Failures in large networks can be prevented with local focus

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We live in an increasingly connected world, a fact underscored by the swift spread of the coronavirus around the globe. Underlying this connectivity are complex networks—global air transportation, the

internet, power grids, financial systems and ecological networks, to name just a few. The need to ensure the proper functioning of these systems also is increasing, but control is difficult.

Now a Northwestern University research team has discovered a ubiquitous property of a complex network and developed a novel computational method that is the first to systematically exploit that property to control the whole network using only local information. The method considers the computational time and information communication costs to produce the optimal choice.

The same connections that provide functionality in networks also can serve as conduits for the propagation of failures and instabilities. In such dynamic networks, gathering and processing all the information necessary to make a better decision can take too much time. The goal is to diagnose a problem and take action before it leads to a system-wide issue. This may mean having less information but being timely.

"Control is about getting the most relevant information and then making the best decision promptly," said Adilson E. Motter, an expert in complex systems and nonlinear dynamics. "We found that no matter how large the network is, it can often be treated as a small or local network for the purposes of control. We call this property locality, and most networks have it. Understanding this network property is key to effectively and efficiently controlling the system."

Motter, who supervised the research, is the Charles E. and Emma H. Morrison Professor at Northwestern's Weinberg College of Arts and Sciences. His research focuses on the network modeling and control of complex physical, biological and engineered systems.

An important feature is that the method can be applied broadly across different types of network systems to control the system when perturbed,

Motter said. In their study, the researchers demonstrate the effectiveness of their method through four concrete examples, including the reduction of epidemic spread through the global air transportation network and the stability control of the Eastern U.S. power grid.

A paper describing the researchers' theory and algorithms will be published the week of July 18 in the *Proceedings of the National Academy of Sciences* (*PNAS*).

More information: Prevalence and scalable control of localized networks, *Proceedings of the National Academy of Sciences* (2022). DOI: 10.1073/pnas.2122566119

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