New IIT Bombay-led network standard offers to improve rural connectivity | Explained

On June 6, IEEE approved a wireless network architecture for affordable broadband access in rural areas, developed at IIT Bombay

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Balu (left) shares information on his phone about government schemes with Devi Singh and Tola Ram at Thana village in Bhim, Rajasthan, October 20, 2019. | Photo Credit: Moorthy R.V./The Hindu

Mobile devices have become an integral part of our lives. We use them to communicate with our friends and family, conduct financial transactions through UPI, connect to the Internet, etc. The connectivity for these devices is enabled via a cellular (mobile) wireless network.

A cellular network, such as a 5G network, includes a set of network equipment connected by communication links. They work together to move data between different

devices and to other networks, e.g., the Internet. A cellular network can be divided into two sub-networks: the access network (AN) and the core network (CN).

What are access and core networks?

The AN consists of base stations that provide wireless connectivity to mobile devices in a limited geographical area, called the coverage area. A network operator usually installs base stations across the length and breadth of the region to be covered. You would have seen these stations in the form of towers with boxes with antennae on top.

The CN of a cellular network has equipment that provides connectivity to other networks, such as the Internet. Unlike AN base stations, the CN operates in a central location, and possibly far from any of the base stations. The CN is linked to a base station by an optical fibre link called the backhaul.

Data from a user's device must pass through both a base station and the CN to reach its desired destination, such as the Internet or another user's device. Even if two users are nearby and are connected to the same or adjacent base stations, the data must pass through the central CN. It may not be apparent to the reader but the CN is essential to support user mobility, a key feature offered by cellular networks.

What impedes rural connectivity?

Even though cellular networks seem omnipresent, their deployment and use vary significantly between urban and rural areas. This is especially true in developing countries like India. According to the latest Telecom Subscription Data from the Telecom Regulatory Authority of India, urban tele-density in the country is 127% while the rural tele-density is 58%. Put another way, on average, an urban user has one or more mobile connections (1.27) whereas only one out of two persons (0.58) is connected. This data suggests an urban-rural digital divide. The situation in most other developing countries is similar or worse.

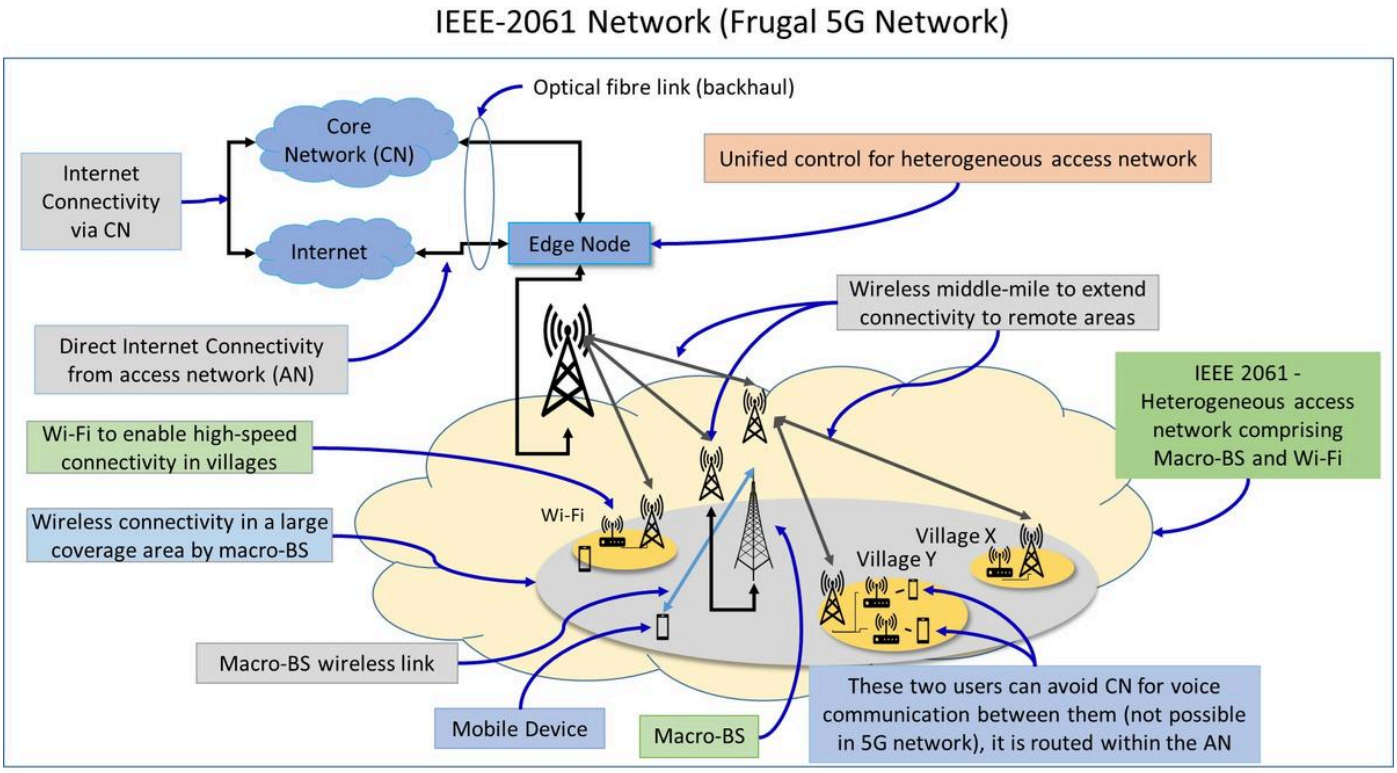
An important factor impeding the deployment and/or use of cellular networks in rural areas is the relatively lower income of the people here. A big chunk of the rural population finds mobile services unaffordable. Other relevant characteristics of rural areas are lower population density, populations distributed in clusters (villages) often separated by vast empty spaces, and remoteness. Taking fibre infrastructure to a far-off village, in the Himalayas, say, to connect the base station there may neither be cost-effective nor easy.

These features of the rural landscape require a communication system that can efficiently cover a large geographical area — yet there has been limited research focus on these factors. Most existing cellular networks cater to the urban populations in economically developed countries, e.g., the 5G network focuses on providing 10 Gbps data rate and 1 ms latency. Rural connectivity lags far behind.

What is the IEEE 2061-2024 standard?

Our research group at IIT Bombay, led by Professor Abhay Karandikar, has been working on affordable rural connectivity for many years and some of the solutions developed in our lab form the basis of the 2061-2024 standard. The standard defines a wireless network architecture for affordable broadband access in rural areas. It was approved on June 6 by the Institute of Electrical and Electronics Engineers (IEEE).

The IEEE-2061 network also includes a CN and AN similar to cellular networks. However, the IEEE-2061 AN is heterogenous wherein different types of base stations coexist: it includes base stations covering large coverage areas — called macro-BS — supplemented by small coverage area Wi-Fi. It is different from the 5G network, where the AN is homogeneous comprising base stations of the same type and typically smaller coverage area.



A schematic illustration of a 'frugal 5G network'. | Photo Credit: Pranav Jha/Special arrangement

The macro-BS in IEEE-2061 can be built with any cellular technology that can support a large coverage area. While the macro-BS provides large-area coverage but possibly lower data rate, Wi-Fi is deployed within villages to provide high-speed connectivity. A key capability of the system is that it allows a device to move from a Wi-Fi based connectivity to a macro-BS connectivity without any service disruption. This is enabled by an integrated AN control functionality in the IEEE-2061 network. As wireless systems evolve, both legacy and new technologies — including 4G, 5G, 6G, Wi-Fi and networks — will coexist and complement each other. In such a heterogenous network, an integrated AN control functionality like the one included in the IEEE-2061 standard will help avoid issues like call drops.

What is a middle-mile network?

Further, the IEEE-2061 standard proposes the use of a multi-hop wireless middle-mile network to extend connectivity to areas where optical-fibre links are not available. A multi-hop wireless middle-mile provides cost-effective connectivity over long distances, eliminating the need for a costly and difficult-to-deploy optical fibre. An IEEE-2061 network can flexibly use one or more technologies like satellites, or long-range Wi-Fi for the middle-mile.

The IEEE-2061 AN also has a direct and alternate path to the Internet, unlike the (4G/5G) network, where Internet connectivity is possible only via the CN. As mentioned earlier, the CN in cellular networks is required to support user mobility. But many mobile network users today are stationary, this is all the more characteristic of rural areas. Therefore, a direct connection to the Internet from an AN, avoiding the centralised CN, would be a more optimal solution for such users. Unlike the 4G/5G networks, an IEEE-2061 network can also avoid the CN for communication between nearby users, which can be directly routed within AN instead. This is like going directly from Belagavi to Hubballi (AN to AN) instead of going to Bengaluru first and then to Hubballi (AN-CN-AN).

In sum

In sum, the IEEE 2061-2024 is the second IEEE standard to come out of the research efforts of Prof. Karandikar's lab at IIT Bombay. It follows on the heels of IEEE 1930.1-2022, a standard on "beyond 5G networks", which also incorporated some of our research ideas as its key elements.

If adopted, IEEE 2061 can help provide affordable connectivity to rural populations. Its novel concepts, including the CN bypass, and integrated AN control may also pave the way towards a flexible and scalable mobile network in future.

Pranav Jha is a scientist with IIT Bombay and the chair of the IEEE working group 'Frugal 5G Networks', which developed the IEEE-2061-2024 standard.