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Identifying 6G Use Cases and Future Trends

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Following NGMN's "6G Drivers and Vision" publication in 2021, the publication of "6G Use Cases and Analysis" marks the next step toward NGMN's work on 6G end-to-end requirements.

The identification of 6G use cases is key to predicting major trends in future usage scenarios and will help to steer the needs and requirements for future generational change. Therefore, operators, technology suppliers, and academic advisors in NGMN joined forces and contributed their views on which 6G use cases they predict will emerge in the future decade.

A total of 50 use cases were identified, categorized into four classes, and mapped into 14 generic use cases. The four classes are:

- **Enhanced human communication**—including use cases that have the potential to enrich human communications, such as immersive experience, telepresence, and multi-modal interaction.
- **Enhanced machine communication**—including use cases reflecting the growth in collaborative robotics, and autonomous machines, the requirement for sensing the surrounding environment, and the need for robots to communicate among themselves and with humans.
- **Enabling services**—including use cases that require additional features, such as high accuracy location, mapping, environmental, or body sensing data.
- **Network evolution**—describing aspects related to the evolution of core technologies, including AI as a service, energy efficiency, and delivering ubiquitous coverage.

High-level analyses and assessments of use cases were conducted at an early stage in several areas, including potential technology components, feasibility, and differentiation to 5G. In the following, a few examples are provided for each class.

Enhanced human communication

People may be able to interact with devices or control machines via brain-machine interfaces. With 6G, brain-computer interfaces (BCIs) may realize the sharing of sensations and thoughts between human and machine, human and human, crossing a long distance, and in real-time. People would feel they have a sort of telekinesis, with their thoughts immediately realized without legacy human interaction in between. With 6G, a new term seems to come into play which will be called Internet of Behavior (IoB), where humans will include their individual characteristics into the information flow.

With more systems being driven by AI technologies, the machine no longer passively waits for users to input. This brings fundamental changes to the human-computer interface (HCI). Machines may sense what humans "do" and reason what humans "want." For example, self-driving cars and personalized healthcare robots are emulating human behaviors. Machines are more focused on understanding and replicating the human mind and brain. Those machines are trying to perceive, recognize, and think like humans, and human-machine interactions will evolve to equal human-like interactions with emotions and mutual understanding.

BCI systems are providing an alternative method of interaction between humans and the world. In the past, most BCIs focused on helping people with severe movement disability by replacing or restoring lost movements. Today, more and more BCIs are aiming as consumer products for all users, and certain functions of the human body can be replaced with machines manipulated by mind.

Enhanced machine communication

A much closer interaction is expected to develop between humans and robots, through the form of collaborative robots, cobots. These connected cobots should be able to reliably read and interpret human actions and intents and react in a trustworthy way, and thereby assist humans in an efficient and safe way. They should be able to work as colleagues on precise and challenging tasks in industries—with the help of digital twins to do the job of robots more efficiently. Or they may work as care assistants in the homes of elders or the disabled, doing the heavy work of humans. A cobot could be a separate machine taking commands or adapting to the situation presented, or closer to humans as an exoskeleton or adaptive wheelchair. Cobots could also form teams among each other, solving tasks together and collaborating with humans on a group level. To unleash the highest potential and efficiency, it should be possible for sets of cobots to jointly define the way they collaborate and even communicate naturally under the control of the network.

Enabling services

Supported by the communication systems of the future, the 6G network may sense the environment. For instance, advanced techniques will be used in security-screening procedures to eliminate security lines at airports. A combination of various sensing modalities may be used to screen people as they move through crowded areas rather than only at entrances. For example, it could be programmed to automatically detect metallic objects of certain kinds that people may be carrying in a crowded controlled area. The network can sense and identify potential threats. In a smart hospital in the foreseeable future, device-free gesture and activity recognition enabled by 6G networked sensing and machine learning will enable functionalities such as gesture recognition, heartbeat detection, fall detection, respiration detection, sneeze sensing, intrusion detection, and so forth, providing

automatic protection to the patients during their daily routines. For instance, the medical rehabilitation system could provide automatic supervision of patients during their physiotherapy exercises. Prompt alerts will be sent upon incorrect movements or gestures in an automatic way, thus significantly improving the capacity of medical rehabilitation.

In future intelligent factories, 6G will enable ultra-high resolution imaging monitory systems and remote operation platform systems. Intelligent factories will leverage these superior sensing solutions to implement contactless, ultra-high precision detection, tracking, and quality control. This enables applications such as detection of slits or leakage on products or equipment using 6G communication networks and devices without the need to install extra infrastructures.

Network evolution

AI can be a tool to optimize performance, but it can also be a general service provided by the mobile network to enable new applications. This is referred to as AI as a service (AIaaS), in which the network with an AI plane or layer will be able to expose and serve distributed AI learning and inference as native AI services where needed.

AIaaS could be utilized by the mobile communication network itself for operation and management (OAM) purposes to realize the vision of zero-touch autonomous networks. For instance, network configuration, function implementation, and more can be implemented, operated, and managed by the network system itself through the continuous learning capabilities offered by AIaaS through the network. The training of the AI models as well as the reference through the AI models for these automation tasks would need the communication, sensing, and computing functions integrated in the 6G networks as a whole, especially when large-scale training and inference models are incorporated on distributed edge nodes. Such distributed nature is the key to make the whole computation and resource management scalable toward more complex tasks and larger areas of intelligence.

Similarly, AIaaS would be an integrated service of the 6G network to enable other use cases for operators' own operational necessities such as dynamic traffic and resource management, as well as the energy-saving mechanisms trying to follow those dynamics. Data management is another example of applications that would benefit from AIaaS. Obtaining vast amounts of data does not mean that the data is either high-quality or usable. As such, AIaaS is necessary to support efficient data processing to select high-quality data while reducing computation complexity and energy consumption.

Besides serving the requirements from the operator's network itself, an important aspect of AIaaS is to create new values by providing distributed AI solutions through the mobile network to external (third-party) user applications, including those driven by deep neural networks. The capability to provide highly efficient and fast convergence training as well as low latency inference would be the key to realize intelligence-of-everything for future humancentric social services as well as advanced smart vertical industries. Examples of the enabled third-party user applications may include but not be limited to vision (image and video) recognition, activity recognition, as well as automatic security inspection in smart factories, and health monitoring in a smart hospital.

6G vs. 5G

At first glance, some of the use cases appear to be in the context of 5G and 5G-advanced. An important observation since the launch of 5G is that the growth in data across mobile and fixed

networks has been enormous, driven primarily by the increasing use of video streaming across all media platforms. As high-capacity networks have become widely available, growth in the use of consumer smartphone apps that use video as the primary means of engagement has followed. Further, the COVID-19 pandemic has dramatically driven data growth, with work-from-home and remote-learning driving the wide-scale adoption of video conference platforms unimaginable just a few years earlier. Together, these changes in services and consumption have influenced network developments in way that were unforeseen when 5G use cases were proposed.

Use cases should, therefore, be recognized as being speculative in nature. At least as important is the ability for mobile and fixed networks to continue to scale, in a flexible way, that is sustainable, energy efficient and cost-effective in order to address the inevitable growth in demand in future decades while minimizing the impact on the environment.

Note: This article features and cites the NGMN White Paper "6G Use Cases and Analysis" developed by the NGMN 6G project team.