

# Mathematicians model 5G mobile communications of the future

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City of the future scheme with the 5G networks. Credit: Konstantin Samuylov

Scientists from RUDN University have created a mathematical model of reliable microwave communication for mobile phones and other devices. The results of the research have been published in a special issue of the *IEEE Journal on Selected Areas in Communications (JSAC)* devoted to microwave communication and will be presented at the "Enabling Technologies, Applications, and Methods for Emerging 5G Systems" international conference at the University Mediterranea of Reggio Calabria (9-11 October 2017).

5G refers to the fifth generation of [mobile communication](#) technologies, international standards still under development and scheduled for release by the nonprofit consortium 3GPP in 2020. 5G networks will provide extremely reliable communication with transmission delays not exceeding one millisecond. Such are the requirements of the so-called tactile internet, where not only data but also haptic sensations are transmitted over the [network](#). For example, a surgeon can remotely perform an operation with an artificial hand and sense a feedback within a thousandth of a second. Similar ultra-low delays are necessary for self-driving vehicles or virtual reality applications, for instance, in order to transmit a hologram that accurately conveys emotions and gestures. The second feature of fifth-generation networks is the ability to support high user density—up to a million devices per square kilometer can connect to each other at an average speed of about 100 megabits per second. Third, the peak speed in 5G networks may reach tens of gigabits per second.

On the verge of the 5G era, research aimed at enabling gigabit-rate transmission via millimeter wave channels (mmWave) is of enormous interest. mmWave technology is already used in static environments with stationary devices, particularly indoors, but its implementation in mobile networks with moving transceiving devices and which require the coordination of several moving devices is problematic for a number of reasons. The announcement of the *JSAC* special issue on mmWave provoked a staggering response of the scientific community: In less than four months, *JSAC* received 96 papers, the majority of which came from the most prominent research groups in the field. After a rigorous selection, 38 papers were published in two issues of the journal in July and September of this year, including the study conducted by an international team of scientists from the Royal College, London (UK), Tampere University of Technology (Finland) and RUDN University (Moscow, Russia).

"In our paper, we analyze the use of the microwave range in high-density urban mobile networks. This range allows to provide both ultra-high speed and ultra-high throughput communication to devices in rapid motion and in high-density conditions, for example, on a busy street or in a large shopping center. However, the use of millimeter waves in such environments poses serious problems related to the quality of wireless communication. These include signal attenuation at relatively small distances, up to hundreds of meters, and connection sensitivity to line-of-sight blocking. The ultrashort wave transmitter is directed toward the receiver, and the radio channel is like a narrow cone of light: Whenever there is a foreign object on its way (a person, a car, even a lamp post) the communication is blocked. By means of a [mathematical model](#), we seek to find ways to use the microwave range despite its limitations while maintaining quality," says Dr. Konstantin Samuylov, the head of the Institute of Applied Mathematics & Communications Technology of RUDN University.

While one part of the international research team was working on structural issues and long-term prospects, the other was making simulators—software tools that technically model the system of the future. These were used by the scientists to solve the problem of communication reliability—how to maintain the communication between devices despite the discontinuous nature of the connection.

Besides signal loss, the researchers have been working on other problems that exist in 5G. One of them is effective radio resource ([frequency range](#)) allocation in the network. LTE stands for Long-Term Evolution of mobile communication systems, the standard developed by the 3GPP consortium. The LTE standard is the basis of 5G networks, but today, its allocated frequency range is close to saturation, meaning that there are not enough radio frequencies to meet the requirements of 5G networks. The second problem is related to power consumption. In order to operate efficiently, the network requires a huge amount of electricity. A shortage

may result in servers, cloud systems, routers and network components running out of energy.

"The first challenge is that the capacity of mobile communication frequencies will soon be exhausted; the second is that network equipment will face electricity deficit," Prof. Samuylov said.

Opening up a new frequency range, mmWave, to high-density [mobile networks](#) is an attempt to respond to one of these challenges. A solution to the communication blocking problem in a heterogeneous mobile network has also been suggested. If an mmWave connection is blocked, then it can be transferred to a Wi-Fi network, or, if necessary, to an LTE network. This is a very simplified picture of the connection reliability measures in a 5G network. To analyze such a network, mathematicians solve optimization problems, for example, to minimize transceiver power consumption or to optimize the frequency range.

"Ultramodern 5G communications and various [communication](#) scenarios based upon them may be implemented in the future. Whether they will be implemented or not is a matter of collaboration between the academic community and the industry. It is going to be a long way, and the work done by scientists should be reflected in the standards developed by international organizations," the scholar added.

Among other achievements of his team, Prof. Samuylov mentioned their participation in the IEEE Globecom, a major worldwide conference on telecommunications.

"This year, I have 20 people from abroad working with me, including our compatriots with PhD degrees. Now, we start to pay foreign scientists money, and not vice versa. It is difficult for us to compete with the West at the technology level, mainly because we do not produce hardware components. But we are engaged in mathematical modeling

and are competitive due to the internationally high level of the Russian mathematical school. Today, the Institute of Applied Mathematics & Communications Technology of RUDN University employs about one hundred people, half of whom have high qualifications and wages above the Moscow average. This is unprecedented for Russian higher education nowadays," the scientist concluded.

**More information:** Vitaly Petrov et al, Dynamic Multi-Connectivity Performance in Ultra-Dense Urban mmWave Deployments, *IEEE Journal on Selected Areas in Communications* (2017). [DOI: 10.1109/JSAC.2017.2720482](https://doi.org/10.1109/JSAC.2017.2720482)

Provided by RUDN University

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