TECHNOLOGY

Algorithm Seeks To Advance Space Communications

HOUSTON—A Worcester Polytechnic Institute (WPI)-led cognitive radio experiment using an external International Space Station (ISS) testbed offers potential advances in intelligent wireless communications.

Those advances could have terrestrial and underwater as well as deep-space applications for military and civilian users, two researchers from the Massachusetts school say.

The experiments combined transceivers and software aboard the space station's Space Communications and Navigation (SCAN) testbed. SCAN was launched aboard a 2012 ISS resupply mission for deployment on an external Express Logistics Carrier (ELC) to develop improvements in space communications and on the ground at NASA's Glenn Research Center.

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> —Alex Wyglinski, professor, WPI

The algorithm developed through the effort, as-yet unnamed, can sense and adjust to disturbances caused by space weather, such as solar flares, and atmospheric turbulence due to lightning, high winds, thermal extremes and even fog. While WPI's space-to-ground testing was carried out using S-band communications, further development could extend the cognitive learning advancement to other broadcast bands, including Ka and optical, according to Alex Wyglinski, a WPI professor of electrical and computer engineering, and Randy Paffenroth, a WPI associate professor of mathematical sciences.

Cognitive radio

"Folks have been talking about cognitive radio for several decades, and folks have looked at various techniques and research topics and the implementation of cognitive radio," Wyglinski explained in an October phone interview about the work, carried out in August 2018 and June 2017.

"But personally, I believe that through this project we have started putting the cognitive into cognitive radio. This work is sort of a starting point for future research projects and implementation. Hopefully, it will help to push the current state of the art in terms of satellite communications, space communications and other forms of communications as well."

NASA contributed $123,500 to the research effort as well as access to the ISS SCAN Testbed, ground-based facilities at Glenn and personnel.

The effort, also involving researchers from Pennsylvania State University, programed transceivers at either end of a the ISS/Glenn communications loop to recognize the onset of familiar space and atmospheric disturbances that could disrupt the link but also sense new ones for which they were not programmed to recognize and compensate by altering power levels. Further efforts could nurture the Artificial Intelligence nature of the algorithm to alter the bandwidth and possibly change channels based on the system's ability to self-characterize the transmission environment and adapt, Wyglinski said.

The concept is called Deep Reinforcement Learning.

"The idea here is classic in machine learning," explained Paffenroth during the phone interview. "We have training data and measured data from the environment. The idea is that instead of someone just coming up and saying here are a bunch of rules for deciding how to allocate spectrum and how to tweak the various knobs on the radio, you actually give [the transceiver software] lots of examples of the environment and examples of performance in those environments. And it learns the rules. Then it's in a new environment—not the ones it's trained on—but it has learned enough from the ones you have given it to figure out how it should manipulate the radio in this new environment."

Experimental rigor

Using the ISS for their experiment added more rigor to the cognitive radio algorithm they developed because of the challenges of both the space environment and the Earth's atmosphere, Wyglinski noted.

Future human explorers working on Mars, and even planetary science missions featuring rovers like Opportunity—which was silenced on the surface of the red planet earlier this year by a global Martian dust storm—could benefit by working with or possessing wireless communications systems smart enough to adapt to changing environments, he said.

Commanding and voice exchanges are already challenged by the great distances between Earth and Mars, leading to one-way time delays of up to 20 min.

While cognitive radio cannot shorten the delay, it could allow distant astronauts to maintain a focus on their surroundings and mission objectives rather than on their communications gear, according to Wyglinski and Paffenroth. Similar efficiencies could be extended to satellite, aerial and subsea communications, they believe.

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