Nature offers guidance on organising dynamic networks

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Today, for many, computer networks are an indispensable infrastructure that interconnects people, places and organisations. But increasingly they are beginning to creak as their complexity grows. Biological systems through years of evolution can offer clues on how to cope, as a research project has demonstrated.

"Even a minor perturbation on a network can cause major problems," says Dr Ozalp Babaoglu at the University of Bologna. "Simply adding a computer or installing an operating system can suddenly mean that the printer stops working or you can't access your files."

The problem is caused by complex systems, where a large number a simple elements interact. And networking can be complex. Millions of interconnected nodes create inherent complexity and a growing

sophistication of interactions between devices means complexity exists even when the number of devices is modest.

Enter the BISON project funded under the European Commission's FET (Future and Emerging Technologies) initiative of the IST programme.

BISON is inspired by Complex Adaptive Systems like ants, fireflies and even single cells. "Complexity in computing is already a problem, and traditional methods are no longer adequate to address the problems," says Babaoglu, BISON's coordinator. "And it's going to get worse as the internet becomes increasingly complex. Biological systems, on the other hand, are incredibly resilient and amazingly robust, so we're taking inspiration from a system that we know works."

BISON took a 'modular' approach, using simple and predictable services as building blocks, or protocols, to develop more complex functions.

Using simple protocols the group validated its approach by developing a load-balancing protocol, which is very important to stop traffic from overwhelming a particular node. With the proof of principle established, it's hoped others will begin designing further tools.

"The load balancing protocol was inspired by negative chemotaxis," says Babaoglu. Chemotaxis is a process where single cells or multicellular organisms move towards a chemical stimulus. Negative chemotaxis in the digital world prompts data to spontaneously disperse, effectively balancing the data load across the network.

Ant behaviour guides routing

BISON focused on adaptive routing and radio power management to tackle the fundamental challenge in ad hoc networks of a constantly changing network topology. Not only are nodes moving but they are

constantly entering and leaving the network. What's more, power is a crucial issue: use more power to boost the signal and the device runs out of energy. Lower signal power and the network becomes disconnected.

It used Ant Colony Optimisation (ACO), a computing scheme inspired by the way ants leave and follow paths to find the shortest route to food.

In the computing paradigm, tiny packets of data, called ants, are sent out to find the most efficient routing choice based on the twin needs of connectivity and power management. Called AntHocNet, it is an attempt to create an ACO routing algorithm, which works efficiently in Mobile Ad hoc Networks, combining reactive path finding and repairing with proactive path maintenance and improvement.

The attempt looks successful. BISON conducted a large series of simulations of its AntHocNet against an algorithm for routing data across Wireless Mesh Networks called AODV, an important reference in the computer science field.

"We were successful in developing robust, adaptive protocols," said Babaoglu. "But we were surprised that their performance was so good. We expected to lose performance, but our protocols are comparable to what's available today."

BISON also developed a synchronicity protocol inspired by fireflies. Synchronicity is important to time the execution of certain functions in a network. Fireflies very quickly synchronise their light emission, rather like clapping in an audience, and Babaoglu says it could become the basis for developing a heartbeat on the internet.

The expertise of the group is in part the reason for its success. "We have a mathematical biologist, for example, who helped a lot. The ants were a common model, but he introduced us to other biological processes like

chemotaxis and cell adhesion that are much more promising."

Most of BISON's work is not yet ready for commercial deployment, though the AntHocNet is very close, but the team's approach is very promising and has generated a lot of interest among researchers. In the meantime, work will continue in another FET project, studying Dynamically Evolving, Large Scale Information Systems (DELIS).

Source: IST Results