# Internet congestion stirs up data storms

The worldwide network of computer networks known as the Internet handles an enormous amount of traffic every day. At any given moment, hundreds of thousands of users are sending messages or browsing the 80 million or more pages of the World Wide Web. Congestion has become such a problem (SN: 3/23/96, p. 181) that some sites provide daily Internet "weather reports," detailing average delays in reaching sites at different times in various parts of the world.

Groups monitoring Internet traffic have observed spikes of extremely high activity—or data storms—that appear quickly, then subside. A congestion spike may result from a specific event, such as the recent landing of a spacecraft on Mars (SN: 7/12/97, p. 20), or from network failures, as happened last week. At other times, however, a spike appears to have no discernible cause.

Researchers now suggest that intermittent congestion spikes punctuating routine traffic are inevitable because the Internet is essentially a public resource whose users are generally not charged fees according to the amount of data exchanged. "We can connect human behavior at an individual level with the global behavior of the Internet," says physicist Bernardo A. Huberman of the Xerox Palo Alto (Calif.) Research Center.

Huberman and his colleague Rajan M. Lukose describe their findings in the July 25 SCIENCE.

In the mathematical model developed by Huberman and Lukose, the usefulness of the Internet is proportional to the speed with which users can access information at remote sites. At the same time, because they usually do not pay costs linked to consumption, users don't differentiate between activities that require the transfer of large amounts of information, such as downloading graphic files and browsing Web sites, and those that require much less, such as electronic mail, or E-mail.

Thinking their actions have little effect on the overall performance of the Internet, users get greedy, Huberman argues. When they expect or discover congestion and noticeable delays, however, they alter their behavior.

Typically, users who experience congestion tend to believe that others do so as well and expect that if they try again later, the network is likely to be less congested. Those who encounter little delay tend to take advantage of the apparent lull in activity.

Depending on the situation, Web surfers can switch very rapidly from no use or restrained use to heavy use and vice versa. Such switches reflect different needs and amounts of impatience in obtaining information, the researchers say.

Their equations representing this system show that the collective effect of these individual decisions, made independently and in the context of uncertainty about the true state of the Internet at any given time, produces wide, unpredictable fluctuations in activity from moment to moment, highlighted by intermittent congestion spikes.

To determine whether such spikes actually occur in Internet traffic, Huberman and Lukose recorded the round-trip times of standard messages, known as pings, sent between a computer at Stanford University and one in the United Kingdom. To focus on short-term fluctuations in activity, they sent nearly 10,000 messages over the course of about 45 minutes. The data clearly indicated the presence of frequent congestion spikes, in the form of unusually long delays, occurring at random times and lasting a fraction of a second. The spikes are superimposed on a noisy background.

The researchers obtained similar results in tests between computers in different parts of the United States and even in just the San Francisco Bay Area.

"The bursts of congestion skew the [overall Internet] statistics," Huberman says, making the calculated average delay meaningless. "What's important is not the spikes but what happens in between," he adds. Most of the traffic goes through promptly.

To avoid congestion, users ought to be charged in proportion to the amount of data transmitted, Huberman contends. Such charges would make people more directly aware of their role in overtaxing the capacity of the Internet.

"Both the present congestion of the Internet and technologies for improved performance in the future Internet are active subjects of study," says Mark A. Luker, who manages the network connections program at the National Science Foundation in Arlington, Va.

"I think pricing schemes are a wise and sound approach," says economist Jeffrey K. MacKie-Mason of the University of Michigan in Ann Arbor, one of the first researchers to investigate pricing mechanisms in response to Internet congestion. Various network pricing schemes are now being tested, he says, and the measurements and traffic analysis made by Huberman and Lukose are a useful contribution. *—I. Peterson*

# HIV protein prepares virus' next victims

Once HIV infects a person, it risks falling victim to its own deadliness. The AIDS virus reproduces efficiently only inside immune cells that have been activated out of their natural resting state, yet it ultimately kills those cells. Moreover, very few immune cells in the body are normally in the activated state.

"This creates a problem for the virus. Very quickly, it will run out of suitable hosts," says Chiang J. Li of the Dana-Farber Cancer Institute in Boston.

Li and his colleagues may now have found how HIV resolves this apparent paradox. The virus makes a protein that activates quiescent immune cells and transforms them into suitable hosts for replication, they report in the July 22 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

"HIV, being a very adaptive virus, has in its evolution been able to develop a way to help its own replication," notes Anthony S. Fauci, director of the National Institute of Allergy and Infectious Diseases in Bethesda, Md.

The viral protein in question goes by the name of Tat. Scientists have long recognized its ability, when inside cells, to turn on viral and cellular genes. Now, Li's group has disclosed a novel extracellular role for the protein.

Cells infected with HIV typically secrete large amounts of Tat. Researchers have hypothesized that the secreted protein stimulates the proliferation of some cells, leading to AIDS-related cancers such as Kaposi's sarcoma.

Two years ago, Li and his colleagues reported that immune cells exposed to Tat sometimes commit suicide. As they examined their results more closely, however, the investigators realized that the majority of immune cells exposed to Tat simply became activated.

In the new research, Li's team shows that immune cells exposed to Tat display on their surface proteins that are characteristic of activated cells.

The investigators then established that the AIDS virus reproduces efficiently inside the Tat-activated cells. Moreover, antibodies that bind Tat prevent the protein from priming the immune cells for HIV reproduction, they report.

The researchers further discovered that the viral protein activates immune cells by binding to cell surface proteins called integrins, which then trigger a signaling cascade within the cell.

Li suggests that his group's research should encourage efforts to develop drugs or a vaccine that will block Tat's actions.

That may be easier said than done, says Fauci, noting that several drug companies have already pursued such Tat inhibitors vigorously and met with failure.

"It was clear that the virus has a number of ways to evade our attempts to interfere with Tat. So at least the first round of that fight was given up by the drug companies," says Fauci. Still, the work of Li's group may inspire those firms to tackle Tat once again, he adds. *—J. Travis*