Complex dynamic systems

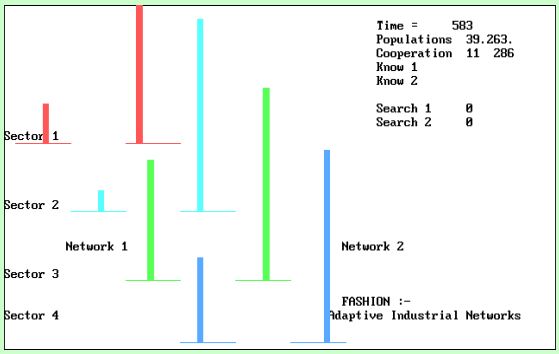
Peter Allen, Professor of Evolutionary Complex Systems at Cranfield University, described recent developments in the theory of complex adaptive systems, and some of the practical applications of the theory in fields as diverse as Japanese automotive manufacture and Canadian fishery policy.

Today, businesses and organisations must deal with the production and delivery of increasingly complex products and services, in a rapidly changing and uncertain environment. This requires the constant updating of the co-ordination and integration of the activities of many diverse and different businesses whose concerted output is responsible for the product and its delivery. Survival and sustainability require that we learn how to bring about self-transformation, adaptation and change in ourselves, in our organisations and in the networks in which we are embedded.

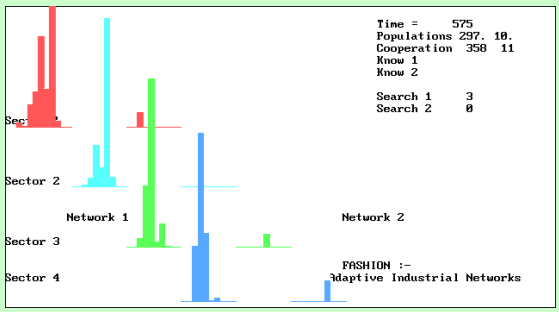
One way to achieve a high rate of delivery of new products and services, and rapid adaptation to changing conditions, is through self-organising networks of suppliers. Here, products emerge as the result of a changing pattern of collaboration of a network of suppliers, both competing and co-operating, each expert in its own domain. The network is characterised by long-term relationships between nodes, but does not always require the same partners to be involved all the time. Different nodes can rapidly come together or separate for production and delivery.

Such networks are examples of 'complex adaptive systems' – systems which co-evolve with their environment and with each other and

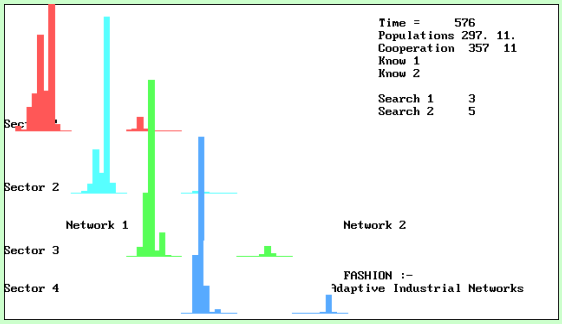
Exploration v. efficiency



When two supplier networks compete without exploration, their performance is comparable. Network 2 wins, but both survive.



When Network 1 tries 3% exploration, it convincingly outperforms Network 2.



When Network 2 responds with 5% exploration, Network 1 still wins.

are themselves capable of change - of their internal structures, their functionality and direction. The success of such systems is the product of the dynamic tension between two modes of operation – 'exploration' and exploitation.

These two modes are radically different. The qualities required for exploration are freedom and the ability to move into uncharted territory, while those required for efficient exploitation are the ability to make and act upon rational analyses of the processes and costs of the system. But these are contrary qualities. Pressure for greater measurable accountability and short term share-holder value makes it increasingly more difficult to protect the presence of the qualities required for exploration against the simpler, more easily measured qualities for exploitation, as any research director will know from discussions with the finance director.

A recent study of Toyota revealed the ways in which they derive benefit from an approach which embodies these principles. Toyota uses a 'set-based' design approach in which the development of a new model is initiated from several different 'starting concepts'. These are all explored at some length in parallel before options are eliminated.

This contrasts with the more usual practice in the automotive industry where after a rapid overview, a starting concept is defined which becomes the basis for an iterative process which 'hill-climbs' up to acceptable performance. However, in this case they generate knowledge only of their 'hill' while Toyota generates knowledge about the landscape. The Toyota approach enables a choice between a wider range of options so as to yield greater profitability in the short term, and more useful knowledge for future model design.

The big question then is "How much of one's resources should one put into exploration?" Simulation of idealised supplier networks revealed that networks with a 'small' propensity to explore options beat those that concentrated entirely on efficient execution, and also beat those that devoted too much resource to exploration. (See figures)

Which leaves open the questions "How much is small but enough?" and "How much is too much?". The theory does not yet give the finance director an easy algorithm. But it does provide scientific support for the intuition that 'lean is not enough'.