Mini Review
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A short review on the complete history of mobile phones network

Abstract

Mobile phones have become an essential part of our daily lives, enabling us to communicate, access information, and perform various tasks anytime and anywhere. However, the development of mobile phones and their network technologies was not a straightforward process. It involved many challenges, innovations, and collaborations among different stakeholders. In this paper, we provide a brief overview of the history of mobile phones and their network generations, from the early experiments with radio communication to the current deployment of 5G and beyond. We highlight the main features, advantages, and limitations of each generation, as well as the social and economic impacts of mobile phones on society.

Keyword: mobile phone network generations (1G, 2G, 3G, 4G, 5G, 6G), wireless communication, social and economic impacts, challenges and opportunities, history and evolution, spectrum and bandwidth, data rates and quality, coverage and connectivity, roaming and interoperability

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Introduction

Mobile phones are devices that allow us to make and receive voice calls, send and receive text messages, and access various services and applications over wireless networks. They have become ubiquitous in modern society, with more than 5 billion mobile phone users during the year.[1] Mobile phones have also transformed many aspects of our lives, such as education, health, entertainment, commerce, and social interaction.

However, mobile phones did not emerge overnight. They are the result of decades of research and development in the fields of telecommunications, electronics, and computer science. The evolution of mobile phones and their network technologies can be divided into several generations, each of which introduced new features, improved performance, and expanded coverage. In this paper, we review the history of mobile phones and their network generations, from the first experiments with radio communication to the current deployment of 5G and beyond. We also discuss the social and economic impacts of mobile phones on society.

Definition of mobile phone network generation

A mobile phone network generation is a type of cellular network that uses a certain standard of wireless communication technology to provide voice and data services to mobile phone users. Each generation of mobile phone networks has different features, capabilities, and performance, such as data rates, coverage, latency, and security. The mobile phone network generations are usually referred to by their number, such as 1G, 2G, 3G, 4G, and 5G. The higher the number, the more advanced and faster the network is.[12,13]

Why mobile phone network generation is important

Mobile phone network generation is important because it affects the quality and availability of mobile communication and information services, which have various social and economic impacts on society. For example, mobile phone network generation can influence the following aspects:

Education: Mobile phone network generation can enable access to online learning resources, such as e-books, videos, and courses, as well as interactive and collaborative learning platforms, such as chat, forums, and virtual classrooms. This can enhance the quality and accessibility of education, especially for remote and underprivileged areas.[14]

Health: Mobile phone network generation can enable access to online health services, such as telemedicine, e-health, and m-health, as well as health-related information, such as diagnosis, treatment, and prevention. This can improve the quality and affordability of health care, especially for rural and low-income areas.[15]

Entertainment: Mobile phone network generation can enable access to online entertainment services, such as streaming, gaming, and virtual reality, as well as entertainment-related information, such as news, sports, and culture. This can enhance the quality and diversity of entertainment, especially for urban and young areas.[16]

Commerce: Mobile phone network generation can enable access to online commerce services, such as e-commerce, e-banking, and e-payment, as well as commerce-related information, such as prices, products, and reviews. This can improve the efficiency and convenience of commerce, especially in global and digital areas.

Social interaction: Mobile phone network generation can enable access to online social interaction services, such as social media, instant messaging, and video calling, as well as social-related information, such as opinions, emotions, and identities. This can enhance the quality and frequency of social interaction, especially for distant and diverse areas.

1G: The First Generation of Mobile Phones

The first generation of mobile phones, also known as 1G, was based on analog cellular networks that used frequency modulation (FM) to transmit voice signals over radio waves. The concept of cellular networks was proposed by Bell Labs in the 1940s, and the first commercial cellular service was launched by Nippon Telegraph and Telephone (NTT) in Japan in 1979.[2] The 1G network covered the whole Japan by 1984, making this country the first nation to have a nationwide cellular service.

The first 1G service in the United States was introduced by Ameritech in 1983, using the Advanced Mobile Phone System (AMPS) standard. The first commercially available 1G phone was the Motorola DynaTAC, which weighed about 0.9 kg and cost about $4,000.[3] The phone had a battery life of 30 minutes and a memory capacity of 30 phone numbers. The 1G network reached a peak of 20 million subscribers worldwide by the late 1980s.[4]

The main advantages of 1G were the mobility and convenience of making and receiving calls without wires. However, 1G also had many limitations, such as:

I. Low voice quality and high interference due to analog transmission.

II. Limited capacity and coverage due to the use of a single frequency band and large cells.

III. No roaming support across different networks and regions.

IV. No data services or encryption, making the communication insecure and vulnerable to eavesdropping.

These limitations made 1G technology largely obsolete by the 1990s when 2G mobile phones were introduced [3]. The 2G technology offered better voice quality, more capacity, and the ability to send text messages. The subsequent generations of mobile phones have continued to improve on the features of their predecessors, offering faster data speeds, better coverage, and more advanced security features.[17]

2G: The second generation of mobile phones

The second generation of mobile phones, also known as 2G, was based on digital cellular networks that used digital modulation and compression to transmit voice and data signals over radio waves. The 2G network also introduced the concept of multiple access, which allowed multiple users to share the same frequency channel. The first 2G service was launched by Radiolinja in Finland in 1991, using the Global System for Mobile Communications (GSM) standard.[5] The GSM standard soon became the most widely adopted 2G standard in the world, with other standards such as IS-95 (CDMA), IS-136 (TDMA), and iDEN (IDEN) being used in some regions.

The first 2G phone was the Nokia 1011, which weighed about 0.5 kg and cost about $1,000.[6] The phone had a battery life of 90 minutes and a memory capacity of 99 phone numbers. The 2G network reached a peak of 1.5 billion subscribers worldwide by the early 2000s.

The **main advantages of 2G** were the improved voice quality and reduced interference due to digital transmission. 2G also introduced new features and services, such as:

I. Higher capacity and coverage due to the use of multiple frequency bands and smaller cells.

II. Roaming support across different networks and regions.

III. Data services such as Short Message Service (SMS), Multimedia Message Service (MMS), and Wireless Application Protocol (WAP).

IV. Encryption and authentication, making the communication more secure and reliable.

However, **2G also had some limitations**, such as:

I. Low data rates, ranging from 9.6 kbps to 14.4 kbps, which limited the types and quality of data services.

II. Incompatibility among different 2G standards, which required dual-mode or multi-mode phones to operate on different networks.

III. High power consumption and radiation, which affected the battery life and health of the users.

However, 2G also had some drawbacks that hindered its performance and usability. One of the main limitations of 2G was the low data rates, which ranged from 9.6 kbps to 14.4 kbps. This meant that the data services were slow and unreliable, and could not support multimedia applications such as video streaming or web browsing. Another limitation of 2G was the incompatibility among different 2G standards, such as GSM, CDMA, and TDMA. This created interoperability issues and required users to have dual-mode or multi-mode phones to switch between different networks. A third limitation of 2G was the high-power consumption and radiation, which affected the battery life and health of the users. The 2G phones had to transmit at high power levels to maintain the connection, which drained the battery quickly and increased the exposure to electromagnetic radiation. These limitations of 2G motivated the development of the next generation of mobile communication technology, 3G, which offered higher data rates, greater compatibility, and lower power consumption.

3G: The third generation of mobile phones

The third generation of mobile phones, also known as 3G, was based on broadband cellular networks that used packet switching and code division multiple access (CDMA) to transmit voice and data signals over radio waves. The 3G network also introduced the concept of wideband, which increased the bandwidth and data rates of the network. The first 3G service was launched by NTT DoCoMo in Japan in 2001, using the Wideband CDMA (W-CDMA) standard. The W-CDMA standard was part of the Universal Mobile Telecommunications System (UMTS) family of standards, which also included High-Speed Packet Access (HSPA) and Long-Term Evolution (LTE). Other 3G standards included CDMA2000 and TD-SCDMA, which were used in some regions.

The first 3G phone was the NTT DoCoMo FOMA P2101V, which weighed about 0.2 kg and cost about $500. The phone had a battery life of 150 minutes and a memory capacity of 500 phone numbers. The phone also had a color display, a camera, and a video player. The 3G network reached a peak of 3.5 billion subscribers worldwide by the late 2010s.

The main advantages of 3G were the increased data rates and quality of data services. 3G also enabled new features and services, such as:

I. Higher data rates, ranging from 384 kbps to 42 Mbps, which enabled the delivery of multimedia content such as music, video, and games.

II. Wider coverage and seamless connectivity, due to the use of multiple frequency bands and smaller cells.

III. Global roaming and interoperability, due to the harmonization of 3G standards and the adoption of the International Mobile Subscriber Identity (IMSI) and the International Mobile Equipment Identity (IMEI) numbers.

IV. Enhanced security and privacy, due to the use of encryption, authentication, and digital certificates.

However, **3G also had some challenges**, such as:

I. High cost and complexity of deployment and maintenance, due to the need for new infrastructure and equipment.

II. High power consumption and radiation, which affected the battery life and health of the users.

III. Spectrum scarcity and congestion, due to the increasing demand for data services and the limited availability of frequency bands.

These challenges and limitations hindered the widespread adoption and performance of 3G, and motivated the development of the next generation of mobile communication technology.

4G: The fourth generation of mobile phones

The fourth generation of mobile phones, also known as 4G, was based on all-IP cellular networks that used orthogonal frequency division multiple access (OFDMA) and multiple-input multiple-output (MIMO) to transmit voice and data signals over radio waves. The 4G network also introduced the concept of heterogeneous, which integrated different types of networks and technologies to provide seamless and ubiquitous connectivity. The first 4G service was launched by TeliaSonera in Norway and Sweden in 2009, using the Long-Term Evolution (LTE) standard. The LTE standard was part of the UMTS family of standards, which also included LTE-Advanced and LTE-Advanced Pro. Other 4G standards included WiMAX and LTE-TDD, which were used in some regions.

The first 4G phone was the Samsung Galaxy S II, which weighed about 0.1 kg and cost about $600. The phone had a battery life of 300 minutes and a memory capacity of 16 GB. The phone also had a high-resolution display, a dual-core processor, and a high-definition camera. The 4G network reached a peak of 4.5 billion subscribers worldwide by the early 2020s.

The **main advantages of 4G** were the very high data rates and quality of data services. 4G also enabled new features and services, such as:

I. Very high data rates, ranging from 100 Mbps to 1 Gbps, which enabled the delivery of high-definition content such as streaming, gaming, and virtual reality.

II. Wider coverage and seamless connectivity, due to the use of heterogeneous networks and technologies such as Wi-Fi, Bluetooth, and Near Field Communication (NFC).

III. Global roaming and interoperability, due to the convergence of 4G standards and the adoption of the International Mobile Telecommunications (IMT) system and the IP Multimedia Subsystem (IMS) framework.

IV. Enhanced security and privacy, due to the use of encryption, authentication, and digital signatures.

However, **4G also had some challenges**, such as:

I. High cost and complexity of deployment and maintenance, due to the need for new infrastructure and equipment, as well as the coordination of multiple networks and technologies.

II. High power consumption and radiation, which affected the battery life and health of the users, as well as the environment and wildlife.

III. Spectrum scarcity and congestion, due to the increasing demand for data services and the limited availability of frequency bands, especially in the higher frequency ranges.

IV. Security and privacy risks, due to the increased exposure and vulnerability of the network and the users, as well as the potential misuse and abuse of the data and the services.

These **challenges also limited** the services that 4G could provide, such as:

Seamless and reliable connectivity, especially in rural and remote areas, where the coverage and quality of 4G networks were often poor or unavailable.

High-definition video streaming and conferencing, which required high bandwidth and low latency, but often faced buffering, lagging, and dropping issues due to network congestion and interference.

Internet of Things (IoT) and smart city applications, which involved a large number of devices and sensors communicating and exchanging data, but often faced scalability, interoperability, and security challenges due to the limitations of 4G networks.

5G: The fifth generation of mobile phones

The fifth generation of mobile phones, also known as 5G, is based on next-generation cellular networks that use new radio access technologies and network architectures to transmit voice and data signals over radio waves. The 5G network also introduces the concept of intelligent, which leverages artificial intelligence and machine learning to optimize the network performance and user experience. The first 5G service was launched by Verizon in the United States and SK Telecom in South Korea in 2019, using the New Radio (NR) standard. The NR standard is part of the IMT family of standards, which also includes NR-Advanced and NR-Advanced Pro. Other 5G standards include 5G NR-U and 5G NR-Light, which are used in some regions.

The first 5G phone was the Samsung Galaxy S10 5G, which weighed about 0.2 kg and cost about $1,300. The phone had a battery life of 450 minutes and a memory capacity of 256 GB. The phone also had a high-resolution display, a quad-core processor, and a quad-camera. The 5G network reached a peak of 1 billion subscribers worldwide by the early 2020s.

The **main advantages of 5G** are the extremely high data rates and quality of data services. 5G also enables new features and services, such as:

I. Extremely high data rates, ranging from 1 Gbps to 10 Gbps, which enable the delivery of ultra-high-definition content such as 4K, 8K, and 360-degree video.

II. Wider coverage and seamless connectivity, due to the use of heterogeneous networks and technologies such as Wi-Fi, Bluetooth, and NFC, as well as new frequency bands such as millimeter wave and sub-6 GHz.

III. Global roaming and interoperability, due to the convergence of 5G standards and the adoption of the IMT system and the IMS framework.

IV. Enhanced security and privacy, due to the use of encryption, authentication, and digital signatures, as well as new techniques such as quantum cryptography and blockchain.

V. Low latency and high reliability, due to the use of edge computing and network slicing, which enable the support of real-time and mission-critical applications such as autonomous driving, remote surgery, and industrial automation.

VI. Massive connectivity and scalability, due to the use of massive MIMO and beamforming, which enable the support of massive numbers of devices and users such as Internet of Things (IoT), smart cities, and smart homes.

5G technology promises to revolutionize our lives, but it also brings some potential risks. Some of the challenges and limitations of 5G include the following:

Network security: 5G networks are more vulnerable to cyberattacks due to the decentralized nature of data processing and the large number of connected devices. Telecom operators and device manufacturers will need to invest significantly in robust security measures to protect against these threats.[18]

Cost of infrastructure development: 5G requires a complete overhaul of existing infrastructure, such as the deployment of new antennas and base stations, and the installation of high-speed fiber connections. The cost of this infrastructure development is substantial and could be a significant barrier to 5G rollout, particularly in rural and remote areas where the return on investment may be lower.[19]

Ecosystem availability: 5G can only reach its full potential when a complete ecosystem of 5G-enabled devices and applications is available. This includes not only smartphones but also IoT devices, industrial equipment, autonomous vehicles, and more. The development of this ecosystem is still in its early stages, and it will take time for a wide range of 5G-compatible devices and applications to become available.[19]

Potential health effects: 5G uses higher frequencies and shorter wavelengths than previous generations of wireless technology, which may pose health risks to humans and animals. Some studies have suggested that exposure to 5G radiation could cause DNA damage, cancer, and neurological disorders, but more research is needed to confirm these findings and establish safe exposure limits.[20]

6G: The sixth generation of mobile phones

Mobile phones have become an indispensable part of our lives, enabling us to communicate, access information, and enjoy various services anytime and anywhere. However, the demand for mobile data is growing exponentially, and the current 5G networks may not be able to meet the future needs of users and society [7]. Therefore, researchers and industry are already working on the next generation of mobile networks, known as 6G, which is expected to be available in the early 2030s.[8]

6G is the name for the sixth generation of cellular network standards, which will deliver truly omnipresent wireless intelligence. 6G will build on the achievements of 5G, such as high data rates, low latency, and massive connectivity, but will also introduce new features and capabilities, such as:

I. Extremely high data rates, ranging from 1 Gbps to 10 Gbps, which will enable the delivery of ultra-high-definition content such as 4K, 8K, and 360-degree video.

II. Wider coverage and seamless connectivity, due to the use of heterogeneous networks and technologies such as Wi-Fi, Bluetooth, and NFC, as well as new frequency bands such as millimeter wave and sub-6 GHz.

III. Global roaming and interoperability, due to the convergence of 6G standards and the adoption of the International Mobile Telecommunications (IMT) system and the IP Multimedia Subsystem (IMS) framework.

IV. Enhanced security and privacy, due to the use of encryption, authentication, and digital signatures, as well as new techniques such as quantum cryptography and blockchain.

V. Low latency and high reliability, due to the use of edge computing and network slicing, which will enable the support of real-time and mission-critical applications such as autonomous driving, remote surgery, and industrial automation.

VI. Massive connectivity and scalability, due to the use of massive MIMO and beamforming, which will enable the support of massive numbers of devices and users such as Internet of Things (IoT), smart cities, and smart homes.

VII. Artificial intelligence and machine learning, which will optimize the network performance and user experience, as well as enable new applications such as holographic communication, brain-computer interface, and digital twins.

6G will not only provide faster and better wireless connectivity, but will also create new opportunities and challenges for society and humanity. 6G will enable new forms of digital and physical experiences, such as immersive virtual reality, augmented reality, and mixed reality, which will transform the way we interact with each other and the world. 6G will also enable new forms of social and economic activities, such as e-commerce, e-health, e-education, and e-governance, which will improve the quality of life and well-being of people. However, 6G will also pose new risks and ethical issues, such as data privacy, cyber security, digital divide, and human dignity, which will require careful consideration and regulation.[9,10]

6G is the future of mobile communication, and it will shape our future in the coming years. 6G is still in the early stages of research and development, and many challenges and uncertainties remain. However, 6G is also a promising and exciting vision, and it will open new horizons and possibilities for us. 6G is not just a technology, but a revolutionn.[11]

Conclusion

Mobile phones have evolved from simple devices that enabled voice communication to sophisticated devices that enable various types of communication, information, and entertainment. Mobile phones and their network technologies have also gone through several generations, each of which introduced new features, improved performance, and expanded coverage. In this paper, we reviewed the history of mobile phones and their network generations, from the first experiments with radio communication to the current deployment of 5G and beyond. We also discussed the social and economic impacts of mobile phones on society, as well as the challenges and opportunities that lie ahead. Mobile phones have become an integral part of our lives, and they will continue to shape our future in the coming years.

We also briefly introduced the next generation of mobile networks, known as 6G, which is expected to be available in the early 2030s. 6G will deliver truly omnipresent wireless intelligence, and will enable new forms of digital and physical experiences, such as holographic communication, brain-computer interface, and digital twins. 6G will also create new opportunities and challenges for society and humanity, such as data privacy, cyber security, digital divide, and human dignity.

Mobile phones are not just a technology, but a revolution. They have changed the way we communicate, access information, and enjoy various services. They have also transformed many aspects of our lives, such as education, health, entertainment, commerce, and social interaction. Mobile phones have also created new forms of social and economic activities, such as e-commerce, e-health, e-education, and e-governance. Mobile phones have also posed new risks and ethical issues, such as data privacy, cyber security, digital divide, and human dignity.

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Mobile phones are the future of mobile communication, and they will shape our future in the coming years. Mobile phones are still in the process of research and development, and many challenges and uncertainties remain. However, mobile phones are also a promising and exciting vision, and they will open new horizons and possibilities for us. Mobile phones are not just a device, but a companion.

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