Are complex networks and systems more stable than simpler ones?

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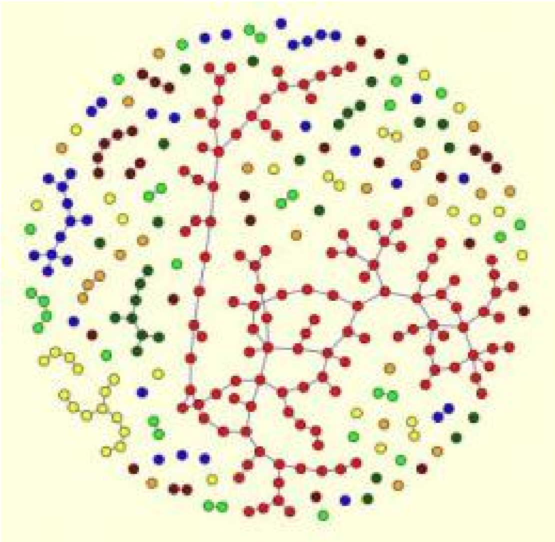

The points in red represent the formation of a super-connected group or "giant component" within this network. Credit: Raissa D'Souza/UC Davis

A large complex system or network that sustains multiple life forms - such as the Great Barrier Reef off Australia's north coast - would seem to be more likely to be stable to disturbances than a simple one.

Logically, complexity and diversity would seem like the best way to go for everything to survive and flourish in such complex ecosystems as the Great Barrier Reef or the Amazon Rainforest in South America, but instead could this be their fatal flaw?

Research published in *Nature Communications* by RMIT's Professor Lewi Stone from the School of Science (Maths discipline) confirms this could be the case. Stone said by revisiting and reviewing various studies of networks, in conjunction with his own research and methodology, he had found that we should expect more complex systems are likely to be more fragile.

"Consequently, this means we need to give great care to our highly diverse tropical rain forests and our coral reefs, because despite their greater complexity and diversity, they may be incredibly fragile," he said.

The same principle holds for a wide range of complex networks in completely different contexts including systems biology, neuronal networks, the internet, and even interconnected banking systems.

Stone looked at Robert May's celebrated theoretical work of the 1970s - Will a large complex system be stable? - in Nature 1972, which contradicted the established paradigm of the time by demonstrating that complexity leads to instability in biological systems.

May's analysis was fairly barebones and dealt purely with random systems without taking into account realistic features, for example, plant species compete among themselves, while plants and their pollinators provide mutual support to one another. These are far from random systems and much more complex.

"Simple relationships are found to govern these intractable models, and control the parameter ranges for which biological systems are stable and feasible," he said.

"These results have long been sought after, since little is known as to how systems with large-scale mutualistic aid persist given their supposed inherent instability. Until now the equations underlying these models have been too complex to analyse - no one expected the emergence of simple general principles."

An unusual aspect of Stone's work is that the analysis of model and real empirical networks is only achievable on introducing a simplifying Google-matrix reduction scheme. This completely new direction proposed by Stone's research should have many applications in the future for studying complex systems having large-scale interaction architectures.

"We use the same basic mechanism at the heart of Sergei Brin and Larry Page's "Google matrix" invented in 1998, which ranks web pages as it sifts through billions of hyperlinks across the world-wide-web."

"From this perspective, the Google matrix was made use of in Mathematical Biology some 10 years before its invention by Google, and appeared in my PhD dissertation - in 1988," Stone said.

More information: Lewi Stone, The Google matrix controls the stability of structured ecological and biological networks, *Nature Communications* (2016). DOI: 10.1038/ncomms12857