Wireless study predicts trouble and solution for 5G cellular

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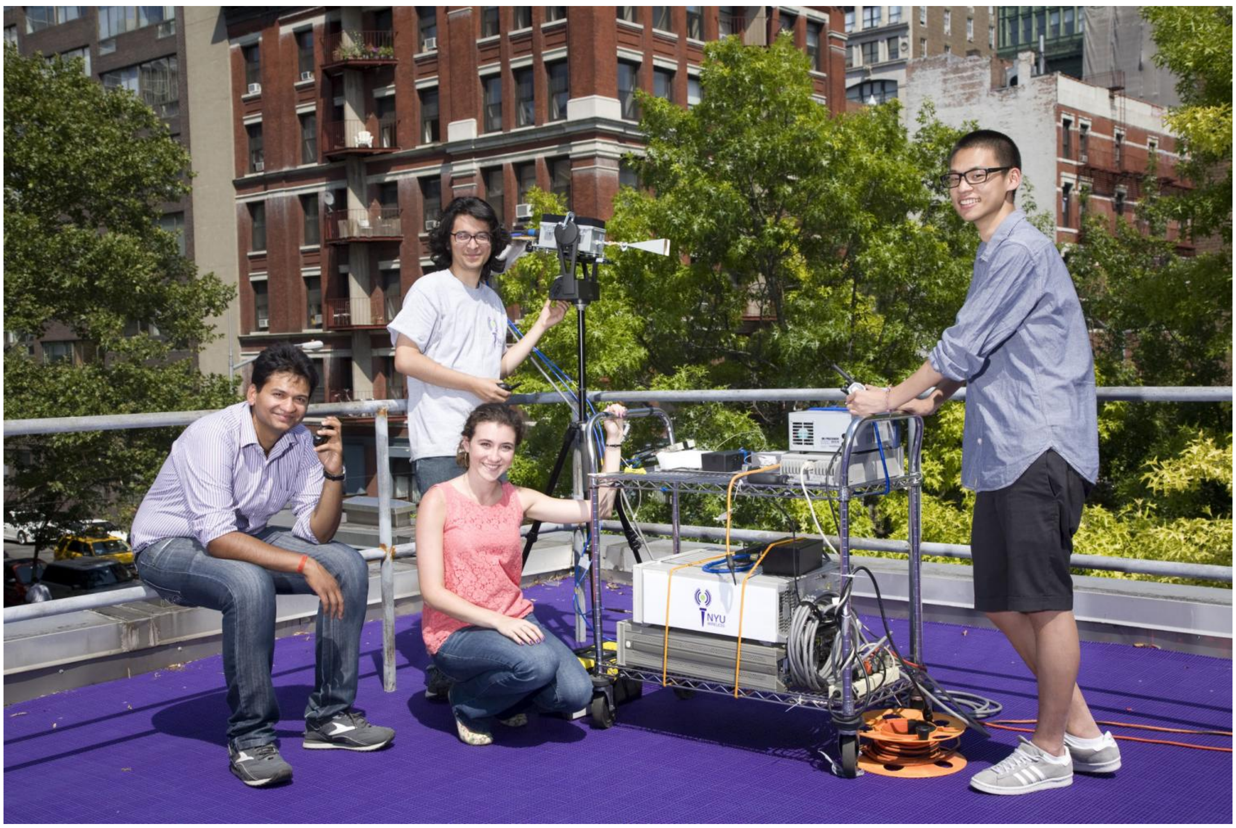

Students of NYU and NYU-Poly use channel sounder to test the reaction of millimeter radio waves in Manhattan's notoriously difficult environment for wireless reception. Left to right: Viral Bhagalia, NYU-Poly telecommunication networks graduate student; (rear) George Wong, NYU College of Arts and Science undergraduate student; Rimma Mayzus, NYU-Poly electrical engineering undergraduate student; and Kevin Wang, NYU-Poly computer engineering and mathematics undergraduate student. Credit: New York University

The 3rd Generation Partnership Project (3GPP), comprising seven telecommunications standard development organizations, will soon choose among channel models to adopt as testing standards for 5G cellular systems. However, a new study by Theodore (Ted) S. Rappaport, the Ernst Weber/David Lee professor of electrical engineering at NYU Tandon School of Engineering and founding director of NYU WIRELESS, suggests that the three-parameter "alpha-beta-gamma" (ABG) model used in the past by 3GPP for predicting signal coverage might spell trouble at frequencies above 6 gigahertz (GHz).

The research, published this month in the *IEEE Vehicular Technology Transactions*, is based on an extensive set of 30 measurement campaigns from 2 GHz to 73 GHz. It was conducted with co-authors from Aalborg University in Denmark, and industry partners, and is part of the Ph.D. work of NYU Tandon School of Engineering graduate student Shu Sun. The study argues for a better, simpler, alternative model that uses just a single parameter, the "path loss exponent," which can be used as a global standard for predicting signal coverage.

Rappaport explained that study shows how the present-day ABG model disobeys fundamental physics, and how the simpler model offers greater predictive accuracy over use-cases that were never measured in the first place. He said the work found significant errors in applying the decade-old channel path loss models to millimeter-wave (mmWave) 5G wireless. "For example, the commonly used ABG model will predict that fewer base stations will be required in the early, non-interference phase of mmWave buildout, when in fact more base stations will be needed," said Rappapoort. He added that the old models will also predict fewer base stations are needed in the mature phase of buildout, when actually there will be much more interference and thus the need for more base stations. "Basically, the ABG channel models the industry is likely to continue using paint an overly rosy picture both in the early and mature phases of 5G buildouts," he said.

The paper's comparison of three 3GPP candidate large-scale propagation path loss models, in field studies covering a vast range of microwave and mmWave frequencies and use-cases, found that:

- The ABG path loss model, likely to be adopted by 3GPP, under-predicts path loss when relatively close to a transmitter, with implications for low-power internet-of-things devices, and over-predicts path loss far from the transmitter, with implications for mmWave, since the ABG model erroneously predicts that mmWave will exhibit relatively weaker signals than it should at longer distances, according to Rappaport.
- The simple close-in (CI) free-space reference distance model, which requires only one model parameter to describe signal strength over all frequencies and distances, is based on fundamental physical principles, and can be generalized to a CI model with frequency-dependent slope (CIF). These new models are more conservative when analyzing interference-limited systems over distances greater than 200 meters, and more realistic when modeling signal strengths at both far distances (> 500 meters) and at close-in distances (within 50 meters of the transmitter). In other words, the CI model exhibits more stable model parameter behavior across frequencies and distances, and yields smaller prediction error in sensitivity tests across distances and frequencies, when compared to ABG, according to Rappaport.
- The CI model with a one-meter reference distance proposed by NYU WIRELESS in a Sept, 2015 paper in *IEEE Transactions on Communications*, is suitable for outdoor environments, while the CIF model is more appropriate for indoor modeling.

Rappaport said the key to the simpler model is the use of a close-in free space reference distance in the first meter of radiation from an antenna. He explained that the one-meter reference distance is based on the fundamental physics of radio propagation going back to the work of Harold Friis at Bell Laboratories in the 1930s. "The use of just a single model parameter, the path loss exponent, and a standard reference distance of one meter, makes the CI model easier to use, more accurate, easier to understand, and more compact in complex computer simulations that will be used to experiment and design future 5G Cellular," he said. "And it works well from 500 megahertz all the way to 100 GHz. The physics should work well into the Terahertz region."

Rappaport pointed out that NYU WIRELESS, the world's top 5G research center, according to Fierce Wireless, recently made open-source channel modeling simulators available for free. "This study is yet another discovery that hopefully will bring accuracy and fundamental grounding to the 3GPP deliberations that are moving at a very fast clip. As the wireless community makes this sea change—this jump to frequencies never before used—the channel models published this month in the IEEE Vehicular Technology Transactions offer a way forward for a very simple, fundamental standard model that offers benefits over how things have been done in the past." He added that such an approach will also help generations of future engineers as they try and tie engineering fundamentals to the practice of wireless engineering.

More information: ieeexplore.ieee.org/stamp/stam … number=7434656&tag=1

Provided by New York University