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Innovation and utilization of 5G mobile service

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HIGHLIGHTS

- Learn and introduce the content of 5G mobile services
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ABSTRACT

In the 21st century, with the development of the Internet and mobile devices, a variety of mobile services can meet the real life needs of users. These requirements often involve some offline physical resources, such as parking spaces, document printing and binding, and book lending. The use of these physical resources often includes online information exchange and offline physical activities. At this stage, with the rapid development of social economy and the advancement of science and technology, 5G has become the focus of research in the field of communication to a certain extent, and its standards have also detonated the global battles of the group, about 5G spectrum. The allocation of the United States has been the first to complete. In order to win the first-generation mobile communication technology, 5G communication technology is waiting for it, and in a certain sense, it has greatly promoted the sustainable development of the Internet of things.

1. Introduction

Mobile communication has experienced four generations of development. The fifth generation mobile communication system (5G) will fully support the Internet of Things business while greatly improving the experience of the mobile Internet service, realizing the relationship between people and things, between people and things. Massive intelligent interconnection. Compared with 4G, 5G has 1 to 2 orders of magnitude improvement in user experience rate, connection density, mobility, traffic density, end-to-end delay, spectrum efficiency, energy efficiency, cost, etc. The mobile communication network architecture is implemented. Future mobile communications with higher bandwidth, smaller cells, denser and more flexible seamless coverage requirements will rely more on optical communication networks that provide stable high-capacity channels and flexible resource allocation capabilities. The optical network in the 5G era will face greater opportunities and challenges than ever before, and optical networks and wireless networks will eventually move toward convergence and unification.

From 1G to 4G, the core of mobile communication is human-to-human communication, and personal communication is the core business of mobile communication. But 5G communication is not just human communication, but Internet of Things, industrial automation, and driverlessness are introduced. Communication starts from the communication between people and then to the communication between people and things, until the communication between machines and machines.

The fifth generation of mobile communication technology (5G) is the highest peak of the development of mobile communication technology at present, and it is also the important force that human beings hope not only to change their lives but also to change society.

5G is based on 4G, and it puts forward higher requirements for mobile communication. It not only has a new upgrade in speed but also in power consumption and delay. As a result, the business will also be greatly improved, and the development of the Internet will also enter the era of intelligent Internet from the mobile Internet.

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2.1 High speed

Compared to 4G, the first problem that 5G has to solve is high speed. As the network speed increases, the user experience and experience will be greatly improved. The network can be faced with unlimited VR/Ultra HD services, and services with high network speed requirements can be widely promoted and used. Therefore, the first feature of 5G defines the speed increase.

In fact, like every generation of communication technology, it is very difficult to say exactly what the speed of 5G is. On the one hand, the peak speed is different from the actual experience speed of the user, and the speed of different technologies will be different. The peak requirement for 5G base station is not less than 20Gb/s. Of course, this speed is the peak speed, not every user experience. With the use of new technologies, there is room for improvement at this speed.

This speed means that users can download a high-definition movie every second, or they can support VR video. Such high speeds provide opportunities and possibilities for future businesses that require high speed.

2.2 Ubiquitous network

With the development of the business, the network business needs to be all-encompassing and widely existed. Only in this way can we support a richer business and use it in complex scenarios. The ubiquitous network has two levels of meaning. One is extensive coverage and the other is deep coverage.

Broadly refers to the various places in our social life, which need to be widely covered. In the past, the mountain valleys did not necessarily need network coverage, because there are few people living, but if you can cover 5G, you can deploy sensors in large quantities to change the environment, air quality and even landforms. This is very valuable for monitoring earthquakes. 5G can provide a network for more such applications.

Depth refers to the depth of coverage in our lives, although there are already network deployments. We have a 4G network in our home today, but the quality of the bathroom in the home may not be very good. The underground parking garage has basically no signal, and it is now acceptable. With the advent of 5G, the bathrooms and underground parking garages with poor network quality can be widely covered with a good 5G network.

To a certain extent, the ubiquitous network is more important than the high speed. It is only to build a network with a small coverage and high speed. It can not guarantee the service and experience of 5G, and the ubiquitous network is a fundamental guarantee for the 5G experience. There are no ubiquitous networks in the three major scenarios of 3GPP, but the ubiquitous requirements are implicit in all scenarios.

2.3 Low power consumption

To support large-scale IoT applications, 5G must have power requirements. In the past few years, wearable products have developed, but many bottlenecks have been encountered. The biggest bottleneck is the poor experience. Take a smart watch as an example. Recharge every day, even less than one day. All IoT products require communication and energy. Although communication can be achieved by various means today, the supply of energy depends on batteries. If the communication process consumes a lot of energy, it is difficult to make the Internet of Things products widely accepted by users.

If you can reduce the power consumption, and let most IoT products charge once a week, or even once a month, you can greatly improve the user experience and promote the rapid spread of IoT products. The eMTC evolved based on the LTE protocol, and the LTE protocol was tailored and optimized for better communication between objects and for lower cost. The eMTC is deployed on a cellular network, and its user equipment can directly access the existing LTE network by supporting 1.4MHz RF and baseband bandwidth. The eMTC supports a peak rate of up to 1 Mbps for both uplink and downlink. NB-IoT is built on a cellular network and consumes only about 180 kHz of bandwidth. It can be deployed directly on GSM networks, UMTS networks or LTE networks to reduce deployment costs and achieve smooth upgrades.

NB-IoT can be deployed based on GSM network and UMTS network. It does not need to rebuild the network like 5G core technology, but although it is deployed on GSM and UMTS networks, it is still a rebuilt network. Its ability to greatly reduce power consumption is also to meet the needs of 5G for low-power IoT applications. Like eMTC, it is an integral part of the 5G network system

2.4 Low latency

A new scene for 5G is a highly reliable connection for driverless, industrial automation. Information exchange between people, a delay of 140 milliseconds is acceptable, but if this delay is used for driverless, industrial automation is unacceptable. The minimum requirement for 5G for latency is 1 millisecond or even lower. This puts a harsh demand on the network. And 5G is an inevitable requirement for the application of these new fields.

Driverless cars need to be interconnected by the central control center and the car. The car and the car should also be interconnected. In high-speed operation, a brake needs to send information to the car in an instant to react, about 100 milliseconds. Time, the car will rush out a few tens of meters, which requires the information to be sent to the car in the shortest delay, braking and vehicle control reaction.

This is especially true for drones. If hundreds of unmanned formations fly, very small deviations can lead to collisions and accidents, which requires information to be transmitted to the flying drone in a very small time delay. In the process of industrial automation, the operation of a mechanical arm, if it is to be extremely refined, to ensure the high quality and precision of the work, it also requires minimal delay and the most timely response. These characteristics are not so high in traditional human-to-human communication, even when people communicate with machines, because people's reactions are slower and do not require the efficiency and refinement of machines. Whether it is a drone, a driverless car or industrial automation, it is operated at a high speed, and it also needs to ensure timely information transmission and timely response at high speed, which imposes extremely high requirements on time delay.

To meet the requirements of low latency, we need to find various ways to reduce the delay in the construction of 5G networks. Techniques such as edge computing will also be adopted in the 5G network architecture.

2.5 Internet of Everything

In traditional communication, the terminal is very limited. In the fixed telephone era, the telephone is defined by the crowd. In the era of mobile phones, the number of terminals has exploded, and mobile phones are defined by personal applications. In the 5G era, terminals are not defined by people, because each person may have several, and each family may have several terminals.

In 2018, China's mobile terminal users have reached 1.4 billion, of which mobile phones are the mainstay. The communication industry's vision for 5G is every square kilometer, which can support 1 million mobile terminals. In the future, access to the terminals in the network is not only our mobile phone today, but also more and more strange products. It can be said that every product in our life is likely to access the network through 5G. Our glasses, mobile phones, clothes, belts, and shoes all have access to the Internet and become smart products. Doors and windows, door locks, air purifiers, fresh air blowers, humidifiers, air conditioners, refrigerators, and washing machines in the home are all likely to enter the era of intelligence. Through 5G access to the network, our family has become a smart home.

In the social life, a large number of devices that were previously impossible to connect to the Internet will be networked and smarter. Public facilities such as cars, manhole covers, utility poles, and trash cans have been difficult to manage in the past, and it is difficult to be intelligent. And 5G can make these devices become smart devices.

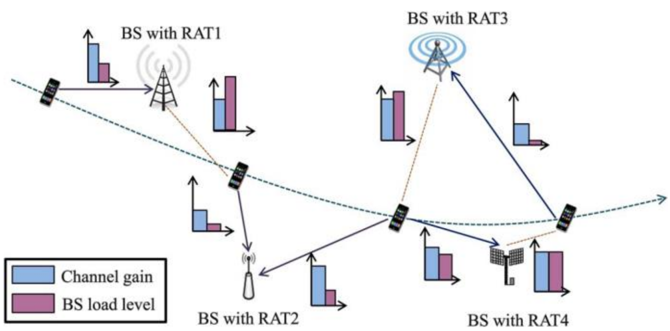

Fig. 1. User association in a multi-RAT network over many frequency bands is complex. In this simplified scenario, a mobile user in turn associates with different BSs based on a tradeoff between the gain to that BS and the traffic load (congestion) that it is experiencing.

2.6 Refactoring security

Security issues don't seem to be a fundamental issue discussed by 3GPP, but it should also be a fundamental feature of 5G.

The traditional Internet has to solve the problem of information speed and unimpeded transmission. Freedom, openness and sharing are the basic spirit of the Internet. However, based on 5G, the intelligent Internet is established. The intelligent Internet is not only to achieve information transmission, but also to establish a new mechanism and system for society and life. The basic spirit of intelligent Internet is security, management, efficiency and convenience. Security is the first requirement of the intelligent Internet after 5G. Assuming that 5G is built but it is impossible to rebuild the security system, it will cause tremendous destructive power.

If our driverless system is easy to break, it will be like the movie shows that the car on the road is controlled by hackers, the intelligent health system is broken, the health information of a large number of users is leaked, the smart family is broken, and there is no security at home. Guarantee. This situation should not occur, and the problem is not solved by tinkering.

In the 5G network construction, the security problem should be solved at the bottom. From the beginning of network construction, security mechanisms should be added, information should be encrypted, the network should not be open, and special security mechanisms need to be established for special services. . The network is not completely neutral and fair. To give a simple example: on the network guarantee, ordinary users access the Internet, and there may be only one system to ensure that their network is unblocked, and users may face congestion. However, the intelligent transportation system requires multiple systems to ensure its safe operation and ensure its network quality. When the network is congested, the network of the intelligent transportation system must be ensured. And this system is not the general terminal can access management and control.

2. The application of 5G technology

Ultra-high speed network data transmission and storage. The development of 4G technology provides powerful technical support for high-definition video and large-capacity data. In the future, the 5G technology data download speed will be up to 3.6G/s, which will not only further increase data transmission based on 4G technology. Speed, but also greatly exceeds the speed of existing disk reading and writing, can effectively save data storage space, optimize network security services, 5G technology ultra-high-speed data transmission and storage features can be more convenient for remote video calls, realistic virtual game smart applications The use of the effect, and the use of ultra-high-speed operation features of 5G technology can increase the application control accuracy of remote control applications.

Enhance the business needs of users. The development of 5G technology will provide reliable technical support for users' needs. No matter where the user is in the world, whether in a busy and crowded city or in a remote and remote corner, 5G technology can guarantee people's time. Communication, in other words, the application of 5G technology does not accept traffic changes, location changes and time constraints, and can provide users with high-quality communication services anytime, anywhere.

A highly compatible converged network. In the future, with the continuous development of 5G technology, on the basis of 4G technology, various forms of networks such as TV network, broadcast network, Internet, and telecommunication network will be merged together with high compatibility. Achieve low cost, low cost, that is, to achieve maximum network service benefits through the high compatibility of 5G technology.

High-density heterogeneous networks. As the number of users of mobile communication service networks continues to increase, the system capacity needs to be further increased. In this case, high-density heterogeneous networks based on 5G technology can use high-frequency multiplexing to increase system capacity while reducing cell size. Improve the capacity of mobile communication networks to provide users with more reliable and convenient communication services.

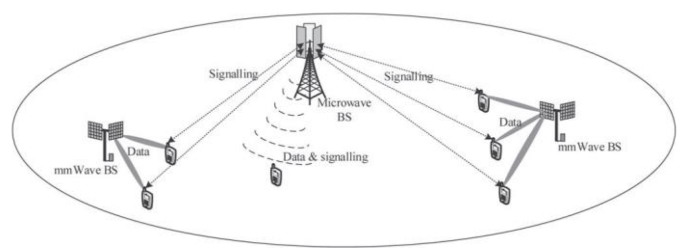

Fig. 2. MmWave-enabled network with phantom cells.

3. The challenges of 5G

As the optical transport network of the main bearer network, facing the bearer demand of 5G network with large bandwidth and high capacity, low delay, high reliability, flexibility and intelligence, combined with the current status and development trend of optical transport network technology, its future development will Faced with the following challenges:

First, the choice of low latency and flexible high performance solutions and the implementation of ultra-low latency of end-to-end ms is a typical performance requirement for 5G networks, and flexibility will be the basic attribute of 5G networks for users. In order to adapt to the flexibility of 5G network service applications, the optical transport network needs to provide flexible bearer bandwidth, such as bandwidth adjustment based on the electrical layer (G.HAO, FlexO/E, etc.), and optical layer-based bandwidth adjustment (flexible gate Grid, adjustable transceiver, etc.), but how flexible adjustment of these bandwidths works seamlessly with the actual application of 5G services (including the transmission network between the preamble network, the backhaul network and the core network transmission network). Flexible coordination, etc.) still faces many problems that require further study. When the optical transport network is long-distance networking, the main delay is brought by the physical fiber link, and the extension of the fiber link generally has no other technical solutions except for selecting a better physical link route. Therefore, the optical transport network reduces the delay. The technology will focus on node processing, the most important of which is electrical layer signal processing, such as FEC and DSP processing technology. Because the processing delay of these technologies is inversely related to the transmission performance, how to further reduce the transmission performance while ensuring the transmission performance. Processing delays will face technical challenges.

Second, the optical transmission technology scheme is selected and implemented according to the typical bearer requirements of the mobile network, and the transmission network is mainly composed of a preamble network, a backhaul network, and a core network transmission network. According to the development goal of the current 5G vision, whether it is pre-transmission, backhaul and core network transmission, the optical transmission network is faced with diversified challenges in the selection and implementation of technical solutions, especially the 5G network currently has no end-to-end performance indicators as a whole. The division and the division of the wireless network element pre-transmission function are further clarified. The choice and implementation of 5G optical transmission solutions still faces enormous challenges and uncertainties. Especially the pre-transmission network is more obvious. Typical ultra-large capacity and high-density wireless access have made the fiber-optic direct drive mode of the pre-transmission network not widely applicable in 5G networks. Further research is needed to select which transmission technology that satisfies the pre-transmission performance and functional requirements, and the wired interface system between the wireless pre-transmission network elements.

4. The outlook of 5G

3G and 4G connect people, while 5G connects everything. According to relevant company data, the number of connected terminals will reach 25 billion to 50 billion by 2020. From my personal point of view, I think it may be out of place to predict the future development of 5G with a single level of "user number" in the narrow sense. In the future, 5G “users” will be more extensive and exponentially growing—home, cars, production lines, robots, drones, agricultural bases, high-speed railways, cities, and so on, almost everything will be connected. In the 5G era, our lives will become more different, 5G will support the scene: communication between vehicles and other terminals; smart city; remote monitoring, medical and robotics; augmented reality (AR) and virtual reality (VR); new Morphologically safe over-the-horizon drone control.

In essence, the purpose of building a 4G network is to closely communicate with each group, thus reflecting the interconnection between people. In comparison, 5G network can connect all things and reflect higher interconnection value. As of 2020, there will be around 25 billion connected terminals worldwide. Therefore, it can be seen that if the 5G network is simply limited to the level of users, it is difficult to meet the network situation in the new era, which needs to be comprehensively improved. After entering the 5G era, the network will cover daily life, specifically related to urban construction, high-speed rail construction, construction of agricultural bases, drones, production lines and homes.

After entering the new era of 5G, the daily life of the people will be reflected in all-round improvement. This is because 5G can be used to support different types of terminal communication. Under this premise, remote monitoring and smart city are built, and virtual reality and augmented reality are also connected. By using the new over-the-horizon approach, real-time control can be achieved for drones.

However, it should not be overlooked that compared to other types of connection technologies, network connections based on 5G have a higher level of complexity. This is because 5G objectively highlights greater adaptability and flexibility, and it also shows strong differences for various types of terminals. In the current state, micro sensors, mobile hotspots, and smartphones can all be connected to the network. In addition, 5G can also be used to support smaller base stations, enabling a variety of scenarios to be deployed according to local conditions.

The industry's general forecast is that 5G will be deployed as early as 2019, which will bring ultra-low latency, multi-gigabit download and upload rates, more efficient machine communication with more than 10 years of battery life, and support for multiple frequency bands. Shared spectrum, a more reliable and secure network capable of supporting mission-critical services (zero tolerance), and greater coverage and efficiency in response to the proliferation of data and networking terminals.

5. Engineering Requirements for 5G

In order to more concretely understand the engineering challenges facing 5G, and to plan to meet them, it is necessary to first identify the requirements for a 5G system. The following items are requirements in each key dimension, but it should be stressed that not all of these need to be satisfied simultaneously.

Different applications will place different requirements on the performance, and peak requirements that will need to be satisfied in certain configurations are mentioned below.

For example, very-high-rate applications such as streaming high-definition video may have relaxed latency and reliability requirements compared to driverless cars or public safety applications, where latency and reliability are paramount but lower data rates can be tolerated.

1) Data Rate: The need to support the mobile data traffic explosion is unquestionably the main driver behind 5G. Data rate can be measured in several different ways, and there will be a 5G goal target for each such metric:

a) Aggregate data rate or area capacity refers to the total amount of data the network can serve, characterized in bits/s per unit area. The general consensus is that this quantity will need to increase by roughly 1000× from 4G to 5G.

b) Edge rate or 5% rate is the worst data rate that a user can reasonably expect to receive when in range of the network, and so is an important metric and has a concrete engineering meaning. Goals for the 5G edge rate range from 100 Mbps (easily enough to support high-definition streaming) to as much as 1 Gbps. Meeting 100 Mbps for 95% of users will be extraordinarily challenging, even with major technological advances. This requires about a 100× advance since current 4G systems have a typical 5% rate of about 1 Mbps, although the precise number varies quite widely depending on the load, the cell size, and other factors.

c) Peak rate is the best-case data rate that a user can hope to achieve under any conceivable network configuration. The peak rate is a marketing number, devoid of much meaning to engineers and likely to be in the range of tens of Gbps. Meeting the requirements in (a)-(b), which are about 1000× and 100× current 4G technology, respectively, are the main focus of this paper.

2) Latency: Current 4G roundtrip latencies are on the order of about

15 ms, and are based on the 1 ms subframe time with necessary overheads for resource allocation and access. Although this latency is sufficient for most current services, anticipated 5G applications include two-way gaming, novel cloud-based technologies such as those that may be touchscreen activated (the "tactile Internet" [9]), and virtual and enhanced reality (e.g., Google glass or other wearable computing devices). As a result, 5G will need to be able to support a roundtrip latency of about 1 ms, an order of magnitude faster than 4G. In addition to shrinking down the subframe structure, such severe latency constraints may have important implications on design choices at several layers of the protocol stack and the core network (cf. Section III).

3) Energy and Cost: As we move to 5G, costs and energy consumption will, ideally, decrease, but at least they should not increase on a per-link basis. Since the per-link data rates being offered will be increasing by about 100×, this means that the Joules per bit and cost per bit will need to fall by at least 100×. In this article, we do not address energy and cost in a quantitative fashion, but we are intentionally advocating technological solutions that promise reasonable cost and power scaling. For example, mmWave spectrum should be 10–100× cheaper per Hz than the 3G and 4G spectrum below 3 GHz. Similarly, small cells should be 10–100× cheaper and more power efficient than macrocells. A major cost consideration for 5G, even more so than in 4G due to the new BS densities and increased bandwidth, is the backhaul from the network edges into the core. We address backhaul and other economic considerations in Section IV-C. As for energy efficiency, we address this more substantially in Section III-C.

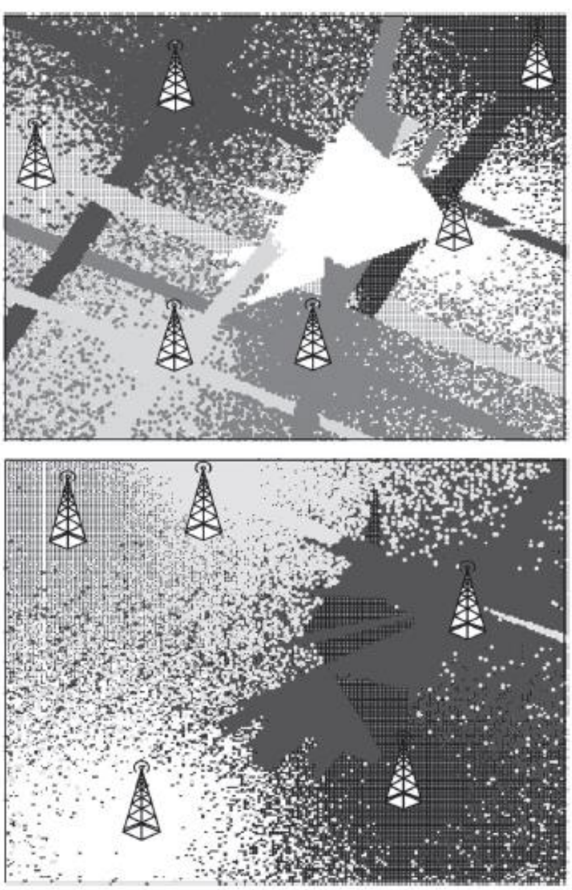

Fig. 3. Calculated mmWave BS associations with real building locations. The shaded regions correspond to association with the BS centered at that shade. Blocking, LOS vs. non-LOS propagation, and beam directionality render our usual notion of cell boundaries obsolete.

6. DESIGN ISSUES FOR 5G

In addition to supporting 1000× higher data rates, 5G networks must decrease latencies, lower energy consumption, lower costs, and support many low-rate connections. In this section, we discuss important ongoing research areas that support these requirements. We begin with the most fundamental aspect of the physical layer—the waveform—and then consider the evolution of cloud-based and virtualized network architectures, latency and control signaling, and energy efficiency.

The Waveform: Signaling and Multiple Access

The signaling and multiple access formats, i.e., the waveform design, have changed significantly at each cellular generation and to a large extent they have been each generation's defining technical feature. They have also often been the subject of fierce intellectual and industrial disputes, which have played out in the wider media. The 1G approach, based on analog frequency modulation with FDMA, transformed into a digital format for 2G and, although it employed both FDMA and TDMA for multiple access, was generally known as "TDMA" due to the novelty of time multiplexing. Meanwhile, a niche spread spectrum/CDMA standard that was developed by Qualcomm to compete for 2G became the dominant approach to all global 3G standards. Once the limitations of CDMA for high-speed data became inescapable, there was a discreet but unmistakable retreat back toward TDMA, with minimal spectrum spreading retained and with the important addition of channel-aware scheduling. Due to the increasing signal bandwidths needed to support data applications, orthogonal frequency-division multiplexing (OFDM) was unanimously adopted for 4G in conjunction with scheduled FDMA/TDMA as the virtues of orthogonality were viewed with renewed appreciation.

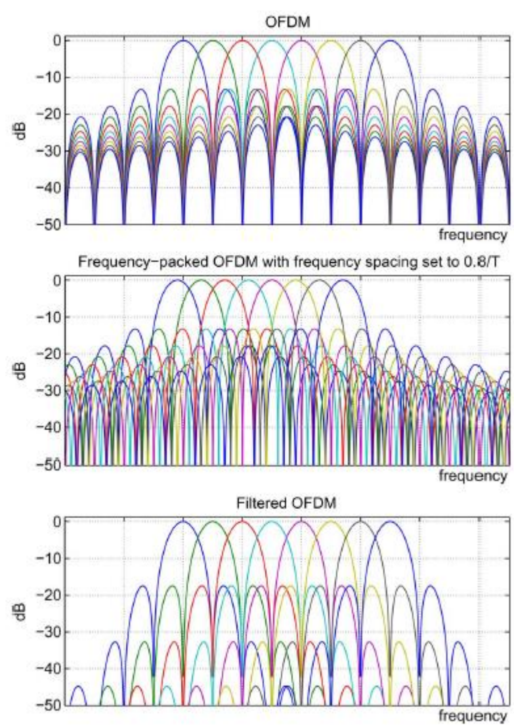

Fig. 4. Frequency-domain magnitude responses of some adjacent waveforms for OFDM, frequency-packed OFDM, and filtered OFDM. The two signaling formats alternative to OFDM trade subcarrier orthogonality for either better spectral efficiency (frequency-packed OFDM) or lower out-of-band emissions (filtered OFDM).

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