6G networking is starting to take shape

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Why will we need 6G?

6G networking will be built on new technologies that do not yet exist, and will enable use cases not yet defined.

Operators are only just starting to roll out 5G networks, and most users have not yet experienced 5G services. 5G technology encapsulates a great deal of innovation that we have yet to exploit. It supports higher speeds, greater reliability and lower latency than 4G, and enables a great many new use cases that the communications industry will be developing for many years to come. However, we can anticipate that the new technology of 5G will be found to be limiting. Players in the communications industry are already thinking about what these limits will be, and are developing the fundamental technologies needed to push past them. The new use cases in the 6G era require some imagination. Previous generations of mobile networks have enabled existing wireline applications to be mobile at a reasonable cost. 6G involves applications that do not yet exist in any form. These applications lean heavily on virtual reality, and high-performance, real-time computing will be just as important to the network as communications.

What is 6G?

6G researchers are looking into a great many technologies. We can categorise them into four basic groups.

- **Terahertz wireless spectrum.** Signals will need to be transmitted in ranges above the millimetre-wave (mmWave) bands used for 5G in order to achieve speeds beyond those delivered by 5G networks. The next wireless performance frontier beyond mmWave is Terahertz (THz). THz frequencies can carry vast amounts of data, but also suffer from severe path loss. The large capacity of THz spectrum and the short propagation distances (which in turn limit interference) lead some researchers to suggest that there is no need to license spectrum. An application would use what it needs, when it needs it and would give it up when not using it, making use of shared access spectrum approaches that are emerging today. Much antenna development work needs to be done before moving into the THz frontier. This is one of the primary reasons to start thinking about 6G now. The use of THz spectrum is also the most striking departure from 5G.

- **Machines, not humans, as the primary users.** The vast amounts of 6G data and the rates at which it can be transmitted are way beyond the capacity of humans to handle directly. 6G will be primarily about connecting machines that are involved in handling very complex tasks, such as remote surgery, leaving humans to focus on what they want to achieve, rather than how to carry out the task. 5G will soon be going some way down that path with very low latency, enabling virtually instantaneous response 6G will allow for machine-controlled tasks that are even more complex. The business case for 6G depends upon these machine innovations, as well as networking. iPhones will become quaint relics, akin to how we think of flip phones today.

- **Distributed intelligence.** 6G is not about quickly transmitting a lot of data for people to use; it is about applications getting and acting on data. The virtually instantaneous transmission of 6G data means that much of the understanding of how to react must be physically very close to the source. Highly complex applications cannot wait for data to be transmitted long distances back and forth. Machines will anticipate what will be needed from distant systems and will bring the necessary data and intelligence very close to the place of decision for as long as it is required. Most 6G traffic will be internal to the network, unlike in today's networks where nearly all the traffic travels to a user end-point. Distributed intelligence systems will be needed to take advantage of 6G's performance, for example, to continuously land airliners 10 seconds apart. 6G networking depends on the development of these distributed intelligence applications.

- **Trust.** The biggest obstacle to 6G is not physics but psychology. How can people decide to trust a system that they are not directly controlling and that could be sabotaged by an outside force? Self-driving cars will give us some insight into both the means to build systems that we trust our lives to and the pace at which society will accept them. The technologies and policies developed there will be an essential part of 6G. 6G will force regulators to grapple with how to ensure their citizens can trust the systems that they are using. Today's internet privacy concerns are but a very early indicator of the need to build trust.

Is 6G just an extension of 5G?

There are no proposed 6G capabilities that are not already embodied, to some extent, in 5G. Indeed, 6G may just be a higher-performance 5G. The intended agility of 5G standalone networks built with virtualised infrastructure means that 5G could evolve for a long time, embracing new innovations without the need for a different generation of networking. NTT DOCOMO published a whitepaper entitled "5G Evolution and 6G", which suggests just such an evolution.[1] The NGMN Alliance in Europe and the Next G Alliance in North America are both focused on an evolution of 5G networks towards 6G. It is also possible that 6G will manifest as 5G networks that use THz radio.

When will 6G happen?

Samsung and some others have put a 2030 date on 6G. China's MIIT set a 2029 deployment date in an announcement in December 2020. There are no concrete development plans with milestones, so any date is speculation. 2029/2030 seems the earliest point at which significant new technology would be ready. None of the types of development milestones that are always part of major new international standards have yet been set.

How will 6G be developed?

Most 6G work today is in the form of laboratory explorations and discussions among industry consortia. These activities are just getting started. Figure 1 shows some of the notable participants.

Figure 1: Overview of some the key participants in the development of 6G

Category	Name	Details
Universities	Oulu (Finland)	Has active support from Nokia[2]

1 NTT DOCOMO (2020), *5G Evolution and 6G.* Available at: https://www.nttdocomo.co.jp/english/binary/pdf/corporate/technology/whitepaper_6g/DOCOMO_6G_White_PaperEN_20200124.pdf.

2 University of Oulu (2018), *University of Oulu to begin groundbreaking 6G research as part of Academy of Finland's flagship programme*. Available at: https://www.oulu.fi/university/6genesis.

Category	Name	Details
Universities	NYU (New York, USA)	Supported by some vendors and operators[3]
Universities	Surrey (UK)	Has launched a 6G innovation centre[4]
Major vendors	Samsung	Has published 6G work and sponsored various alliances[5]
Major vendors	Nokia	Has published 6G work and sponsored various alliances[6]
Major vendors	Ericsson	Has published 6G work and sponsored various alliances[7]
Major vendors	ZTE	Has signed a strategic co-operation agreement with China Unicom for 6G[8]
Operators	NTT DOCOMO	Has discussed the evolution of 5G into 6G[1]

Source: Analysys Mason, 2021

Many major operators are also participating in industry alliances, as shown in Figure 2.

Figure 2: Industry alliances that are working on 6G

Name	Details
Next G Alliance	• North America-focused • Related to ATIS • All large North American operators are involved
NGMN	A global organisation with support from a wide range of operators worldwide
REINDEER	Led by Ericsson and funded by the EU Horizon 2020 effort
Hexa-X	Led by Nokia, but other vendors (such as Ericsson and Intel) are also involved

Source: Analysys Mason, 2021

Conclusion

Most of the telecoms industry is focused on 5G, but it has long had the ability to work towards new innovations that take a long time to develop. There have been five generations of mobile networking; there will be a sixth that pushes to fulfill the parts of 5G that will prove too difficult and to put the latest technology innovations to use.

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3 NYU Wireless, Available at: https://wireless.engineering.nyu.edu/.

4 University of Surrey (2020), *University of Surrey unveils its 6G Innovation Centre and distinctive 6G vision*. Available at: https://www.surrey.ac.uk/news/university-surrey-unveils-its-6g-innovation-centre-and-distinctive-6g-vision.

5 Samsung (2020), *Samsung's 6G White Paper Lays Out the Company's Vision for the Next Generation of Communications Technology*. Available at: https://news.samsung.com/global/samsungs-6g-white-paper-lays-out-the-companys-vision-for-the-next-generation-of-communications-technology.

6 Nokia (2020), *Nokia to lead the EU's 6G project Hexa-X*. Available at: https://www.nokia.com/about-us/news/releases/2020/12/07/nokia-to-lead-the-eus-6g-project-hexa-x/.

7 Ericsson (2021), *Ericsson a key player in EU drive to develop 6G multi-antenna technologies*. Available at: https://www.ericsson.com/en/news/2021/1/ericsson-in-eu-6g-drive.

8 ZTE (2020), *ZTE and China Unicom sign a strategic cooperation agreement on 6G*. Available at: https://www.zte.com.cn/global/about/news/20200520e1.html.