Economy and Society Volume 33 Number 3 August 2004: 411–424

Is all the world a complex network?[1]

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Texts reviewed

Barabási, Albert-László (2002) *Linked: The New Science of Networks*, Cambridge, MA: Perseus Publishing.
Buchanan, Mark (2002) *Small World: Uncovering Nature's Hidden Networks*, London: Weidenfeld & Nicolson.
Taylor, Mark C. (2001) *The Moment of Complexity: Emerging Network Culture*, Chicago, IL, and London: University of Chicago Press.
Urry, John (2003) *Global Complexity*, Cambridge: Polity Press.

I

Each of these four books provides an examination of two key features haunting current social science analysis: networks and complexity. Indeed, if one were looking for the likely 'next big thing' in social science exploration, a strong case could be made that it will be exactly 'networks and complexity'. There is an excited embrace of these twin concepts among an increasing range of social scientific (and humanities) research, detailed at great length in these books. Rather suddenly networks and complexity are all the rage (though in economics these have had a longer pedigree – see the discussion and references in Barabási, chapter 14, and Buchanan, chapter 11, both of which deal with complex networks and the economy).Given the formidable premium on 'doing something different' or 'thinking differently' in our intellectual culture – particularly in its more avant-garde quarters – we can only expect the rapid development of this particular set of conceptual tools. Whether these endure, of course, is another matter.[2] But probably these will prove to be more robust than most. As will become clear in a moment their twin formulation has the advantage of neatly incorporating several other current intellectual fashions under the 'network and complexity' conceptual umbrella, notably 'globalization' and the 'information society'.

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ISSN 0308-5147 print/1469-5766 online
DOI: 10.1080/0308514042000225725

The task of doing justice to these books is a difficult one. Although they share a set of similar overlapping concerns they approach these in different ways and in somewhat different registers. But all are enthusiastic about the consequences of the network–complexity encounter. Barabási's and Buchanan's books are the most similar (from now on respectively *Linked* and *Small World*). Barabási is a physicist who is credited with many of the formal discoveries of technical network theory, particularly as they pertain to the nature of the Internet.[3] His is a popular account of these developments aimed at the general reader. Buchanan is a science journalist and writer, who provides an equally popular treatment of almost exactly the same topics as does Barabási in *Linked*. Indeed, their chapter titles and sequence almost completely mirror one another.[4] On the other hand, as its sub-title suggests, Taylor's book (hereafter *Moment of Complexity*) concentrates on the cultural aspects of complexity and networks and, although this is explicitly linked to the idea of a 'network culture', his book is mainly about cultural *theory* as rendered into network and complexity terms. This makes *Moment of Complexity* very much a book of high cultural theory. Finally, John Urry's book (hereafter *Global Complexity*) is in many ways the most ambitious of the four. For Urry, 'complexity' has completely taken over the world and has gone global: the planet is one global complex networked 'structure' (or several inter-linked ones – see his chapter 3).

For the purposes of this review, and the benefit of those not so familiar with all the claims made on behalf of complexity and network analysis, I first outline as far as possible a set of common themes that all the books share. Then I go on to engage critically with each of them. We start with the claims made for complexity.

II

Complexity is the term used to refer to self-reinforcing dynamic systems with many feedback mechanisms. In these complex systems operating in a social context, behaviour is modified as a reaction to what other agents do. The non-linearity of these systems means that small amounts of change in inputs can have dramatic and unexpected effects on outputs. Formally, complexity is equated with the number of different items or elements that must be dealt with simultaneously by the organism or organization. But its distinctive feature is to stress the world as a system in construction, a dynamic formulation encouraging the notion of a continual process of spontaneous emergence. Multiple possible outcomes are typically associated with the mathematically inscribed non-linear modelling techniques used to isolate the network topologies. Turbulence and uncertainty abound in this environment, often further described as 'open systems ecologies', where perpetual novelty results. Filling one niche simply provides new niches, and small perturbations can affect the future of multiple combinations of events.

III

When we move on to *networks* perhaps it is worthwhile initially drawing a distinction between what one might term 'technological networks' and 'social networks'. *Technological networks* have mainly to do with electronic communications and transport technologies. These are often known as the 'network industries', typified by chains of interlinked nodes forming a grid-like structure (see Shy 2001). On the other hand, there are *social networks* where it is the social ties themselves that are thought of in network terms, and these are much more fluid in construction and operate according to social norms and other cultural practices. The point about this distinction is that network industries can be easily thought of as being co-ordinated and governed in several different ways, crudely put, by hierarchies, by markets or by informal social networks themselves. Thus, in this case, a technical network can be governed by market means, involving competition on the basis of price differentiation, or via administrative and hierarchical means, or via means of the norms of social networks. In the case of social networks proper, however, there is a genuine question as to whether it is sensible to think of these as 'co-ordinated and governed' either by market means or by hierarchical means. This is because both these prior forms of co-ordination involve a completely different logic of governance than that offered by the notion of social networks themselves. This implies that social networks would simply be reduced to a market form of organization or a hierarchical one, and, if this were the case, then the notion of social networks as a distinct category of organization – existing with their own logic of operation – would have been dissolved by these means of governing them or co-ordinating them. Thus, social networks are best considered to be governed or co-ordinated only by means that articulate social networks themselves. If not, the three different 'ways of organizing the social' begin to lose their specificity and cannot be properly and consistently distinguished one from another – they all become understood as just variations of the general category 'social networks'. The market form of co-ordination and the hierarchical one are both reduced to being forms of networks. Without a separate conception of 'social network co-ordination and governance', conceived in distinction from market or hierarchy, say, there is a danger that too much gets loaded onto a single notion of social networks.[5] If everything is a network then nothing is.

The point about drawing this distinction between technical and social networks, and trying to maintain a separation between different forms of co-ordination and governance – where one of these is a special form of social network co-ordination – is that these books precisely do not hold fast to these distinctions, although they discuss various features of them. Indeed, they go further and argue that something I shall call 'complex technical networks' (which does not directly coincide with the 'network industries' as just mentioned above, though they are related) now provides the operational means to understand all the underlying 'structures' of physical, biological and social life. There is a single logic to all natural and social life forms, embodied in the idea of 'technical network complexity'; there is a universal

choice of network architecture that is no mere coincidence but the confirmation of a universally influential effect (*Linked*, p. 111; *Small World*, p. 116). This arises spontaneously but not accidentally. And it can be uncovered by paying close analytical attention to physical structures, biological evolution and phenomena like the Internet, all of which display and manifest the characteristics of this single 'technical network complexity'. But, above all else, this technical network complexity can be commonly specified in terms of the logic of mathematical topology.[6] In addition, I put 'structures' in inverted commas deliberately since in part these analyses are driven by a concern to replace the notion of 'structures' in analytical life with that of 'flows and fluids' (this is particularly the case with *Global Complexity*). Structures are too static and Newtonian in style – they lack the dynamism of the quantum world. So Einstein's quantum physics acts very much as the backdrop against which complex networks are considered (*Linked*, chapter 8; *Global Complexity*, chapter 2). Thus at a fundamental level – and once again, it must be said – it is the imagery of physics and mathematics that is being directly imported into the social sciences to bolster its analytical credentials. But this imagery in not being used metaphorically. In the case of the complex networks considered in these books, their social aspects can be accessed immediately by considering them as mathematically specified systems directly analogous to physical ones. There is a single architecture that informs all complex networks.[7]

IV

The third common theme running through these books is that of the self-organizing nature of complex networks and their essentially endogenous character.[8] There is no arranged external stimulus – organization is not the result of an encounter with an external environment. Insofar as order can be thought of under these circumstances, it happens not because of selection but despite it, a function instead of the spontaneous propagation that is self-organization. The 'learning' that is involved in these systems is not, then, equivalent to a classic systems-environment model, where the adaptation of the system to its environment is controlled externally and according to which the adaptation of the system occurs in the course of various encounters making up the learning process. Rather this is replaced by an organizational *systemic closure*. This closure is operational in so far as the effects produced by the system are the reasons for the maintenance of systemic organization. *Where there is sufficient complexity, the system performs internal self-organization and exerts self-control.* The information the system thereby provides about its environment is a system-internal construct – there is no need for a directing activity from the 'outside'. To coin a phrase directly from *Linked*, it is a 'Web without a Spider' (chapter 15). Any reference to an 'outside' is merely a special case of self-reference – the language of self-reflexive circuits is rife in these books (see, in particular, *Moment of Complexity*, chapter 3).

But if network complexity is to be dynamic there must be some 'energy' within the system that drives it. This is provided by the 'work' that the

organisms or agents in the network contribute, which is of two kinds. First, there is strict 'internal' work, combining and recombining the existing configuration of elements and agents. But then there is another kind of work, which involves the internalization of the 'external' agents and elements; in the case of social networks, new members, new partners, new customers, new suppliers, etc. Only if there is a constant injection of the energy provided by these twin interrelated means will the network system thrive (become a 'dissipative structure'). In turn, this means that the recruitment of new energy – by motivating the internal agents, by shaking up the organization, by providing new sets of challenges – becomes a key issue. Generally the more turbulent the internal environment, the more energy is being produced and used up, and the more dynamic and robust is the network. So the key to the recruitment of new energy from 'outside', as it were, is what is going on 'inside'. And that energy must be recognized and reconfigured internally (so as to preserve the endogenous character of genuine self-organization – though see below).

However, there are some thresholds – upper and lower boundaries – to the extent of this turmoil if the complex network system is not to collapse. To establish order, there must be neither too many connections nor too few. Too few, and the network energy is too low, so collapse threatens. But too many connections – at the limit full connectivity with every element connected to every other one – and the system becomes hopelessly unstable (Simon 1996). Instead, what is needed is a system in which there are loosely coupled connections (a 'decompositional hierarchy') so that most components receive inputs from only a few of the complex network system's other components, enabling change to be isolated into local neighbourhoods (network 'hubs' – see below). This controls the rate of change and establishes an order in the network system.

Clearly, stable states are thus delicately balanced. The more connections there are, i.e. the greater the potential network energy, the more likely it is that the internal system will be thrown into turmoil. And there is a tendency for the system to gravitate towards maximum connectivity – towards the 'edge of chaos', as it has been termed – since this gives it the advantage of maximum energy. But, if there are too many of these connections, when the system is perturbed, elements and agents will fly off from one 'attractor' to another or create a new attractor (an attractor is a limited range of occupied network topological space). This accounts, then, for both the idea of change in these kinds of networks – they evolve as the system moves from one attractor to another, creating new connections – and why the question of stability and order is the flip side of this evolution. The system is always delicately poised between stability and disorder.

This can also theoretically account for Mark Granovetter's 'strength of loose ties' idea. Looser and less dense connections are a strength, necessary for stability and network robustness. *Linked*, *Small World* and *Global Complexity* all pay attention to Granovetter's pioneering work (1973, 1983) on the application of network theory to social relationships. Granovetter acts a crucial link between the mathematical logic of technical network topology and its deployment in respect to the world of social relations and business as discussed in these books.

But, this also demonstrates one of the unsolved paradoxes of the self-organizing principle of complex network relationships when pitched into a social world. The need for there to be some 'management' of the system to prevent it moving too closely to the 'edge of chaos' would seem to be both a necessary and a redundant feature of networks conceived in this manner. Systems 'automatically' evolve towards this point – a point where small and large avalanches of co-evolutionary change cascade – because this state gives them a selective advantage. Getting near here (but not past it) provides a competitive advantage over those systems that do not reach it. At this point, small changes in behaviour lead to widely different 'fitness levels' – at first peaking and then tumbling to very low fitness levels. So, the key to organizational success is to learn how to manage this trend towards the edge of chaos; to stay near it but not to let things become truly chaotic; to find an intermediate region that maximizes system fitness by combining sustainable levels of flexibility and stability.

However, if networks are genuinely self-organizing then there would seem to be no reason for these kinds of managerial or regulatory interventions. The fact that this is an implicit requirement to prevent the 'descent into chaos' raises a genuine issue as to the self-organizing status of complex networks. Admittedly, if left entirely to themselves these systems would, one suspects, eventually return from chaos, but at what cost and under what circumstances? The temptation to intervene managerially, in an attempt to avoid this cost, is clearly ever present. In fact, this issue is posed directly in *Linked* and in *Small World* on several occasions, though its implications are not fully explored. For instance, the role of Microsoft in the development of computer operating systems considered in *Linked* (pp. 104–6), which is seen there as an epitome of the fitness model of complexity in action, cannot be considered independently of the recent intervention by the Department of Justice in the US to prevent the system degenerating into a completely closed network. The pressure was on to break up Microsoft precisely to preserve the positive consequences of its complex network-like output structure. Similarly with the prosecution of so-called 'MafiaBoy' (a Canadian 15-year-old) who hacked into the Internet in 2000 (*Linked*, pp. 115–16). He had the potential nearly to cripple the WWW and therefore to upset its self-organizing character dramatically. Both of these 'interventions' came from 'outside' the network system. So complex networks are not just free floating and self-organizing but require a supporting system or regulatory regime operating from the outside that intervenes to upset them or stabilize them at times. So one must surely remain unconvinced of the degree to which scale-free networks are invulnerable to 'systemic failure' and to which they have a high tolerance of error. Rather, they are typified by a combination of robustness and vulnerability, which at times does lead to their collapse. While the delicate relationship between robustness and vulnerability is recognized in these books, its implications for the idea of self-organization are not. In addition, Barabási in *Linked* discusses the issues of potential 'cascading failure' that is a feature of all grid-type network systems, but is again rather silent on what lessons this offers for the supposed self-organizing character of networks. A

recent example of such a cascading failure was the electricity power supply collapse and blackout that happened on the east coast of the US and Canada in August 2003. This was not a good example of the self-organizing (and therefore self-regulating) capacity of a classic network structure, but rather the direct result of a failure in that self-organization via the lack of investment in the infrastructure to support it. Rectifying this would require an external intervention to stimulate investment, increase capacity and reduce the incentives in the then-current system to over-load the grid supply network while at the same time selling even more electricity profitably to consumers at the retail end of the supply chain.[9] The general point here is that any such system is always already regulated or managed from the 'outside' and will continue to be so as a matter of practical operational existence.

V

The fourth common element shared by all four books is a fascination with the Internet and the World Wide Web (WWW). Indeed, it might be said that it was the development of this electronic medium that provided the stimulus for the current interest in complex networks among a wide range of commentators and academics. The treatment of the WWW/Internet also provides a link between the technical side of complex networks and their more social aspects.

Both *Linked* and *Small World* begin their explorations of the role of the Internet/WWW with a discussion of the famous 'six degrees of separation' issue pioneered by Stanley Milgram (1967). Milgram was intrigued by the seeming fact that everybody was potentially linked to everybody else in the world by only six relational moves in a chain of connections. What this demonstrates, Milgram and others thought, was that the world was one incredible network and a very 'small world' indeed. Thus, potentially at least, I should be able to 'contact' the North Korean leader Kim Jong-il ('The Great Leader'), say, involving a chain of just six intermediaries. But, even if this could be done, a reasonable question would be 'how meaningful would it be?' As the authors point out, the whole exercise presumes a kind of grand flat and 'democratic' structure to the social world. The problem encountered in the real world, of course, is that there are *boundaries and limits* to the degree to which it is possible to count others as real contacts available for any meaningful social interaction let alone ones simply available to communicate with. The actual world is made up of *barriers* – socially constructed and reproduced, calculated for and regulated, monitored and policed – which prevent (often for good reasons) the complete integration of everyone on a global scale (and even on a national, local or community-level scale). This is all aided by technical means, of course – like passwords, data encryption, fire walls, brute physical barriers, and so on, in the case of the Internet. What a concentration on the mathematical technicalities of the 'six degrees' issue and the Internet does is push these real obstacles to the endless possibilities of communication firmly into the background. But they are

precisely the interesting and telling ones from the point of view of any meaningful 'analysis of the social', even one conducted in network terms.

As a result of these obstacles, of course, the social world in not at all democratic in this sense. In fact, this is well recognized in both *Linked* and *Small World*. They both tell a very interesting story about how the early formulations of small world networks were progressively undermined as it became clear that there is a tendency for networks to create hubs as these provide more stability and robustness. Hubs establish a kind of 'hierarchy' within networks and this in turn gives a certain advantage to key positions or players (hubs are described as 'aristocrats' in *Small World*, p. 119). One consequence is that 'the rich get richer' as indicated in chapter 7 of each book (see also *Small World*, p. 104). Those who by luck or manoeuvre find themselves in a key position or space in the network can reap a virtuous cycle of advantage. And there is not much that can be done about this if one takes these analyses at face value. This is where the consequences of the supposed self-organizing nature of social networks kicks in once again, since, if the underlying mathematical architecture establishes this outcome, there is nothing that can be done to redress it. Any interventionary culture will simply fail – it will collapse as it comes up against the inexorable logic driven by the self-organizing complexity of ubiquitous networks.[10] But none of these complications fundamentally alters the basic 'small world' architecture of the Web, it is argued. They just extend the numbers in the chain of connections: from six we go to ten and then on to nineteen (*Linked*, p. 34)

VI

It is *Moment of Complexity* and *Global Complexity* that use the existence of the Internet and WWW to the greatest extent to explore the new ways cultural relationships are being re-configured. *Moment of Complexity* presents a sophisticated analysis of this and links it directly to the emergence of a network culture.[11] Broadly, a network culture involves the movement from grid-like geometric conceptions of cultural relationships to fluid-like ones redolent with circuitous loops and mobile surfaces. The architecture of Frank Gehry and the paintings of Chuck Close are used to exemplify this movement; the operation of the WWW confirms its immanent existence. Although Close uses a very obvious 'grid-like' structure to execute many of his most famous paintings (particularly in the case of his self-portraits which are considered in *Moment of Complexity*), Taylor argues that these grids get lost in their networked complexity: as they are turned and twisted, as more detail is crammed into each cell, as the viewer moves back from and advances towards the canvas, as clear visual information retreats into sensual noise. Similarly, he suggests with the pixels on a computer screen. In both cases, on close inspection, form becomes complex, and fractals are set in a kind of motion.[12]

Although *Moment of Complexity* is hard-nosed and innovative in many

respects, like most contemporary cultural theory it is saturated by a concern with visual imagery, and takes most of its intellectual leads from this 'visual turn'. Taylor's *virtual* network culture is ultimately a *visual* network culture, even as it considers things like the WWW. It is the screen that occupies attention here (chapter 7: 'Screening information'). But whether the issue is an architectural drawing, the canvas of a painting, the screen of a television, cinema or computer monitor, these act as a kind of 'mirror' that reflects back onto the observer. Cultural subjectivity and identity are posed directly in this context. Thus the notion of 'identity' (including political identity), for instance, becomes one inscribed within a recognition/mis-recognition conceptual structure – one fundamentally driven by the idea of the imaginary. The 'other' is inscribed on the surface of the 'mirror' (screen canvas, drawing, text), and the category of identity cannot escape this conceptual embrace.[13] With these formulations the categories identity and subjectivity are ultimately narcissistically configured. But the problem here is what lies 'beyond the Other'. What lies 'behind the mirror', as it were? What occupies that long, damp and dark space *behind* the screen/canvas/text, etc., cut off from intellectual investigation by the brightness of the reflection and the self-reflexivity it encourages? These questions cannot be properly posed by the visual turn in cultural theory.

In fact, *Moment of Complexity* does half pose this issue since it sees the computer screen more as a permeable membrane than an impenetrable wall (pp. 199–200), but this only disturbs the image further by making all the ripples and waves of the fluid even less stable. In asking what a screen hides, however, questions of self-consciousness and memory are interestingly raised in *Moment of Complexity*. Here would have been an opportunity perhaps to have pushed the analysis beyond the contours of a language of 'multiple screenings', 'unprecedented noise' and knowledge seen as 'screened information' to express the nature of meaning and sense emerging in Taylor's complex world (though, to my mind, chapters 7 and 8 – where these issues are discussed – are the most telling and innovative of the book).

VII

A final set of questions about these books is posed most clearly by the radical approach to cultural analysis advanced by *Moment of Complexity* and *Global Complexity*. These press the idea that an understanding of complex networks has completely transformed the analytical style needed to cope with post-structural modernity and the information society. What is demanded by the advent of these changes is a fluid space for the conception of networks and their operation, one that continually changes shape, celebrating the idea of movement, performance, the process of creative exorbitance, dancing 'bodies', talk as action not communication (or representation as signification), an endless process of direct practices, with no 'foreshadowing' in terms of a discernible outcome that might be constructed in advance (see *Global Complexity*, chapter 4:

'Networks and fluids'). Above all, it is against the predicable, the calculable, the standardized and the routinized that, it is suggested, are characteristics of structural styles of analysis. Thus they promote a kind of open systems methodology (of which there are many variants).

Now, without wishing to necessarily defend all structural styles of analysis, it is important to confront some of these suggestions with a reality test. The trouble is that the world is not one that is in continuous state of flux. It is not all movement and performance. Most of the time things stay the same – too often and for too long for many of us! While ideas associated with an open systems approach are attractive in one sense, they are also difficult to handle and to sustain in the longer run. They are attractive because they seem to prevent the ossification of thought and practice and an unimaginative, non-innovative analytical approach. But open, complex network systems and their methodology inevitably display a high degree of redundancy. As they are expansive and always threatening to collapse (because of the continual threat of leakages, overflowings and undoings built into their dynamic), it becomes difficult to stabilize the networks they embody. Where and when do the fluid performances by the actors stop and a relatively fixed representation emerge? Yet another opening could always be potentially attachable to the existing configuration, so that there is a never-ending cascading of opportunities to disrupt and to re-configure. This sets up high levels of redundancy, as the 'system' must over-compensate for the inevitable experimental 'failures' that are written into its evolutionary dynamic. Both L*inked* (p. 248) and *Moment of Complexity* (p. 139) mention redundancy, which they see as an attribute necessary for network robustness. But high redundancy also comes at a cost. Such 'systems' are expensive to run (intellectually and practically) and therefore relatively economically inefficient. Continual intellectual or social experimentation implies substantial waste, as failure has to be paid for. An over-abundance of connections is also dangerous for network stability, as mentioned above. The advantage of a differentiated and more limited intellectual and organizational horizon suggested by a differentiated idea of coordination and governance, and the creation of competing organizational frameworks in an attempt to understand order, is that this presents the opportunity to compartmentalize the 'organization of the social' and, to some degree at least, to stabilize it. It means actors can find out where they are and what they are doing. An intellectual and organizational constancy and consistency is installed – at least for a reasonable period of time. This is useful in that it means experiences and reflections can be assessed, knowledges consolidated and re-produced, successful models copied and compared. Not everything is under a continual scrutiny and in a continual state of flux.

Take the long, rich and enormously complex history of industrialization as an example. This can be conveniently divided into several different phases that capture the essential characteristics of different 'little structures' of the productive process: 'craft production', 'the American system of manufactures', 'mass (or Fordist) production', 'flexible (or lean) production' and currently a further possible emergent variant, the 'information economy'. With each of these models there is

broad agreement on what they entail and the characteristics of the production and distribution systems they involve, their typical firm type, labour relations regime, accumulative and regulatory form and capabilities, etc. (though this is still less clear for the emergent 'information economy' form, if there is one – see Thompson (2003b)). Nor do they have to be seen as involving a necessary linear unfolding emerging one after another, but rather as coexistent possibilities within a complex structural assemblage at any one time. These models can be used to draw contrasts between their different aspects, to stabilize knowledge about them, help place particular developments in a context and aid in the general business of suggesting what can be done to improve things or change things.[14] Thus there are real benefits to be gained from being able to produce the kinds of guidelines that are embodied in models of this type, and there is therefore good reason to continue this activity in the case of the complex network processes considered in these books.

From this point of view the analysis of social processes requires the following operational procedures to render them into useful analytical devices and to make them manageable. First, they need to be periodized to divide them up into meaningful phases for contrasts, comparisons, etc., as summarized by the discussion of 'little models' just undertaken. Second, they need to be given some 'structure' (elements and levels involved, relationships between these, nature of 'events', etc.) so as to generate the periodization just mentioned. Third, there is a need for some theory about how change occurs (rapid discontinuities, disjunctures, smooth passages, slow evolution, the agency involved, etc.). Fourth, there needs to be some idea as to 'where' the process is going, not in the sense of an 'end to history' or teleological 'final destination', but in terms of a meaningful objective or aim. Thus, in the case of a 'peace process', for instance, there must be at least some idea of what peace means – and similarly in the case of the 'globalization process' considered in *Global Complexity*. There needs to be some idea of what globalization means as the concrete manifestation of a societal form. Without this it is difficult to see how sensibly analytical work can be done. Finally, there is a need continually to ask the question 'where are we in this process?' (which itself requires the notion of an 'end' in the sense just indicated). All this adds to the strictures about the need for some simple and well-understood, relatively stable 'analytical models' to aid an understanding of this dynamic.[15]

Finally, there is a real *political danger* in not recognizing the need to organize deliberately for a closure, to limit the possibilities associated with complete openness and a celebration of the unpredictability of the future. I am reminded, here, of a passage from Machiavelli's *The Prince* (1984[1532]). There are at least two Princes in *The Prince*, a foolish Prince and the wise Prince. In the chapter entitled 'On fortune's role in human affairs and how she can be dealt with', Machiavelli contrasts the attitudes of these two Princes to the construction and maintenance of the irrigation systems in their states (1984: 82). The wise Prince pays close attention to his flood defences, carefully constructing channels and ducts, fostering and maintaining them. On the other hand, the foolish Prince neglects his irrigation system and lets it fall into decay. What happens when the flood comes, asks Machiavelli? The foolish Prince is swept away, destroyed by the

flood. The wise Prince, on the other hand, survives. His defences work to carry the water harmlessly away. The moral is obvious here. *Fortuna* is always threatening to strike. If you do not prepare your defences you are in danger of being swept away by it. Rendered into a language recognizable in *Moment of Complexity* and *Global Complexity*, texts, screens, canvases, etc., are always threatening to 'overspill' with meaning, just like irrigation systems in the case of water. This could so easily lead to incoherence and triviality. How can this threat be contained or avoided? If nothing is done, *we* will all be swept away by the tide along with the Prince. Better not to forget to erect some intellectual and practical barriers against the potential complete openness, fluidity and leakages. But these warnings are not just pertinent for 'network culture', they are also pertinent to the realm of politics more generally, as Machiavelli first intended. There is a need to 'divide things up' so as robustly to manage the relationships between them.

VIII

Clearly networks are important and worthy of close scrutiny and study. Each of these books has something worthwhile to say about them. They each have their strengths. But there is a danger if networks are given too exalted a status. If they are generalized so far that they encompass everything, then they end up including nothing. This danger is very apparent when one conceives of networks as embodying a universal architecture that pertains to all aspects of natural existence. In *Moment of Complexity*, for instance, myths, language, mathematics, writing, culture, the mind and the brain, the body, and much more besides are all argued to be examples of what Taylor terms 'complex adaptive systems', i.e. networks (chapter 7). But perhaps networks need to be confined to more limited roles than this, particularly if they are to illuminate any analysis of the social. At the least it is necessary to keep apart the technological and the social aspects of networks, if nothing else because social networks are not as amenable to a mathematical treatment as are their technical counterparts. And in the case of the social world there are a range of other clearly demarcated forms of coordination and governance that compete with networks: various forms of market organization, multi-level governance, neo-corporatist private interest governance, hierarchical supra-nationalism and inter-governmentalism, multilateralism, etc., etc. Furthermore, networks are themselves in need of governance if their 'downsides' (too quick a closure to other participants, inward looking and defensiveness in their operation) are not to overtake and destroy their undoubted benefits (see Thompson 2003a: ch. 6). As for anything else, there need to be limits to the embrace of networks.

Notes

1 This title suggested itself to me on reading David Cohen's 'All the world's a net' (*New Scientist*, 13 April 2002, pp. 24–9), which introduces the topic with reference to the

first two books reviewed here. This provided my first encounter with the full claims of formal network theory.

2 Barabási predicts that the twenty-first century 'will most likely be the century of complexity' (p. 197)

3 This book parallels Duncan Watts' recent popular exposition *Six Degrees: The Science of a Connected Age* (2003). Watts has also done pioneering work on formal network theory, particularly on the 'small worlds' issue discussed below. See Watts and Strogatz (1998) and Watts (1999).

4 For instance, both their chapter 7s are entitled 'The rich get richer'.

5 These points are argues at length in Thompson (2003a).

6 Formally, the topology of a network is the structure of its interactions, contours and scales – i.e. its 'connectivity'. These structures can take a number of forms such as: complex, distance power, tree, nearest neighbour, small world, torus, discrete, random, scale free and others.

7 Clearly, the affiliation to actor network theory (ANT) is evident here. ANT tries to dissolve the distinction between the physical and the social world by promoting the idea of 'actor-networks' involving 'actuants' – physical *or* social active agents that are articulated in the dynamic flows of open relational network structures. See Thompson (2003a: chs 3, 8) for an extended discussion of this approach. The affinity between ANT and the complex network approach adopted in these books is drawn attention to in *Global Complexity* (p. 122).

8 The following paragraphs in this section summarize the way network complexity is dealt with in *Linked*, chapter 9; *Small World*, chapter 8; *Moment of Complexity*, chapters 5 and 6; and *Global Complexity*, chapter 2. All cover a similar ground.

9 In fact the US electric grid is not designed to be fail proof. Rather it is designed to be run 99.9 per cent of the time. That works out to about one failure every ten years, which makes the blackout of 2003, while dramatic, also predictable. New York's previous blackout was in 1977. For other portions of the US Northeast it was in 1965. (Parts of the US Pacific west also suffered a blackout in 1996.) According to the US Energy Department, while energy demand had doubled over the previous twenty-five years, investment in high-voltage transmission lines had fallen by 45 per cent. The Department predicted that the capacity of the nation's high-voltage electric grid network would increase by only 6 per cent in the next decade, while electricity use and production would jump by 20 per cent. In the wake of the blackout, the US Energy Secretary at the time (Stephen Abraham) suggested it would cost $50 billion to modernize the US national grid. (This information was gleaned from *Knowledge@Wharton Newsletter*, 27 August–9 September 2003: 'Lights out: lessons from the blackout').

10 Regulators come and go, but the topology and the fundamental natural laws governing [the Web] are time invariant. As long as we continue to delegate to the individual the choice of where to link, we will not be able to significantly alter the Web's large-scale topology, and we will have to live with the consequences' (*Linked*, p. 175).

11 An echo from the work of Manuel Castells (1996, 2001) resounds loudly here.

12 Of course it would be possible to take a different critical view on the paintings of Chuck Close, and consider them alongside two other contemporary painters who deliberately use rectilinear organization, geometric grids and proportional measuring systems in their paintings, namely Bridget Riley and Euan Uglow. Here I speak from recent experience of viewing exhibitions of each of these three 'grid-style' painters. The question they all pose in this respect – and from the perspective of the self-organizing character of Taylor's network culture (see p. 131) – is how far the grid imposes itself upon the subject of the painting, rather than it being discovered or formulated within it. Set against this comparative background Close's technique surely falls into an intermediate position between Riley and Uglow. Riley's grid is imposed from without. There is little sign of 'internal' self-organization here. On the other hand, Uglow's grids emerge more from the subjects of the paintings themselves. They are part of the paintings, energetic

and unruly whole. So what about Close? To my mind his grids operate much more forcibly as an imposition from the outside than recognized by Taylor. In addition, of course, any painting would appear 'complex' as the eye moves close to the canvas since this always distorts the ostensible subject matter.

13 Of course, there is an alternative – and in my view equally unsatisfactory – way of thinking about subjectivity and identity in cultural theory. This is to see it emerging as a consequence of the position one occupies within social relationships. Different subjectivities/identities emerge from different positions agents occupy in the social hierarchy.

14 For a rigorous and largely successful analytical attempt to deal with this type of approach in a 'narrative' sense, see Abbott (2001).

15 What this ultimately amounts to is a methodological imperative to 'interrupt time', to 'stop' the flow of history so as to generate some analytical stability. Of course actual time does not stop. The evolutionary imperative continues. But this just means that there must be a difference between evolutionary time proper and analytical time. For analytical purposes it is necessary to stop time so as to appreciate what the consequences of the actual continual flow of time really are. And one of the purposes of interrupting time in this way is to provide the space for a representation of it.

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