Strategic Knowledge Sharing:
A Small-Worlds Perspective

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Abstract

This paper is about designing knowledge sharing in wicked systems. The perspective the paper takes is that of the self-organising 'small worlds' phenomenon. Specifically, this paper will argue that strategic knowledge sharing can be viewed as designing small-worlds networks so as to allow a wicked socio-technical system to self organise a co-ordinated strategic response to unpredictable environmental changes. The evidence used will come from the softer systems literature, the biology (insect) literature and the social-network literature.

The Problem

Centralised governance of effective knowledge sharing is very difficult in times of rapid change, especially for purposeful, information rich, socio-technical wicked systems. The lines of communication quickly become clogged, leaders suffer information overload unable to fully appreciate problems at the local level. Decentralisation of knowledge sharing runs the risk of causing local overload, key information not being prioritised or depending on actors who only have experience at processing local problems. Alternatives such as 'middle-out' (Keen, 1999) have been suggested, where strategically informed middle level actors play a coordination role between the top and bottom level actors. This paper explores an alternative using the small-worlds phenomenon which is itself seen as a self organisation response which enables actors in a wicked and dynamic socio technical system to knowledge share an effective strategic response to environmental surprises.

For those who are concerned about the deep rooted assumption that all socio-technical systems needs hierarchy to become organised, this paper can be seen as a small contribution to the anti 'hands on' top-down view of leadership where some 'John Wayne' figure leads the herds of awestruck battlers through some life threatening disaster. Rather leadership is seen as designing a socio-technical system that is capable of allowing knowledgeable actors to interact strategically as they see the situation requires using their different experiences. To those who have some appreciation of the very limited impact even caring 'hierarchical leaders' can really have on the activities of any complex system, such as regional government, this paper may provide some improved sense of the complexity of leadership in these a dynamic situations. That said, this paper is not primarily about how to organise a response but rather how to envisage a self organising socio-technical wicked system. Examples of wicked problems in which this self organisation design is believed to be required includes broad area wildfires, rapidly evolving environmental disasters such as the one outlined below, blitzkrieg warfare, industry reorganisations and national IT policy in recent times.

Wicked Problems And Wicked Systems

A wicked problem is defined by Rittel and Webber (1973) *as* one which:

1) *Has no definitive formulation,*

2) Its solution is not true-or-false, but rather good-or-bad,
4) There is no immediate and no ultimate test of any solution,
5) Is a 'one-shot operation' since there is no opportunity to learn by trial and error,
6) Does not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan,
7) Is essentially unique,
8) Can be considered to be a symptom of another problem,
9) Results from a discrepancy that can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution, and
10) Does not allow the planner the right to be wrong.

Item 9, where the explanation of the problem is crucial to perceptions of its resolution is central to the design thinking in this paper. A description of a wicked socio-technical system is therefore defined as a system made up of people, supported by technology, who appreciate they are dealing mainly with these wicked problems. This means most human organisations. Although not explicitly mentioned, these problems are also dynamic; they change over time due to a mixture of events including new technology, new knowledge and a shift in participants' perspective. The design task is therefore seen as allowing actors in a wicked strategic problem to self organise what they see as an acceptable resolution.

This paper will discuss the self organisation, and the small-worlds phenomenon, providing two examples of wicked problems.

Self Organisation

The concept of 'self organising systems' is in danger of loosing its effectiveness due to becoming as vague as general systems theory and autopoesies with their abstract talk of generic open and closed systems. For example, Romme (1995) defines a self organising system as one that is both open and closed; evoking the old debate about what is a closed system. Minger's (1997) definition of autopoesies (self reproducing) would appear to subsume self organising systems, however, doing so may hide some of the advantages of using the perspective of self organising systems for automatic knowledge sharing when wicked systems are faced with problem. In order to be able to reproduce a system needs to be organised, but it may be hierarchical. A self organised system is one that does not need a hierarchy to respond to environmental surprises. It is the assumption of the need for a hierarchy to direct knowledge sharing that is being challenged. Self organisation is not being used here in the sense of the development of identity in a hostile environment like the establishment of the early Christian Church, the labour movement or the feminist movement. Rather, this paper is concerned with how a wicked socio-technical system might be designed to share knowledge so as to provide an effective response to environmental surprises with no explicit internal hierarchy. Ideas about how these systems might be designed come from analogies with the world of insects. Some swarm ant nests like some bee nests have no boss, no corporate plan, no strategic planner but a higher level organisation has *emerged* that serves to enable the unsuspecting insects to make a strategic response to unpredictable large scale problems that suddenly impinge upon their world.

There is an extensive literature (eg. Minger, 1997) on self-reproducing, self-replicating, and similar systems. This paper will bypass revisiting these and merely synthesise from two related phenomenon. The first is the empirical scientific biological literature about what insect colonies do to share knowledge to provide an effective strategic response to problems. The second comes from the small-worlds literature which has recently moved from the sociometric literature to the sciences as more and more biological systems are seen to use the small-worlds structure to share knowledge. These will be discussed in term of a story from the 'crisis management' literature which tells what actually happened in response to a rapidly changing community based problem, in particular when the strategic response voided any pretence of controlled top-down knowledge sharing.

The Insect Literature

There has been a lot written about self organisation in the biological sciences. Much of this literature is presented as a mathematical analysis of patterns that emerge, e.g. waves, sand dunes, tree structures and the markings on animals. Camazine et al. (2001) however, provide an empirically based explanation using insect systems. This paper's interpretation of what is meant by self organisation draws heavily on this, thus draws on analogies from the world of the insect nest. Camazine et al. observe that some complex actions emerges through simple interactions internal to the system, without intervention by external directing influences. More formally they define self organisation as:

> *"a process in which pattern at the global level of a system emerges solely from numerous interactions among the lower level components of the system. Moreover, the rules specifying interactions among the systems components are executed using only local information. [p8]*

Camazine et al. (2001) do not accept that the queen is somehow 'giving instructions' to the millions of insects who have never been near her. The term 'queen' is misleading; the term 'womb' would be more acceptable from a knowledge sharing perspective. Each individual ant or bee bases its behaviour on its perception of the position and behaviour of it nearest neighbour rather than knowledge of the global behaviour of the whole group. Local dynamic knowledge sharing is all that is present yet the insects are able to make strategic responses to a global threat on the whole nest. A strategic response somehow 'emerges' from lower level actions, evidenced by the very existence of a nest which has specialised integrated operations. The individual ants are not even thinking about this higher order purpose but rather are only concerned with their own small function in the nest. If this emerging strategy appears different to the actions of lower level activities then the system may be described as complex. Individual ants forage for food, build the nest, care for the eggs and milk the queen, yet somehow these activities have become co-ordinated to provide a species that has successfully survived for millions of years.

Camazine et al. summarise the now significant amount of empirical research that has been conducted on insect nests to better understand how a strategic response can emerge. For example a few ants in a Petri dish were found to move sand around in a random fashion achieving nothing. When enough ants were added the probability increased of the production of a randomly constructed shape that the ants recognised, and responded to. The presence of these certain shapes acted to suddenly start the ants working in a coherent manner, constructing recognisable elaborate structures. In another example an ant's nest was damaged and metal plates used to divide the damaged area in such a way that knowledge sharing between the two damaged areas was impossible. The strategic response, the reconstruction, matched perfectly. When the dividing plate was removed the rebuilt sections look like one overall rebuilding exercise perfectly orchestrated. In summation of this empirical literature Camazine et al. (2001) identify a series of conditions necessary to enable the insect activity emerge a knowledge sharing system that results in a coherent strategic response. These include the presence of:

- Group Influence
- Stigmergy,
- Decentralised Control, Dense Heterarchies, and
- Dynamic Knowledge Sharing.

Group Influence

Camazine et al. do not clearly label this attribute of a self organising group; rather they sum it up as "I do what you do". The idea starts with noticing that members of a group copy or mimic those around them, they are influenced by the actions of others. Children do what their parents do, artisans learn from their Masters, business school teach the 'echo of lies' of how management is done, and when at work we pick up the corporate culture, we become team players, we learn the preferred way of doing things around here, if we want to 'get along'. Examples of our compliance to our local group norms include our dress, religion, food and ethics. However, we can from time to time insert some small minor variation based on experiences we learnt elsewhere. This is analogous to our genetic make-up, we are only minor variants of our parents. An invention, a new recipe or a clothes fashion change are examples of an individual changing a group's behaviour but if we are honest one person usually makes very little difference on the generic behaviours of a community. This 'get along, go along' behaviour seems related to our very strong 'inclusion' needs; we need to belong to some group. Horses are trained by threatening to exclude them from the herd, which is far more sustaining as a threat than physical pain. The worse punishment we inflict on other humans is solitary confinement. The need to belong is seen as explanation of why 'herd' species and insect colonies are influenced by the behaviour of the whole group; "I do what you do".

Being influenced by the behaviours of others, especially those immediately around you, is central to self organisation. An insect is born and perceiving the world will be intimately integrated with what the insects colony around are doing, she will merely do what the ants immediately around her do, using what ever genetically received devices she has at her disposal. The empirical evidence of this from the insect research includes the behaviour of fire flies. When swarmed, fire flies, with their flashing tails, will all end up synchronising their flashing. The fire flies will alter their flash time and speed under the influence of the group. Infectious yawns, synchronised reproductive cycles, synchronous breathing and 'mobbing' are all examples of human group behaviour influencing individual behaviour. Wilson (1983) a librarian thinking about the demand for books, uses the term 'cognitive authority' to identify which of those around us we choose to mimic. In an insect colony it is assumed the individual insects can only choose to mimic, to listen to, those immediately around them. Modern people, who have access to the media, books, different corporate cultures, and are able to travel to numerous different communities have a much wider choice of cognitive influences from which to mimic.

In this social setting knowledge sharing between those in immediate contact is expected to have largely already occurred. When a crisis occurs more than one insect knows the same things.

Stigmergy

Camazine et al. (2001) are very nervous about the idea that colonies of insects carry in their heads a detailed recipe or fully laid out blueprint of what, for example, a nest should look like, a detailed vision of what the finished construction should do and be. This is justified with the empirical evidence for how nests respond to different physical situations. The insects build allowing for the physical conditions encountered, so every nest is slightly different. Yet overall common design features are observable. This is attributed to the insects not knowledge sharing but merely responding with a set of alternatives.

Stigmergy is a term attributed by et al. to Grasse (cited in Camazine, 1959). It refers to the mechanism whereby a swarm insect (ants, bees) is stimulated to work constructively towards their purpose by the presence of work in progress. The half completed work of other like-insects is recognised as an 'event' which induces automatic *responses* from those that see and recognise it. For example an ant may see a pair of pillars and respond by building an arch between them without having communicated directly with the earlier builders. This is an indirect form of knowledge sharing; event driven asynchronous knowledge sharing. The human equivalent may be the response of rescuers when a building is seen to collapse or a child is seen to be treaded badly. In place of stigmergy, Michener uses the expression, "indirect social interactions", in systems management it may be called asynchronous knowledge sharing through design. It may be the quantity of pheromones on the half finished building works or it may be the physical shape that acts as the asynchronous stimulus, for insects.

It is possible to appreciate the importance of asynchronous knowledge sharing to the running of a complex system (one that has emergent properties) like an ant nest by drawing on the analogy of a modern corporation. The existence of multinational corporations has been attributed to the faxes, (e)mail and web pages; asynchronous knowledge sharing. The size and control of a large organisation is restricted in terms of oral knowledge sharing. While oral synchronous knowledge sharing is very important, time zones, legal records and very detailed specification require 'written', asynchronous knowledge sharing. The nations that have developed joint synchronous and asynchronous knowledge sharing have been dominant in economic and scientific terms. At a more modest level Camazine et al. are suggesting a more subtle form of asynchronous or indirect social interaction and thus motivation in the presence of half completed tunnels, pheromone paths and other work in progress.

Given the centrality of purposeful activity to systems thinking and design (Ulrich, 2002) (Checkland, 2000) it seems necessary to mention this here. Purposeful activity is presented by Checkland and Ulrich as an emergent property from the large self conscience human brain, which is thought to enable us to be able to appreciate the drivers (purpose) for our action, stand outside ourself. Should insects be thought to be engaged in purposeful activity, unlike the parts of an alarm clock? Are not the insects living out some genetic drivers such as to bring up young, to continue the gene pool? Surely any human self organising system would need to anticipate that the participants would be able to ask themselves why they are or should act. Moreover, language could be used to provide a driver to act. Therefore, in human self organising systems it may be necessary to emphasise why people should act if it is not physically obvious to them. However, Camazine et al. understate the influence of purposeful activity, even ones from genetic survival, for the insects compared to group interaction influences. They place much more emphasis on the insect responding than to having some driving force for they are trying to achieve. The genetic drivers of gene survival is not emphasised possibly because most of the insects never see or come in contact with the young.

Decentralised Control and Dense Heterarchies

The Decentralised Control attribute identified by Camazine et al., is defined as a particular "architecture of information flow". Each insect responds to the insects immediately around to learn what is to be done, not from messages received from well informed individuals (leaders) in the upper echelons of a control hierarchy. The organisation chart is one of small clusters of interacting insects responding to one stimulus such as a half built arch in one part of the nest, or a food retrieval clique at another location in the nest. There is not a tree like hierarchical knowledge sharing flow up and down; rather the structure is more of a series of independent clusters of workers who ninety percent of the time only communicates directly with the other members of their cluster (clique, small-worlds). Only when they are unable to solve a problem with the local knowledge sharing will they venture out to ask another cluster. The Dense Heterarchies attribute reinforces the image of a series of separate yet connected small clusters with each focusing on different but loosely interconnected tasks. Heterarchies are inter-independent groups, not hierarchical and yet not totally independent clusters. This raises concerns about how a strategic response is possible by these roughly independent responding clusters. The small world's literature may help.

Small-Worlds

The previous section briefly introduced some of the findings from the empirical biological research as presented by Camazine et al. The next thread of the synthesis presented in this paper is that derived from the sociometric literature. In order to develop some appreciation of the knowledge sharing system considered so central to insect nest life, it is perhaps necessary to discuss this literature, or at least one part of it, the small-worlds literature.

The small-worlds phenomenon was popularised by Migram's experiments later captured in a play and film 'Six Degrees Of Separation" (Watts, 1999). The idea being that it appears that any two people picked at random are connectable via a chain of not more than six intermediate acquaintances. This seems counter intuitive given that for most of us frequent direct two way conversation only occurs with less than 20 people; our small world cluster. In socio-metric network terms, this suggests an overall population network which is neither 'everyone knows everyone else' nor one where local clusters of socially interactive persons have no means of contacting other clusters. The reality is a mix of the two, imperfect knowledge sharing between clusters. In rather simplistic terms a small world network can be illustrated as per figure 1. So if pushed to send a message from one cluster to another, it is usually possible for us to find a 'weak link' between the clusters, who can carry a message betweens these clusters. In figure 1, if A wants to send a message to F, whom they do not know, then first they would ask friends in cluster 1. B says they know someone C in cluster 2 who may be able to pass the message on. When C gets the message she asks her friends and D suggest E who does know F. Solid lines represent knowledge sharing between people who talk to each other very frequently and dotted lines are between people who talk very infrequently.

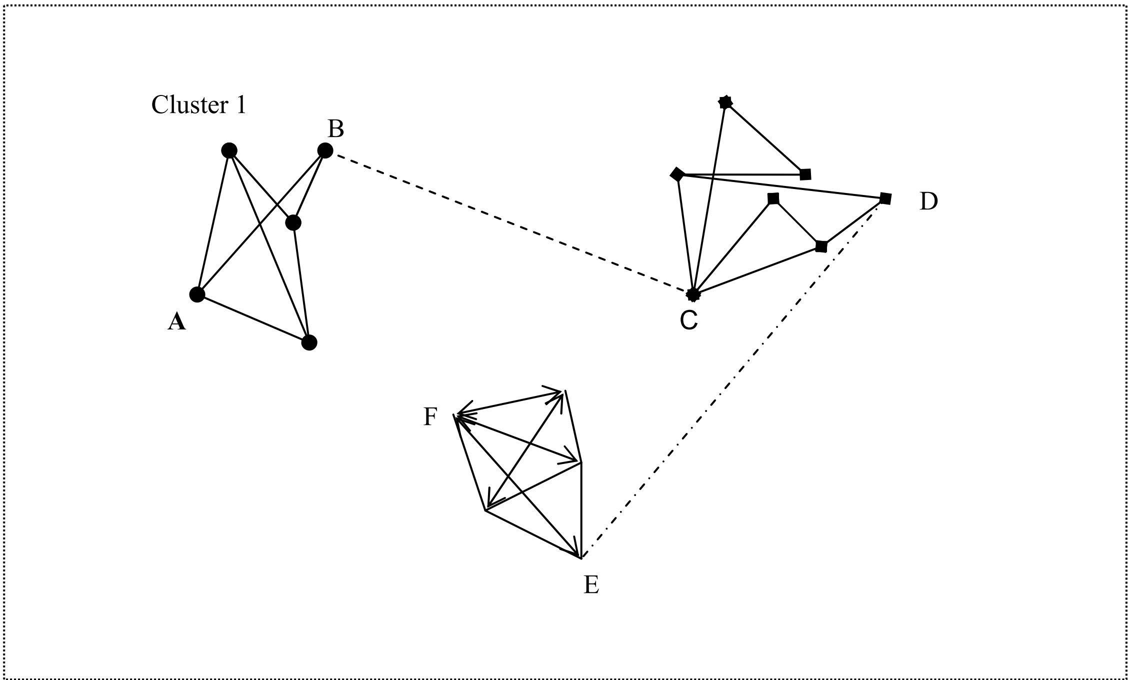

Figure 1: Small-Worlds

The small-worlds phenomenon provides a way of seeing knowledge sharing between small groups of ants working one particular project cluster, and occasional sharing with other groups of ants working within a different project cluster. It is perhaps predicable from the knowledge sharing theory literature (Hare, 1976) which highlights that we can only have direct two way knowledge sharing with a limited number of people due to the exponential growth of knowledge sharing channels given an increase in people. With 3 people wishing to communicate with each other freely there are only three knowledge sharing channels that have to be kept open (A to/from B, A to/from C, and B to/from C). For 4 people there are 6, and for 5 there are 10 channels that have to be serviced. For people that may mean pleasantries, as well as being able to physically get to and from them (same time, same place). Having to service a lot of channels become time consuming.

So, with an ants nest it is possible to imagine a situation where an ant responds to the ants immediately around it obeying self organisation driver one (I do what you do) and joins in doing whatever they are doing, perhaps building a new passageway. When a problem arises with the harmony of this activity no-one in the ant's immediate cluster knows what to do. One of them talks to an ant nearly that was not involved in the passage building, an ant from another cluster it only weakly know. This weakly known stranger may communicate that it is very busy collecting food. This then stimulates the passage builders to start collecting food. When a crisis occurs in this task then the ants look around for previously weak messages about other tasks.

The small worlds research (Killworth, 1979; Watts, 1999; Matsuo, 2001; Richardson, 2001; Buchanan, 2002) extends the social network research (eg. Mizruchi, 1994; Scott, 1996; Durrington, 2000; Cross, 2002) by suggesting what network shapes have self organised both in human groups, the natural environment, in written communication and in biological systems. The management literature is increasingly seeing knowledge management as a social networking problem (Hansen, 1999) (Roubelat, 2000; Reagans, 2003) and in particular Hansen (1999) studied management issues related to knowledge sharing using weak links.

Examples

To summarise, the above suggests that small-worlds networks allow for effective knowledge sharing both in time of routine and when a strategic response is required. This suggests that anyone responsible for designing the knowledge sharing network in their organisation might use this lens to evaluate their communications systems. Two very simple examples are now discussed. The first is an account of how a community level problem was responded to with special emphasis on the knowledge sharing issues. Hopefully, the analogy to ants nest and the small-worlds phenomena is apparent.

Comfort (1994) argues that the citizens' response to a oil spill near Pittsburgh in 1988 was a self organised one, as the situation was too rapid and too complicated for a simple top down leadership response. She reports that the crisis began with a four million diesel fuel tank collapsing which causes a chain of events that then resulted in a seventeen mile long emulsified oil and water mixture flowing down and over the locks and dams along the Monongahela River, extending bank to bank. The River provided drinking water for the Pittsburgh metropolitan region but the risk of damage to water filtration systems made the water authorities shut down the water intakes, resulting in a lack of water for either drinking or fire suppression. For two weeks alternative arrangements had to be organised requiring the co-ordination of 25 different types of organisations, public, private, and community non profit. The Zoo, the fire service, medical services, the Coast Guard, hazard waste services, car washes, and bottled water companies all had to be co-ordinated.

One can easily imagine groups of concerned persons forming informal clusters around their particular concern, or expertise. The bottled water people may be one, the fire services another and so on. Most of their knowledge sharing would be within their cluster, perhaps on a one to one basis. Every now and then these clusters would need information from another concerned cluster such as the bottled people trying to understand how long the crisis would last, or how to get access to extra transport, or bottle manufacturing facilities. They would use their 'weak link' to make contact with another cluster, as they would to keep overall appreciation of what is going on. The whole system will only work if there are both the locally knowledgeable clusters and the presence of effective weak links.

One knowledge sharing centre handled an estimated 37 thousand incoming and outgoing messages during the crisis; 154 per hour 24/7. This would have been a fraction of the knowledge sharing involved. Comfort (1994) emphasises the need for a dynamic decentralised information system, one that provides up to date local and overall information as the situation changes, one able to record messages asynchronously and then supply relevant message to inquirers at a later time. The danger is that critical information would not be stored and located effectively and so not correctly identified due to the sheer mass of messages being generated. This was not possible through one hierarchical knowledge sharing hub. A self-organisation or small world's knowledge sharing system is required one that at present needs to use human memory and their general awareness.

Another simple but familiar wicked problem may help. This one cannot use hierarchical control of knowledge sharing because inventive and creative research.

A University is made up of numerous groups undertaking research in their own discipline area. This typically involves small groups from one or two to laboratories of 10 to 20. These know much the same 'stuff', the discipline specific research methods, the literature and the worldwide experts. View these research groups as small-worlds knowledge clusters. The strategic imperative, common purpose, some of these wicked system clusters may appreciate is the need for multi-discipline research to provide a comprehensive research effort to deal with wicked problems such as poverty, terrorism or natural disaster response. This common purpose will spread through the weak links. The Research Dean may encourage this concern by allocating increased resources to multi-disciplined research solutions. Each cluster has specialist knowledge and any excessive attempt to insist all its members spend a significant proportion of their time getting to know other cluster's research in detail may distract from them developing their own knowledge. However, these clusters do need to be 'weak linked' both with each other and with clusters knowledgeable about research resources. These weak links will need to be synchronous and asynchronous (stigmergy), web pages, internal research newspapers, publication listings, signage, question asking software like 'askme.com", web publishing of seminar PowerPoint slides, financial rewards and Listserve public acknowledgement of achievements are examples of the asynchronous (stigmergy) weak linking. Telephone lists by knowledge area, cross discipline coffee groups and conferences are examples of synchronous weak linking. The role of the Research Dean is merely to provide effective responses to those that do multi-discipline research compared to those that do not, and to encourage weak linking (not strong linking) between groups that would not normally even appreciate each others existence. Given the common purpose and the presence of weak links, the self organisation perspective anticipates that member of the clusters will knowledge share and self organise a response appropriate for the knowledge of the entire University.

Conclusion

There is not much new about many of these activities perhaps because weak linking across clusters is naturally efficient, an unappreciated theory in use (Argyris and Schon, 1978). However, this paper has attempted to make this theory explicit, into an explicit image that makes sense of what is going on. This, it is hoped, will make the governance of strategic knowledge sharing more explicit. Given the complexity of wicked problems and the creativity needed to respond to them, hierarchical control of either participant's actions or of their knowledge sharing is considered naive. The exact opposite of a 'need to know' knowledge sharing policy is required. Participants are to be encouraged to decide for themselves what they need to know and to be aware where they can get that information easily, as in the oil spill example.

This paper has argued that strategic knowledge sharing can be viewed as designing small-worlds networks so as to allow a self organised strategic response to wicked problems. Knowledgeable clusters and (a)synchronous weak links can both identify wicked problems and respond strategically. A designer of this sort of network needs to encourage knowledgeable clusters which are only weak linked together (a)synchronously. Perhaps with a commercial organisation the designer may allocate resources to encourage a particular common purpose. Two examples of wicked problems being handled by wicked systems were outlined. In one the wicked problem was a rather obvious oil spill threatening many dimensions of a community. In the other the wicked problem required innovation and creativity. Both should not be managed in a hierarchical sense.

Future research may continue the work to make explicit the design of existing social networks in public and research communities, so as to better appreciate if they follow a small world structure. The limits of (a)synchronous 'weak links' may also warrant further investigation, as might the role for ICT. Other suggestions include how people communicated, with whom, when involved in a crisis; what information did they want they could not get? How the self organisation process works also needs to made more explicit.

References

Argyris, C. and D. A. Schon (1978). *Theory In Practice*. San Francisco, Jossey-Bass.

Buchanan, M. (2002). *Nexus: Small Worlds*. NY, W.W. Norton.

Camazine, S., J.-L. Deneubourg, et al. (2001). *Self-Organization in Biological Systems*. Princeton, Princeton University Press.

Checkland, P. (2000). "Soft Systems Methodology: A Thirty Year Retrospective." *Systems Research and Behavioural Science* **17**(1): S11–S58.

Comfort L.K. (1994). "Self-Organization In Complex Systems." *Journal of Public Administration Research and Theory* **4**(3): 393–

Cross, R., S. P. Borgatti, et al. (2002). "Making Invisible Work Visible: Using Social Network Analysis to Support Strategic Collaboration." *California Management Review* **44**(2): 25–46.

Durrington, V. A., J. Repman, et al. (2000). "Using Social Network Analysis to Examine the Time of Adoption of Computer-Related Services Among University Faculty." *Journal of Research on Computing in Education* **33**(1): 16–27.

Hansen, M. T. (1999). "The Search-Transfer Problem: The Role Of Weak Ties In Sharing Knowledge Across Organization Subunits." *Administrative Science Quarterly* **44**(1).

Hare, A. P. (1976). *Handbook of Small Group Research*. New York, Free Press.

Keen, P. (1999). Middle-Out Ideas, http://pwaa002790.psiweb.com/cworld30.htm. **2004**.

Killworth, P. D. and H. R. Bernard (1979). "A Pseudomodel Of The Small World Problem." *Social Forces* **58**(2): 477–505.

Matsuo, Y., Y. Ohsawa, et al. (2001). A Document As A Small World, www.miv.t.u-tokyo.ac.jp/~matsuo/homepageeng.html. **2003**.

Mingers, J. (1997). "Systems Typologies in the Light of Autopsies: A Reconceptualization of Boulding's Hierarchy, and a Typology of Self-Referential Systems." *Systems Research and Behavioural Science* **14**: 303–313.

Mizruchi, M. S. (1994). "Social Network Analysis: Recent Achievements and Current Controversies." *Acta Sociologica* **37**: 329–343.

Reagans, R. and B. McEvily (2003). "Network Structure and Knowledge Transfer." *Administrative Science Quarterly* **48**: 240–267.

Richardson, K. A. and M. R. Lissack (2001). "On the Status of Boundaries Both Natural and Organizational: A Complex Systems Perspective." *Emergence* **3**(4): 32–49.

Rittel, H. W. J. and M. M. Webber (1973). "Dilemmas in a General Theory of Planning." *Policy Sciences* **4**: 155–169.

Romme, A. G. L. (1995). "Self-organizing Processes in Top Management Teams." *Journal of Business Research* **34**: 11–34.

Roubelat, F. (2000). "Scenario Planning as a Networking Process." *Technological Forecasting and Social Change* **65**: 99–112.

Scott, J. (1996). "Software Review: A Toolkit for Social Network Analysis." *Acta Sociologica* **39**: 211–216.
Ulrich, W. (2002). "Critical Systems Heuristics". *Informed Student Guide in the Management Sciences*. H. G. Daellenbach and R. L. Flood. London, Thomson Learning**:** 1–2.
Watts, D. J. (1999). "Networds, Dynamcs and the Small World Phenomenon." *American Journal of Sociology* **105**(2): 493–527.
Wilson, P. (1983). *Second Hand Knowledge*. Westpost, Connecticut, Greenwood Press.