CHAPTER 4

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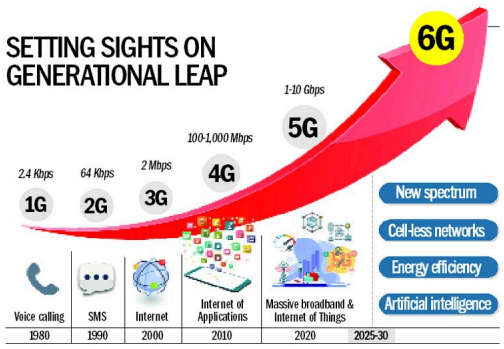
The new generations of digital telephony 2 G and UMTS, 3.5 G, 4G

4.1 sub-objectives

- Define mobile phone generations (1G to 5G).
- Introducing the 6G perspective.

4.2 *introduction*

Mobile networks have not stopped for several years the development of the increase, several generations have indeed been born (1G ,2G ,3G ,4G 5G and soon the 6G not yet implemented) and have seen remarkable evolution in providing exceptional and constantly increasing bandwidth, a wider and wider



4.3 The second generation of GSM “2G”

4.3.1 Features of the 2G

The second generation of mobile telephony, or 2G, has several significant advantages over the first generation, 1G. The main points of comparison are:

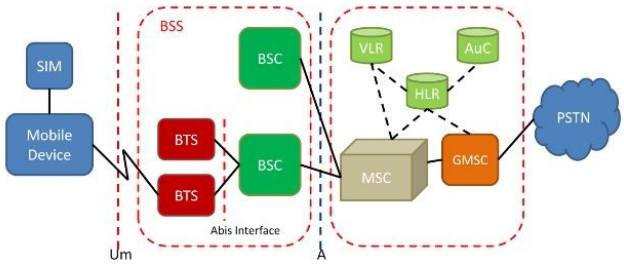
- **Digital transmission:** Unlike 1G, which used an analog signal, 2G uses a digital signal, allowing better call quality and increased security through digital encryption
- **Transmission speed :** Maximum data rates for 2G are relatively low, reaching up to 1 Mbps in ideal conditions, but more typically around 9.6 Kbps for standard services
- **Services offered:** 2G has enabled the introduction of services such as SMS (Short Message Service) and MMS (Multimedia Messaging Service), thus paving the way for text and multimedia communication

4.3.2 Evolution and associated technologies

2G (GSM) has also given rise to developments such as **GPRS** and **EDGE**,

- **GPRS (General Packet Radio Service):** is a standard for mobile telephony derived from GSM often referred to as **2.5G**, which has improved the theoretical rates up to **171.2 Kbps**, facilitating access to mobile Internet (**2.5G allows SMS and MMS** to be transmitted).
- **EDGE (Enhanced Data Rates for GPRS Evolution)** is a mobile phone standard, an evolution of GPRS. often referred to as 2.75G which has allowed speeds up to 384 Kbps. (2.75G allows small video to be transmitted).

Terminals (devices) are identified by a unique 15-digit identification number called **IMEI** (**International Mobile Equipment Identity**). Each SIM card also has a unique (and secret) identification number called **IMSI (International Mobile Subscriber Identity) .** This code can be protected with a 4-digit key called PIN. The SIM card thus allows each user to be identified independently of the terminal used when communicating with a base station. communication is done through the access network and the core networks.



But to go further and offer services beyond WAP consultation or receiving emails and getting closer to those used on computers, it was necessary to change the architecture. 3G has been designed to meet the growing demand for mobile connectivity and multimedia services.

4.4 The third generation of GSM "3G- UMTS" Universal Mobile Telecommunication Services

3G is a technology standard for mobile phones and laptops, just like GSM or EDGE. It is an evolution of the latter, since it allows to obtain a higher data rate.

4.4.1 Main features of 3G

- **Transmission speed:**3G provides data speeds of up to several megabits per second, making it easier to browse the Internet, stream video and make video calls. 3G standards, such as UMTS (Universal Mobile Telecommunications System), were established to guarantee minimum speeds of 144 Kbps in motion and up to 2 Mbps under stationary conditions
- **multimedia services :** 3G has introduced advanced features such as video calling, mobile television and mobile Internet access, making smartphones more functional.
- **simultaneous transmission:** Unlike 2G, which could usually only handle one type of communication at a time (voice or data), 3G allows simultaneous transmission of voice and

data (3G can transmit a standard video of normal size) .

4.4.2 Benefits of 3G

- Better call quality: 3G digital transmission reduces noise and improves clarity of voice calls.
- Mobile Internet Access: The ability to access the Internet at significantly faster speeds has paved the way for a multitude of mobile applications and online services.
- Increased capacity: 3G can handle more users simultaneously without significant service degradation, which is essential in densely populated areas

Despite its many advantages, 3G technology also has some limitations:

- Limited coverage: In some remote areas, network coverage may be insufficient
- Power consumption: 3G devices typically consume more energy than previous generations, which can affect battery life
- Infrastructure costs: The deployment of 3G networks requires significant investments in infrastructure, which can lead to high costs for operators

4.5 The fourth generation of GSM "4G"

The fourth generation of mobile telephony, commonly known as 4G, was introduced in the 2010s and represents a significant advance compared to previous generations, notably 3G. It is mainly characterized by much higher data transmission speeds and better network capacity. (4G allows to transmit high quality videos)

4.5.1 Main features of 4G

- **Transmission speed:** 4G offers speeds from 100 Mbps to 1 Gbps, allowing fast internet access, ideal for high definition video streaming and downloading heavy files
- **LTE technology:** The main standard of 4G is LTE (Long Term Evolution), which uses packet switching techniques to provide data services. This also allows the implementation of VoLTE (Voice over LTE), which improves the quality of voice calls.
- **Improved mobile Internet access:** With 4G, users can enjoy an Internet experience comparable to that of fixed connections, making it possible to watch streaming videos, online games and other data-intensive applications.

4.5.2 Benefits of 4G

- **higher flow rates :** 4G offers significantly higher speeds than those available with 3G, facilitating activities such as live streaming and video conferencing without latency.
- **Reduced latency:** Thanks to an optimized network architecture, the latency in communications is significantly reduced, which improves the user experience during real-time activities such as online games or video calls
- **Increased capacity: 4G** can handle more users simultaneously without significant service degradation, which is essential in densely populated areas

4.5.3 applications and services

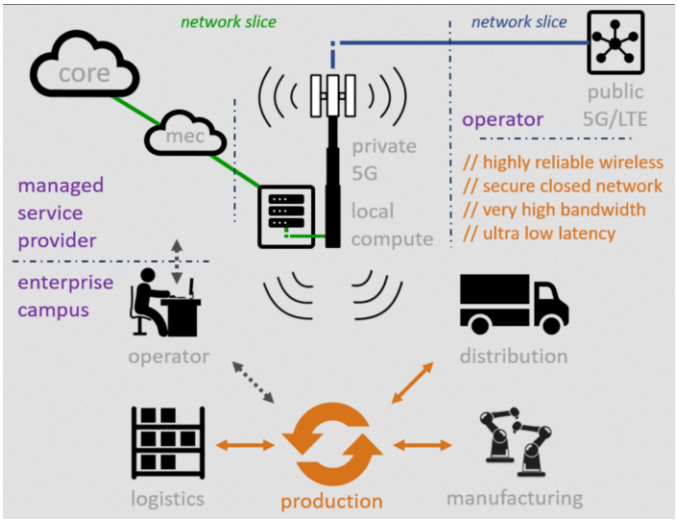
4G has led to the emergence of many modern services and applications:

- HD video streaming: Users can watch movies and shows in high definition without interruption.
- Online games: Games that require a fast and stable connection have become more accessible thanks to high speeds.
- Internet of Things (IoT): Improved connectivity has also fostered the development of IoT devices, allowing for seamless communication between various connected devices.

The fourth generation of mobile networks has transformed how users interact with their mobile devices and access the internet. By delivering fast speeds, reduced latency and improved network capacity, 4G has set a new standard for mobile communications and paved the way for continuous innovation in wireless technologies.

4.6 the fifth generation of GSM "5G"

The fifth generation of mobile telephony, known as 5G, is the latest technology standard for cellular networks, which will be deployed from 2019. It represents a major advance over 4G, offering much higher data transmission speeds, reduced latency and increased network capacity.



4.6.1 Main features of 5G

- **Transmission speed:** 5G can reach theoretical speeds of up to 10 Gbps, which is about ten times faster than 4G. In practice, average observed speeds are about 186.3 Mbps in the US, with peaks of up to 432 Mbps in South Korea
- **Reduced latency:** The latency, which is the time it takes for a signal to go back and forth between the user and the network, can drop to 1 millisecond with 5G, compared to about 30-60 milliseconds for 4G. This allows for real-time applications such as online games and augmented reality
- **Increased capacity:** 5G can connect up to one million devices per square kilometre, compared with just 4,000 devices for 4G. This is crucial for densely populated urban areas and the development of the Internet of Things (IoT)

4.6.2 underlying technologies

- Use of a variety of frequencies: 5G uses a range of frequencies from low (600-900 MHz) to high (24-47 GHz), allowing for better coverage and higher speeds
- Small cells and beamforming: To compensate for the limitations of millimetre-wave range, 5G relies on a dense network of small cells that improve coverage in urban areas. Beamforming allows antennas to direct signals directly to user devices, improving efficiency

4.6.3 Applications and benefits

5G is paving the way for many new applications:

- Smart cities: Increased capacity and low latency enable the deployment of connected infrastructure in cities, such as sensors for traffic management or surveillance systems.
- Industrial automation: Industry 4.0 applications will benefit from ultra-reliable, low-latency communication for critical processes such as robotics and remote control
- Connected health: Telemedicine can be improved through fast and reliable connections, allowing real-time medical consultations.

5G technology represents a significant transformation in the mobile communications space, not only offering unprecedented data speeds but also an infrastructure capable of supporting an increasing number of connected devices. Although its roll-out is still ongoing and challenges remain in terms of infrastructure and costs, its implications for various sectors are broad and promising.

4.7 The sixth generation of GSM “6G”

The sixth generation of mobile phones, known as 6G, is the next evolution in wireless technologies, expected around 2030. It promises to revolutionize connectivity with extremely high data speeds, ultra-low latency and unprecedented network capacity.

4.7.1 Main features of the 6G

- Transmission speed: 6G aims to achieve data speeds of up to 1 Tbps (terabit per second), which is about 100 times faster than 5G. This will allow for instant downloads and ultra-high definition content streaming, including 8K videos and immersive augmented and virtual reality experiences
- Ultra-low latency: Latency could drop below 1 millisecond, enabling critical real-time applications such as remote surgery and autonomous driving.
- New frequency spectra: 6G will operate at frequencies of up to several hundred terahertz (THz), allowing very high-speed data transmissions.

4.7.2 underlying technologies

- **Intelligence Artificielle (IA) et Apprentissage Automatique (AA) :** Ces technologies joueront un rôle crucial dans l'optimisation des réseaux 6G, en permettant une gestion proactive et en améliorant la sécurité du réseau

- **Communication Quantique :** Cette approche promet d'améliorer la sécurité des transmissions de données grâce à des techniques d'encryptage quantique, rendant toute tentative d'interception détectable
- **Réseaux Maillés :** Contrairement à l'architecture traditionnelle en étoile de la 5G, la 6G pourrait adopter un modèle de réseau maillé où chaque appareil peut transmettre des données pour les autres,

4.7.3 Applications potentielles

- **Smart Cities and the Internet of Everything (IoE):** 6G will provide massive connectivity, with the ability to connect up to 10 million devices per square kilometer, facilitating the development of smart urban environments where devices interact autonomously.
- **Telemedicine and remote surgery:** With ultra-low latency and high speeds, 6G will transform healthcare by enabling remote surgical procedures with increased precision.
- **Holographic communication:** 6G could make holographic communication possible, offering a new dimension to remote interactions, both in the professional and personal settings

The sixth generation of mobile networks represents a major step forward in wireless communications. While still in the research and development phase, its promises of speed, efficiency and practical applications could radically transform how we interact with the digital world. First commercialization expected around 2030, with pre-commercial trials starting in 2028