

> In that Empire, the Art of Cartography attained such Perfection that the map of a single Province occupied the entirety of a City, and the map of the Empire, the entirety of a Province. In time, those Unconscionable Maps no longer satisfied, and the Cartographers Guilds struck a Map of the Empire whose size was that of the Empire, and which coincided point for point with it. The following Generations, who were not so fond of the Study of Cartography as their Forebears had been, saw that that vast Map was Useless, and not without some Pitilessness was it, that they delivered it up to the Inclemencies of Sun and Winters. In the Deserts of the West, still today, there are Tattered Ruins of that Map, inhabited by Animals and Beggars; in all the Land there is no other Relic of the Disciplines of Geography. (Borges, 1999/1975: 212)

In Baudrillard's interpretation it is the map in which we live; a simulation of reality. Yet here the map is presented as being in tatters, as a copy of a copy of a copy, a simulacra of the original.

This thesis puts forward the notion that recently there have been shifts towards a different cartography; a much altered one such that the map is no longer being placed over the territory as a papered-veil but rather is meshing together: the territory is becoming the map as the environment increasingly becomes sentient and wired into a pervasive digital-physical systemic-global whole. Whilst this may have similarities to the visions of a noosphere

(Chardin, 1959; 1969; 1974) and/or the global brain (Bloom, 2000; Dyson, 1997; Heylighen, 1997; Provencal, 1998; Russell, 1995; Stock, 1993), this development takes a step further towards a functional geoweb of physical-digital interaction in real-time. By way of example I turn now to look at some of the early stages in technically-mediated geographical mappings.

The rise in digital mapping that is informing mobile users are layered with information and geodata. Such maps are building upon earlier cartographic representations of location in order to offer up-to-the-minute information about a specific location as well as links to further, more specialised, information about each place. Digital maps are integrating comprehensive search data with identity profiling. No wonder then that Google, the pre-eminent search engine, was one of the first to utilise their search resources into mapping services: Google Maps and Google Earth. Google Maps, as the name suggests, offers a street map satellite image to a location search-word, or postcode. From this the user can ask for a list of restaurants, for example, within the requested area and be shown digital pointers to each restaurant that appears also in the Google search engine. In this way, Google has simply superimposed its search engine with visual mapping facilities. This application, like others similar, can be downloaded to any compatible handheld device with Internet connection. An extension of Google Maps, in range and complexity, is Google Earth, an application that allows the user to move to any location worldwide upon a 3-D globe, to focus in on virtually any street in any city using satellite maps. Google states that its satellite map images are taken from the last 3 years and are updated on what they term as a 'rolling basis'.[87] Most cities are covered in high resolution whereby streets, houses, cars, and statues, etc, can be seen. Other locations, in more rural or sensitive areas, do not have so high a resolution. Saying this, a user, in a matter of a minute, can focus quite clearly upon such places as The Forbidden City in Beijing, China; as well as Pyongyang, North Korea. The resolution for these cities is such that the user/viewer is able to magnify to the level whereby vehicles and statues are visible.

What makes Google Earth of greater significance is that it is open to user-collaboration and additions. In this way other users are able to create add-ons that further supply location-pins and information links to online sources and images about specific sites. In the case of North Korea one adventurous user has meticulously created the location-placemarks for over 330 sites in North Korea which picks out anti-aircraft locations as well as museums, schools, and the inevitable statues of Kim II – Sung. Google Earth is also being used for mapping, and tracking, how the avian flu outbreak is travelling. The journal 'Nature' has created its own mash-up on avian-flu outbreaks which integrates its data regularly from the World Health Organisation and the UN Food and Agricultural Organisation (Butler, 2006b). From Google Maps & Google Earth has spawned the phenomenon of digital map '*mashups*', which is important for social networks of mobility.

A 'mashup' is a World Wide Web application that combines content from various sources into a single application, like a mosaic. And digital maps are becoming a prime source for mashups since Google publicly released its

[87] Details at: http://earth.google.com/faq.html#20

application programming interface in order to enable users to develop their own maps to piggyback on Google's – hence the mapping mashups. In this sense such applications are indeed bridging the gap between physical and digital geographies and scapes:

> Online mapping is evolving into a historic nexus of disparate technologies and communities that is changing the fundamental use of the Internet, as well as redefining the concept of maps in our culture. Along the way, map mashups are providing perhaps the clearest idea yet of commercial applications for the generation of so-called social technologies they represent. (Mills, 2005)

Such commercial applications as referred to here can include location-points for restaurants, cinemas, shops, etc. Also, a newly released online mapping service called MapEngine allows businesses to integrate maps with directions and other location-specific information into their websites. However, in terms of civil and user functionality and applicability mashups are being appropriated for practical geodata such as hurricane movements, petrol prices, and crime statistics (One of the more popular Google Maps mashups is the Chicago Crime map where crimes are listed by type, street, district, postcode, etc). Other examples include real estate and travel mashups: *Dartmaps*[88] offers real-time locations of commuter trains in Dublin; *FBOweb*[89] provides tracking for airline flight status over North America; *TravelPost* allows travellers to post journal entries and photos onto maps, as well as providing hotel reviews. For real estate, *HomePriceRecords*[90] lists the

[88] See http://dartmaps.mackers.com/
[89] See http://www.fboweb.com/fb40/login/
[90] See http://homepricerecords.com/

price people paid for their houses whilst *HomePages*[91] combines data on houses for sale with details on neighbourhood information such as school and park locations.

Other types of mashups concentrate on local community information such as people sharing maps on local walks; maps that feature potholes in roads or dangerous areas; or more global-community events such as major sporting events.[92] These applications are increasingly being made available for mobile devices such as PDAs and smartphones in order to further strengthen social networks, in collaboration with a sporadic increase in local neighbourhood information. *Blogmapper*[93] for example, allows bloggers to create maps for their blog entries in order to locate their web-talk to actual physical localities. *Placeopedia*[94] is an online site that maps physical places to locations mentioned in Wikipedia articles, discussed previously. In a more creative and innovative manner there is the research of *Bio Mapping,*[95] a research project that explores how individuals can make use of information about their own bodies:

> The Bio Mapping tool allows the wearer to record their Galvanic Skin Response (GSR), which is a simple indicator of emotional arousal in conjunction with their geographical location. This can be used to plot a map that highlights point of high and low arousal. By sharing this data we can construct maps that visualise where we as a community feel stressed and excited. (http://biomapping.net/)

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[91] See http://www.homepages.com/

[92] 'Virtually Torino' offers a mashup on the Winter Olympics at Torino to show where the specific events are taking place - http://googleblog.blogspot.com/2006/02/virtually-torino.html

[93] See http://blogmapper.com/

[94] See http://www.placeopedia.com/

[95] See http://biomapping.net/

The rate of information feedback is moving into real-time. Not only biology but social systems – traffic, people, places – are being brought into a complex loop of data streaming. One such corporate project is Microsoft's research into real-time navigation: 'Senseweb'.

Senseweb aims to stream real-time traffic conditions direct from department of transport webcams to give users a visual rendition of local conditions. This will be supplemented by up-to-the-minute information on the availability of local parking spaces, local petrol prices, as well as temperature forecasts. Other information to be included will be real-time data streamed from participating restaurants, via a device linked to Microsoft's central database, giving information on seating spaces and waiting times (Greene, 2006). Eventually it is hoped that Senseweb will be incorporated into Windows Live Local (Microsoft's 'Virtual Earth' online mapping platform): 'By tracking real-life conditions, which are supplied directly by people or automated sensor equipment, and correlating that data with a searchable map, people could have a better idea of the activities going on in their local areas' (Greene, 2006). At present the major software companies, such as Google and Yahoo, are racing to produce a prominent online mapping platform that will utilise real-time data streaming in order to assist mobile navigation. However, any user participating with these major mapping programs will inevitably have to sacrifice some of their own information as part of registration. To be able to make 'more informed decisions', as Microsoft publicises, a person in return must willingly give up information about their own movements, whereabouts, social habits, purchasing preferences, and identity. Mobility is increasingly incorporating a burden for the person wishing to be mobile.

Complex mobilities incorporate a capacity to merge, and move between, both physical and digital geographies, through relations of connectivity, communication, and information. Mobility is increasingly about being in a mesh of data – enmeshed in a developing sensored environment whereby information is processed by multiple parties. In order to move legitimately, such a person has to accept incorporation into a complex network of informational tracking and verifications; mobility within the surveillance of mobility:

> Along with the increasing incorporation of devices such as mobile phones, laptop computers, wireless devices, and the Internet into everyday mobilities, practices of watching, following, and monitoring someone who is absent, far away, and on the move get at the crux of social relations in contemporary society (Germann Molz, 2006: 392).

The interrelations between corporate and civil use of such emerging capabilities are vying for user/market share with, as yet, ambiguous signs of how this software will influence social trends and navigation of local spaces. Yet as computing is predicted to become ever more ubiquitous it is expected to dissolve into physical surroundings, making itself almost invisible, forming complex interdependencies of information flows as part of an embedded environment (Greenfield, 2006).

Current research is developing towards an integration of physical mapping with digital data is what was described earlier as the 'Internet of Things' (Biddlecombe, 2005). Here, a technically augmented environment becomes interlinked with sensoring devices to form a complex feedback-responsive physical-digital system that facilitates accelerated information flows into a pervasive human-computer systemic environment. The complexity of such a system would far surpass any previous models and would go some way in combining both physical and digital/virtual worlds towards a more fully responsive and aware symbiotic relationship that would have significant implications for the social. Or, as Greenfield writes, the 'sheer complexity of ubiquitous systems' is yet to come (2006: 163). I turn now to examine this.

Sensoring the Ecosystem: towards a Digital Gaia

Technology leapfrogs upon technology and is constantly in need of updating, so it seems a reasonable request for the US Defense Advanced Research Projects Agency (DARPA) to consider today's computer maps of the Earth to be inaccurate. Recently much money has been poured into producing better computer generated terrain maps of the Earth using both radar and laser scanning (Piquepaille, 2005), with a future view for placing radio-towers on the moon or Mars. Even Google has attempted to slide in on the action by releasing Google Mars.[96] Yet whilst these infrastructures are reminiscent of the military-industrial complex agenda for *Total Information Awareness* or *Full Spectrum Dominance*, the future shifts appear to be in terms of smart sensors, whereby complex information-sharing computerised devices at the

[96] See: http://www.google.com/mars/

miniature, or even nano level, will be able to 24/7 monitor ecological, social, or biological environments and people:

> These new computers would take the form of networks of sensors with data-processing and transmission facilities built in. Millions or billions of tiny computers — called 'motes', 'nodes' or 'pods' — would be embedded into the fabric of the real world. They would act in concert, sharing the data that each of them gathers so as to process them into meaningful digital representations of the world. Researchers could tap into these 'sensor webs' to ask new questions or test hypotheses. Even when the scientists were busy elsewhere, the webs would go on analysing events autonomously, modifying their behaviour to suit their changing experience of the world. (Butler, 2006a)

Such a scenario would drastically alter the material and social fabric of the living world. The research and implementation for such networks are well under way. Gaetano Borriello, a computer scientist at the University of Washington, who works on integrating medical sensors with their surroundings — such as continuous monitors of heart rate and blood oxygen — is researching on how obtaining real-time data from the physical world via computerised sensor networks will alter the relationship between physical and digital.

Sensor webs are being developed for all kinds of ecological research, from tracking the flow of ice glaciers in Norway, soil diversity and nutrient cycling, to sensors strapped to pigeon flocks in order to measure the level of toxins and pollutants in the air through which they fly (Bleecker, 2005; Butler, 2006a). One project being undertaken between The Australian Institute of Marine Science (Aims) and James Cook University is called 'Digital Skins'. Here, smart sensors developed originally for use in nuclear power stations are placed in the ocean and also in water catchments on the mainland and communicate with each other to monitor events such as coral bleaching (Krausmann, 2006). The way it works is that each sensor has its own numerical address and operating system which uses GPS to locate itself. The information collected from the coral reef is then sent wirelessly – as far as 70 km in some instances – into a central database. Every day terabytes of information is collected which is then sent over a grid-computing system into networks of parallel processing which allows various research institutes to share their computer processing power in order to transcribe the collated information much faster (Krausmann, 2006). Various environmental research programs are being established which use wireless networked sensors to monitor and relay ecological information about the physical world through digital systems composed of hubs and nodes. Such a shift in complex systems of physical-digital information gathering is providing new insights into how human-environmental interrelations are impacting upon global processes.

Dr. Alexandra Isern, a program director at the US National Science Foundation (NSF) hopes to learn 'more about soil contaminants, land changes, water flow, invasive species, ocean cycles, continent formation, the places atmospheric carbon are stored, the reasons that volcanoes erupt and the ways viruses and gene fragments move through the environment' (Broad, 2005). Isern envisions motes - custom-designed computer chips and sensors that are wireless and powered by batteries or solar cells – as 'dotting swaths of North America and running through the waters of the West Coast from California to Canada' (Broad, 2005). In the past few years the NSF has spent more than $100 million in planning and research on new sensor research projects, and it foresees spending more than $1 billion in large ecological projects in the upcoming years. In one current project, in the San Jacinto Mountains in California, scientists are turning 30 acres of pines and hardwoods in California into a futuristic vision of environmental study: 'they are linking up more than 100 tiny sensors, robots, cameras and computers, which are beginning to paint an unusually detailed portrait of this lush world, home to more than 30 rare and endangered species' (Broad, 2005). However, the stakes are now bigger than relatively small regional sensoring.

Deborah Estrin, director of the Center for Embedded Networked Sensing in Los Angeles, California, sees 'the sensor-web revolution as an important thread in a grander tapestry of global monitoring, which involves billions of dollars being poured into projects to monitor the continents and oceans' (Butler, 2006a). For example, upcoming projects include:

- The $200 million EarthScope project from the NSF: 3,000 stations are to be erected that will 'track faint tremors, measure crustal deformation and make three-dimensional maps of the earth's interior from crust to core. Some 2,000 more instruments are to be mobile - wireless and sun- or wind-powered - and 400 devices are to move east in a wave from California across the nation over the course of a decade' (Broad, 2005)

- The National Ecological Observatory Network (NEON) is to be established at an estimated cost of $500 million. The plan is for a coast-to-coast NEON to 'involve perhaps 15 circular areas 250 miles in diameter, each including urban, suburban, agricultural, managed and wild lands. Each observatory would have radar for tracking birds and weather as well as many layers of motes and robots and sensors, including some on cranes in forest canopies' (Broad, 2005)

- The 'Interagency Working Group on Earth Observations', backed by the National Science & Technology Council within the Executive Office of the President, US, has recently published their *Strategic Plan for the U.S. Integrated Earth Observation System* (IWGEO, 2005). Their vision is to discover, access, collect, manage, archive, process, and model earth geological data in order to better forecast such flows as weather, energy resources, natural resources, pre and post-disasters, as well as a host of other integrated processes. In their words: 'The Earth is an integrated system. Therefore, all the processes that influence conditions on the Earth are linked and impact one another. A subtle change in one process can produce an important effect in another. A full understanding of these processes and the linkages between them require an integrated approach, including observation systems and their data streams' (IWGEO, 2005: 47)

The report *Strategic Plan for the U.S. Integrated Earth Observation System* (IWGEO, 2005) resembles a complexity science approach to the global environment. It talks of integrated systems and their interrelated nonlinear connections; how a subtle change can cause an important effect in the global system. However, a caveat here is required: the above projects for environmental mapping contain shades of a western geographical imagination. Cartography, as a pioneering navigational science and art, has long been used for validating colonial expansion, Imperial incursions, and for designating western territorial trophies. The geographical imagination is continually formed as residues of knowledge build one upon the other as images become re-appropriated for the emerging geographies. A geographical digital sensoring of continents and oceans can be seen as 'a globalizing intellectual imposition of the European geographical imagination' (Cosgrove, 2001: 12).

The western global imagination has participated in the de-centring of global geographies in past centuries, and may again be party to later digital formations of knowledge gathering and geo-strategies of dominance and power. As with the *Plan for the U.S. Integrated Earth Observation System* which aims to monitor, track, catalogue, and forecast global processes and movements, geographical spaces will be subjected to a digital western gaze. Denis Cosgrove views the western gaze as 'implicitly imperial, encompassing a geometric surface to be explored and mapped, inscribed with content, knowledge and authority' (2001: 15). Through such means Empires construct a world that is 'global, urban-centred, hierarchical, and visually distanciated' (Cosgrove, 2001: 21). As previously discussed, imperial hierarchical strategies are in contestation with shifts to decentralize and distribute informational processes through complex interrelations. It will therefore be significant to see how bottom-up and non-western strategies are successful in the mapping and dissemination of physical-digital information. A complexity theory approach to this position would posit an increased mesh of relations between people, objects, and environment towards a more inclusive integrated system, in contrast to top-down control architecture. This would be in-keeping with what is being discussed in relation to an 'Internet of things' (Biddlecombe, 2005) and a future sensored 'smart' environment populated by unseen ubiquitous computing (Greenfield, 2006).

The latest technological developments in mobile information-sharing devices are being developed into a strategy for Earth monitoring. It is a combined field of knowledge, development, and implementation that is required for making possible a more specialised awareness of global processes happening in real-time and which may have both hugely significant, and even catastrophic, effects upon a shared global future. The human-technical hybrid, the symbiotic working relationships between humans and their computerized devices/environments, and the accelerated mobility in the movements of information, people, objects, and needs are entwined with the global functioning of a complex systemic environment. The global systemic world may soon be moving towards a momentous shift, perhaps the most important paradigmatic shift since the Renaissance: it may be moving towards an integrated physical-digital global complexity in real time.

An Integrated Global Complexity in Real-Time

Current metaphors, themes, and trends seem to be those of intensity, acceleration, and technological innovation. Der Derian acknowledges Virilio when he states:

> As I see it, we've passed from the extended time of centuries and from the chronology of history to a time that will continue to grow ever more intensive...it leads to a radical reorganization both of our social mores and of our images of the world. This is the source of the feeling that we're faced with an epoch in many ways comparable to the Renaissance: it's an epoch in which the real world and our image of the world no longer coincide. (Der Derian, 2001: 119)

I agree with the initial observation that an ever increasing intensity will lead to a radical reorganisation of our social mores. However, as this thesis has shown, images of the world are steering towards a deliberate and more accurate representation of the real world, as computerised representations and collected data is forming a layered informational environment that serves to model physical reality. With a possible merger of human senses with silicon (and perhaps later quantum) networks, complexity that was earlier observed within human biology and the Earth's biosphere may converge into a more collaborative whole. This could indeed finally become, in a future envisioned state, the practical and working representation of a whole 'complex organism' concept that has so pervaded science-fiction, technological, and Internet circles for years; the culmination perhaps of the citizen-body commonwealth of Hobbes's Leviathan.

This thesis concludes by addressing issues that conceptualise a future of increased immersion in technologies of information; concepts taken from developing technologies along the lines of present trends. It is not fanciful, nor is it inevitable. Complexity behaviour informs that future states are unpredictable as much as they are partly mapped by increasing complexification. In keeping with this scenario the future could look like the following:

> In 15 years, we are likely to have processing power that is 1,000 times greater than today, and an even larger increase in the number of network-connected devices (such as tiny sensors and effectors). Among other things, these improvements will add a layer of networking beneath what we

> have today, to create a world come alive with trillions of tiny devices that know what they are, where they are and how to communicate with their near neighbours, and thus, with anything in the world. Much of the planetary sensing that is part of the scientific enterprise will be implicit in this new digital Gaia. The Internet will have leaked out, to become coincident with Earth. (Vinge, 2006)

Such a convergent end-point may be viewed as the logical outcome of an ever increasing global complexity (Chaisson, 1987; Chaisson and Chaisson, 2001; Wright, 2000). What Vinge refers to as the new digital Gaia is a global planetary sensoring networked through an upgraded Internet that has 'leaked out' into a human convergence. The human thus becomes a player within the feedback loops and informational processing of a truly global complex system. That such a vision may sound more utopian than anything is a valid criticism; yet possible futures have nearly always been born from vision rather than a lack of. With the decreasing cost of technology there is also some reason to hope that the developing countries may soon have the means to become equitable in access. However, as this chapter has noted, there are also clandestine complexities working within both the military-industrial-machine of *Full Spectrum Dominance*, as well as there being dictatorships that deliberately firewall civilian access and participation. These are obstacles that are not easily overcome, and access to personal information and how it is used is likely to be one of the central issues in the upcoming years as innovation struggles with ownership; as complex civil collaborations clash with centralised control.

Complex relations between people, objects, and information will be massively stepped up if there is a shift towards an 'Internet of things' with an embedded environment. In this scenario ubiquitous computing will be part of the social and natural environment as sensor microprocessors are lodged into everything from Nature, to buildings, to household objects, in such a way that it will become a pervasive presence. Greenfield rather optimistically considers this to be, in one form or another, an inevitability, and refers to this ubiquitous computing (ubicomp) paradigm as 'everyware':

> Everyware is information processing embedded in the objects and surfaces of everyday life...the extension of information-sensing, -processing, and -networking capabilities to entire classes of things we've never before thought of as "technology" (Greenfield, 2006: 18).

Greenfield writes that this state of ubicomp is one where information is made accessible at any point in space and time upon requirement such that social relations are enmeshed within an enveloping field of information that is more than the sum of its parts. By this Greenfield suggests that emergent effects are likely from the ubicomp environment as a person's relations with their environment becomes more whole, interdependent, and within a continual flow. The result being that 'where everyware is concerned, we can no longer expect *anything* to exist in isolation from anything else' (Greenfield, 2006: 128). Users, Greenfield asserts, will see their transactions with 'everyware' as being essentially social in nature yet remaining dynamic, unpredictable, and forming multiple networks:

> Before they are knit together, the systems that comprise everyware may appear to be relatively conventional, with well-

> understood interfaces and affordances. When interconnected, they will assuredly interact in emergent and unpredictable ways. (Greenfield, 2006: 141).

In this scenario complex relations with one's environment takes on emergent properties and acts as an inclusive temporal-spatial networked social habitus. As a caveat Greenfield does warn that 'everyware' has the potential for clandestine state use for monitoring and tracking, and urges that the choice to be 'on the Net' should always be a voluntary one. The optimistic assertions placed onto ubiquitous computing have so far avoided the more dystopian accounts of control being exerted over enmeshed individuals. The irreversible path dependence of complex systems can arguably 'lock-in' a monitored control society as well as an informational coded-society operating in real-time with greater advantages in mobility and communications. With such predictions of an increasingly sensored and enmeshed environment it is difficult to see how living 'off the Net' will be a choice.

Both utopian and dystopian scenarios appear to indicate an increased complexification of interrelations with daily objects and a person's immediate social environment. This will consist of multiple information flows, technically-mediated points of reference, and increased interactions with 'things', mediated via information-processing devices. Daily dealings with physical objects and routines are likely to be increasingly replaced by dealings with bits and flows of information. This seemingly can only lead to a further compression of time and space that was characterised as an early feature of globalisation (Beck, 1998; Robertson, 1992; Urry, 2003a). The emerging global complexity that is converging physical-digital scapes is thus also intensifying sites of place/space/time.

To emphasise the argument presented in this thesis, linear thinking is no longer an effective mode of analysis as multiple interrelations will make it almost impossible to predict how social relations will develop or progress. Complexity theory, at this stage, will represent a more suitable model for the social sciences to view multiple socio-technical interdependencies as person-object-environment becomes ever-more enmeshed within a functioning complex social system. What this thesis shows is that the complexity sciences can significantly represent how global-social processes are unfolding, and as such should be recognised as a convincing and significant model to understand, and interpret, the trajectory of unstable, nonlinear, and unpredictable social futures.

CONCLUSION

> 'To drown in treacle is just as unpleasant as to drown in mud. People today are in danger of drowning in information; but, because they have been taught that information is useful, they are more willing to drown than they need be. If they could handle information, they would not have to drown at all'
>
> 'It is not important to have said a thing first, or best – or even most interestingly. What is important is to say it on the right occasion'
>
> 'Knowledge is power, they say. But if only power were knowledge, that would be something worth thinking about'

Sayings of Idries Shah

In this thesis I have mapped/traced complexity theory and complexity science over several movements, linking it from empirical shifts around a body of literature on the physical sciences (Chapter One), to its overlaps and interpretations within the social sciences and various disciplinary fields (Chapter Two). I have also analysed the models, metaphors, and analogies of complexity theory, and how these metaphorical extrapolations have shifted and been appropriated. In this context my research first examined complexity, information, and entropy, within a socio-cultural context, with reference to biological analogies (Chapter Three). Here I showed that information flows are central to the maintenance of dynamic complex systems, and that analogous structures exist to social systems in the biological realms. The concept of information within social and biological networks moved this research onto examining the physical and theoretical implications of networks

(Chapter Four). Here I analysed the growth of networks, and network infrastructures, as a precursor to complex systems, ending with a shift towards possible applications. This formed a bridge to the next part of the thesis; namely, various ‘performances’ of complexity theory.

This latter section of the thesis included researched studies of the uses of the mobile phone for self-organised groupings – *smart mobs* – and several significant protest events where complex informational networks were shown to come into play. This led to a discussion of blogging and self-organised online networks (Chapter Five). This was a significant part of my research as it provided analytical data to be examined through a complexity theory perspective. Here I was able to apply complexity theory to case studies and find correspondences with how particular social practices are being performed in mediation with communication technologies. When I first began my research into blogging in 2003 this was largely an unknown realm of online activity. In the intervening years this phenomenon has undergone a rapid growth into what is currently an influential and much-publicised form of social interaction and engagement. This validates my original purpose for taking this subject as a significant topic upon which to focus. Naturally, such a topic outdates itself almost immediately and nearly on a daily basis reports and incidents have been appearing that corroborate what I have argued in this thesis. It would have been virtually impossible to combine all these developments into this research as it would have entailed a body of work that was under a constant state of dynamic and in-flux re-writing. This feature may be a testimony to the dynamic nature of complexity theory, yet it is impractical for my purposes here.

This thesis also examined how self-organised complex networks responded to the 2004 Indian Ocean tsunami (Chapter Six). This enabled me to gain material upon how various ad-hoc and bottom-up social networks were able to form and operate under sudden and testing circumstances. Some of the empirical data was surprising in the level, intensity, and sheer scale of participation. From this part of my research particularly I learned to appreciate how complex interrelationships can manoeuvre around traditional forms of human communication to produce emergent effects of startling potential. Whether overly optimistic or not, I felt it necessary to show how complexity as a theory could 'perform' under these unexpected circumstances.

This led me to the final segment on 'performing complexity' where I examined complex forms of technically-mediated cooperation, followed by interventions into civil society as well as non-cooperative complexities versus hierarchical control structures (Chapter Seven). It was indeed clear in this research that technically-mediated connections can neither be assumed nor expected, and as such require an effort to maintain - and often a struggle. These contestations are important in the ongoing research into complex systems. Potential future(s) are not certainties; instead, they involve negotiations and movement in the understanding that circumstances, as well as networks, ties, bonds, and relations, are things in flux.

Finally, I addressed the implications of complexity theory for possible future(s) of systemic, networked physical-digital spaces and complex global interrelations and interdependencies of communication (Chapter Eight). I examined possible scenarios in the way complex processes may re-formulate and re-construct social environments. I found that increased social complexity not only suggests novel ways in which to negotiate place, space, and time, but also that it infers dominant technological ties and dependencies.

These forays and investigations into the emergence of complex, technically-mediated flows of informational physical-digital relations formed the features of what I term the '*New Complexities*.' These *new complexities* are forms of mobilities that deal with re-configured relations between people, places, objects, and environment. The final chapter finished by stating that daily dealings with physical objects and routines will be increasingly supplemented by dealings with 'bits' and complex interrelated flows of information. What the *new complexities* cover are shifts in social relations and behaviour once certain digital communication technologies become a principal mediator in the connection and interrelations between people and their daily, social contacts.

Complexity theory, as a theoretical mode of analysis within the social sciences, manifests both strengths and weaknesses. As stated throughout this thesis the strengths, which I consider to outweigh the weaknesses, lie in the ability for a theoretical analysis that can account for the dynamic and nonlinear behaviour of systems that are constantly in-flux and adapting to changing environmental conditions. In this manner the complexity sciences provide a suitable model in which to view distributed social relations as person-object-environment becomes ever-more enmeshed within functioning complex social systems and sub-systems. Because of the increased flows of relationships and connections developing between people, artefacts, and the social environment, complexity theory becomes significant for understanding social patterns of the 21st Century. This, I argue, is what makes the focus of this research important. It is not vital to say a thing first (already much has been written on the complexity sciences); rather what is significant is the relevance of the material to the time and the subject. Recent, and ongoing, changes in social communications and technically-mediated information flows and connectivity make it imperative to use and develop complexity theory in order to better understand social processes that are dynamic and nonlinear. I contend that connectivity and complexity will define much of future social patterns. Noted physicist Stephen Hawking has already stated that he considers this present century to be a century of complexity (cited in Urry, 2005a: 235).

However, there are weaknesses in complexity theory in that there is a tendency for models of increasing complexification to suggest a directional path that hints of teleological progress. In socio-technical discourses, as this thesis has engaged with, this theoretical leaning can all too easily promote a position of technological determinism. I have alluded to this when making reference to the ideas around the 'technological singularity' (Kurzweil, 2003; Vinge, 1993), as well as the debate around socio-cultural evolution within 'game rules' (Wright, 2000). Complexity theory explains how increasing complexification within systems occur, yet this neither promises progress nor alludes to a grand 'end point'. It is easy for complexity theory to be appropriated for futuristic visions of a highly technologised and cyber-noir future. Yet this, I feel, evades the main point that I have stressed throughout this thesis: that complexity theory can describe how *social relations* are becoming more *interdependent* and *connected*. In this thesis I have moved complexity theory out of the natural sciences into the social sciences.

One of the features of this thesis has been to suggest a movement of discourse, theories and concepts from the natural sciences into the social domain for the purposes of re-conceptualising and analysing social connections and networks. Yet, as I have alluded to at points throughout this thesis, this does not qualify all such borrowings, and neither am I supporting the idea of overlapping reductionist biological, chemical and/or physical mappings onto social phenomena. Such attempts are clearly problematic at best and implausible at worst. Yet I maintain that there are insights to be gained from such a transdisciplinary dialogue. In earlier chapters of this thesis I made use of analogies, correspondences, and similarities between natural and social phenomena. I took these positions in order to clarify how particular patterns, movements, behavioural features, are not isolated anomalies; instead, such correspondences can help to illustrate how interconnected webs of relations and dependencies are to be found in most spheres of activity, both organic and inorganic. Also, that there have been instances where this traffic has been two-way; one such example being information theory/cybernetics which was important in helping to understand the informational nature of molecular biology. However, such appropriations have their limits.

My research differs from other complexity theory research in that it deals with the very latest emerging trends, movements, and shifts in social-technical developments. In this thesis I have examined how information technology can become a mediator for complex systems; as such, the development of communication infrastructures and networks has been central to this research. This includes the importance of computer simulations which I have relied on for some of my data. In this context I have made current contributions to modelling the increasing self-organising nature of local-global connectivity in terms of positive feedback loops, attractors, network clusters, tipping points and bifurcations. I have also considered how various sub-sets of complex systems can exist within a larger global environment and to view these operating in spheres for civil engagement, empowerment, and empathy. Importantly, this thesis has examined accelerating forms of connectivity and collaboration as well as the struggle with hierarchical structures of containment and centralised control. Admittedly, much of the focus of my research has been on the positive consequences of collaboration and complex webs. There are a great many 'complex fears' that have not been dealt with here. Indeed, complexity processes can also signify negative consequences.

For example, complex decentralised networks can be a boon for viruses – both biological and cyber – as in the spread of emerging pathogens and virulent technological risks (Adam, Beck and Loon (eds) 2000; Beck, 1992; Van Loon, 2002). Complexity theory also considers the asymmetrical networks and global microstructures of terrorist organisations (Arquilla and Ronfeldt, 2001b; Knorr Cetina, 2005). Further, there are the often over-looked risks in extra-terrestrial forces that have previously in Earth history bombarded and intervened into terrestrial affairs such that this shining blue planet appears critically vulnerable. As Clark notes, 'the question of what belongs wholly to our planet, and what is incoming from beyond its perimeters, in this regard, will always retain a degree of undecidability' (Clark, 2005: 181). In short, there can be no free ride. If anything, the complexity sciences teach that present systems, whether ecological, technological, or social, are open to violent interventions as much as they are to progress, which is the very nature of bifurcations and tipping-points. And if current records on human history are anything to go by, it is the violent 'shocks' that have contributed most to how civilizations have risen, been glorious, and ebbed into historical footnotes (Diamond, 2005; Tainter, 1988). In *The Collapse of Complex Societies* Tainter describes how great civilizations created vast and complex technological and social infrastructures that harnessed energy and resources to the point of scarcity. Such were the requirements of these densely woven interrelations that the complex 'machine' became locked-in to its own greedy dependency and triggered its own implosion (Tainter, 1988).

In this regard complexity theory contributes to the social sciences the understanding of path-dependency and the 'lock-in' effect. Path-dependency informs social science that sometimes it cannot escape its own locked-in systems, and this is the case whether the system is for the better or worse. In some cases an inefficient or quirky system becomes standardised, such as the QWERTY keyboard, which through positive-feedback loops quickly gained ascendancy. To be 'locked-in' to a potentially destructive path, such as global warming, can prove catastrophic to the system in the long-run. The ecological tipping points that are often referred to by media and environmentalists (Lovelock, 2006) are a part of the contribution that complexity theory makes;

and social science needs to be made aware of the nature of unintended consequences as well as the nature of change. What complexity theory allows for, perhaps more than any other social theory, is the potential to adapt dynamically to changing environmental situations, and this includes recognising the self-reflexivity of a system.

The notion of self-reflexivity is important for social theory, as is the understanding that global relations are systems in process, in differing states of flux. Melucci sees the self-reflexive capacity of complex systems as enabling individuals to 'find themselves involved in a plurality of memberships arising from the multiplication of social positions' (Melucci, 1989:108). Increased opportunities for self-reflexive behaviour through access to global flows of information is enabling individuals to adapt from being a 'mundane' cosmopolitan towards becoming a 'global' citizen (Tomlinson, 1999). As Beck has noted, the world of modern technologies and global flows has transformed the playing field so that 'globalization includes globalization *from within*, globalization *internalized*' (Beck, 2002: 24 – italics in original). This internal self-reflexivity has allowed individuals to become nodes themselves within the global 'information scapes', with an enhanced capacity to amplify their participation within the larger system. Such correspondences were discussed in this thesis between complexity theory and global civil society. It was also remarked how observing and analysing complex phenomena was itself a form of second order complexity, or hyper-complexity, and that as the researcher on this material I too was incorporated into this self-reflexive position.

As social processes constantly flow, merge, and network, so too must social theory display the capacity to engage with dynamic interdependent social structures that grow, adapt, and learn through processes, flows, and uncertainties rather than the old paradigm of order, mechanical structure, and centralisation. Social science has been influenced in varying degrees from the recognition that recent scientific insights of the twentieth-century have refigured Western notions of time and space, and have levered open multiple doors to new interventions, interpretations, and invasions. In fact, such knowledge has 'changed our understanding and the meaning of physical reality… with the result that *all of nature is emerging as fundamentally dynamic*' (Adam, 1990: 89 – italics in original). Social critic Barbara Adam accordingly notes the shift towards the perception of environmental processes as being 'fundamentally dynamic', which hints of the cross-over from the natural to the social sciences.

Complexity theory as it stands in the natural sciences manifests patterns of behaviour, connections, flows, etc; yet it cannot account for conscious action with which I have addressed in the case studies of my research. In other words, I have imported concepts from the complexity sciences yet I have appropriated them into social environments of deliberate action, with notions of ethics and responsibility. I stated in this thesis that reflexive agency on the part of the participant brings into play important issues of ethical responsibility. Such issues belong to the realm of social science and should not be taken to be a part of the natural science import. In this respect, perhaps complexity theory has a different role to play within a social environment. In a way this becomes a part of what I have termed the *new complexities*. Such complex systems of technically-mediated collaborative networks create capacities for self-reflexive social acts of responsibility in a manner perhaps not allowed for previously. This is a significant consideration when engaging in social science complexities for the future. With a global environment that is shifting towards new interdependencies, connections, and relationships, it is time to re-evaluate the terms of reference being used, so as to better reflect an environment that is 'fundamentally dynamic'.

One reflection of the 'social' becoming more dynamic is the shift from delayed information to real-time streaming of data from location-based networks. As this research examined, communication networks are being established that alert and locate users irrespective of whether their communication devices are switched off or not (Cascio, 2005). Other uses of real-time data include urban consumer services such as traffic conditions, local services and prices, and social networks (Greene, 2006; Lane, 2004; Mills, 2005; Saveri, 2004). Benefits here include efficiency, cost and time reduction, and possible enhanced social relations. Negative connotations such as user registry and supplied personal information leading to state and corporate surveillance and direct consumer targeting were also touched upon in this thesis. Sensoring developments were shown to be leading towards increased real-time feedback monitoring of environmental processes. Examples include monitoring coral reefs (Krausmann, 2006); glacier flows (Butler, 2006a); to more ambitious ecological sensor networks (Broad, 2005; IWGEO, 2005). Even data streaming via the human physical body is under development and has been patented (Adam, 2004a). These trends indicate a shift towards an environment that is enveloped with information: an entangled information field that comprises a ubiquitous computerised environment. This has been named as 'Everyware' (Greenfield, 2006); an all-encompassing socio-technical mediated environment connected and coalesced with informationally 'smart' objects and RFID-encrypted relations (Bleecker, 2005; Sterling, 2005). In this context complexity theory is able to model how increased efficiency in the storage, utilisation, and flows of information and increased free energy can drive systems towards increased complexification. Similarly, complexity also models how feedbacks may occur too fast and therefore exacerbate unevenness.

The *new complexities* that this research has focused on describe an increased convergence between person-technology-environment that has implications for re-configuring what constitutes the 'social' and 'community'. Goonatilake (1999) sees the different information modes of human/genetic, cultural, artefact (his terms) as social webs and collective information carriers. Goonatilake sees this as moving towards a meta-communications environment that will dramatically shift present communication networks:

> The future will thus result in intense communications not only between machines and humans, but also with genetic systems so that information in the three realms of genes, culture and machines will result in one interacting whole. The three for all purposes would be interacting as one communicating system. This meta communicating system will make the present communicating modes and patterns appear trivial. These new merging effects will be played out and realised through dramatic changes in the communications matrices of the

> world. Communities are but the collectivities within which this communication occurs and ensuing actions result. (Goonatilake, 1999: 197)

Goonatilake ties increased information flow with heightened complexification, and considers the move to place information in devices external to the human (Goonatilake terms this as *exosomatic*) as contributing to cultural complexity. This would, according to Goonatilake, quicken the growth of complex relations between human-artefact-environment as 'the flow of information outside the biological system is bound to increase faster than that within the biological as exosomatic devices increasingly take the load of human scientific workers' (Goonatilake, 1991: 116). Just as the adherents of 'everyware' describe a pervasive ubiquitous computing environment – an enveloping information mesh – so too does Goonatilake see a merging of bio-info technologies through complex feedback mechanisms:

> the three different information flows can then combine into one macro flow...The first system becomes the environment for the second, as the second system becomes the environment for the first and a set of coupled systems co-evolving with each other it emerges... there are mutual feedback processes between a core and the environment resulting in the co-evolution of both. These feedback loops would be information. The development of one system would then be irrevocably coupled to the development of the other, the total system evolving from both together... in all flow-line categories there is a phylogenetic genetic tendency for an increase of information and of complexity. (Goonatilake, 1991: 131)

This scenario is predicated on an acceleration of information flows and socio-technical developments adapted to accommodate this.

Acceleration of information processing and storage technologies are considered as essential to this heightened social complexification and hybridity of relations between biological and non-biological informational systems. Again, this bears similarity to what complexity theorist de Rosnay considers as the 5th Paradigm:[97] 'the unified theory of the self-organisation and the dynamics of complex systems, the hybridisation of the natural and the artificial, the "mechanisation" of the biological and the "biologization" of the machine are major trends that fuel and reinforce this need' (de Rosnay, 2000: 239). In the 5th paradigm the sciences of complexity and chaos theory provide for an emerging cultural shift that re-configures humanity as a social creature in symbiosis with a technologically-enhanced environment:

> human beings, their societies, their machines (mechanical or electronic), and their co-evolving infrastructures and infostructures, connected by communications networks and regulatory loops, now form a series of indissociable nested systems, a new global living organism. (de Rosnay, 2000: 255)

According to de Rosnay such a shift will re-configure the humanities and social sciences and vitalize emergent, decentralized and bottom-up features of social democracy and catalyze forms of collective intelligence as stages in a symbionomic humanity (de Rosnay, 2000). Similarities are to be found here with Levy's work (1999, 2001) on collective intelligence and collaborative interrelations which were discussed in this thesis.

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[97] The other 4 Paradigms being the Copernican revolution; the Cartesian revolution; the Darwinian revolution; and the systemic revolution.

Despite these potential and/or creative visions it is still important to remember that the nature of the complexity sciences is one of unpredictability and uncertainty. Complexity theory often reminds the researcher of what s/he does not know or cannot know. As Clark suggests, the study of 'complex dynamical systems reminds us that all but the simplest events are haunted by undecidability, which has implications for all organized responses to the eventfulness of our world' (2005: 182). Complex systems provide the social sciences with a frame of reference for dynamic processes that are informed through continual flows, movement, and impacts. Complexity theory offers a means of understanding how states of order are maintained through acts of negotiation: through contestations, collaborations, connections and re-connections. Yet these processes are not totally random; there are emerging patterns. At its most simplest complexity theory can explain that at a heightened state of arrangements, when a system is most sensitive to fluctuations and disturbances, 'tipping points' can push a system into breakdown (disorder) or breakthrough (greater complexification). Earlier epochal shifts have been interpreted as resulting from tipping point bifurcations (Laszlo, 1986; 1991). Gladwell, also, has provided some notable examples of how small impacts can potentially drive larger systems into a bifurcatory state (2000). And these are significant points for social science to take into account.

Complex systems also deal with contingencies of sustainability and containability, which is why complexity theory has made significant inroads into both environmental science and military policy. Complexity theory has the potential to raise pertinent and relevant questions about ecological systems and degrees of sustainability that are important issues in current global climate trends[98] (Capra, 1996; 2002; Laszlo, 2006; Sahtouris, 1999), as well as 'contain-ability' of chaotic perturbations which has not gone unnoticed by military strategists and thinkers (Alberts and Czerwinski, 1997; Dillon, 2005; Schmitt, 1997). In this manner complexity theory is able to examine future shifts whereby increased bottom-up decentralised structures contest with top-down control architectures.

In this thesis I have examined complexity theory within the domain of the 'social'. That is, I have mapped the movements of complexity discourse from the natural sciences into the social. And this has not always proved easy as there is always the danger of too-easily slipping into accounts of reductionism or of being too liberal with metaphorical borrowings. Through the writing of this thesis, however, I have attempted to combine complexity science with emerging shifts in socio-technical relations in a way that theorises these changes. In this way I consider this thesis to have contributed also to theorising the nature of change and the processes that inform and contribute to social processes of change. Also, by understanding the often unpredictable and dynamic nature of change complexity theory must by necessity leave the future open to negotiation, as an open system.

In a dynamic nonlinear world, all methods for assessment must contain inherent limits. As Cilliers states, 'we can make clear, testable assertions about complex systems. We can increase the knowledge we have of a certain system,

[98] The 'butterfly effect' of chaos theory was first proposed by meteorologist Edward Lorenz

but this knowledge is limited and we have to acknowledge these limits' (2005: 263). Complexity theory then comes complete with its own caveat, and informs social science that there is no perfect knowledge of complex systems. I am not proposing that complexity theory is, or will be, the only successful mode for analysis yet it possesses the characteristics of being one of the current approaches most likely to retain its relevance as globalising society extends into the 21st century. Complexity theory can examine a global participatory culture that is diverse, interrelated, interdependent, and connected by dynamic, often unstable, networks and relations. Complexity theory helps to understand a world increasingly characterised by events not understood by linear frameworks and thus opens the window onto a world that is unpredictable, uncertain and often on the fringes of instability, whilst also maintaining adaptability, re-configuration, and non-randomness. Also, complexity theory helps to understand the necessity for flow and movement, and the importance of social networks. This thesis showed how people can harness their connectivity for the greater good, as well as the danger and vulnerability of unchecked interdependencies. In this manner complexity theory is able to show that being part of a system can bring its own responsibility, and that contribution to such a system need not be grand, only meaningful.

Complexity theory then has something very important to say about social processes in a way that other sociological approaches lack. This thesis has shown that social-global relations have become increasingly interpenetrated and as such involve much interdependency, and that these interdependencies are dynamic, fluctuating systems that can re-configure themselves in unpredictable ways, leading to unintended consequences.

Where to take complexity theory next is a significant question. As complex systems are inherently unpredictable, yet contain patterns of path-dependence, lock-in, and 'order from chaos', complexity theory is an important contribution to any 'sociologies of the future'. Not to offer a 'predict and provide' model, yet as a means of engaging with sociological issues of a turbulent nature. Complex phenomena may involve chaotic relations yet complexity as a theory is able to analyse discernable patterns in such seeming chaos. Complexity theory cannot map where such a global world is definitely heading, yet it offers possibility for insight and involvement. In this context complexity science requires an interdisciplinary environment and is ideal for creating bridges between disciplines. It is in forming such networks of research and collaboration that complexity as a theory and discipline has much to offer, and more room to develop.

Complexity science's contribution is in showing that social science can no longer be ignorant to how the global system is locked into an intricate web of relations and influences to the point that everything matters – not only the big things. In this, complexity theory stands as a significant contribution to understanding rapidly developing economic, environmental, technical and socio-cultural trends.

BIBLIOGRAPHY

Adam, B. (1990) *Time and Social Theory*. Cambridge: Polity Press.

Adam, B. (1995) *Timewatch : The Social Analysis of Time*. Cambridge: Polity Press.

Adam, B. (1998) *Timescapes of Modernity : The Environment and Invisible Hazards*. London: Routledge.

Adam, B.;Beck, U. and Loon, J. v.(Eds.) (2000) *The risk society and beyond : critical issues for social theory*. London ; Thousand Oaks, Calif.: SAGE.

Adam, D. (2004a) *Computerising the body: Microsoft wins patent to exploit network potential of skin*. The Guardian: July 6th 2004

Adam, D. (2004b) *Only Connect*. The Guardian: September 18th 2004

Agence-France-Presse (2005) 'SMS to warn of quakes' http://www.news.com.au/story/0,10117,15029138-38196,00.html (accessed 24/5/05)

Ahtisaari, M.;Engestrom, J. and Nieminen, A. (Eds.) (2003) *Exposure - from friction to freedom*. I-Print.

Alberts, D. and Czerwinski, T. (Eds.) (1997) *Complexity, Global Politics, and National Security*. Washington, DC: National Defence University.

Allen, P. (1997) *Cities and Regions as Self-Organizing Systems: Models of Complexity*. Amsterdam: Gordon and Breach.

Appadurai, A. (2001) *Globalization*. Durham ; London: Duke University Press.

Arquilla, J. and Ronfeldt, D. (2001a) 'Networks, Netwars, and the Fight for the Future'. *First Monday,* **6** (10)**,** URL: http://firstmonday.org/issues/issue6_10/ronfeldt/index.html.

Arquilla, J. and Ronfeldt, D. F. (2001b) *Networks and Netwars : The Future of Terror, Crime, and Militancy*. Santa Monica, CA: Rand.

Arthur, B. (1994) *Increasing Returns and Path Dependence in the Economy.* Michigan: University of Michigan Press.

Arthur, B. (1995) 'Complexity in Economic and Financial Markets'. *Complexity,* **1** (1).

Arthur, B.;Durlauf, S. and Lane, D. (Eds.) (1997) *The Economy As An Evolving Complex System*. Reading, Massachusetts: Perseus Books.

Artigiani, R. (1987) 'Revolution and Evolution: applying Prigogine's dissipative structures model'. *Journal of Social Biological Structures,* **10** 249-264.

Artigiani, R. (1991) 'Social Evolution: A Nonequilibrium Systems Model' In *The New Evolutionary Paradigm*. (Ed) Amsterdam: Gordon and Breach, pp. 93-129.

Atlee, T. (2003) *The Tao of Democracy*. Cranston, RI: Writers' Collective.

Augros, R. and Stanciu, G. (1987) *The New Biology: Discovering the Wisdom in Nature*. Boston, MA: New Science Library.

Axelrod, R. (1990) *The Evolution of Co-operation*. London: Penguin.

Axelrod, R. (1997) *The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration*. Princeton, NJ: Princeton University Press.

Axelrod, R. and Cohen, M. (1999) *Harnessing Complexity: Organizational Implications of a Scientific Frontier*. New York: Free Press.

Ball, P. (2004) *Critical Mass: How One Thing Leads to Another*. London: Heinemann.

Barabasi, A.-L. (2003) *Linked*. London: Plume.

Bardini, T. (2000) *Bootstrapping: Dougles Engelbart, Coevolution, and the Origins of Personal Computing*. Stanford, CA: Stanford University Press.

Bateson, G. (1985) *Steps To An Ecology Of Mind*. New York: Ballantine Books.

Baudrillard, J. (1994) *Simulacra And Simulation*. Ann Arbor: The University of Michigan Press.

Bauman, Z. (2000) *Liquid modernity*. Cambridge: Polity.

BBC-News (2006) 'Google move 'black day' for China' http://news.bbc.co.uk/1/hi/technology/4647398.stm (accessed 3/2/06)

BBC (2005a) 'Blogging from East to West' http://news.bbc.co.uk/1/hi/programmes/click_online/4398243.stm (accessed 2/04/05)

BBC (2005b) 'Global blogger action day called' http://news.bbc.co.uk/go/pr/fr/-/1/hi/technology/4278241.stm (accessed 21/2/05)

BBC (2005c) 'Mobile growth 'fastest in Africa'' http://news.bbc.co.uk/2/hi/business/4331863.stm (accessed 23/03/05)

Beaumont, R. (1994) *War, Chaos, and History*. Westport, CT: Praeger.

Beck, U. (1992) *Risk society : towards a new modernity*. London ; Newbury Park, Calif.: Sage Publications.

Beck, U. (1998) *What is Globalization?* Cambridge: Polity Press.

Beck, U. (2002) 'The Cosmopolitan Society and its Enemies'. *Theory, Culture & Society,* **19** (1-2)**,** 17-44.

Beck, U.;Giddens, A. and Lash, S. (1994) *Reflexive Modernization*. Cambridge: Polity Press.

Bell, D. (1999/1973) *The Coming of Post-Industrial Society: A Venture in Social Forcasting*. New York: Basic Books.

Ben-Jacob, E. (1998) 'Bacterial wisdom, Godel's theorem and creative genomic webs'. *Physica A,* **248** 57-76.

Benyus, J. M. (2002) *Biomimicry : innovation inspired by nature*. New York: Perennial.

Bergson, H. (1944/1910) *Creative Evolution*. New York: Random House.

Berners-Lee, T. (1999) *Weaving the Web*. London: Orion Books.

Bertalanffy, L. v. (1995/1968) *General System Theory*. New York: George Braziller.

Best, S. and Kellner, D. (2001) *The Postmodern Adventure: Science, Technology, and Cultural Studies at the Third Millenium*. London: Routledge.

Bhattacharya, S. (2005) *500,000 people injured by Asian tsunami*. *New Scientist*, 04 January 2005

Biddlecombe, E. (2005) ' UN predicts 'internet of things'' http://news.bbc.co.uk/1/hi/technology/4440334.stm (accessed 19/11/05)

Bleecker, J. (2005) 'A Manifesto for Networked Objects — Cohabiting with Pigeons, Arphids and Aibos in the Internet of Things' http://research.techkwondo.com/files/WhyThingsMatter.pdf (accessed 7/3/06)

Bloom, H. (2000) *Global Brain: The Evolution of Mass Mind from the Big Bang to the 21st Century*. New York: John Wiley & Sons, Inc.

Bohm, D. (1995/1980) *Wholeness and the Implicate Order*. London: Routledge.

Bonabeau, E.;Dorigo, M. and Theraulaz, G. (1999) *Swarm intelligence : From Natural to Artificial Systems*. New York ; Oxford: Oxford University Press.

Borges, J. L. (1999/1975) *Collected Fictions (Trans. Andrew Hurley)*. London: Penguin.

Borton, J. (2005) 'Tsunami bloggers in tribal news network' http://www.atimes.com/atimes/Southeast_Asia/GA05Ae02.html (accessed 15/10/05)

Boyd, C. (2005) ' Text messages aid disaster recovery' http://news.bbc.co.uk/2/hi/technology/4149977.stm (accessed 24/5/05)

Broad, W. (2005) *A Web of Sensors, Taking Earth's Pulse*. New York Times: May 10th 2005

Brooks, D. and Wiley, E. O. (1986) *Evolution as Entropy: Toward a Unified Theory of Biology*. London: University of Chicago Press.

Brzezinski, M. (2004) *Fortress America: On the front lines of Homeland Security - an inside look at the coming surveillance state*. New York: Bantam.

Brzezinski, Z. (1970) *Between Two Ages: America's Role in the Technetronic Era*. New York: Viking.

Buchanan, M. (2002) *Nexus: small worlds and the groundbreaking science of networks*. New York: Norton & Co.

Burke, J. (1999) *The Knowledge Web : from electronic agents to Stonehenge and back - and other journeys through knowledge*. New York: Simon & Schuster.

Burke, J. (2003) *Twin Tracks : the unexpected origins of the modern world*. New York: Simon & Schuster.

Burke, J. and Ornstein, R. (1995) *The Axemaker's Gift: A Double-Edged History of Human Culture*. New York: Putnam.
Butler, D. (2006a) 'Everything, Everywhere'. *Nature,* **440** 402-405.
Butler, D. (2006b) 'Mashups mix data into global service'. *Nature,* **439** 5-6.
Byrne, D. (1998) *Complexity Theory and the Social Sciences: An Introduction*. London: Routledge.
Calcutta-Telegraph (2004) 'SMS & scurry for ministers' http://www.telegraphindia.com/1041227/asp/nation/story_4178678.asp (accessed 27/12/04)
Campbell, J. (1984) *Grammatical Man: Information, Entropy, Language and Life*. London: Penguin.
Capra, F. (1982) *The Tao of Physics*. London: Fontana.
Capra, F. (1985) *The Turning Point: Science, Society and the Rising Culture*. London: Fontana.
Capra, F. (1988) 'The Role of Physics in the Current Change of Paradigms' In *The World View of Contemporary Physics: Does it need a new meta-physics?* Kitchener, R. (Ed) New York: SUNY Press, pp. 144-155.
Capra, F. (1996) *The Web of Life: A New Synthesis of Mind and Matter*. London: HarperCollins.
Capra, F. (2002) *The Hidden Connections*. London: HarperCollins.
Cascio, J. (2004) 'The Tsunami Next Time' http://www.worldchanging.com/archives/001828.html (accessed 9/06/05)
Cascio, J. (2005) 'CAP' http://www.worldchanging.com/archives/003065.html (accessed 30/10/05)
Castells, M. (1996) *The Rise of the Network Society. Vol. 1 of The Information Age: Economy, Society, and Culture*. Oxford: Blackwell.
Castells, M. (1997) *The Power of Identity*. Cambridge, Mass ; Oxford: Blackwell.
Castells, M. (1998) *End of Millennium*. Malden, MA: Blackwell Publishers.
Castells, M. (2002) *The Internet Galaxy*. Oxford: OUP.
Castells, M.;Fernandez-Ardevol, M.;Linchuan Qiu, J. and Sey, A. (2006) 'Electronic Communication and Socio-Political Mobilisation: A New

Form of Civil Society' In *Global Civil Society 2005/6*. Glasius, M.,Kaldor, M. and Anheier, H. (Ed) London: Sage.

Cellular-News (2005) 'Disaster zones get easier telecoms deployment' http://www.cellular-news.com/story/11651.shtml (accessed 24/5/05)

Ceruti, M. and Pievani, T. (1998) 'Biological Evolution and Cultural Evolution: Toward a Planetary Consciousness' In *The Evolutionary Outrider: The Impact of the Human Agent on Evolution*. Loye, D. (Ed) Westport, Connecticut: Praeger, pp. 151-164.

Chaisson, E. (1987) *The Life Era: Cosmic Selection and Conscious Evolution*. New York: Atlantic Monthly Press.

Chaisson, E. and Chaisson, L. J. (2001) *Cosmic evolution : the rise of complexity in nature*. Cambridge, Mass.: Harvard University Press.

Chardin, T. d. (1959) *The Phenomenon of Man*. London: Collins.

Chardin, T. d. (1969) *Building the Earth*. New York: Avon Books.

Chardin, T. d. (1974) *The Future of Man*. London: Fontana.

Charny, B. (2005) 'SMS enlisted for Tsunami warning system?' http://www.zdnetasia.com/news/communications/0,39044192,39212474,00.htm (accessed 24/5/05)

Chesters, G. (2004) 'Global Complexity and Global Civil Society'. *Voluntas,* **15** (4), 323-342.

Chesters, G. and Welsh, I. (2005) 'Complexity and Social Movement(s): Process and Emergence in Planetary Action Systems'. *Theory, Culture & Society,* **22** (5), 187-211.

Cilliers, P. (1998) *Complexity and Postmodernism*. London: Routledge.

Cilliers, P. (2005) 'Complexity, Deconstruction, and Relativism'. *Theory, Culture & Society,* **22** (5), 255-267.

Clark, N. (2005) 'Ex-orbitant Globality'. *Theory, Culture & Society,* **22** (5), 165-186.

Coates, T. (2003) 'The Mass Amaturisation of (Nearly) Everything' In *Exposure - from friction to freedom*. Ahtisaari, M.,Engestrom, J. and Nieminen, A. (Ed) I-Print, pp. 53-57.

Coll, S. (2005) *In the Gulf, Dissidence Goes Digital*. Washington Post: Tuesday, March 29th:

Coren, R. (1998) *The Evolutionary Trajectory: The Growth of Information in the History and Future of Earth*. Amsterdam: Gordon and Breach.

Cosgrove, D. (2001) *Apollo's Eye: A cartographic Genealogy of the Earth in the Western Imagination*. Baltimore: The John Hopkins University Press.

Coveney, P. and Highfield, R. (1995) *Frontiers of Complexity: The Search for Order in a Chaotic World*. London: Faber & Faber.

Crandall, J. (2005) 'Operational Media' http://www.ctheory.net/articles.aspx?id=441 (accessed 11/11/05)

Crumlish, C. (2004) *The Power of Many: How the Living Web is Transforming Politics, Business, and Everyday Life*. San Francisco: Sybex.

Csanyi, V. (1998) 'Organization, Function, and Creativity in Biological and Social Systems' In *Evolution, Order and Complexity*. Boulding, E. L. K. a. K. E. (Ed) London: Routledge.

Davies, P. C. W. (1988) *The Cosmic Blueprint : new discoveries in nature's creative ability to order the universe*. New York: Simon and Schuster.

De Kerckhove , D. (1998) *Connected Intelligence*. London: Kogan Page.

De Landa, M. (2000) *A Thousand Years of Nonlinear History*. New York: Zone Books.

de Rosnay, J. (2000) *The Symbiotic Man: A New Understanding of the Organization of Life and a Vision of the Future*. New York: McGraw Hill.

Deibert, R. (2002) 'Dark Guests and Great Firewalls: The Internet and Chinese Security Policy'. *Journal of Social Issues,* **38** (1)**,** 143-159.

Deibert, R. (2003) 'Deep Probe: The Evolution of Network Intelligence'. *Intelligence & National Security,* **18** (4)**,** 175-193.

Der Derian, J. (2001) *Virtuous War: Mapping the Military-Industrial-Media-Entertainment Network*. Oxford: Westview Press.

Diamond, J. M. (2005) *Collapse : how societies choose to fail or succeed*. New York: Viking.

Dickey, B. (2004) 'Internet in the Sky' http://www.govexec.com/story_page.cfm?articleid=28919&printerfriendlyVers=1& (accessed 11/11/05)

Dijk, J. v. (1999) *The Network Society*. London: Sage.

Dillon, M. (2003) ' Virtual Security: A Life Science of (Dis)order'. *Millennium: Journal of International Studies,* **Volume 32** (3), 531-558.

Dillon, M. (2005) *Global Security in the 21st Century: Circulation, Complexity and Contingency*. Chatham House: The Royal Institute of International Affairs: (pp. 2-3)

Dinerman, T. (2004) 'Can the US really build a global persistent surveillance system?' http://www.thespacereview.com/article/216/1 (accessed 14/01/05)

Dorogovtsev, S. N. and Mendes, J. F. F. (2003) *Evolution of Networks: From Biological Nets to the Internet and WWW*. Oxford: Oxford University Press.

Drexler, K. E. (1990) *Engines of Creation: The Coming Era of Nanotechnology*. New York: Random House.

Durkheim, E. (1984/1893) *The Division of Labour in Society*. Hampshire: Macmillan.

Dyson, G. (1997) *Darwin among the Machines: the evolution of global intelligence*. Reading, MA: Perseus Books.

Economist (2005) 'The real digital divide' http://www.economist.com/printedition/displaystory.cfm?Story_ID=3742817 (accessed 12/03/05)

Eldredge, N. (1985) *Time Frames: The Rethinking of Darwinian Evolution and the Theory of Punctuated Equilibria*. New York: Simon and Schuster.

Eldredge, N. (1998) 'Ultra-Darwinian explanation and the biology of social systems' In *Evolution, Order and Complexity*. Boulding, K. a. K., E (Ed) London: Routledge.

Elliot, E. and Kiel, D. (1997) 'Nonlinear Dynamics, Complexity, and Public Policy: Use, Misuse, and Applicability' In *Chaos, Complexity, and Sociology: Myths, Models, and Theories*. Eve, R. A.,Horsfall, S. and Lee, M. E. (Ed) London: Sage, pp. 64-78.

Epstein, J. M. (1997) *Nonlinear Dynamics, Mathematical Biology, and Social Science*. Massachusetts: Addison-Wesley Publishing Company, Inc.

Eve, R. A.;Horsfall, S. and Lee, M. E. (Eds.) (1997) *Chaos, Complexity, and Sociology: Myths, Models, and Theories*. London: Sage.

Ferguson, M. (1981) *The Aquarian Conspiracy: Personal and Social Transformation in the 1980s*. London: Routledge & Kegan Paul.

Fonseca, J. (2002) *Complexity and Innovation in Organizations*. London: Routledge.

Frisby, D. and Sayer, D. (1986) *Society*. London: Tavistock Publications.

Garfunkel, J. (2004) 'Online Political Writers: Reactions to the Tsunami Catastrophe (December 29th '04)' http://civilities.net/OPW-Tsunami (accessed 1/09/05)

GCRSS (1996) *Open the Social Sciences : Report*. Stanford, Calif.: Stanford University Press.

George, F. H. (1965) *Cybernetics and Biology*. London: Oliver & Boyd.

Gergen, K. (2002) 'The challenge of absent presence' In *Perpetual Contact: mobile communication, private talk, public performance*. Katz, J. and Aakhus, M. (Ed) Cambridge: CUP.

Germann Molz, J. (2006) ''Watch us wander': mobile surveillance and the surveillance of mobility'. *Environment and Planning A,* **38** 377-393.

Geyer, F. and Zouwen, J. v. d. (1994) 'Norbert Wiener and the Social Sciences'. *Kybernetes,* **23** (6/7), 46-61.

Gibson, O. (2005) *Gates unveils his vision of a future made of silicon*. The Guardian: October 28th 2005

Giddens, A. (1986) *The Constitution of Society : outline of the theory of structuration*. Berkeley: University of California Press.

Giddens, A. (1990) *The Consequences of Modernity*. Cambridge: Polity Press.

Gillmor, D. (2004) *We the media*. Sebastopol, CA: O'Reilly.

Gladwell, M. (2000) *The Tipping Point: how little things can make a big difference*. Boston: Little, Brown.

Glasius, M.;Kaldor, M. and Anheier, H. (Eds.) (2006) *Global Civil Society 2005/6*. London: Sage.

Gleick, J. (1998) *Chaos: The Amazing Science of the Unpredictable*. London: Vintage.

Gleick, J. (1999) *Faster*. New York: Pantheon Books.

Goerner, S. (1995) *Chaos and the Evolving Ecological Universe*. Amsterdam: Gordon and Breach.

Goerner, S. (1999) *After the Clockwork Universe: The Emerging Science and Culture of Integral Society*. Edinburgh: Floris Books.

Goodwin, B. (1997) *How the Leopard Changed its Spots: The Evolution of Complexity*. London: Orion Books.

Goonatilake, S. (1991) *The Evolution of Information: Lineages in Gene, Culture and Artefact*. London: Pinter Publishers.

Goonatilake, S. (1999) *Merged Evolution: Long-Term Implications of Biotechnology and Information Technology*. Amsterdam: Gordon and Breach.

Graham, S. and Marvin, S. (2001) *Splintering Urbanism : networked infrastructures, technological*. London: Routledge.

Gray, A. (2004) 'Killer waves hit beach only hours after I swam in the sun' http://news.scotsman.com/international.cfm?id=1466852004 (accessed 13/10/05)

Gray, W. and Rizzo, N. (Eds.) (1973) *Unity Through Diversity: A Festschrift for Ludwig von Bertalanffy*. New York: Gordon and Breach.

Green, N. (2002) 'On The Move: Technology, Mobility, and the Mediation of Social Time and Space'. *The Information Society,* **18** (4)**,** 281-292.

Greene, K. (2006) 'Microsoft's Plan to Map the World in Real Time' http://www.technologyreview.com/read_article.aspx?id=16781&ch=infotech (accessed 15/05/06)

Greenfield, A. (2006) *Everyware: The dawning age of ubiquitous computing*. Berkeley, CA: New Riders.

Gribbin, J. (1984) *In Search of Schrödinger's Cat: Quantum Physics & Reality*. London: Bantam Books.

Gribbin, J. (1995) *Schrödinger's Kittens and the Search for Reality*. New York: Little, Brown & Company.

Gribbin, J. (2004) *Deep Simplicity: Chaos, Complexity, and the Emergence of Life*. London: Allen Lane.

Griffin, D.;Shaw, P. and Stacey, R. (2000) *Complexity and Management: Fad or Radical Challenge to Systems Thinking?* London: Routledge.

Hafner, K. and Lyon, M. (1996) *Where Wizards Stay Up Late : the origins of the Internet*. New York: Simon & Schuster.

Haken, H. (2000) *Information and Self-Organization: A Macroscopic Approach to Complex Systems*. New York: Springer.

Hardt, M. and Negri, A. (2001) *Empire*. Cambridge, MA: Harvard University Press.

Hayles, K. (Ed.) (1991) *Chaos and Order : complex dynamics in literature and science*. Chicago: Chicago University Press.

Helmreich, S. (1998) *Silicon second nature : culturing artifical life in a digital world*. Berkeley, CA: University of California Press.

Helsingin-Sanomat (2005) 'Divers' website gets nearly a million hits in days after tsunami' http://www.helsinginsanomat.fi/english/article/1101978179423 (accessed 29/10/05)

Heylighen, F. (1996) 'The Growth of Structural and Functional Complexity during Evolution' http://pespmc1.vub.ac.be/Papers/PapersFH.html#RTFToC60 (accessed 21/10/03)

Heylighen, F. (1997) 'Towards a Global Brain: Integrating Individuals into the World-Wide Electronic Network' http://pespmc1.vub.ac.be/Papers/PapersFH.html#RTFToC60 (accessed 12/11/03)

Heylighen, F. and Bollen, J. (1996) 'The World-Wide Web as a Super-Brain: from metaphor to model' In *Cybernetics and Systems '96*. Trappl, R. (Ed) Singapore: World Science.

Ho, M.-W. (1996) 'Natural Being and a Coherent Society' http://www.i-sis.org.uk/natbein.php (accessed 22/07/04)

Ho, M.-W. (1998) *The Rainbow and the Worm: The Physics of Organisms*. Singapore: World Scientific.

Ho, M.-W. (1999) 'The Organic Revolution in Science' http://www.i-sis.org.uk/organic.php (accessed 22/7/04)

Ho, M.-W.(2000) 'The Organic Revolution in Science and Implications for Science and Spirituality'."Future Visions" State of the World Forum:New York

Hobart, M. and Schiffman, Z. (1998) *Information Ages: Literacy, Numeracy, and the Computer Revolution*. Baltimore: John Hopkins University Press.

Holland, J. (1996) *Hidden Order: How Adaptation Builds Complexity*. Reading, MA: Perseus Books.

Horgan, J. (1997) *The End of Science : Facing the Limits of Knowledge in the Twilight of the Scientific Age*. London: Little, Brown & Company.

Huberman, B. (2001) *The Laws of the Web: patterns in the ecology of information*. Cambrdige, MA: MIT Press.

IFTF (2004) *The New Spatial Landscape: Artifacts for the Future*. Institute for the Future: March 2004

IWGEO (2005) *Strategic Plan for the U.S. Integrated Earth Observation System*. National Science & Technology Council (Executive Office of the President): (pp. 1-166)

Jantsch, E. (1975) *Design for Evolution: Self-Organization and Planning in the Life of Human Systems*. New York: George Braziller.

Jantsch, E. (1980) *The Self-Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution*. Oxford: Pergamon Press.

Jantsch, E. (1981a) 'Autopoiesis: A Central Aspect of Dissipative Self-Organization' In *Autopoiesis: A Theory of Living Organization*. Zeleny, M. (Ed) New York: Elsevier North Holland, Inc.

Jantsch, E. (Ed.) (1981b) *The Evolutionary Vision: Toward a Unifying Paradigm of Physical, Biological, and Sociocultural Evolution*. Boulder: Westview Press.

Jdanko, A. J. (1994) 'An Evolutionary and Entropic Interpretation of Information'. *Kybernetes,* **23** (9)**,** 34-47.

Johnson, B. (2005) *Emergency services*. The Guardian: Thursday January 6, 2005

Johnson, S. (2002) *Emergence: The Connected Lives of Ants, Brains, Cities and Software*. London: Penguin.

Jones, G. (1980) *Social Darwinism and English Thought: The Interaction Between Biological and Social Theory*. Sussex: Harvester Press.

Jones, R. A. L. (2004) *Soft Machines : nanotechnology and life*. Oxford: Oxford University Press.

Kafatos, M. and Nadeau, R. (1999) *The Non-Local Universe: The New Physics and Matters of the Mind*. New York: OUP.

Kahn, R. and Kellner, D. (2004) 'New Media and Internet Activism: from the 'Battle of Seattle' to blogging'. *New Media & Society,* **6** (1)**,** 87-95.

Kaku, M. (1998) *Visions: How Science will Revolutionize the 21st Century and Beyond*. Oxford: OUP.

Kauffman, S. (1993) *The Origins of Order: self-organization and selection in evolution*. New York: Oxford University Press.

Keane, J. (2003) *Global Civil Society?* Cambridge: Cambridge University Press.

Kelly, K. (1994) *Out of Control: The New Biology of Machines*. London: Fourth Estate.

Kelly, K. (2005) 'We Are the Web' http://www.wired.com/wired/archive/13.08/tech.html (accessed 20/8/05)

Kern, S. (2000/1983) *The Culture of Time and Space: 1880-1918*. Cambridge, MA: Harvard University Press.

Khalil, E. and Boulding, K. (Eds.) (1998) *Evolution, Order and Complexity*. London: Routledge.

King, R. (2002) 'Self-Organizing Systems' http://www.memetaworks.com/rants/sos.html (accessed 27/11/03)

Kirkpatrick, D. and Roth, D. (2004) *10 Tech Trends: Why There's No Escaping the Blog*. *Fortune*, Monday, December 27th

Klein, N. (2000) *No Logo*. London: Flamingo.

Knight, W. (2005) *Tsunami warning system is not simply sensors*. *New Scientist*, 04 January 2005

Knorr Cetina, K. (2005) 'Complex Global Microstructures: The New Terrorist Societies'. *Theory, Culture & Society,* **22** (5)**,** 213-234.

Kohn, D. (1996) 'The Teledesic Network: Using Low-Earth-Orbit Satellites to Provide Broadband, Wireless, Real-Time Internet Access Worldwide' http://www.isoc.org/inet96/proceedings/g1/g1_3.htm (accessed 21/12/04)

Kollock, P. (1998) 'Social Dilemmas: The Anatomy of Cooperation'. *Annual Review of Sociology,* (24)**,** 183-214.

Krausmann, J. (2006) 'Sensors watch Barrier Reef coral (BBC Online)' http://news.bbc.co.uk/1/hi/technology/4618086.stm (accessed 08/02/2006)

Krugman, P. R. (1995) *The Self-Organizing Economy*. Cambridge, MA: Blackwell Publishers.

Kuhn, T. (1996 - 1st Edition 1962) *The Structure of Scientific Revolutions*. London: The University of Chicago Press.

Kurzweil, R. (2003) 'Kurzweil's Law (aka "the law of accelerating returns")' http://www.kurzweilai.net/meme/frame.html?m=1 (accessed 29/01/04)

Lane, G. (2004) *Social Tapestries: public authoring and civil society*. Proboscis: July 2004 (pp. 1-9)

Langton, C. G. (Ed.) (1989) *Artificial Life: the proceedings of an interdisciplinary workshop on the synthesis and simulation of living systems*. California: Addison-Wesley Publishing Company, Inc.

lankabusinessonline (2004a) ' Lanka Disaster - Lines Busted' http://www.lankabusinessonline.com/full_story_search.php?newscode=95472216&subcatcode=10 (accessed 12/10/05)

lankabusinessonline (2004b) 'Saving Grace' http://www.lankabusinessonline.com/full_story_search.php?newscode=620330730&subcatcode=5 (accessed 24/5/05)

Lash, S. and Urry, J. (1994) *Economies of Signs and Space*. London: Sage.

Laszlo, A. and Laszlo, E. (1997) 'The Contribution of the Systems Sciences to the Humanities'. *Behavioral Science,* **14** (1)**,** 5-19.

Laszlo, E. (1972a) *Introduction to Systems Philosophy: Toward a New Paradigm of Contemporary Thought*. New York: Gordon and Breach.

Laszlo, E. (1974) *A Strategy for the Future: The Systems Approach to World Order*. New York: George Braziller.

Laszlo, E. (1986) 'Technology and Social Change: An Approach from Nonequilibrium Systems Theory'. *Technological Forecasting and Social Change,* **29** 271-283.

Laszlo, E. (1991) *The Age of Bifurcation: Understanding the Changing World*. Philadelphia: Gordon & Breach.

Laszlo, E. (1992) 'Information Technology and Social Change: An Evolutionary Systems Analysis'. *Behavioral Science,* **37** 237-249.

Laszlo, E. (1994) *Vision 2020: Reordering Chaos for Global Survival*. Philadelphia: Gordon & Breach.

Laszlo, E. (1996) *Evolution: The General Theory*. New Jersey: Hampton Press.

Laszlo, E. (2001) *Macroshift: Navigating the Transformation to a Sustainable World*. San Francisco: Berret-Koehler Publishers, Inc.

Laszlo, E. (2006) *The Chaos Point: The World at the Crossroads*. Charlottesville, VA: Hampton Roads.

Laszlo, E. (Ed.) (1972b) *The Relevance of General Systems Theory*. New York: George Braziller.

Latour, B. (1993) *We Have Never Been Modern*. Hemel Hempstead: Harvester Wheatsheaf.

Law, J. (2004a) *After Method: mess in social science research*. London: Routledge.

Law, J. (2004b) 'Disaster in Agriculture: or Foot and Mouth Mobilities' Centre for Science Studies, Lancaster University at http://www.comp.lancs.ac.uk/sociology/papers/law-disaster-mobilities-foot-and-mouth.pdf

Law, J. and Mol, A. (2002) *Complexities: Social Studies of Knowledge Practices*. Durham and London: Duke University Press.

Leadbeater, C. and Miller, P. (2005) *The Pro-Am Revolution: How enthusiasts are changing our economy and society*. Demos: (pp. 1-70)

Levy, P. (1999) *Collective Intelligence: Mankind's Emerging World in Cyberspace*. Cambridge, MA: Perseus Books.

Levy, P. (2001) *Cyberculture*. Minneapolis: University of Minnesota Press.

Lewin, R. (1992) *Complexity: Life at the Edge of Chaos*. New York: MacMillan.

Libicki, M. C. (2004) *Mesh and the Net: Speculations on Armed Conflict in a Time of Free Silicon*. University Press of the Pacific.

Liebhold, M. (2004) *Infrastructure for the New Geography*. Institute for the Future: August 2004

Liu, M. (2005a) *Big Brother is Talking*. *Newsweek*, October 17th, 2005

Liu, M. (2005b) *Line of Defense*. *Newsweek*, October 24th, 2005

Loewenstein, W. (1999) *The Touchstone of Life: Molecular Information, Cell Communication, and the Foundations of Life*. Oxford: Oxford University Press.

Losowsky, A. (2004) *21st Century Protest*. The Guardian: Thursday March 25 2004

Lostcoders (2005) 'Mobile phone plays valuable role in wake of tsunami disaster' http://www.lostcoders.net/index-single-754.htm (accessed 9/06/05)

Lovelock, J. (1988) *Gaia*. Oxford: Oxford University Press.

Loye, D. (1991) 'Chaos and Transformation: Implications of Nonequilibrium Theory for Social Science and Society' In *The New Evolutionary Paradigm*. Laszlo, E. (Ed) Amsterdam: Gordon and Breach.

Loye, D. (2000) *An Arrow Through Chaos: How We See Into The Future*. Rochester, VT: Park Street Press.

Lyotard, J.-F. (1984) *The Postmodern Condition: A Report on Knowledge*. Manchester: Manchester University Press.

Mackenzie, A. (2002) *Transductions: bodies and machines at speed*. London: Continuum.

Mackenzie, A. (2003) Personal Communication (26/11/03)

Mackenzie, A. (2005) 'The Problem of the Attractor'. *Theory, Culture & Society,* **22** (5)**,** 45-65.

MacMillan, R. (2005) *Text Messages to Mobilize Inauguration Protesters*. Washington Post: 19th January, 2005

Maenpaa , P. (2001) 'Mobile Communication as a Way of Urban Life' In *Ordinary Consumption*. Gronow, J. and Warde, A. (Ed) New York: Routledge.

Maffesoli, M. (1996) *The Time of the Tribes: The Decline of Individualism in Mass Society*. London: SAGE.

Margulis, L. (1993) *Symbiosis in Cell Evolution*. New York: Freeman.

Margulis, L. (2001) *The Symbiotic Planet: A New Look at Evolution*. London: Phoenix.

Martin, H. (2005) 'Blogs and vlogs: how citizen reporters get the news out first' http://newsstore.theage.com.au/apps/newsSearch.ac?page=1&sy=age&kw=hugh+martin&pb=all_ffx&dt=selectRange&dr=1year&so=relevance&sf=author&rc=10&rm=200&sp=nrm&clsPage=1&rc=10&rs=91 (accessed 1/09/05)

Marx, K. and Engels, F. (1952/1848) *The Manifesto of the Communist Party*. Moscow: Foreign Languages

Maturana, H. and Varela, F. (1980) *Autopoiesis and Cognition: The Realization of the Living*. London: D. Reidel Publishing Company.

Maturana, H. and Varela, F. (1998) *The Tree of Knowledge: The Biological Roots of Human Understanding*. Boston: Shambhala.

McGann, R. (2004) 'The Blogosphere By the Numbers' http://www.clickz.com/stats/sectors/traffic_patterns/article.php/3438891: November 22nd, 2004

McLennan, G. (2003) 'Sociology's Complexity'. *Sociology,* **37** (3)**,** 547-564.

McLuhan, M. (1962) *The Gutenberg Galaxy: the making of typographic man*. London: Routledge & Kegan Paul.

McLuhan, M. (1970) *Counterblast*. London: Rapp and Whiting.

McLuhan, M. and Fiore, Q. (1971) *The Medium is the Massage*. London: Penguin.

Melucci, A. (1989) *Nomads of the Present*. London: Hutchinson Radius.

Miller, J. G. (1978) *Living Systems*. New York: McGraw-Hill.

Mills, E. (2005) 'Mapping a revolution with 'mashups'' http://www.zdnet.com.au/insight/software/soa/Mapping_a_revolution_with_mashups_/0,39023769,39223127,00.htm (accessed 20/11/05)

Minsky, M. (1986) *The Society of Mind*. New York: Simon & Schuster.

Mitchell, W. (1999) *E-Topia: "Urban Life, Jim - But Not As We Know It"*. Cambridge, MA: MIT Press.

Mitchell, W. (2003) *Me++ : the cyborg self and the networked city*. Cambridge, Mass.: MIT Press.

Mitleton-Kelly, E. (Ed.) (2003) *Complex Systems and Evolutionary Perspectives on Organisations: The Application of Complexity Theory to Organisations*. Oxford: Pergamon Press.

Mobile, V. (2005) 'Text donations raise over £1 million for the DEC Tsunami Appeal' http://about.virginmobile.com/about/media/news/community/2005/2005-01-25/ (accessed 9/06/05)

Moravec, H. (1989) 'Human Culture: A Genetic Takeover Underway' In *Artificial Life: the proceedings of an interdisciplinary workshop on the synthesis and simulation of living systems*. Langton, C. G. (Ed) California: Addison-Wesley Publishing Company, Inc.

Moravec, H. (2000) *Robot: Mere Machine to Transcendent Mind*. Oxford: Oxford University Press.

Morowitz, H. (1969) *Energy Flow in Biology: Biological Organization as a Problem in Thermal Physics*. New York: Academic Press.

Morowitz, H. (2002) *The Emergence of Everything*. Oxford: Oxford University Press.

Mulhall, D. (2002) *Our Molecular Future : How nanotechnology, robotics, genetics, and artificial intelligence will transform our world*. Amherst, N.Y.: Prometheus Books.

Munck, R. (2002) 'Global Civil Society: Myths and Prospects'. *Voluntas,* **13** (4), 349 - 361.

Naisbitt, J. (1984) *Megatrends: Ten New Directions Transforming Our Lives*. London: Macdonald & Co.

Negroponte, N. (1995) *Being Digital*. London: Hodder & Stoughton.

Nicolis, G. and Prigogine, I. (1989) *Exploring Complexity*. New York: W.H. Freeman & Company.

Nietzsche, F. (1968/1922) *The Will To Power*. New York: Vintage.

Noveck, B. S. (2005) 'A Democracy of Groups' http://www.firstmonday.org/issues/issue10_11/noveck/index.html (accessed 11/11/05)

Nowotny, H. (2005) 'The Increase of Complexity and its Reduction: Emergent Interfaces between the Natural Sciences, Humanities and Social Sciences'. *Theory, Culture & Society,* **22** (5), 15-31.

O'Reilly, T. (2005) 'What Is Web 2.0: Design Patterns and Business Models for the Next Generation of Software' http://www.oreillynet.com/lpt/a/6228 (accessed 19/11/05)

Parsegian, V. L. (1972) *This Cybernetic World: Of Men, Machines and Earth Systems*. New York: Doubleday & Company.

Pattee, H. (Ed.) (1973) *Hierarchy Theory: The Challenge of Complex Systems*. New York: George Braziller.

Pelton, J. (2000) *E-Sphere: The Rise of the World-Wide Mind*. Westport, CT: Quorum Books.

Perrow, C. (1984) *Normal accidents : living with high-risk technologies*. New York: Basic Books.

Piquepaille, R. (2005) 'Better terrain maps of Earth... and beyond' http://blogs.zdnet.com/emergingtech/wp-trackback.php?p=69 (accessed 6/11/05)

Plato (1977) *Timaeus and Critias*. Harmondsworth: Penguin.

Poindexter, J. (2002) 'Overview of the Information Awareness Office' http://www.fas.org/irp/agency/dod/poindexter.html (accessed 14/01/05)

Prigogine, I. (1997) *The End of Certainty*. New York: The Free Press.

Prigogine, I. and Nicolis, G. (1977) *Self-Organization in Non-Equilibrium Systems*. New York: John Wiley & Sons.

Prigogine, I. and Stengers, I. (1985) *Order out of Chaos: Man's New Dialogue with Nature*. London: Flamingo.

Provencal, Y. (1998) *The Mind of Society: From a Fruitful Analogy of Minsky to a Prodigious Idea of Teilhard de Chardin*. Amsterdam: Gordon and Breach.

Putnam, R. (1995) 'Bowling Alone: America's Declining Social Capital'. *Journal of Democracy,* **6** (1)**,** 65-78.

Qiang, X. (2004) *The 'blog' revolution sweeps across China. New Scientist*, 24th November, 2004

Quarantelli, E. L. (1998) *The Computer based Information/Communication Revolution: A Dozen Problematical Issues and Questions They Raise for Disaster Planning and Managing*. Disaster Research Center, University of Delaware, Newark, DE: (pp. 27)

Qvortrup, L. (2003) *The Hypercomplex Society*. New York: Peter Lang Publishing.

Rafael, V. (2003) 'The Cell Phone and the Crowd: Messianic Politics in the Contemporary Philippines'. *Public Culture,* **15** (3)**,** 339-425.

Ravetz, J. and Sardar, Z. (1994) 'Complexity: Fad or Future?' *Futures,* **26** (6).

Rescher, N. (1998) *Complexity: A Philosophical Overview*. New Brunswick: Transaction Publishers.

Rheingold, H. (2003a) 'From the Screen to the Streets' http://www.inthesetimes.com/comments.php?id=414_0_1_0_C (accessed 22/03/05)

Rheingold, H. (2003b) *Smart Mobs: The Next Social Revolution*. Cambridge, MA.: Perseus Publishing.

Rheingold, H. (2005a) 'Mobile and Open: A Manifesto' http://www.thefeaturearchives.com/topic/Culture/Mobile_and_Open__A_Manifesto.html (accessed 12/11/05)

Rheingold, H. (2005b) 'On The Madrid Smart Mobs of March, 2004' http://www.smartmobs.com/archive/2005/03/11/march_11_remem.html (accessed 12/03/05)

Rheingold, H. (2005c) 'Smartmobbing Disaster Relief' http://www.thefeaturearchives.com/101351.html (accessed 24/05/05)

Rheingold, H. (2005d) 'Smartmobbing Urban Catastrophe' http://www.thefeaturearchives.com/101572.html (accessed 01/09/05)

Rheingold, H.;Saveri, A. and Vian, K. (2005) *Technologies of Cooperation*. The Institute for the Future: (pp. 31)

Robertson, R. (1992) *Globalization : social theory and global culture*. London: Sage.

Rose, J. (1994) 'The Early Years: Some comments on the Origins and Concepts of Cybernetics'. *Kybernetes,* **23** (6/7)**,** 23-27.

Roszak, T. (1994) *The Cult of Information*. Berkeley: University of California Press.

Russell, P. (1995) *The Global Brain Awakens: Our Next Evolutionary Leap*. Palo Alto, CA: Global Brain Inc.

Rycroft, R. and Kash, D. (1999) *The Complexity Challenge: Technological Innovation for the 21st Century*. London: Pinter.

Sahtouris, E. (1998) 'The Biology of Globalization' http://www.ratical.org/LifeWeb/ (accessed 10/10/03)

Sahtouris, E. (1999) 'Living Systems in Evolution' http://www.ratical.org/LifeWeb/ (accessed 10/10/03)

Sahtouris, E.(2000) 'Living Systems, the Internet and the Human Future'.Planetwork, Global Ecology and Information Technology:San Francisco

Saveri, A. (2004) *The Cybernomadic Framework*. Institute for the Future: March 2004

Schmitt, J. F. (1997) 'Command and (Out of) Control: The Military Implications of Complexity Theory' In *Complexity, Global Politics, and National Security*. . Alberts, D. and Czerwinski, T. (Ed) Washington, DC: National Defence University., pp. 219-246.

Schrödinger, E. (1962) *What is Life? The Physical Aspect of the Living Cell*. Cambridge: Cambridge University Press.

Science-Daily (2002) '"Internet In The Sky" Will Guide Unmanned Vehicles Into Battle, Aid In Emergencies' http://www.sciencedaily.com/releases/2002/04/020424073127.htm (accessed 11/11/05)

Shapiro, A. (1999) *The Control Revolution: How the Internet is putting individuals in charge and changing the world we know*. New York: PublicAffairs.

Simmel, G. (1997) 'The Metropolis and Mental Life' In *Rethinking Architecture : a reader in cultural theory*. Leach, N. (Ed) New York: Routledge, pp. 69-79.

Slevin, J. (2000) *The Internet and Society*. Cambridge: Polity Press.

SmartMobs (2004) 'Were Spanish Smart Mobs Spontaneous?' http://www.smartmobs.com/archive/2004/09/17/iii_were_span.html (accessed 09/02/05)

Spencer, H. (1971/1896) *Herbert Spencer: Structure, Function and Evolution*. London: Michael Joseph.

Staedter, T. (2005) 'Spray-On Computers Reach Hard Places' http://dsc.discovery.com/news/briefs/20051114/specknet_tec_print.html (accessed 27/11/05)

Standage, T. (1998) *The Victorian Internet : the remarkable story of the telegraph and the nineteenth century's on-line pioneers*. New York: Walker and Co.

Stephenson, W. D. (2004) '10-point "smart mobs for homeland security" strategy' http://www.stephensonstrategies.com/stories/2004/09/29/10pointPlanToMakeSecurityM.html (accessed 01/09/05)

Stephenson, W. D. (2005) 'Roaming Messenger: hot presence application for emergency use (24/10/05)' http://stephensonstrategies.com/categories/smartMobsForHomelandSecurity/ (accessed 5/11/05)

Sterling, B. (2005) *Shaping Things*. Cambridge, MA: The MIT Press.

Stewart, I. (1990) *Does God Play Dice?* London: Penguin.

Stock, G. (1993) *MetaMan: Humans, Machines, and the Birth of a Global Super-organism*. London: Bantam Press.

Stock, G. and Campbell, J. (1998) 'Human Society as an Emerging Global Superorganism: a biological perspective' In *Evolution, Order and Complexity*. Boulding, E. L. K. a. K. E. (Ed) London: Routledge.

Strogatz, S. (2003) *SYNC: The Emerging Science of Spontaneous Order*. New York: Hyperion.

Surowiecki, J. (2004) *The Wisdom of Crowds: Why the Many are Smarter than the Few*. London: Little, Brown.

Tae-gyu, K. (2005) 'Cell Phones Alert Users of Natural Disasters' http://times.hankooki.com/lpage/tech/200501/kt2005010918551311800.htm (accessed 24/05/05)

Tainter, J. A. (1988) *The Collapse of Complex Societies*. Cambridge, Cambridgeshire ; New York: Cambridge University Press.

Taylor, M. C. (2001) *The Moment of Complexity: emerging network culture*. London: The University of Chicago Press.

Taylor, R. (2002) 'Interpreting Global Civil Society'. *Voluntas,* **13** (4)**,** 339-347.

The-Internet-Society (2005) 'The Internet Rises to the Challenge of Public Warning' http://www.isoc.org/challenge/ (accessed 29/10/05)

Thomas, L. (1980) *The Lives of a Cell: Notes of a Biology Watcher*. London: Allen Lane.

Thrift, N. (1999) 'The Place of Complexity'. *Theory, Culture & Society,* **16** (3), 31-69.

Toffler, A. (1981) *The Third Wave*. London: Pan Books.

Tomlinson, J. (1999) *Globalization and culture*. Oxford: Polity.

Townsend, A. and Moss, M. (2005) *Telecommunications Infrastructure in Disasters: Preparing Cities for Crisis Communications*. Center for Catastrophe Preparedness and Response & Robert F. Wagner Graduate School of Public Service, New York University: April 2005 (pp. 45)

Turettini, E. (2004) 'How cell phones may have helped Southern Asia' http://www.textually.org/textually/archives/2004/12/006534.htm (accessed 13/10/05)

Turney, D. (2004) 'The People's Network' http://www.drewturney.com/stories.php?articleID=596 (accessed 30/03/05)

Urry, J. (2000) *Sociology Beyond Societies*. London: Routledge.

Urry, J. (2003a) *Global Complexity*. Cambridge: Polity Press.

Urry, J. (2003b) 'Small Worlds and the New 'Social Physics''. *Global Networks: a journal of transnational affairs,* **4** (2), 109-130.

Urry, J. (2004) 'The Complexities of the Global' Centre for Science Studies, Lancaster University at http://www.comp.lancs.ac.uk/sociology/papers/urry-complexities-global.pdf

Urry, J. (2005a) 'The Complexities of the Global'. *Theory, Culture & Society,* **22** (5), 235-254.

Urry, J. (2005b) 'The Complexity Turn'. *Theory, Culture & Society,* **22** (5), 1-14.

Van Loon, J. (2002) *Risk and technological culture : towards a society of virulence*. London: Routledge.

Vinge, V. (1993) 'The Technological Singularity' http://www.kurzweilai.net/meme/frame.html?m=1 (accessed 29/01/04)

Vinge, V. (2006) 'The Creativity Machine'. *Nature,* **440** 411-412.

von Neumann, J. (1959) *The Computer and the Brain*. New Haven: Yale University Press.

Waddington, C. (1977) *Tools for Thought*. London: Jonathan Cape.

Wagner, M. (2004) 'Sri Lankan Chronicles Tsunami Aftermath Using Text-Messaging And Blogs' http://securitypipeline.com/shared/article/printablePipelineArticle.jhtml;jsessionid=KGBYM3DJT0V1SQSNDBECKH0CJUMEKJVN?articleId=56800178 (accessed 12/10/05)

Walby, S.(2004) 'Complexity Theory, Globalisation and Diversity'.British Sociological Association:University of York

Waldrop, M. (1994) *Complexity: The Emerging Science at the Edge of Order and Chaos*. London: Penguin.

Wallage, S. (2005) 'M-Banking Finds Success in Africa' http://www.thefeature.com/article?articleid=101636&ref=08622f810092d84110e295a9849e35ef::4812 (accessed 08/06/05)

Watts, D. (2003) *Six Degrees: The Science of a Connected Age*. London: Heinemann.

Watts, D. J. (1999) *Small Worlds : the dynamics of networks between order and randomness*. Princeton, N.J.: Princeton University Press.

Weiner, T. (2004) 'Pentagon Envisioning a Costly Internet for War' http://www.fromthewilderness.com/free/ww3/011905_pentagon_internet.shtml (accessed 11/11/04)

Whitehead, A. N. (1929) *Process and Reality*. London: Cambridge University Press.

Wiener, N. (1954) *The Human Use of Human Beings: Cybernetics and Society*. Boston: Houghton Mifflin Company.

Wiener, N. (1961) *Cybernetics: or control and communication in the animal and the machine*. Cambridge, MA: M.I.T. Press.

Wilson, E., O. (1975) *Sociobiology : The New Synthesis*. Cambridge, Mass ; London: Belknap Press of Harvard University Press.

Wilson, E. O. (1998) *Consilience: The Unity of Knowledge*. London: Little, Brown & Company.

Wolfram, S. (2002) *A New Kind of Science*. Champaign, IL: Wolfram Media.

Wright, R. (2000) *Nonzero: The Logic of Human Destiny*. London: Little, Brown & Company.

Wynne, B. (2005) 'Reflexing Complexity: Post-genomic Knowledge and Reductionist Returns in Public Science'. *Theory, Culture & Society,* **22** (5), 67-94.

Ye, Z. (2003) 'China's Emerging Civil Society' http://www.brookings.org/fp/cnaps/papers/ye2003.pdf (accessed 11/03/06)

Yizhou, W. (2005) 'Civil Society in China: Concept and Reality' http://72.14.203.104/search?q=cache:jysVcSnEKZIJ:www.iwep.org.cn/chinese/gerenzhuye/wangyizhou/wenzhang/civil%2520society.pdf+china%27s+civil+society&hl=en&gl=uk&ct=clnk&cd=3&client=firefox-a (accessed 11/03/06)

Zeleny, M. (1998) 'On the Social Nature of Autopoietic Systems' In *Evolution, Order and Complexity*. Khalil, E. and Boulding, K. (Ed) London: Routledge.