International Journal of Engineering in Computer Science 2024; 6(1): 30-39

International Journal of Engineering in Computer Science

E-ISSN: 2663-3590
P-ISSN: 2663-3582
www.computersciencejournals.com/ijecs
IJECS 2024; 6(1): 30-39
Received: 11-11-2023
Accepted: 19-12-2023

Dr. M Jaithoon Bibi
Assistant Professor, Department of Computer Science with Cognitive Systems, Sri Ramakrishna College of Arts and Science, Coimbatore, Tamil Nadu, India

N Chandra Kumar
B.Sc., CSCS, Department of Computer Science with Cognitive Systems, Sri Ramakrishna College of Arts and Science, Coimbatore, Tamil Nadu, India

Corresponding Author:
Dr. M Jaithoon Bibi
Assistant Professor, Department of Computer Science with Cognitive Systems, Sri Ramakrishna College of Arts and Science, Coimbatore, Tamil Nadu, India

Critical review of network architecture, mobile network evolution, standardization, LTE evolution and future evolution of 5G

Dr. M Jaithoon Bibi and N Chandra Kumar

DOI: https://doi.org/10.33545/26633582.2024.v6.i1a.107

Abstract
In this study, we propose a revolutionary network architectural design approach for future 5G mobile networks, which we believe would be favorable. The suggested design is based on a mobile setting that is centered on the user and integrates a range of wireless and mobile technologies to attain this. Because it is incredible to make changes to any wireless technology, modern or ancient, in a heterogeneous wireless environment, every solution for next-generation mobile and wireless networks should be applied in the service layer, whereas radio access technologies should be applied in the transport layer in the Next-Generation Networks method. Over the last few years, mobile wireless technologies have practice 4 or 5 generations of technology revolution and evolution, namely from 1G to 4G. Current research in mobile wireless technology focuses on advanced implementation of 4G technology and 5G technology.

Keywords: LTE evolution, future evolution of 5G, network architecture

Introduction

When technology can connect not only people but also equipment and sensors, it is at its best. One of the most cutting-edge technologies, 5G would change how people, machines, and sensors communicate in order to create a connected, smarter, and safer society. The quick development of technology has enhanced our quality of life, allowed for fast connection and involvement, and made knowledge readily available. The transition to 5G redefines services by applying S-B-A (Services-based-architecture), AI/ML, and software-defined networks, which would enable economic growth through use cases like “Virtual/Augmented-Reality”, “Machine-Communications”, “Telemedicine, Smart Manufacturing, Smart Utilities, and Smart Cities”. The fifth-generation (5G) mobility networking architecture, or 5G, has the power to completely change how we live, work, communicate, and how society and business work together. In 5G, an environment is being built that will connect virtually each one and the whole thing, including machines, objects, and devices.5G connections the digital barrier by providing not only high-speed connectivity but also higher reliability, higher network capacity, and low latency.

“Speed, capacity, latency, coverage, and reliability” are the most important proponents of a digital network. The “3GPP standards” following 5G network architecture were introduced by the “3rd Generation Partnership Project (3GPP)”, the organization that develop international standards for all mobile communications. The “International Telecommunications Union-(ITU)” and its associates define the necessities and timeline for mobile communication systems, defining a new generation around every decade. The 3GPP develops specifications for those requirements in a series of releases. The “G” in 5G stands for “Generation”. 5G technology planning presents significant advances away from 4G LTE (Long-Term-Evolution) technology, which comes on the lists of 3G and 2G. As explain in related source, there is always a time in The Journey to 5G when several different network generations coexist. For two crucial reasons, 5G must coexist alongside previous networks like it’s pursue in the future:

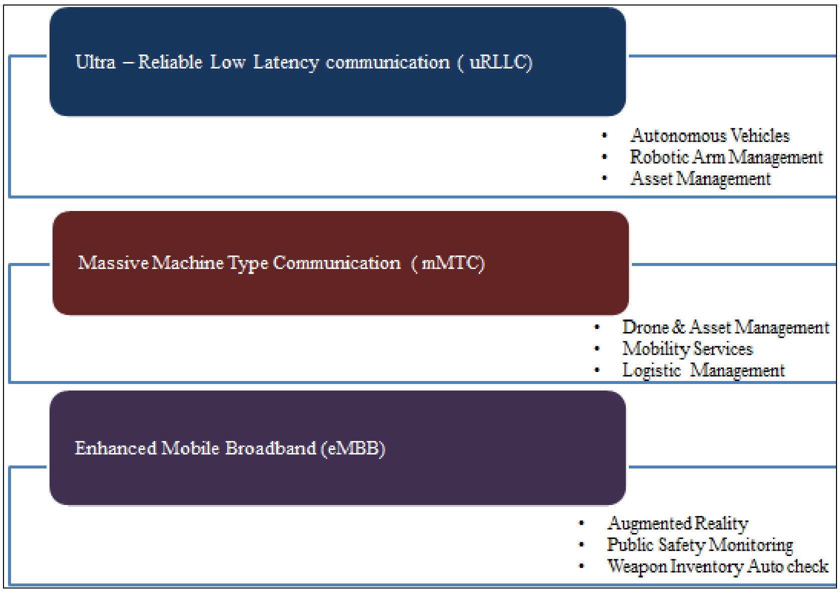

Fig 1: Three different Broadband

1. New network technology development and implementation require a significant amount of time, investment, and cooperation from big organization's and carriers.
2. An adopters will always want to get their hands on new technologies as soon as they are available, while those who have made significant investments in large deployments with presented network technologies, such as 2G, 3G, and 4G LTE, want to use those investments as long as possible, and most likely until the new network is fully viable.

The network-architecture of 5G mobile-technology improves immensely upon earlier period architectures. Large-cell-dense networks enable massive leap in routine. And in addition, the architecture of 5G networks offers improved security compare to 4G LTE networks.

In outline, 5G technologies offer three principle advantages:

- Quicker data transmission speed, upto multi-Gigabit/s speeds.
- Greater-capacity, fueling a massive amount of IoT devices per square kilometer.
- Lower-Latency, down to single-digit milliseconds, which is significantly important in applications such as connected vehicles in ITS applications and autonomous vehicles.

5G Design and Planning Considerations

Complex design factors must be taken into account while developing a 5G network architecture that can serve demanding applications. There isn't a one-size-fits-all solution, for instance, because different applications need data to travel long distances or in big volumes, or a combination of both. To achieve the complete 5G goal, 5G-architecture must handle low, mid, and high-band spectrum from licensed, shared, and private sources.

For this reason, 5G is architected to run on "radio-frequencies" ranging from sub 1 GHz to enormously high frequencies, called "Millimeter-Wave" (or mmWave). The lower the frequency, the out of the signal can travel. The higher the frequency, the added data it can carry.

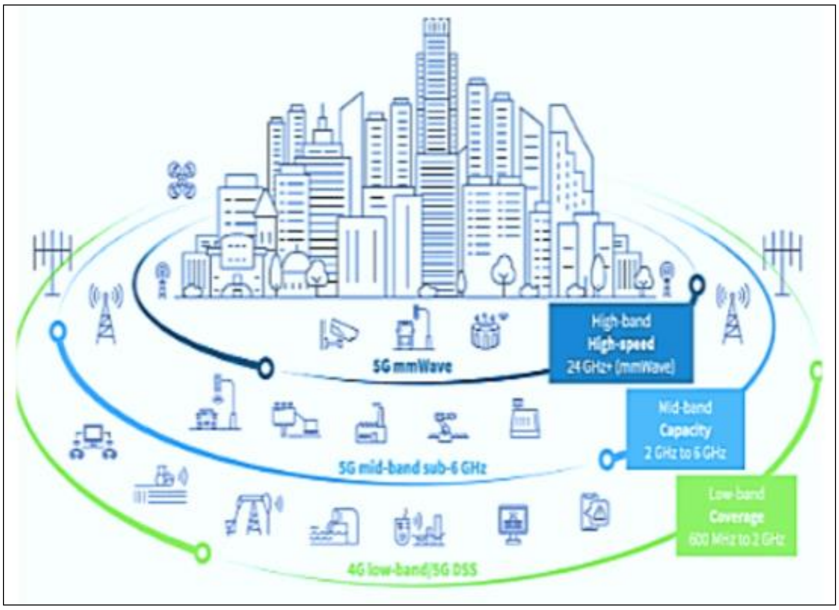

Fig 2: Three Frequency bands

There are 3 frequency bands at the core of 5G networks: 5G high-band (mm-Wave) delivers the maximum frequencies of 5G. These range from 24 GHz to approximately 100 GHz. Because high-frequencies cannot simply move through obstacle, high-band 5G is short range by nature. Moreover, mmWave coverage is limited and requires more cellular communications.

- "5G mid-band" operates in the 2-6 GHz range and provides a capability layer for urban and suburban areas". This frequency band has hit the highest point rates in the hundreds of Mbps.
- "5G low-band" operates below 2 GHz and provides a broad reporting. This band uses spectrum that is accessible and in use today for 4G-LTE, basically providing an LTE 5G architecture for 5G devices that are ready now. Performance of low-band 5G is therefore similar to "4G-LTE", and supports use for 5G devices on the promote nowadays.

Operators must take into account the power requirements of 5G because the average 5G base station design requires more than twice as much power as a 4G base station, in addition to the spectrum availability and application requirements for distance vs. bandwidth considerations.

Considerations for Planning and Deploying 5G Applications: Systems integrators, and those emergent and deploy 5G applications for the verticals we've discussed, will find that it is important to consider trade-offs. For example, key considerations Applications that are optimized for "mm-Wave will" not operate as predictable within buildings and when complete range is required. Optimal-use cases include 5G cellular telecommunications in the 24- to 39-GHz bands, police radar in the Ka-band (33.4- to 36.0-GHz), scanners in "airport security", "short-range radar in military vehicles" and "automated-weapons" on naval ships to detect and take down artillery.

- Devices and conversation must be adjusted for speed in order to support applications for autonomous vehicles and intelligent transportation systems (ITS). For vehicles and gadgets to "make decisions" on turning, accelerating, and braking, near real-time communications, measured in millionths of a second, are essential, and the lowest latency is essential for these applications.
- In contrast, throughput needs to be optimized for video and VR applications. In the future, video applications like medical imaging will be able to fully utilize the enormous amounts of data that 5G networks can accommodate. For 5G to deliver its full vision, the network infrastructure needs to evolve as well. The following diagram illustrates the migration over time, as well as Digi's 5G product plans.

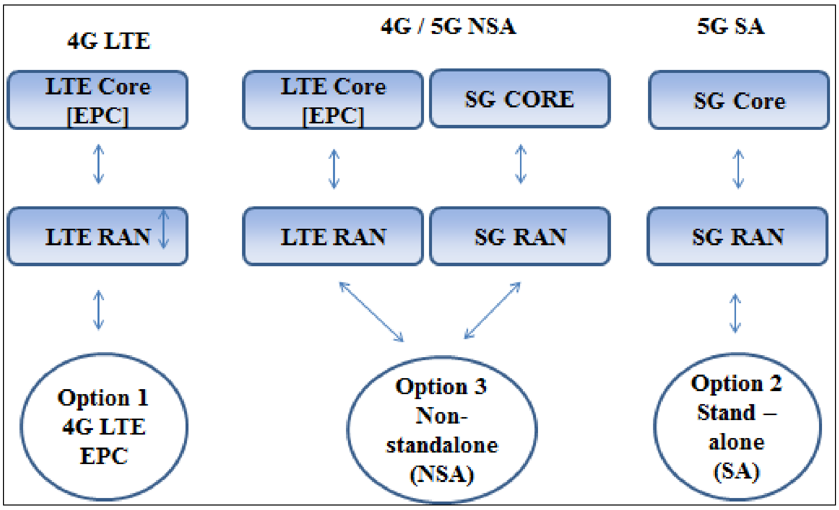

Fig 3: 4G/5G NSA

The initial uses of 5G technology will not be absolutely 5G but will appear in applications where connectivity is shared with existing 4G LTE in what is called "non-standalone-(NSA) mode". When operating in this mode, a device will first connect to the "4G-LTE" network, and if 5G is accessible, the device will be able to use it for further bandwidth.

Core Network

In this part will provide a "5G-core" architecture overview and explain the 5G core mechanism. We will also show how "5G-architecture" compares to the current 4G architecture.

The "5G-core" network, which enable the difficult functionality of 5G networks, is one of three principal components of the "5G-System", also known as "5GS" (source). The other two components are "5G-Access network (5G-AN)" and "User-Equipment - (UE)". The 5G core uses a cloud-aligned service-based architecture (SBA) to support confirmation, protection, session organization and aggregation of traffic from associated devices, all of which requires the compound interconnection of network functions, as shown in the 5G core diagram.

The components of the 5G core construction include:

- User plane Function (UPF)
- Data network (DN), e.g. operator services, Internet access or 3rd party services
- Core Access and Mobility Management Function (AMF)
- Authentication Server Function (AUSF)
- Session Management Function (SMF)
- Network Slice Selection Function (NSSF)
- Network Exposure Function (NEF)
- NF Repository Function (NRF)
- Policy Control function (PCF)
- Unified Data Management (UDM)
- Application Function (AF)

4G Architecture Diagram

When 4G evolved from its 3G ancestor, only minute incremental changes were made to the network-architecture. The following 4G network architecture illustration shows the key components of a 4G core network:

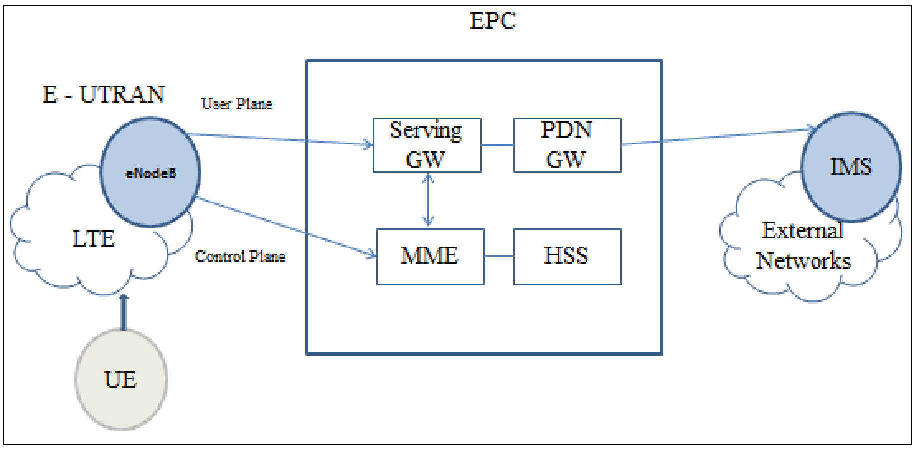

Fig 4: LTE-External Network

In the 4G network architecture, User Equipment (UE) like Smart-phones or cellular plans, connects over the "LTE-Radio Access Network (E-UTRAN)" to the "Evolved-Packet-Core (EPC)" and then further to External Networks, like the Internet. The "Evolved-NodeB (eNodeB)" separates the customer data traffic (user plane) from the network's organization data traffic (control plane) and feed both separately into the "EPC".

5G Architecture Diagram

5G was considered from the ground up, and network functions are opening up by service. That is why this architecture is also called 5G core "Service-Based Architecture"- "(SBA)". The follow 5G network topology figure shows the key mechanism of a 5G core network:

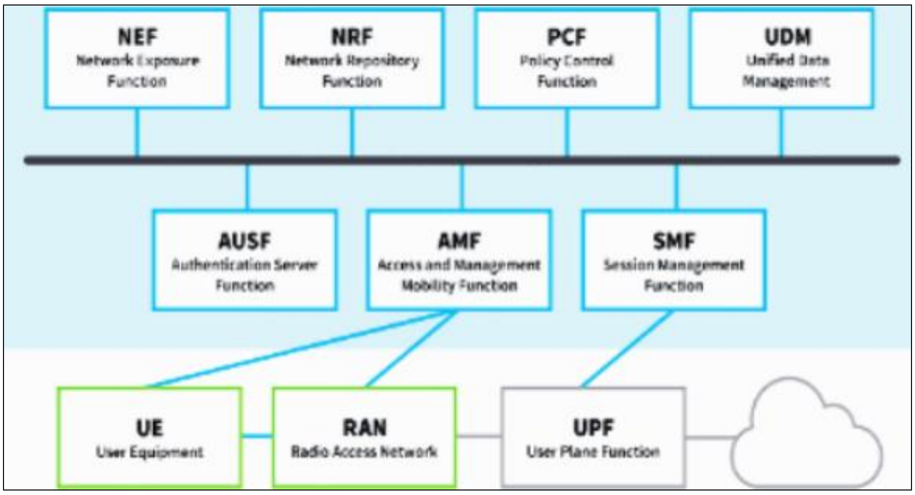

Fig 5: 5G Network Diagram

This is how it goes:

- "User-Equipment"- (UE) like 5G "Smart-phones" or 5G cellular devices connect over the 5G New Radio Access Network to the 5G core and further to "Data-Networks"- (DN), the Internet.
- The "Access and Mobility Management Function"- (AMF) acts as a single-entry point for the UE connection.
- Based on the service requested by the User-Equipment, the Access and Mobility Management Function selects the respective "Session Management Function"- (SMF) for managing the user session.
- The "User Plane Function"- (UPF) transports the IP data traffic (user plane) between the User Equipment (UE) and the external networks.
- The "Authentication Server Function"- (AUSF) allows the AMF to authenticate the UE and access services of the 5G core.
- Other functions like the "Session Management Function"- (SMF), the "Policy Control Function"- (PCF), the "Application Function"-(AF) and the "Unified Data Management"- (UDM) function provides the policy control construction, apply policy decision and accessing contribution information, to administer the network behavior.

As you can see, the architecture of the 5G network is more sophisticated than 4G, but this complexity is necessary to deliver superior service that can be customised to the wide range of 5G use cases.

Difference between 4G and 5G Network Architecture

We'll talk about the differences between 4G and 5G designs in this part. In a 4G LTE network architecture, the "LTE-RAN" and "eNodeB" are usually close together, often at the bottom or close to the cell tower running on particular hardware. The huge EPC on the other hand is often centralized and future away from the "eNodeB". This construction makes "high-speed, low-latency" end-to-end communication demanding to impossible. As principles like 3GPP and infrastructure vendors like Nokia and Ericsson architected the "5G New-Radio (5G-NR)" core, they broke apart the huge EPC and implemented each function so that it can run autonomously from each other on common, "off-the-shelf" server hardware. This allows the 5G core to become decentralized 5G nodes and very flexible. For example, 5G core functions can now be co-located with applications in an edge datacenter, making communication paths short and thus improving end-to-end speed and latency.

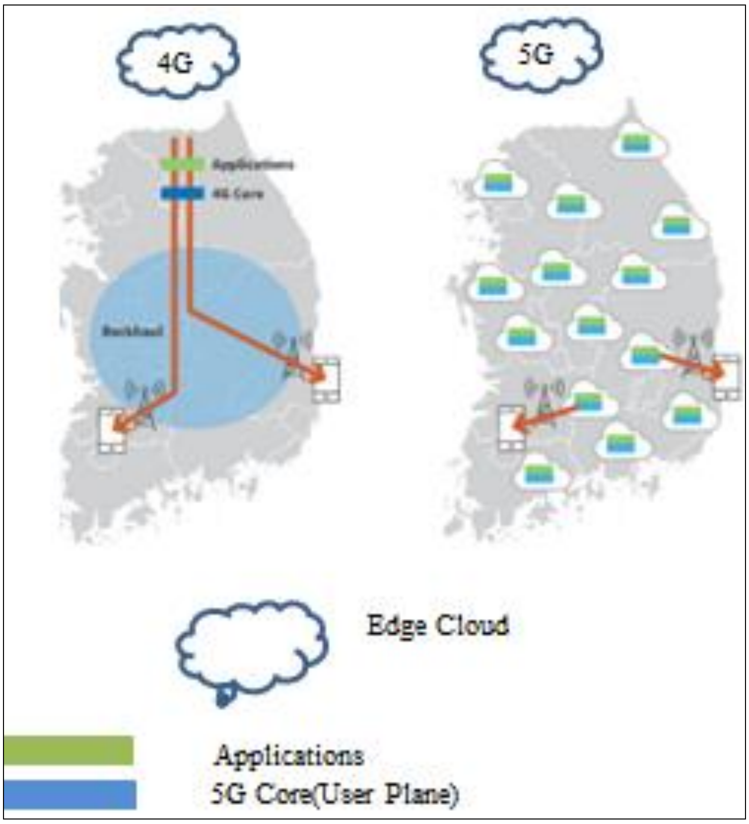

Fig 6: 5G Core Applications

Another benefit of these smaller, more specialized 5G core components running on common hardware is that networks now can be customized through network slicing. Network slicing allows you to have multiple logical "slices" of functionality optimized for specific use-cases, all operating on a single physical core within the 5G network infrastructure.

A 5G network operator may offer one slice that is optimized for high bandwidth applications, another slice that's more optimized for low latency, and a third that's optimized for a massive number of IoT devices. Depending on this optimization, some of the 5G core functions may not be available at all. For example, if you are only servicing IoT devices, you would not need the voice function that is necessary for mobile phones. And because not every slice must have exactly the same capabilities, the available computing power is used more efficiently.

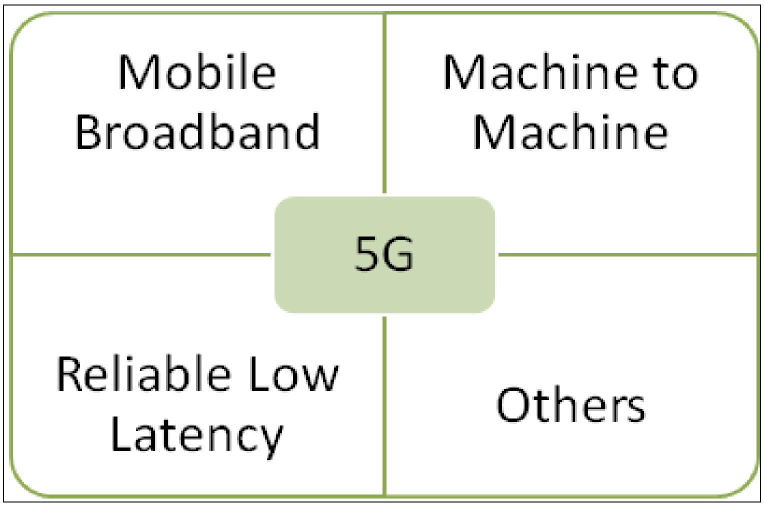

Fig 7: 5G Slicing Applications

Mobile Network Evolution

Communication networks have come a long way since the introduction of first-generation mobile networks in the 1980s. Since then, additional services and higher throughputs have constantly been driving newer generations of mobile networks through GPRS/EDGE, HSPA/HSPA+, LTE/LTE-A Pro, and now the fifth generation network that is commonly referred to as 5G or New Radio (NR).

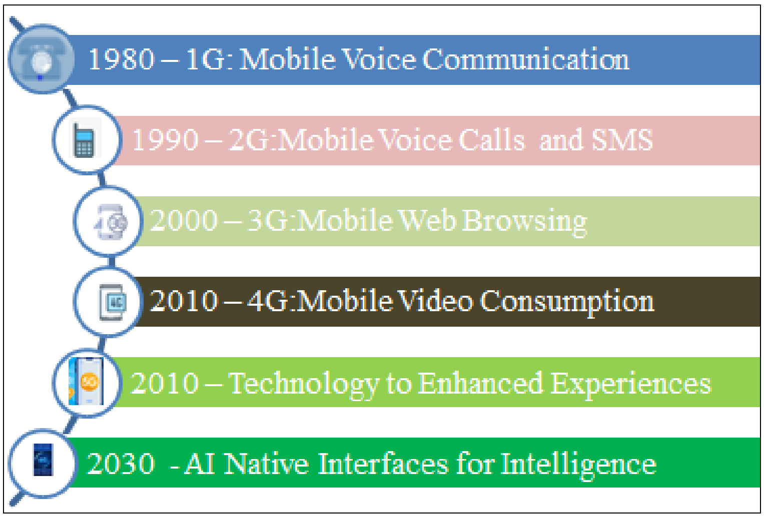

Fig 6: 5G Mobile Evolutions

It is essential to note that intelligent devices – smartphones, wearables, and sensors – complement this evolution in order to realize the full potential of the given services.

5G, in particular, is seen to catalyze the shift from trivial voice and data services towards advanced time-sensitive and mission-critical services like V2X, IIoT, IoMT, robotics, gaming, and AR/VR. This sets an ideal platform for 6G technology and beyond to enable AI native and futuristic use-cases that will evolve in the current decade.

5G Standardization

5G Protocol standardization is the process of tailoring the 5G technology to serve the market requirements and even more, by introducing new applications and services besides the traditional services introduced by the initial mobile networks such as 1G, 2G, 3G, and 4G. The 5G standardization process has been a responsibility of OTSA (Open Trial Specification Alliance), which was tasked to accelerate the standardization and commercial deployment process of 5G. The standardization process adopted new 5G technologies such as New Radio (NR) and NextGen Core, while some stemmed from the initial mobile technologies such as Long Term Evolution (LTE).

5G protocol standardization

3GPP (3rd Generation Partnership Project) Releases

3GPP comprises of several Releases, among which are;

- R99.
- Rel-4 to Rel-16.
- The newly proposed Rel-17 and Rel-18.

Rel-14 and all the initial releases define the previous mobile networks such as 4G, 3G, 2G, and 1G. LTE is defined from Rel-8, LTE-A is from Rel-10, and LTE-A Pro is from Rel-12, to mention just but few recent releases.

3GPP 5G Releases

5G is defined in 3GPP Release 15 (Rel-15) and Release 16 (Rel-16), which constitute the following

1. NextGen Core (NGC) network.
2. New Radio (NR).
3. LTE Advanced Pro Evolution.
4. EPC Evolution.

Among the 5G, new technologies are New Radio and NextGen Core network.

Spectrum for 5G

The 5G spectrum is a range of radio frequencies in the sub-6 GHz range and the millimeter-wave (mmWave) frequency range that is 24.25 GHz and above.

The 5G spectrum refers to the radio frequencies that carry data from user equipment (UE) to cellular base stations to the data's endpoint. LTE networks use frequencies in the sub-6 GHz range and will be sharing the space with 5G traffic. The lower frequency bands will be used for less-densely populated areas because data can travel further, though slower, on these frequencies.

In order to utilize the newly-available mmWave spectrum, 5G networks will have to use the 5G New Radio technology being standardized by the 3GPP.

Spectrum Sharing

5G and LTE networks share LTE's frequencies because 5G is not wholly and immediately replacing LTE. A network operator can use frequency division duplex (FDD) and time division duplex (TDD) technologies to share spectrum. FDD is where different bands of frequency are used by users; one for uplink and the other for downlink. TDD is where one frequency band will be used for uplink and downlink, switching between the two from moment to moment. According to an approved United States patent assigned to AT&T, bands can be dynamically allocated between LTE and 5G in tens of milliseconds.

5G Spectrum: Key Takeaways

1. The frequency bands for 5G networks come in two sets. Frequency range 1 is from 450 MHz to 6 GHz. Frequency range 2 is from 24.25 GHz to 52.6 GHz.
2. To share frequencies used by LTE and 5G networks, frequency- and time division duplexing can be used.
3. Lower frequency spectrum bands will not all be made available for auction because of existing licenses.

Higher frequency spectrum bands are more readily available because they are not currently licensed.

What is LTE (Long-Term Evolution)?

LTE (Long-Term Evolution) is a fourth-generation (4G) wireless standard that provides increased network capacity and speed for cellphones and other cellular devices compared with third-generation (3G) technology.

LTE is a technology for wireless broadband communication for mobile devices and is used by phone carriers to deliver wireless data to a consumer's phone. Over the previous iteration of 3G, LTE provided high speed, higher efficiency, peak data rates and flexibility in bandwidth and frequency.

LTE offers higher peak data transfer rates than 3G, up to 100 Mbps downstream and 30 Mbps upstream. It provides reduced latency, scalable bandwidth capacity and backward compatibility with the existing Global System for Mobile communication (GSM) and Universal Mobile Telecommunications Service (UMTS) technology. The subsequent development of LTE-Advanced (LTE-A) yielded peak throughput on the order of 300 Mbps.

Although LTE is commonly referred to as 4G LTE, LTE is technically slower than 4G but still faster than normal 3G. For this reason, LTE may also be called 3.95G. While LTE speeds reach 100 Mbps, true 4G offers speeds up to 1,000 Mbps. However, different versions of LTE meet 4G speeds, such as LTE-A.

LTE eventually became universally available as a standard that is still commonly available in areas that don't yet have 5G.

LTE has a direct role in the development of the current 5G standard, called 5G New Radio. Early 5G networks, referred to as non-standalone 5G (NSA 5G), require a 4G LTE control plane to manage 5G data sessions. NSA 5G networks can be deployed and supported by the existing 4G network framework, lowering capital and operating expenses for operators rolling out 5G.

Why is LTE called Long-Term Evolution?

The 3rd Generation Partnership Project (3GPP) developed LTE. The standard was described as the next step in the progression of mobile telecommunications as well as progression from the 2G GSM and 3G UMTS specifications. LTE is commonly marketed as 4G LTE.

LTE did not originally qualify as true 4G. The International Telecommunication Union (ITU) initially defined 4G as a cellular standard that would deliver data rates of 1 Gbps to a stationary user and 100 Mbps to a user on the move. In December 2010, the ITU softened its stance, applying 4G to LTE, as well as several other wireless standards.

How does LTE work?

An LTE network employs the multiuser variant of the orthogonal frequency-division multiplexing (OFDM) modulation scheme, called orthogonal frequency-division multiple access (OFDMA), for its downlink signal.

OFDMA enables the LTE downlink to transmit data from a base station to multiple users at higher data rates than 3G, with improved spectral efficiency. Single-carrier FDMA is used for the uplink signal, which reduces the transmit power required of the mobile terminal.

The upper layers of LTE are based on Transmission Control Protocol / Internet Protocol, which results in an all-Internet Protocol network, like that of wired communications. LTE supports data transmissions such as mixed data, voice, video and messaging traffic.

LTE-A uses multiple input, multiple output (MIMO) antenna technologies similar to that used in the IEEE 802.11n wireless local area network standard. MIMO and OFDM enable a higher signal-to-noise ratio at the receiver, providing improved wireless network coverage and throughput, especially in dense urban areas.

LTE-A requires devices to be fit with a special chip. Broadcom, Nvidia and Qualcomm all make chips that support LTE-A. A vast majority of smartphones support LTE-A.

How popular is LTE around the world?

Telephone companies launched LTE at different times in different countries. Some European carriers adopted the standard as early as 2009, while North American operators introduced the spec in 2010 and 2011.

Open signal found that across 87 countries, the average availability of 4G networks was 80%. In 2020, the big three U.S. mobile operators - AT&T, T-Mobile and Verizon -- scored 90% and above in the 4G availability category. 4G LTE and 5G are replacing 3G across North America and Western Europe, with major 3G networks scheduled to be shut down in 2022.

According to the Global mobile Suppliers Association (GSA), in 2022, LTE had connected two-thirds of global mobile users - equaling 6.6 billion subscriptions. The GSA also reports that up to 791 telecom operators ran LTE networks across the globe, with 336 as LTE-A networks.

4G LTE features

LTE offers users several features, including the following

- Audio and video streaming. LTE has faster download and upload speeds than 2G and 3G.
- Real-time connection to services. With voice over LTE, users can talk to others without experiencing lag or jitter.
- Even faster speeds with LTE-Advanced. Download and upload speeds with LTE-Advanced are two to three times faster than standard LTE. All LTE Advanced devices are backward-compatible with standard LTE.
- Carrier aggregation. This LTE-Advanced feature improved network capacity, adding bandwidth of up to 100 MHz across five component carriers (bands) with 20 MHz bandwidth each. LTE-A handsets combine frequencies from multiple component carriers to improve signal, speed and reliability.

LTE internet of things (IoT) specifications

In June 2016, 3GPP Release 13 delivered new IoT cellular connectivity options designed for IoT machine-to-machine (M2M) use. LTE-machine-type communication (LTE-M) and narrowband IoT (NB-IoT) were both based on the LTE standard, but with significant changes to enable low-power wide area network M2M operations.

LTE-M delivers data speeds of around 1 Mbps, while NB-IoT supports up to 26 Kbps in downlink. These drastically reduced data speeds increase the battery life of M2M devices that use the IoT cellular standards. For sensors and other devices that need mobility on the cellular network, NB-IoT can support a battery life of up to 10 years. LTE-M can support up to 10 years of battery life on two AA batteries, but only if the device is static and broadcasting for seconds daily. If a device is on, moving about on an LTE network and using LTE-M supported voice features, the battery life will be reduced.

NB-IoT examples include in smart buildings and cities, consumer agriculture and metering.

What is a private LTE network?

Private LTE networks are scaled-down versions of public LTE networks. They are designed to provide private cellular coverage over a company's campus, distribution center or in airports, stadiums and other locations.

Private networks use unlicensed or shared spectrum to deliver coverage to cellphones and other devices. This includes the global, unlicensed 5 GHz band and 3.5 GHz band, which in the U.S. is called the Citizens Broadband Radio Service (CBRS) shared band.

To establish private LTE services, an organization needs an LTE microcell or small cell, core network servers and compliant devices with a SIM card. Many major cellphone manufacturers support LTE spectrum bands that can be used for private services.

Major Android phone manufacturers began to support the CBRS band in 2019.

Apple introduced support for CBRS (Band 48) connections with its iPhone 11 launch in September 2019. Numerous companies produce routers, modules and modems that support the CBRS band.

What is voice over LTE?

Voice over LTE (VoLTE) technology enables users to place phone calls over the LTE network as data packets instead of as typical voice calls. This is called packet voice, and it can share packets along a network of several phone conversations.

VoLTE can support many callers and reallocate bandwidth as needed to support it. Other VoLTE features include optimization of bandwidth and enabling the user to see if the phone they intend to call is busy or available.

LTE history and development

There was no global standard for wireless broadband until the advent of LTE. Prior to LTE, GSM had caught on in Asia and Europe, but the major mobile operators in other countries, including the U.S. and Canada, had adopted Code-Division Multiple Access. The goal of LTE was to merge a fragmented market and offer a more efficient network for network operators.

Major milestones in LTE's development include the following:

- 2004. NTT DoCoMo, a Japanese mobile phone operator, proposed making LTE the next international standard for wireless broadband, and work on the LTE standard started.
- 2006. During a live demonstration, Nokia Networks simultaneously downloaded HD video and uploaded a game via LTE.
- 2007. Ericsson, a Swedish telecommunications company, demonstrated LTE with a bit rate of 144 Mbps.
- 2008. Ericsson demonstrated the first LTE end-to-end phone call, and LTE was finalized.
- 2009. TeliaSonera, a Swedish mobile network operator, made LTE available in Oslo and Stockholm.
- 2011. LTE-Advanced was finalized in 3GPP Release 10.
- 2016. 3GPP engineers began developing the 5G standard that will eventually succeed LTE.
- 2017. The first NSA 5G specification was released, becoming widely available in 2018-2019.
- 2021. 5G specification work is ongoing.

The Evolution of 5G

Every generation or “G” of wireless communication takes approximately a decade to mature. The switch from one generation to the next is mainly driven by the operators’ need to reuse or repurpose the limited amount of available spectrum. Each new generation has more spectral efficiency, which makes it possible to transmit data faster and more effectively over the network.

The first generation of wireless communication, or 1G, started back in the 1980s with analog technology. This was followed quickly by 2G, the first network generation to use digital technology. The growth of 1G and 2G was initially driven by the market for mobile phone handsets. 2G also offered data communication, but at very low speeds.

The next generation, 3G, began ramping up in the early

2000s. The growth of 3G was driven by handsets again, but was the first technology to offer data speeds in the 1 Megabit per second (Mbps) range, suitable for a variety of new applications both on smartphones and for the emerging Internet of Things (IoT) ecosystem. Our current generation of wireless technology 4G LTE, began ramping up in 2010.

It’s important to note that 4G LTE (Long Term Evolution) has a long life ahead; it is a very successful and mature technology and is expected to be in wide use for at least another decade.

5G Architecture and the Cloud and the Edge

Let's talk about edge computing within the 5G network architecture.

One more concept that distinguishes 5G network architecture from its 4G predecessor is that of edge computing or mobile edge compute. In this scenario, you can have small data centers positioned at the edge of the network, close to where the cell towers are. That's very important for very low latency and for high bandwidth applications that are carrying the same content.

For a high bandwidth example, think of video streaming services. The content originates in a server that's sitting somewhere in the cloud. If people are connected to a cell tower and let's say, 100 people are streaming a popular TV program, it’s more efficient to have that content as close to the consumer as possible, right there on the edge, ideally on the cell tower.

The user streams this content from a storage media that is on the edge rather than having to stream and transfer this information and backhaul it for 100 people from the central location on the cloud. Instead, using the 5G structure, you can bring to content to the tower just once and then distribute it out to your 100 subscribers.

The same principle applies in applications requiring two-way communication where low latency is needed. If a user has an application running at the edge, then the turnaround time is much faster because the data doesn't have to traverse the network.

In the 5G network structure, these edge networks can also be used for services that are provided on the edge. Since it's possible to virtualize these 5G core functions, you could have them running on a standard server or data center hardware and have fiber running to the radio that sends out the signal. So the radio is specialized, but everything else is pretty standard.

Today, 4G LTE is still growing. It provides excellent speed and sufficient bandwidth to support most IoT applications today. 4G LTE and 5G networks will co-exist over the next decade, as applications begin to migrate and then 5G networks and applications eventually supersede 4G LTE.

Devices Using 5G

5G will evolve over time, and 5G devices will follow suit. Early products will be “5G-ready”, which means that these products have the processing power and Gigabit Ethernet ports needed to support the higher bandwidth 5G modems and 5G extenders now on the horizon.

Later 5G products will have 5G modems directly integrated and have a faster multi-core processor, 2.5 or even 10 Gigabit Ethernet interfaces and Wi-Fi 6/6E radios. These product changes will drive the cost of 5G products up but are required to handle the additional speed and lower latency that 5G networks will offer.

Conclusion

The future of 5G is bright and Digi is excited to bring an expanding variety of new 5G products to market in the years to come. With its faster speed, greater capacity and lower latency, 5G will bring additional functionality and exciting new use cases that 4G cannot deliver. The commercial and government IoT sectors will benefit tremendously from the new 5G architecture, its flexibility and its different components. So look at the next generation and the future business opportunities. And think about how you might need to evolve your systems.

References

1. Huawei: China's Controversial Tech Giant. Council on Foreign Relations. [Internet]. [Cited 2022 Dec 30].
2. Lillis KB. CNN Exclusive: FBI investigation determined Chinese-made Huawei equipment could disrupt US nuclear arsenal communications. CNN Politics. [Internet]. 2022 Jul 23 [Cited 2022 Dec 30].
3. Kharpal A. Huawei says it would never hand data to China's government. Experts say it wouldn't have a choice. CNBC. [Internet]. 2019 Mar 5 [Cited 2022 Dec 30].
4. Corera G. Huawei: MPs claim 'clear evidence of collusion' with Chinese Communist Party. BBC News. [Internet]. 2020 Oct 7 [Cited 2020 Oct 7].
5. What's needed to keep 5G from compromising weather forecasts? GCN. [Internet]. 2020 Sep 29 [cited 2021 Dec 4].
6. Misra S. The Wizard behind the Curtain? – The Important, Diverse, and Often Hidden Role of Spectrum Allocation for Current and Future Environmental Satellites and Water, Weather, and Climate. In: 15th Annual Symposium on New Generation Operational Environmental Satellite Systems; 2019 Jan 10; Phoenix, AZ. American Meteorological Society. [Cited 2019 May 5].
7. Lubar DG. A Myriad of Proposed Radio Spectrum Changes – Collectively Can They Impact Operational Meteorology? In: 15th Annual Symposium on New Generation Operational Environmental Satellite Systems; 2019 Jan 9; Phoenix, AZ. American Meteorological Society. [Cited 2019 May 5].
8. Witze A. Global 5G wireless networks threaten weather forecasts. Nature. 2019 Apr 26;569(7754):17–18. PMID: 31040411.
9. Brackett R. 5G Wireless Networks Could Interfere with Weather Forecasts, Meteorologists Warn. The Weather Channel. [Internet]. 2019 May 1 [cited 2019 May 5].
10. Samenow J. Critical weather data threatened by FCC 'spectrum' proposal, Commerce Dept. and NASA say. The Washington Post. [Internet]. 2019 Mar 8 [cited 2019 May 5].
11. Samenow J. FCC to auction off wireless spectrum that could interfere with vital weather data, rejecting requests from U.S. House and science agencies. The Washington Post. 2019 Mar 13. Available from: https://www.washingtonpost.com. Archived 2019 May 9. Accessed 2019 May 29.
12. Paul D. Some worry 5G may pose huge problems for weather forecasting. The Buffalo Post. 2019 May 27.

Available from:
https://www.buffalopost.com. Archived 2019 May 30. Accessed 2019 May 29.

13. Witze A. Global 5G wireless deal threatens weather forecasts. Nature. 2019 Nov 22;575(7784):577. DOI:10.1038/d41586-019-03609-x. PMID: 31772363.
14. World Meteorological Organization. WMO expresses concern about radio frequency decision [press release]. Geneva, Switzerland; 2019 Nov 27. Available from: https://www.wmo.int. Accessed 2019 Nov 30.
15. Freedman A. Global 5G deal poses significant threat to weather forecast accuracy, experts warn. The Washington Post. 2019 Nov 26. Available from: https://www.washingtonpost.com. Archived 2019 Nov 27. Accessed 2019 Dec 1.
16. European Centre for Medium-Range Weather Forecasts. ECMWF statement on the outcomes of the ITU WRC-2019 conference [Press release]. Reading, UK; c2019 Nov 25. Available from: https://www.ecmwf.int. Archived 2021 Jan 8. Accessed 2019 Dec 1.
17. Freedman A. 'We are deeply concerned': House Science Committee seeks investigation of how 5G could hurt weather forecasting. The Washington Post. 2019 Dec 11. Available from: https://www.washingtonpost.com. Archived 2019 Dec 12. Accessed 2019 Dec 12.
18. 5G Technology World. 5G altimeter interference: aviation versus telecoms. 2021 Dec 23. Available from: https://www.5Gtechnologyworld.com. Archived 2022 Jan 18. Accessed 2022 Jan 19.
19. Bloomberg News. U.S. FAA Issues Safety Alert on 5G Interference to Aircraft. 2021 Nov 2. Available from: https://www.bloomberg.com. Archived 2021 Dec 4. Accessed 2021 Dec 4.
20. CNN. Europe rolled out 5G without hurting aviation. Here's how. 2022 Jan 19. Available from: https://www.cnn.com. Archived 2022 Jan 19. Accessed 2022 Jan 19.
21. France 24. 5G phones may interfere with aircraft: French regulator. 2021 Feb 16. Available from: https://www.france24.com. Archived 2021 Dec 15. Accessed 2021 Dec 15.
22. Shields T, Levin A. Buttigieg Asks AT&T, Verizon to Delay 5G Over Aviation Concerns. Bloomberg News. 2021 Dec 31. Available from: https://www.bloomberg.com. Archived 2022 Jan 2. Accessed 2022 Jan 2.
23. Washington Post. Wireless carriers to limit 5G near airports after airlines warn of major disruptions. 2022 Jan 18. Available from: https://www.washingtonpost.com. Archived 2022 Jan 19. Accessed 2022 Jan 22.
24. TechTimes. Verizon 5G Gets Activated Despite Warnings About Airport Problems; AT&T 5G Follows Suit. 2022 Jan 19. Available from: https://www.techtimes.com. Archived 2022 Jan 22. Accessed 2022 Jan 22.