Location determines social network influence, study finds

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A team of researchers led by Dr. Hernan Makse, professor of physics at The City College of New York (CCNY), has shed new light on the way that information and infectious diseases proliferate across complex networks. Writing in *Nature Physics*, they report that, contrary to conventional wisdom, persons with the most connections are not necessarily the best spreaders.

"The important thing is where someone is located in a network," said Professor Makse in an interview. "If someone is in the core, they can spread information more efficiently. The challenge is finding the core."

That kind of information could help marketers and public relations practitioners conduct more effective of social media and social marketing campaigns. It could also help epidemiologists target resources to reduce the spread of infectious diseases.

To identify the core, Professor Makse and colleagues used a technique call k-shell decomposition. In this process, network nodes with just one link are removed until no single-link nodes remain. The remaining nodes are assigned a k-shell value of one. The process is repeated with higher k-shell values assigned to remaining nodes after each round of cuts. Those nodes that cannot be reduced to a single link are identified as the core of the network and have the highest k-shell values.

In the study, the researchers examined four networks representing archetypical examples of social structures: members of LiveJournal.com;

email contacts in the computer science department at University College London; inpatients of Swedish hospitals, and adult film actors. The latter group was studied because it is a distinct subgroup of the acting profession whose members rarely appear in other genres, Professor Makse explained.

Each network member's position in that network was plotted on a graph with the number of connections along one axis and the k-shell value along the other, e.g. (100, 5), (50, 25). The team found that nodes with many connection hubs located at the periphery of a network, i.e. low k-shell values, were poor spreaders.

However, nodes with fewer connections but locations near the core, i.e. high k-shell values, were just as likely to spread information or infections as similarly situated nodes with more connections. Hence, they conclude the most efficient spreaders are located in a network's inner core.

"In the case of LiveJournal, someone with a thousand friends but a low k-shell level will have less impact than someone with a hundred friends but a high k-shell level," Professor Makse said. "Small players and big players spread just as well if they are at the core of the network.

For the spread of disease, nodes located in high k-shell layers are more likely to be infected and they will be infected sooner than other nodes, the researchers found. "The neighborhood of these nodes makes them more efficient in sustaining an infection in early stages, thus enabling the epidemic to reach a critical mass such that it can fully develop."

This knowledge could greatly help public health officials trying to head off an epidemic in situations where limited quantities of vaccines are available, Professor Makse said. "You try to identify the most likely spreaders and vaccinate them first."

The researchers explained the existence of hubs at the periphery of real networks as a consequence of their "rich topological structure. In a fully random network, all hubs would exist near or at the core and they would contribute equally well to spreading.

While high k-shell value nodes were found to be the best single spreaders, regardless of their connectivity, this did not necessarily hold up for situations involving multiple spreaders. In those cases, connectivity between hubs did not accelerate the spreading because of the overlap of infected areas created by the different spreaders.

"The better spreading strategy using (multiple) spreaders is to choose either the highest k or k-shell nodes with the requirement that no two spreaders are directly linked to each other," the researchers wrote.

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