A Bandwidth Breakthrough

A dash of algebra on wireless networks promises to boost bandwidth tenfold, without new infrastructure.

By David Talbot on October 23, 2012

Academic researchers have improved wireless bandwidth by an order of magnitude—not by adding base stations, tapping more spectrum, or cranking up transmitter wattage, but by using algebra to eliminate the network-clogging task of resending dropped packets of data.

By providing new ways for mobile devices to solve for missing data, the technology not only eliminates this wasteful process but also can seamlessly weave data streams from Wi-Fi and LTE—a leap forward from other approaches that toggle back and forth. "Any IP network will benefit from this technology," says Sheau Ng, vice president for research and development at NBC Universal.

Several companies have licensed the underlying technology in recent months, but the details are subject to nondisclosure agreements, says Muriel Medard, a professor at MIT's Research Laboratory of Electronics and a leader in the effort. Elements of the technology were developed by researchers at MIT, the University of Porto in Portugal, Harvard University, Caltech, and Technical University of Munich. The licensing is being done through an MIT/Caltech start-up called Code-On Technologies.

The underlying problem is huge and growing: on a typical day in Boston, for example, 3 percent of packets are dropped due to interference or congestion. Dropped packets cause delays in themselves, and then generate new back-and-forth network traffic to replace those packets, compounding the original problem.

The practical benefits of the technology, known as coded TCP, were seen on a recent test run on a New York-to-Boston Acela train, notorious for poor connectivity. By increasing their available bandwidth—the amount of data that can be relayed in a given period of time—Medard and students were able to watch blip-free YouTube videos while some other passengers struggled to get online. "They were asking us 'How did you do that?' and we said 'We're engineers!" she jokes.

More rigorous lab studies have shown large benefits. Testing the system on Wi-Fi networks at MIT, where 2 percent of packets are typically lost, Medard's group found that a normal bandwidth of one megabit per second was boosted to 16 megabits per second. In a circumstance where losses were 5 percent—common on a fast-moving train—the method boosted bandwidth from 0.5 megabits per second to 13.5 megabits per second. In a situation with zero losses, there was little if any benefit, but loss-free wireless scenarios are rare.

Medard's work "is an important breakthrough that promises to significantly improve bandwidth and quality-of-experience for cellular data users experiencing poor signal coverage," says Dipankar "Ray" Raychaudhuri, director or the Winlab at Rutgers University. He expects the technology to be widely deployed within two to three years.

To test the technology in the meantime, Medard's group set up proxy servers in the Amazon cloud. IP traffic was sent to Amazon, encoded, and then decoded as an application on phones. The benefit might be even better if the technology were built directly into transmitters and routers, she says. It also could be used to merge traffic coming over Wi-Fi and cell phone networks rather than forcing devices to switch between the two frequencies.

The technology transforms the way packets of data are sent. Instead of sending packets, it sends algebraic equations that describe series of packets. So if a packet goes missing, instead of asking the network to resend it, the receiving device can solve for the missing one itself. Since the equations involved are simple and linear, the processing load on a phone, router, or base station is negligible, Medard says.

Whether gains seen in the lab can be achieved in a full-scale deployment remains to be seen, but the fact that the improvements were so large suggests a breakthrough, says Ng, the NBC executive, who was not involved in the research. "In the lab, if you only find a small margin of improvement, the engineers will be sceptical. Looking at what they have done in the lab, it certainly is order-of-magnitude improvement—and that certainly is very encouraging," Ng says.

If the technology works in large-scale deployments as expected, it could help forestall a spectrum crunch. Cisco Systems says that by 2016, mobile data traffic will grow 18-fold—and Bell Labs goes farther, predicting growth by a factor of 25. The U.S. Federal Communications Commission has said the spectrum of available wireless frequencies could run out within a couple of years.

Medard stops short of saying the technology will prevent a spectrum crunch, but she notes that the current system is grossly inefficient. "Certainly there are very severe inefficiencies that should be remedied before you consider acquiring more resources," she says.

She says that when her group got online on the Acela, the YouTube video they watched was of college students playing a real-world version of the Angry Birds video game. "The quality of the video was good. The quality of the content—we haven't solved," Medard says.