Artificial intelligence for optimized mobile communication

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AI will serve to develop a network control system that not only detects and reacts to problems but can also predict and avoid them. Credit: CC0 Public Domain

While many European states are currently setting up the 5th generation of mobile communication, scientists are already working on its optimization. Although 5G is far superior to its predecessors, even the latest mobile communication standard still has room for improvement:

Especially in urban areas, where a direct line of sight between emitter and transceiver is difficult, the radio link does not yet function reliably. Within the recently launched EU project ARIADNE, eleven European partners are researching how an advanced system architecture "beyond 5G" can be developed by using high frequency bands and artificial intelligence.

A major advantage of 5G is its high frequencies and consequently its high transmission rate, which ensures an almost latency-free connection and fast data transfer. However, high frequencies require a directed system, which in most cases relies on a line of sight (LOS). This means that transmitter and receiver must be able to see each other. Unfortunately, the LOS principle can lead to connection problems, especially in urban and heavily developed areas.

One of the issues responsible for these connection problems in local 5G networks is the cancelling effect. This effect occurs when a signal is transmitted over a LOS connection and simultaneously copied via reflections. The copy overrides the signal from the LOS and cancels it. The result: the signal does not reach the receiver. This multipath propagation via non-line of sight (NLOS) remains a problem for 5G, as it did with its predecessor 4G. For this reason, one of the main aims of ARIADNE is the development of new concepts for better control of LOS and NLOS scenarios to massively improve the reliability of mobile communication links.

Higher efficiency and reliability of 5G

The EU Project, with the full title "Artificial Intelligence Aided D-band Network for 5G Long Term Evolution" brings together partners from research and industry from five countries. The aim is to develop energy-efficient and reliable mobile communication links based on frequencies in the D-band (130—174,8 GHz). With its aggregated bandwidth of

more than 30 GHz, the D-band is perfectly suited for fast data transmission. However, this newly used band is divided into several sub-bands and requires an adaptation of the previously used system architecture and corresponding network control.

ARIADNE aims to create an intelligent communication system "beyond 5G" by combining an innovative high-frequency radio architecture and a new network processing concept based on artificial intelligence. By 2022, the project consortium plans to realize and demonstrate a radio link with extremely high data rates in the 100 Gbit/s range at almost zero latency. The European Union supports the project as part of the Horizon 2020 program. ARIADNE focuses on three major research areas: the development of hardware components, the research of metasurfaces and the adaptation of the network control based on artificial intelligence or machine learning.

Devices for a reliable D-band connection

Fraunhofer IAF contributes its expertise in the field of high-frequency electronics to the development of hardware components: together with partners, the Freiburg scientists are developing new radio technology for communication in the D-band (139—174,8 GHz). "Our focus lies on the development of new radio modules with highest spectral efficiency that capitalize on the frequency diversity and provide a control interface for optimization in the network. For this purpose, we will use our 20 nm InGaAs HEMT technology on silicon for the first time," states Dr. Thomas Merkle, scientist and project manager on the part of Fraunhofer IAF.

Reflecting surfaces

In order to prevent network disturbances in NLOS connections,

ARIADNE is researching metasurfaces and their potential for optimizing radio connections. Metasurfaces are adjustable reflectors for radio waves and are intended to counteract network-processing problems in urban areas. When there is no line of sight between base stations on rooftops and users in urban canyons, the metasurfaces will reflect the radio waves and thus ensure propagation outside the line of sight. A central network control will manage the metasurfaces.

"The concept of metasurfaces is already partially being used in 5G, but so far only for low frequencies. The higher the frequencies of the radio link, the finer the microstructures on the surface have to be. This makes the production of such structures very difficult for frequencies in the D-band," explains Thomas Merkle. For this reason, the project team is researching the development of metasurfaces suitable for both high frequencies and industrial production. At Fraunhofer IAF, the scientists are working on so-called reflect arrays. These are small metasurfaces on antennas used for beam steering and focusing.

AI-based network control

In order to provide a constant and reliable radio link in all weather conditions, machine learning and artificial intelligence (AI) methods will be utilized for network management. Currently, classical mathematical methods are used for most mobile radio management. ARIADNE will employ AI-based algorithms for problem solutions in radio communication. While machine learning aims at a profound data analysis, AI will serve to develop a network control system that not only detects and reacts to problems, but can also predict and avoid them.

The ultimate goal of the project partners is to bring the individual project modules together in a test system and demonstrate its functionality. At the end of the project, they want to present two demonstrators as result of their research: The first demonstrator should

achieve a reliable connection over 100 meters with a data rate of 100 Gbit/s in any weather condition. The second demonstrator is intended as a proof of concept under laboratory conditions, to show how a metasurface can improve the propagation condition of radio transmissions. This should prove the functionality of metasurfaces at high frequencies in the laboratory. At this point, the software development should demonstrate that the AI-based network control system can increase the reliability over the whole D-band network and guarantee the control of the metasurfaces.

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