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Abstract
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Complexity Theory

Helen Hasan

Several years ago a prominent Australian politician, responsible for a new program to 'Network the Nation' used this diagram to try to explain what he envisaged. Popularly referred to as 'The Noodle Nation', the diagram was ridiculed for its apparent complexity. It seems that there are better ways to deal with complex issues!

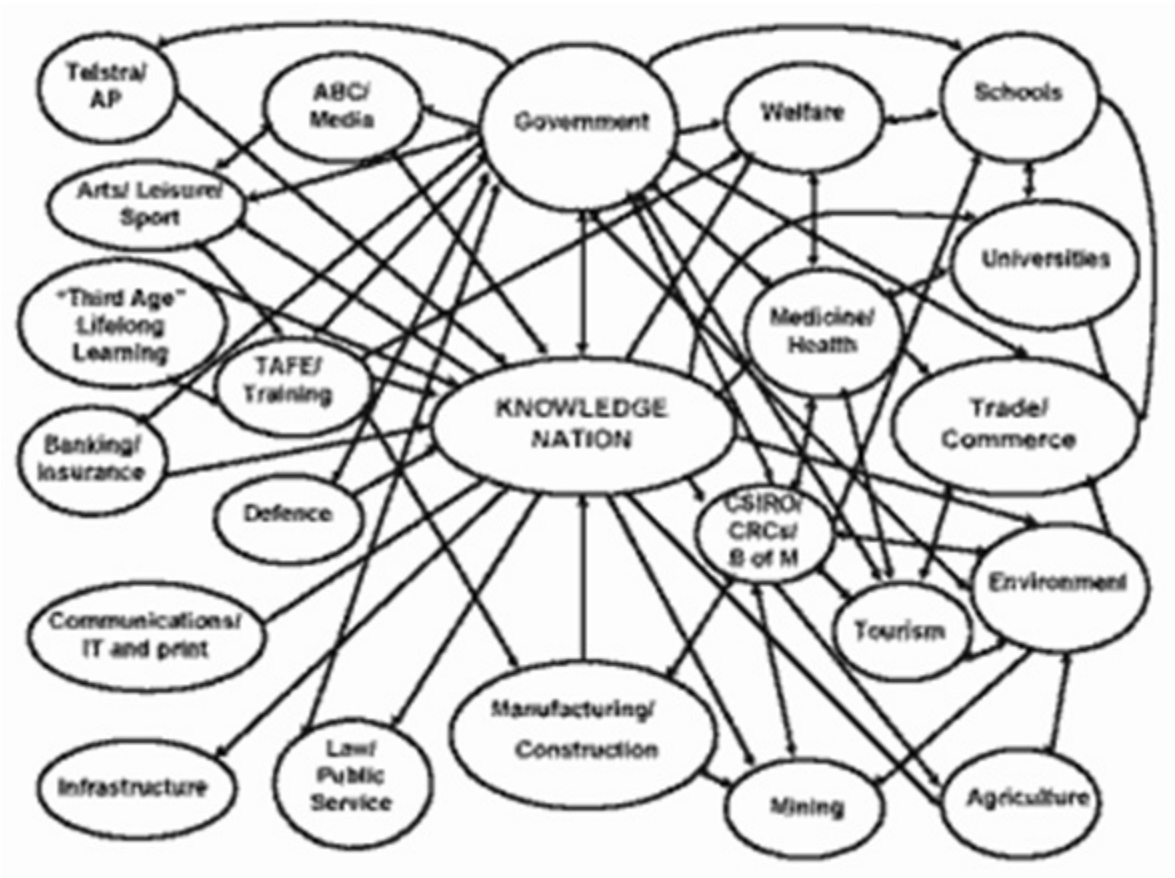

Figure 1. The Noodle Nation diagram

In common parlance, the word 'complex' is often applied loosely to a situation or problem. Even in scientific and academic circles it has many definitions that reflect the complexity of complexity itself. There is no unified field of complexity theory, but rather a number of different fields with intriguing points of resemblance, overlap or complementarities. Most complexity theories are concerned with the behaviour, over time and space, of complex systems. The key finding claimed for all complexity theories is the effective unknowability of the future (Principia).

According to the U.S. Department of Energy Office of Science, complex systems or, more importantly, complex adaptive systems, are described as, 'fluidly changing collections of distributed interacting components that react to both their environments and to one another and whose behaviour in impossible to predict'.

Most people agree that the world is becoming increasingly more complex, i.e. for the physicists among you, Entropy always increases. Considered as a complex adaptive system, the world has growing numbers of interconnected elements, many of which are due to developments in Information and Communications Technologies (ICT), and, in particular, the Internet. The exponential growth of the Internet (Figure 2) together with the World Wide Web (WWW) since the 1990s has surprised everyone and taken us in directions that few predicted. This growth is mainly due to the decision by its creators not to patent or copyright its basic elements, the Hypertext Mark-up Language (HTML), the Hypertext Transfer Protocol (HTTP and the Universal Resource Locator (URL). The consequences of making these freely available to all has resulted in the amazing WWW and is a prime example of the application of principles of Complexity Theory, exemplified in the tweet by Internet founder Tim Berners Lee, 'This is for everyone' at the 2012 Summer Olympic Games in London.

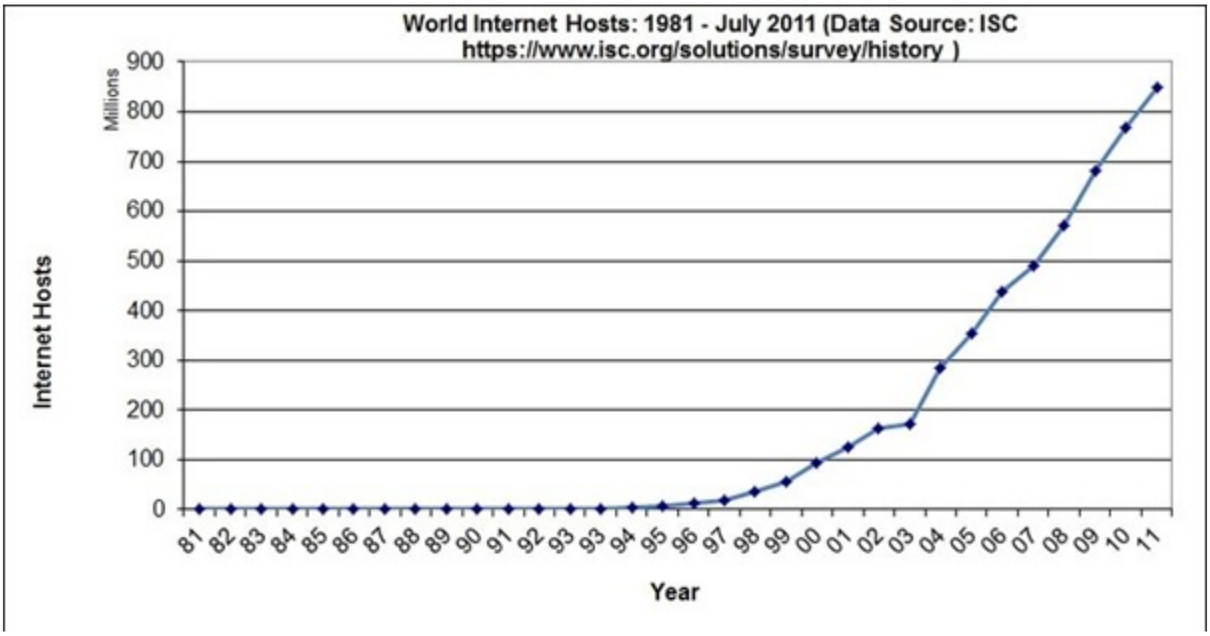

Figure 2. The exponential growth of the Internet since the mid-1990s

Complexity in practice

In order to apply complexity theory to practice, we make a clear distinction between what is really complex, and therefore must be treated as such, and what is merely complicated (Snowden 2002; Kim & Kaplan 2006). Although composed of many intricate parts, *complicated* systems can be understood by careful examination so that their future behaviour can be predicted. *Complex* situations, problems and systems are fundamentally different as they are, 'comprised of populations of interacting entities where the overall system behavior is not predefined but rather emerges through the interactions of its entities' (Kim & Kaplan 2006, p. 37).

Dealing with *complex* problems and situations as if they were merely *complicated* is inappropriate. Complex systems have incomplete, contradictory, and changing requirements and large numbers of diverse components whose interactions are dynamic, rich and non-linear. A complex problem is often referred to as 'wicked' because it is difficult or impossible to solve because of incomplete, contradictory and changing requirements that are often difficult to recognize (Rattle & Webber 1973). Moreover, because of complex interdependencies, the effort to solve one aspect of a wicked problem may reveal or create other problems. Stakeholders may hold contradictory, but valid views of a wicked problem and how it should be solved.

In complex situations and systems, the number of components is sufficiently large that conventional descriptions are not only impractical, but cease to assist in understanding the system. Components in the system are ignorant of the behaviour of the system as a whole, responding only to what is available to it locally. The components also have to interact and their interactions are dynamic, rich and non-linear. The behaviour of the system is determined by the nature of these interactions, not by what is contained within the components so that future behaviour cannot be predicted from the inspection of its components. Such dynamic complex systems exhibit what is popularly referred to as the 'butterfly effect', where even small differences in initial conditions yield widely diverging outcomes rendering long-term prediction impossible. Complex systems operate far from equilibrium conditions, so there has to be a constant flow of energy to maintain the organisation of the system. They are open and it may be difficult or impossible to define system boundaries. This existence of open and ill-defined boundaries adds to the complexity so that complex systems can be understood in different ways from different perspectives.

Principles of Complexity Theory

To understand complexity further we turn to generally agreed principles of Complexity Theory where emergence, co-evolution, self-direction and self-organisation are paramount. According to Kurtz and Snowden (2003) and Middleton-Kelly (2005) the processes of emergence and co-evolution cannot be planned, but can be encouraged by allowing people to be self-organised and self-directed. Precise outcomes cannot be known in advance, but positive outcomes are likely if appropriate incentives and rewards are used to influence the behaviour of the system towards the desired direction. Complex adaptive systems require an environment that allows open sub-systems; interactions and relationships; transformative feedback loops; emergent behaviour; attractors and boundaries; distributed control; shallow structure; and growth and evolution (Kurtz & Snowden 2003; Meson & Jain 2006).

As the previous paragraph shows, there is a particular language of Complexity Theory that needs some explanation, which is now attempted.

Emergence

Emergence is essentially a bottom up process whereby a groundswell of activity enables something to come into being, to become important or prominent. Unlike a top down process, which is deliberately planned with specific outcomes in mind, an emergence process is allowed to determine its own path and own outcomes. Emergent processes can be encouraged by *attractors*, supported and guided, but are usually spoilt if attempts are made to control them before it is ready.

Kautz (2012) claims that the concept of emergence is at the heart of complex systems. He highlights action such as the emergent order resulting from the interactions of self-organising participants; the emergence of team learning as a result of the interaction; co-evolutionary based emergent behavior and structure; emergent complexity at the edge of chaos; the rhythm of working at its own pace; and, the emergent balance between exploitation and exploration.

Attractors

Human activity can be stimulated with attractors (such as incentives, resources and permissions to act independently within reasonable boundaries) to see if beneficial patterns of activity form around the attractor. When beneficial activity emerges we can reward it and try to stabilise the activity so it continues.

In Complexity Theory, the term 'Strange Attractor' is often used in an evolutionary form of a system, which permits high degrees of individual behaviour and in which the end point is always different.

In human systems, the term 'Hidden Attractor' refers to someone or something that is not recognised as having influence until it is removed.

Self-organisation

Self-organisation is the ability of interconnected autonomous agents of a complex adaptive system to evolve into an organised form without external force.

In an organisational context, self-organisation is the spontaneous coming together of a group for a purpose.

Self-Direction

A self-organised group is self-directed if it decides what to do, how and when to do it, with no outside direction. This requires a fundamental departure from the command and control philosophy of traditional ways of organising.

Co-creation and Co-evolution

Co-creation involves new modes of engagement that allow the unleashing of the creative energy of many people, usually with diverse backgrounds and skills, in cooperative endeavour s where there is respect for this diversity and no single person's views dominate decisions made. In such endeavours desired outcomes co-evolve.

Edge of Chaos

Although originating in science and mathematical versions of Complexity Theory, this term is used to represent the situation where people in a well ordered system or situation are stimulated or 'kept on their toes' by the realisation that this order could all fall apart. This can happen in a negative way when a large business is in trouble or a major restructure is underway and the majority of members are disenfranchised or fear for their jobs. On a positive note, the prospect of a major breakthrough or revolutionising technology can revive a stalled or stagnant situation.

Law of Requisite Variety

According to the principle of *requisite variety* proposed by Ashby (1957), the internal diversity of any self-regulating system, such as a self-organising team, must match the variety and complexity of its environment if it is to deal with the challenges posed by that environment. Diversity of knowledge and skill can provide a resource for innovation and learning (John 1998). If the systems that regulate do not have enough (or requisite) variety to match the complexity of the regulated, then regulation will fail and the system will be out of control. If a team is heterogeneous or complex, it is likely to have plenty of variety; if it is simple (homogeneous) the variety is usually low and it will struggle to perform a complex task in a complex environment (Hasan 2006).

Dialectic Relationships

When there are diametrically opposed differences of opinion we often seek to resolve these through some sort of compromise or middle ground. A dialectic solution is one that allows the different points of view to be recognised and retained. Emanating from the work of German philosopher Hegel (1969),a dialectic relationship between a particular position (a *thesis* or proposition) and a diametrically opposed position (its *antithesis*, the negation of the thesis or a reaction to the proposition) allows both to be valid. *Synthesis* resolves the conflict between the thesis and antithesis by reconciling their common truths, and forming a new proposition. In practice, wicked problems with conflicting requirements are not 'solved' in the usual sense of the term, but are resolved (or dissolved) through synthesis. In time this new proposition is itself challenged, creating further wicked problems and this dynamic also contributes to the complexity of the phenomena.

The message of Complexity Theory is that complexity is not something to fear, but a part of life that needs to be treated in ways that are different to the ways non-complex matters are dealt with.

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