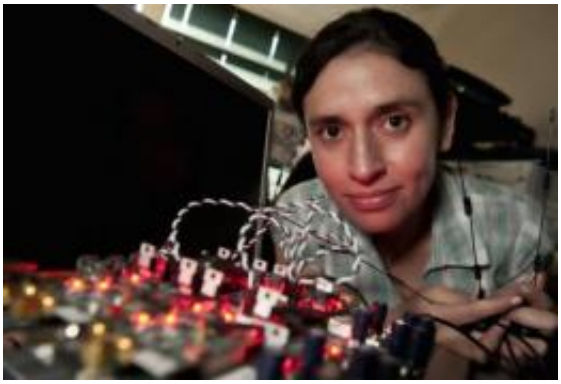
Breakthrough could double wireless capacity with no new towers

September 6 2011



Rice University graduate student Melissa Duarte with a "full-duplex" test device. The technology, which allows wireless devices to "talk" and "listen" to networks on the same frequency, could double throughput on wireless phone networks. Credit: Jeff Fitlow/Rice University

The days of waiting for smartphones to upload video may be numbered. Rice University engineering researchers have made a breakthrough that could allow wireless phone companies to double throughput on their networks without adding a single cell tower.

Rice's new "full-duplex" technology allows wireless devices like cell phones and electronic tablets to both "talk" and "listen" to wireless cell towers on the same frequency -- something that requires two frequencies today.

"Our solution requires minimal new hardware, both for mobile devices and for networks, which is why we've attracted the attention of just about every wireless company in the world," said Ashutosh Sabharwal, professor of electrical and computer engineering at Rice. "The bigger change will be developing new wireless standards for full-duplex. I expect people may start seeing this when carriers upgrade to 4.5G or 5G networks in just a few years."

In 2010, Sabharwal and Rice colleagues Melissa Duarte and Chris Dick published the first paper showing that full-duplex was possible . That set off a worldwide race to demonstrate that the technology could actually be used in a real network. This summer, Sabharwal and Rice's Achaleshwar Sahai and Gaurav Patel set new performance records with a real-time demo of the technology that produced signal quality at least 10 times better than any previously published result.

"We showed that our approach could support higher throughput and better link reliability than anything else that's been demonstrated, which is a plus for wireless carriers," Sabharwal said. "On the device side, we've shown that we can add full duplex as an additional mode on existing hardware. Device makers love this because real estate inside mobile devices is at a premium, and it means they don't have to add new hardware that only supports full duplex."

To explain why full-duplex wireless was long thought impossible for wireless networks, Sabharwal uses the analogy of two people standing far apart inside an otherwise empty arena. If each shouts to the other at the same time, neither can hear what the other is saying. The easy solution is to have only one person speak at a time, and that's what happens on two-way radios where only one person may speak at a given time. Cell phones achieve two-way communications by using two different frequencies to send and listen.

Rice's team overcame the full-duplex hurdle by employing an extra antenna and some computing tricks. In the shouting analogy, the result is that the shouter cannot hear himself, and therefore hears the only other sound in the arena -- the person shouting from far away.

"We send two signals such that they cancel each other at the receiving antenna -- the device ears," Sabharwal said. "The canceling effect is purely local, so the other node can still hear what we're sending."

He said the cancellation idea is relatively simple in theory and had been proposed some time ago. But no one had figured a way to implement the idea at low cost and without requiring complex new radio hardware.

"We repurposed antenna technology called MIMO, which are common in today's devices," Sabharwal said. "MIMO stands for 'multiple-input multiple-output' and it uses several antennas to improve overall performance. We took advantage of the multiple antennas for our full-duplex scheme, which is the main reason why all wireless carriers are very comfortable with our technology."

Sabharwal said Rice is planning to roll its full-duplex innovations into its "wireless open-access research platform," or WARP. WARP is a collection of programmable processors, transmitters and other gadgets that make it possible for wireless researchers to test new ideas without building new hardware for each test. Sabharwal said adding full-duplex to WARP will allow other researchers to start innovating on top of Rice's breakthrough.

"There are groups that are already using WARP and our open-source software to compete with us," he said. "This is great because our vision for the WARP project is to enable never-before-possible research and to allow anyone to innovate freely with minimal startup effort."

Sabharwal's team has gone one step further and achieved asynchronous full-duplex too – that is one wireless node can start receiving a signal while it's in the midst of transmitting. Asynchronous transmission is import for carriers wishing to maximize traffic on their networks, and Rice's team is the first to demonstrate the technology.

"We've also developed a preliminary theory that explains why our system is working the way that it is," Sabharwal said. "That's also important for carriers and device makers, because engineers aren't likely to implement something like this without a clear understanding of fundamental tradeoffs."

More information: arxiv.org/abs/1107.0607

Provided by Rice University