A new terahertz wireless link could bridge the digital divide, says researcher

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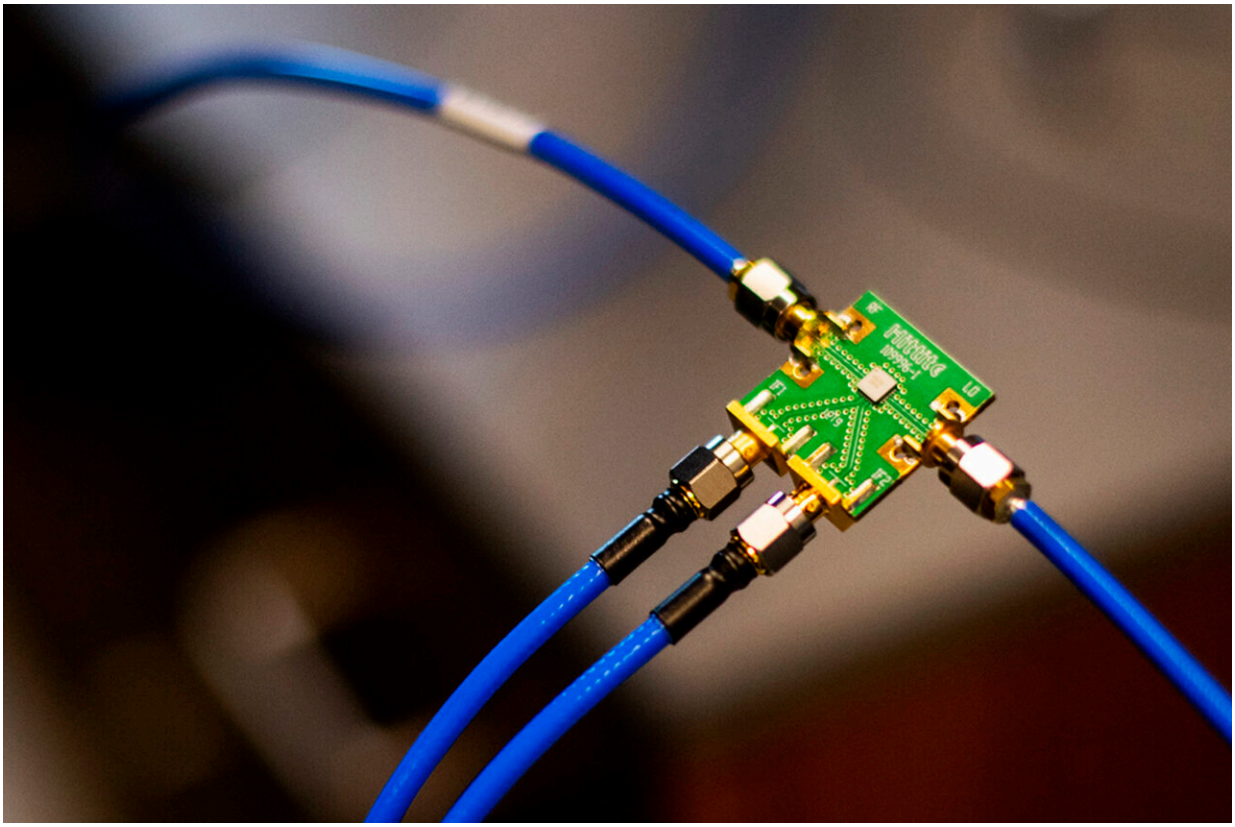

Josep Jornet, an associate professor of electrical and computer engineering at Northeastern, proved it is possible to maintain a two kilometer-long connection using high frequency terahertz technology. It could help increase connectivity for rural communities, even more than 5G technology. Credit: Matthew Modoono/Northeastern University

For years, the idea of 6G was thought to be science fiction. Now, it's closer than ever before, but Josep Jornet, an associate professor of electrical and computer engineering at Northeastern, says there's still room for improvement.

Together with NASA, the U.S. Air Force and Amazon, Jornet proved for the first time that high-speed, high-bandwidth wireless communication at the terahertz frequency is possible across long distances. The research, recently published in *Nature Electronics*, shows that there is a path forward for mass wireless communication, one that could shrink the digital divide felt by rural communities outside high-speed optical fiber networks.

"You need to find a technology that can give you optical-like connectivity without the optical problems, and we think that terahertz technology is that," Jornet says.

The terahertz band is a set of frequencies above 100 gigahertz, pushing past 5G's 71 gigahertz limit. The rollout of 6G wireless will bring this level of service to the public, but although sending signals across the terahertz band has been proven, doing so at a great distance has been all but impossible. The higher the frequency is, the shorter the distance information can travel. For terahertz communications, that would amount to a one-foot communication, Jornet says.

But Jornet has a habit of making the impossible possible.

"My research is driven by showing people that things they believe will not work can work," he says.

Jornet and his team were able to form a 2-kilometer link, the longest terahertz connection ever established on Earth. It wasn't without challenges, though. For starters, a terahertz frequency radio isn't

something Jornet could just find on Amazon, which is why he turned to NASA in the first place.

For years, NASA has been toying with terahertz wireless systems to sense signals in space, but the organization's efforts have been focused solely on receiving signals. When it comes to sending a signal, things get tricky.

Traditionally, a communication radio has a signal generator, a mixer, which adds the information to the signal, and an antenna that converts the signal into something that can be sent out over the airwaves. The problem is that terahertz frequencies are so high and require so much power to reach that any mixer placed in the radio would break. So, Jornet came up with an elegant solution.

"We don't have a mixer that can handle this much power. Fine, let's not have a mixer," he says.

Instead of putting the mixer after the signal source, Jornet and his team fed information straight into the source itself. However, doing so distorted the information to the point where it was a mangled mess. Another problem required another creative solution.

"Instead of trying to fix the information at the receiver, let me pre-distort my signal," he says. "I'm going to make the signal ugly, such that when it goes through the source, it becomes beautiful."

Surprisingly even to Jornet and his team, it worked. They had four days in the U.S. Air Force Base in Rome, New York, to pull off a long-distance terahertz connection, and by day two they were able to send and recover the information without any errors.

"In theory, you do the equations, and it sounds like it would work, but to

make this theory you make many assumptions about how the device works internally," Jornet says. "Many times, when you go through this, you expect it not to work, so we were quite surprised that it actually worked."

The system Jornet and his collaborators designed was hitting frequencies and bandwidths that eclipsed 5G networks by more than "two orders of magnitude."

"In 6G, I think we will be happy with just one more order of magnitude," he says.

The impact of this kind of high-speed, high bandwidth connection would be monumental, providing higher data rates and more connectivity even for rural communities. Until recently with the rollout of 5G, rural communities have fallen between the cracks of the digital divide because the fiber optic cables that form the backbone of cutting edge communication networks are expensive to implement across long distances. But when it comes to wireless terahertz technology, rural communities might have an advantage.

"One of the requirements for this signal to travel is that there should not be obstacles," Jornet says. "You need to have line of sight. That's why we say this is great if you want to connect towers across farms, across lands, which otherwise would have to drill and put fiber optics in."

Jornet predicts that even before 6G is available in cellphones, terahertz will start to make a big difference in communication infrastructure.

"The first use case is going to be you as a user will still be using your phone, but suddenly you'll notice that your network is faster because many times the bottleneck is not your phone, it's the infrastructure," Jornet says. "What we're doing is accelerating infrastructure."

In the long run, cutting the fiber optic cord and transitioning to terahertz wireless will be a boon for more than just rural communities, Jornet says. And that's just the start. As usual, he already has his eye on the horizon–literally.

"As a scientist, my goal is to show that 2 kilometers was just the first stop. We want to go for space because that will also give connectivity to everyone," he says, referencing the Starlink satellite technology being pursued by SpaceX. "You will have connectivity like your Verizon Fios, independent of where you are in the world, just because you have a bunch of satellites orbiting the Earth with the right technology."

"It sounds crazy," he adds. "But it's not any crazier than 10 years ago when you said you could [reach] two kilometers."

More information: Priyangshu Sen et al, Multi-kilometre and multi-gigabit-per-second sub-terahertz communications for wireless backhaul applications, *Nature Electronics* (2022). DOI: 10.1038/s41928-022-00897-6

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