Coordination failure: Researchers provide insight into impacts of too much communication

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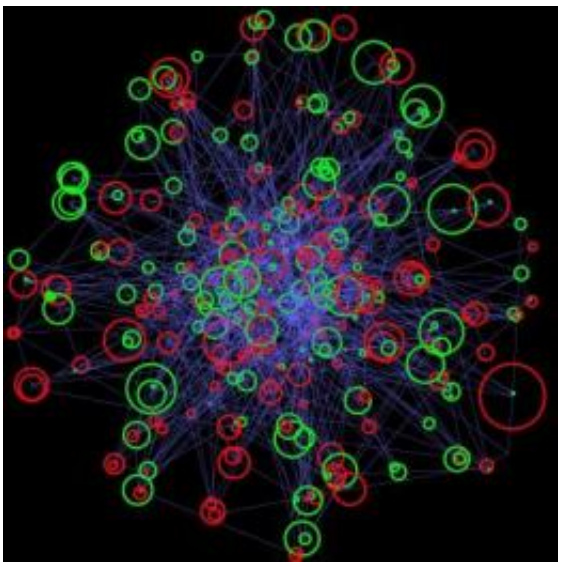

This is a visual representation of a network where there are no delays in the movement of information between individuals. Credit: Rensselaer Polytechnic Institute

(PhysOrg.com) -- Individuals within a networked system coordinate their activities by communicating to each other information such as their position, speed, or intention. At first glance, it seems that more of this communication will increase the harmony and efficiency of the network. However, scientists at Rensselaer Polytechnic Institute have found that this is only true if the communication and its subsequent action are

immediate.

Using statistical physics and network science, the researchers were able to find something very fundamental about synchronization and coordination: if there are sustained delays in communication between just two or three parts of a system, performance of the entire system will eventually collapse. The findings apply to any network system where individuals interact with each other to collectively create a better outcome. This ranges from a flock of birds suddenly dodging to the right in one unified movement to avoid a predator to balancing load in large-scale computer networks to the spread of a rumor throughout an online social network.

The findings were published last month in Physical Review Letters in a paper titled "Network Synchronization in a Noisy Environment with Times Delays: Fundamental Limits and Trade-Offs." The findings were also highlighted among the Editors' Suggestions for that week.

Previous studies by the researchers have revealed that the minute interactions between neighboring individuals, referred to as nodes, are the foundation for overall network performance. The fast, accurate, and balanced movement of information between neighboring nodes is what prevents the birds from scattering and allows a story to accurately spread on the Web.

But, as is frequently the case in real-world scenarios, what happens when the information from your neighbor is not up to date? What occurs when there are delays in the transmission or processing of the information between neighbors? The researchers utilized stochastic differential equations, a type of mathematical equation used to model the time evolution of complex systems with random variables, to determine what happens when delays are input into the system.

"When there are no delays, the more you communicate with your neighbor, the better global performance becomes," said corresponding author for the paper and Associate Professor of Physics, Applied Physics, and Astronomy Gyorgy Korniss. "If there are delays, for a while performance will increase, but even if you work harder to better communicate with your neighbors, eventually performance will decrease until it reaches zero.

"Understanding the impact of delays can enable network operators to know when less communication effort can actually be more efficient for overall performance."

Their equations show that the larger the delay between nodes, the faster the overall coordination of the system will deteriorate. The work also reveals that, even with delays, there is a window of time where increasing communication will improve performance.

But, after a point, you also need to know when to "shut up," Korniss explained. After a certain period of poor communication, he said, no matter how fast or accurate you attempt to make your future communication, all communication is counterproductive.

"Our conclusion that coordination can sometimes be restored by decreasing node connectivity offers an important perspective on today's world with its abundance of connectivity in social and technological systems, raising the question of their stability," said study co-author Boleslaw Szymanski, Rensselaer's Claire & Roland Schmitt Distinguished Professor of Computer Science. Szymanski also serves as director of the Social Cognitive Network Academic Research Center (SCNARC) at Rensselaer.

The work, which is part of SCNARC, could be extended to real-life cases such a social or economic network. An example could be

predicting the response of global markets to the trading of specific stocks, according to the researchers. The equations could someday help network operators to get the biggest pay off from each communication and develop an even stronger understanding of the power of the individual in mass communication.

Provided by Rensselaer Polytechnic Institute