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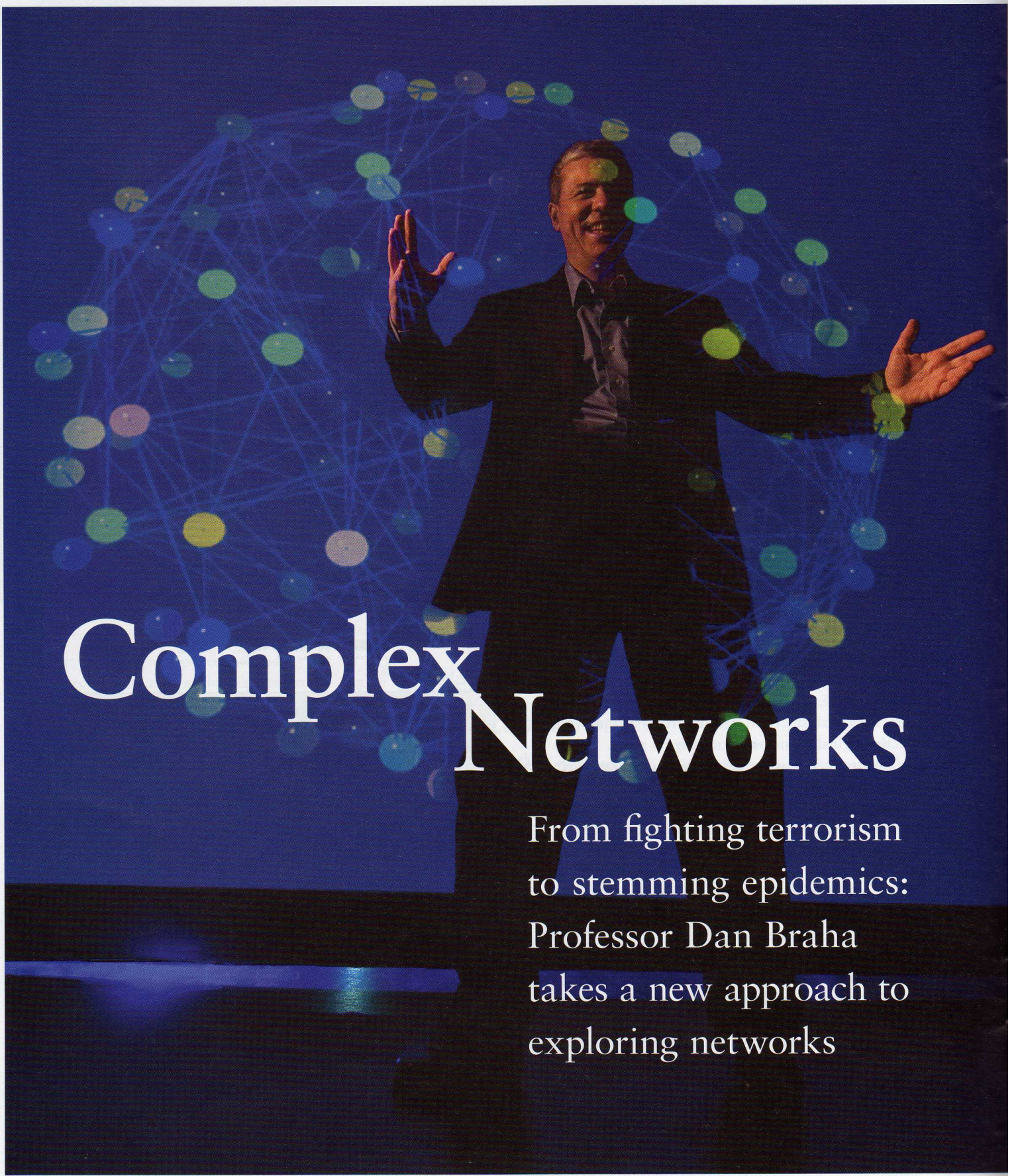
The complex world of Dan Braha

Management Professor untangles the mystery of networks

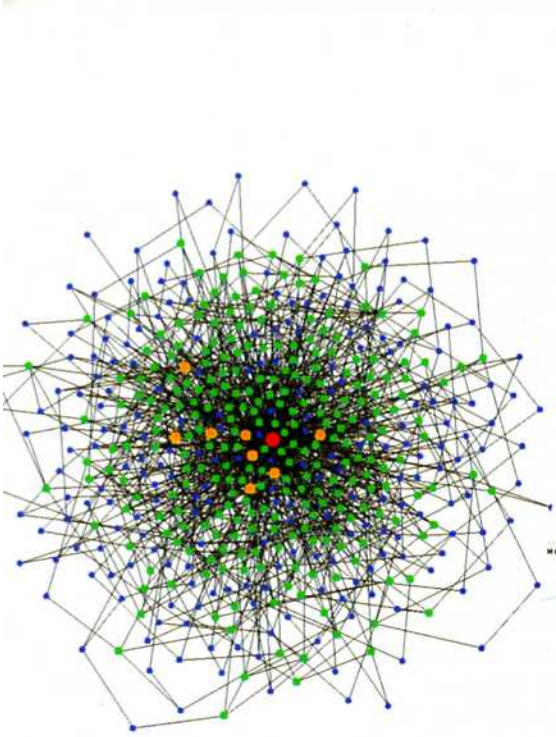
Technology strengthens teacher-student links

Two police chiefs build community connections

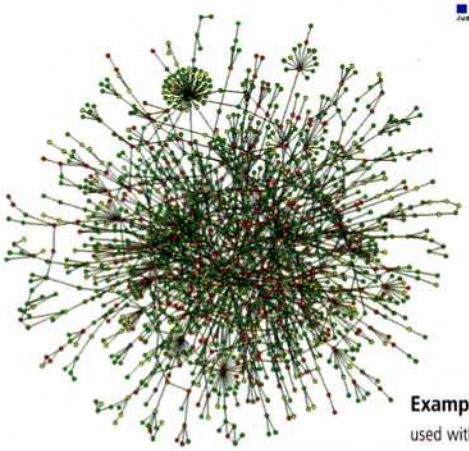


Complex Networks

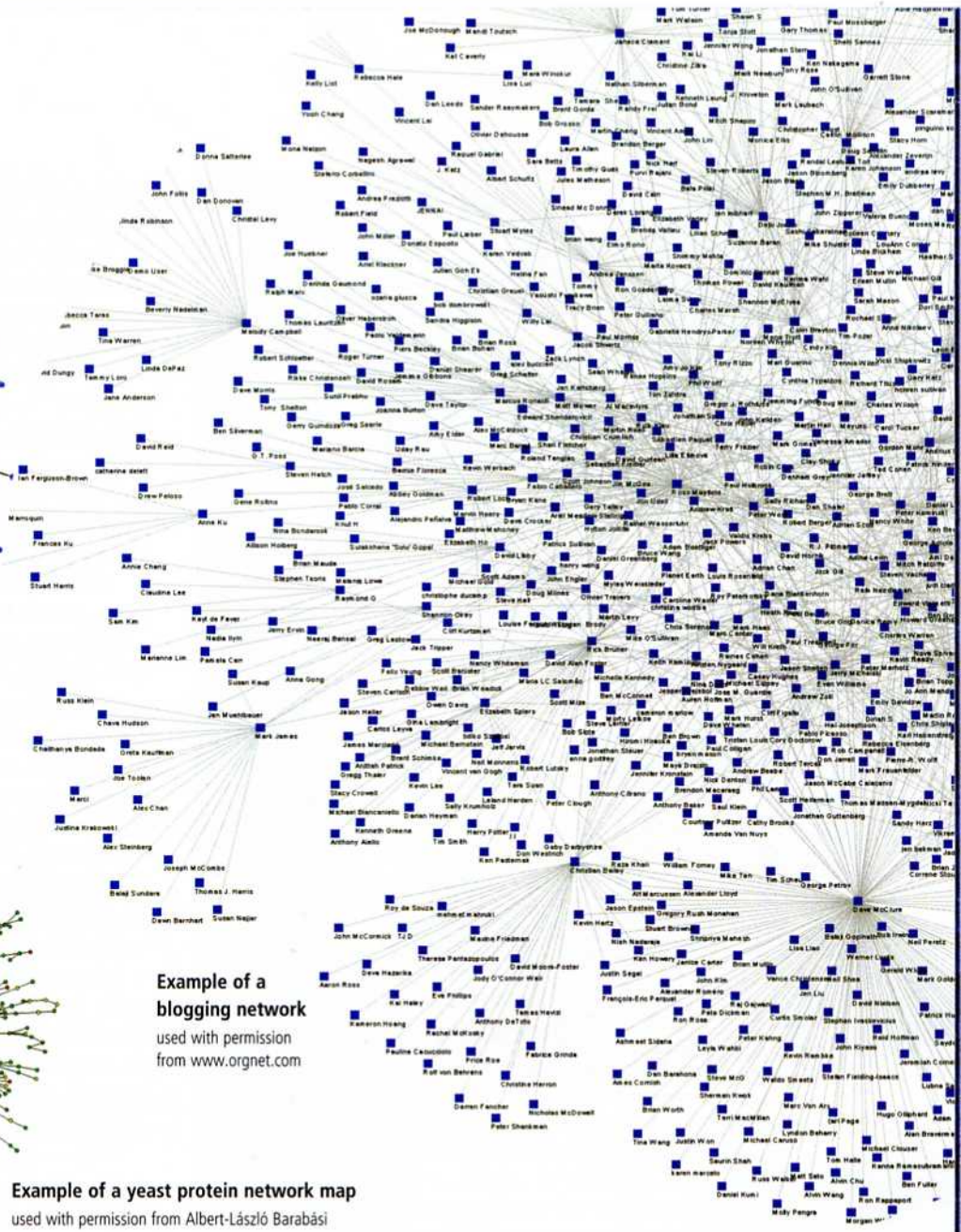
From fighting terrorism to stemming epidemics: Professor Dan Braha takes a new approach to exploring networks



Example of a typical scale-free biological network
used with permission from Philippe Cluzel, University of Chicago



Example of a yeast protein network map
used with permission from Albert-László Barabási



Example of a blogging network
used with permission from www.orgnet.com

By Diane Hartnett

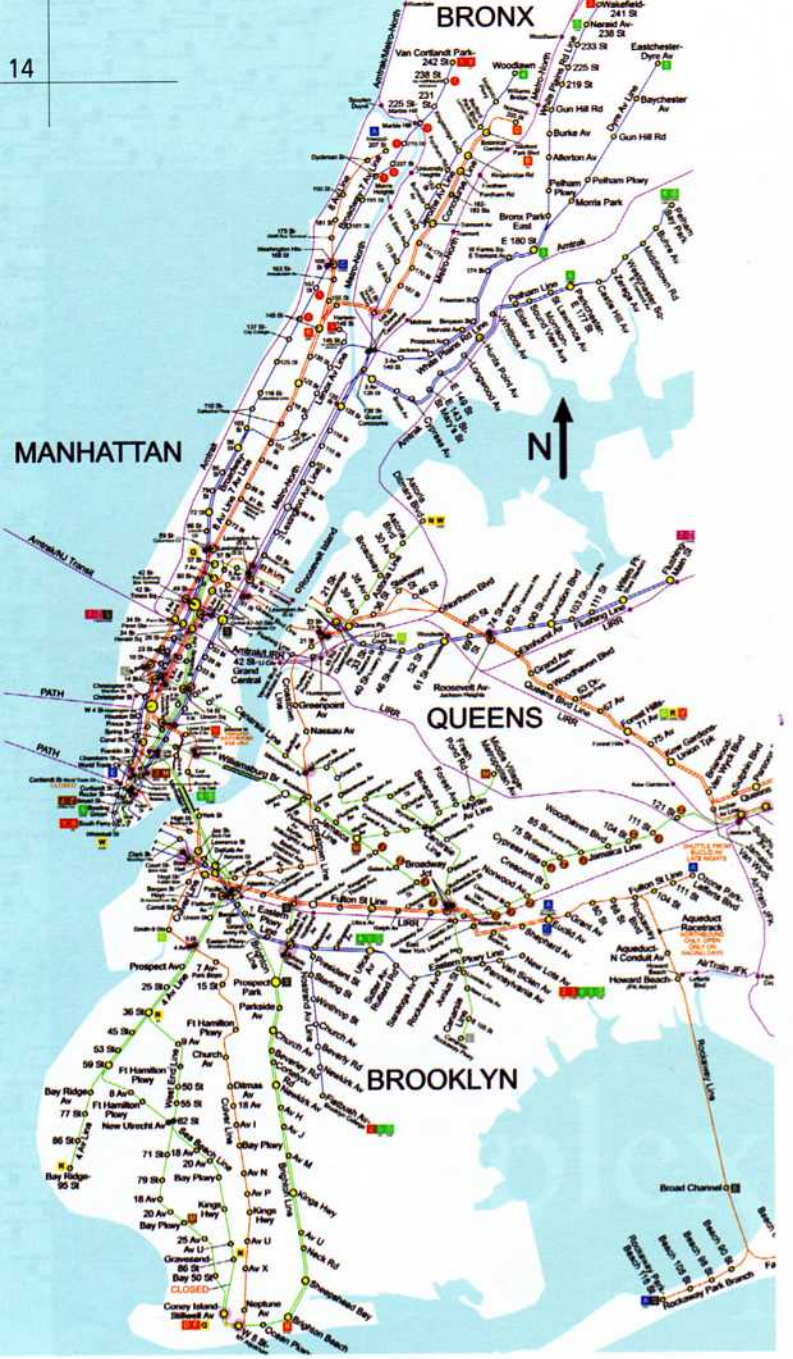
When Professor Dan Braha talks about "complex networks," what might have seemed obscure or complicated becomes fascinating and provocative. And this business professor's research—which, at the most simplistic level, is all about interactions—assumes extraordinary relevance, applicable to everything from building airplanes to halting epidemics, fighting terrorists, stemming computer viruses, and running corporations.

What's more, Braha is so direct and straightforward—as well as enthusiastic and animated—that virtually any audience easily grasps how his work correlates to everyday situations and phenomena.

Braha came to UMass Dartmouth in 2004 from MIT, where he was a visiting lecturer, and Boston University, where he worked as a research scientist. A member of the New England Complex Systems Institute, he's an associate management professor in the Charlton College of Business, yet the bulk of his education and experience is in engineering—he has a doctorate in operations research and industrial engineering from Tel Aviv University, and was an engineering professor at Ben-Gurion University.

"My work involves the interface between technology and management," says Braha, explaining that the cornerstone of his research is the interplay between basic engineering and management concepts.

And at the center of his work are "large scale networks," which can encompass anything from corporations to flu epidemics. In a major paper last fall in the prestigious *Complexity*



Anyone familiar with the subway system of New York City can understand what Dr. Dan Braha means when he talks of "complex networks," complicated series of connections among various elements. Braha has emerged as a leading scholar in this field, which has assumed more importance with its potential for real-world application.

journal, Braha and collaborator Yaneer Bar-Yam (president of the Complex Systems Institute) argue for a new way of looking at networks, a way that will significantly benefit society.

The modern complex network, says Braha, is not the static, "fixed rod" entity that constitutes the traditional viewpoint. Rather, it is a dynamic combination of elements operating more like "flickering strings" with all sorts of connections.

A new view of networks

The study of complex networks is a growing, inter-disciplinary field, as researchers maintain that a new, more accurate understanding would mean better responses to a host of social, scientific, economic, and political issues.

Ask Braha for a basic introduction to his work, and he puts forth construction of an airplane. Consider that the project requires perhaps 6,800 workers, each with a distinct task, as diverse as designing the engine, to choosing seat upholstery, to ordering brake pads. Not one of those workers operates in a vacuum—what each does impacts another's work, and ultimately influences the outcome of the entire project.

"The interactions become as much of a social issue as a technological one," Braha explains. "Let's say one person working on one part of the plane doesn't provide the information the person designing the wings needs. The airplane doesn't fly.

"If something is not managed well, then the system often fails... or there will be delays, or it comes in over budget. To do something well, you must look at a system as a whole, within a large-scale network."

All networks comprise certain elements (or players). "Hubs" are considered the pivotal, commanding elements around and from which the multiple links emanate. In his work, Braha debunks the common notion that hubs are more or less "fixed."

He and Bar-Yam challenge this fixed nature in their piece in *Complexity*. They studied the actions of thousands of emailers over a period of four months. The exchanges constituted a social network, the type exemplified by the popular MySpace and FaceBook.

Conventional wisdom says that the "hub" of such a network is the emailer with far more contacts than anyone else, and that the network changes only slightly over time. Not so, found Braha and Bar-Yam. In reviewing the emails, the pair saw that the hubs changed constantly—a person could send or receive a handful of emails one day, with a deluge the following day.

"The results were astounding. How important someone is changes so fast we might be better off saying it is like '15 minutes of fame'," says Braha.

So, the researchers maintain, the number of contacts someone has within a network is less important than who is communicating with whom, and when.

Braha carries out his research as a scientist, using data and tests to monitor interactions and patterns, then developing his theses. His exploration of networks is multi-faceted, encompassing a wide range of the factors that shape networks and give them their dynamism.

For example, there is "coupling," a term for various interactions and linkages. "If you or I have a mutual friend, we are 'coupled.' Decisions that share attributes are coupled." But why is that important?

Because, explains Braha, "when the degree of coupling increases, the likelihood of more creativity increases. And more coupling can increase the performance of a product.

"At the same time, the system becomes more vulnerable to errors, diseases, viruses."

Consider the dinner party. If you invite only three couples, will the conversation lag? But are six couples too many? Frivolous as the example is, it explains a fundamental premise

Braha articulates: "if the degree of coupling is below a certain threshold, a system will perform well. If it is above that threshold, it becomes more problematic.

"It's like a seesaw. With research and a scientific approach, we can predict the best 'edge' for coupling" in networks that can vary from roadways, to anti-virus computer software, to suitable groupings of persons in the workplace.

Those whom Braha calls "informed decision-makers" understand the significance of coupling within networks—which nodes are more likely to couple repeatedly, and possibly become problematic within the network as a whole. That decision-maker can then direct the necessary resources to prevent that: "the idea is to act before the problem occurs," says Braha.

The future of management

Braha offers an idealized vision of management, when networks are recognized as vibrant, energetic, multi-layered. "I see the managers of the future sitting before a computer that shows a large, enmeshed network. They have backgrounds in science, management, and engineering. They can see that one node might be too far from another, or that another is not robust. So they will play with the system and rearrange it—always taking into account the constraints of reality."

Among the more intriguing applications of Braha's research involves terrorist networks. He argues that governments must look at these networks in a markedly different fashion, acting more flexibly and creatively, and relying less on the traditional approach of assuming a central, supreme hub. Monitoring methods must recognize that terrorist networks and their so-called hubs can change rapidly. For example, a stable, quiet network "node" that suddenly develops more links, and exhibits more activity, could signal a major network change or even terrorist movement—and prompt the appropriate response.

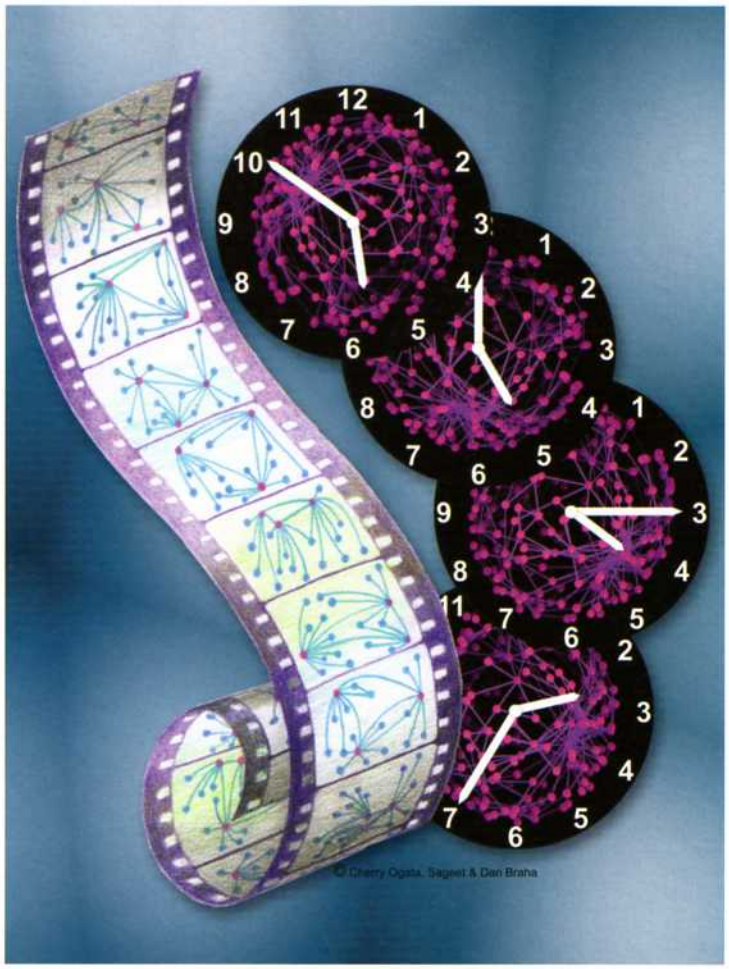
Effective monitoring of terrorist networks, Braha continues, "requires constant surveillance. You have to monitor the degree of erratic behavior continually, over time."

Braha has also examined the management and communication modes that prevail in institutions such as industries, hospitals, or universities—which constitute networks—and for the most part is unimpressed. Formally and officially, these institutions have a conventional, hierarchical structure, says Braha: "The boss is at the top and controls everything.

"And that is completely wrong," in terms of how those institutions actually function. Braha says the "official" structure is based on wishful thinking. Traditional organizational charts, for example, generally reflect theories about how workers interact, how policy is made, and how communication occurs. "They do not capture the reality of how information actually is disseminated."

In actuality, these institutions/networks, with their many employees, "are not hierarchical in reality. They have many loops, are cyclical, and are always changing." Until the institutions recognize that, and modify their structure accordingly, they cannot realize full potential or remain, using Braha's term, "robust."

"The only way to achieve robustness is to connect the nodes in a network in a way different than the hierarchical."



The image above serves to illustrate the research being done by Charlton College of Business Professor Dan Braha on complex networks. It reflects the non-traditional findings he and collaborator Yaneer Bar-Yam have arrived at in their study of the dynamics of links within those networks. The image of the clocks indicates the rapid changes that occur over time in real-world complex network structures. The corresponding film strip represents the thesis that nodes that rank marginally at one point in time become more vibrant, and evolve into local hubs at a different point. This image was designed by Braha, Sageet Braha, and Cherry Ogata. It was the cover art for the December 2006 issue of the journal *Complexity*, which featured an article by Braha and Bar-Yam on their work.

Braha has published his research on networks in a number of journals, and co-authored two books. He has also consulted on communications issues for several large companies, and is continuing his research while teaching about complex managerial systems and operations.

"I've found that UMass Dartmouth offers a flexible and collegial environment that fosters innovation, promotes growth for both the individual and the university, and enables individuals to contribute in a significant way to both research and teaching."

Diane Hartnett is the writer for the university Publications Office.