Digital Communications ||

Third Year, 2ed Semester

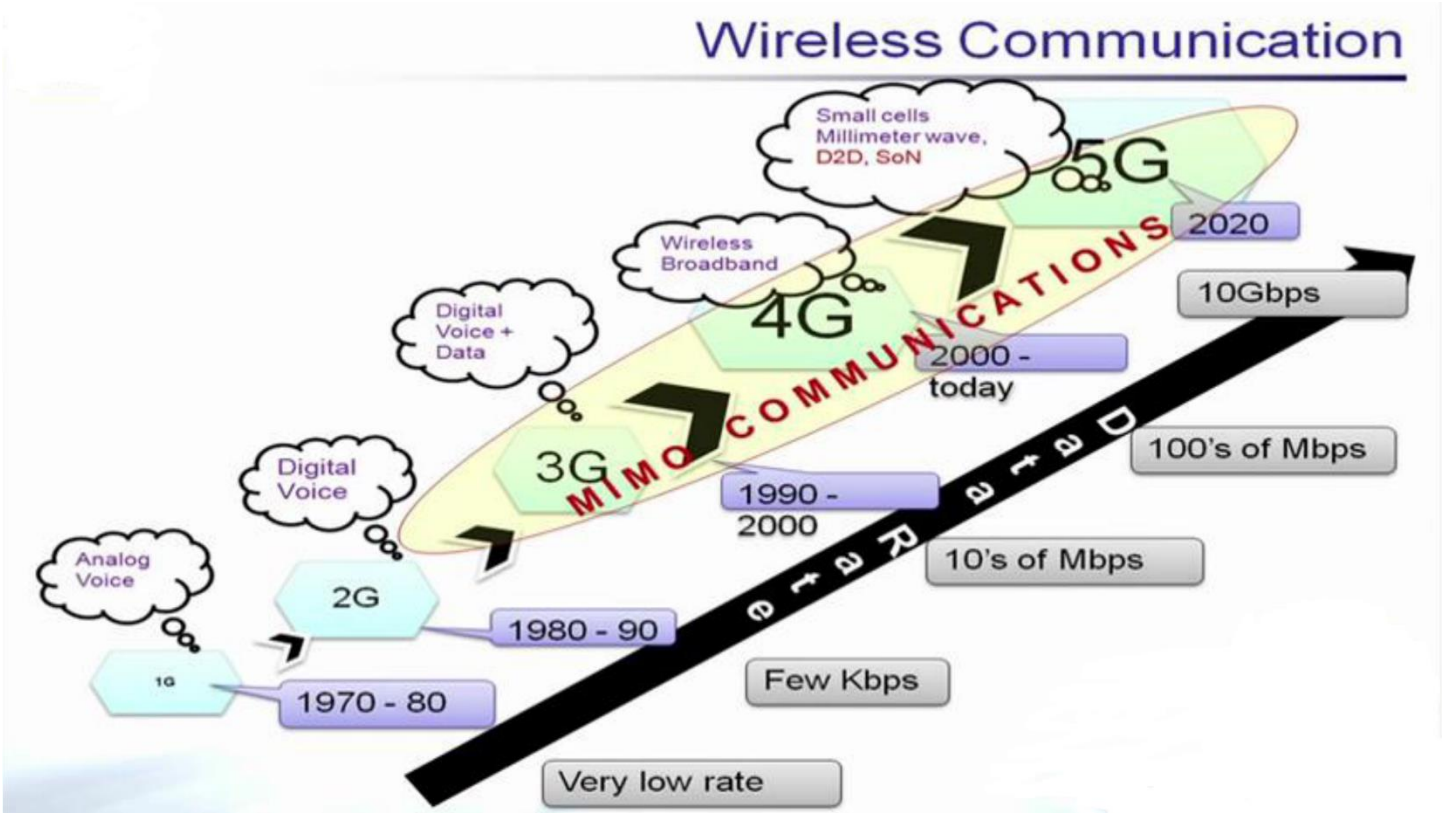
Lecture No.2

Ass. Lecturer: Yousif Allbadi
M.Sc. of Communications Engineering
Yousif_allbadi_eng@uodiyala.edu.iq
yousifallbadi@uodiyala.edu.iq

University of Diyala
College of Engineering
Department of Communications Engineering
2021-2022

Evolution of Wireless Technologies

Briefly look at the evolution of the wireless communication system. That is how the wireless communication systems and standards evolved over the different generations of wireless technologies.



The First Generation 1G

As a matter of first importance when we discuss 1G etc. what does this G stand for? Well, it stands for Generation, so 1G is the first generation of mobile communication systems. In the 1970 - 1980 building up.

Analog mobile phone systems (AMPS) are utilized in parts of America and the United Kingdom.

Total Access Communications Systems (TACS). Nordic Mobile Telephone (NMT) was also used in parts of Europe.

- **FDMA Modulation. Channel capacity of 30KHz and a speed of 2.4kbps.**

➢ The Second Generation 2G

1980-1990
Data Rate: 10-100kbps
Applications: Voice and basic data

The Second Generation	Standards of Technology	Data Rate
2G	GSM	10kbps/user
2G	CDMA	10kbps
2.5G	GPRS	50kbs
2.5G	EDGE	200kbps

GSM: Global System for Mobile Communications.

CDMA: Code Division for Multiple Access.

GPRS: General Packet Radio Service.

EDGE: Enhanced Data for GSM Evolutions.

The second-generation wireless technologies, which as a data rate this is the technology or standard and this is the approximate data rate. 2G as a data rate of approximately 10 kilobits per second per user and another computing 2G standard for another standard in the second generation was CDMA; which also had basic 10 kbps kind of a data rate. And moving on slightly ahead 2G evolved into 2.5G that is 2.5 generation wireless communication in 2.5G. We have technologies such as, GPRS; which enabled a data rate of around 50 kbps, and also another 2.5G or sometimes also called 2.75G standard is the edge, which had a slightly higher data rate of around 200, approximately 200 kbps. These are the basic 2G technologies; which you can see have, these are the beginnings of the digital wireless communication revolution. And, if you are looking at the time scale, these are approximately around the 1990s. These were deployed in various countries and across several continents and approximately, starting with the early 1990s and evolved fully by the late 1990s.

GSM, which is the most popular wireless communication standard; stands for the Global System for Mobile Communications. CDMA stands for Code Division for Multiple Access.

GPRS stands for the General Packet Radio Service and EDGE, which is a 2.5G standard, stands for Enhanced Data for GSM Evolutions.

These are the various standard that is GSM, which is the Global System for Mobile. We have CDMA that is Code Division for Multiple Access. GPRS, which is a General Packet Radio Service, and EDGE, which stands for Enhanced Data for GSM Evolutions and this is the basic scenario of the 2G wireless setting. And moving on this 2G wireless communication system evolved into the 3rd generation wireless communication system. 2G gives way to 3G wireless of the 3rd generation wireless communication systems. We have 3G or the 3rd Generation Wireless Communication Systems.

➢ The Third Generation 3G

1990-2000
Data Rate: 0.3-30Mbps
Applications: Digital Voice, High-speed Data and Video Calling

The Third Generation	Standards of Technology	Data Rate
3G	WCDMA/UMTS	~384kbps
3G	CDMA 2000	~384kbps
3.5G	HSDPA/HSUPA	5-30Mbps
3.5G	1EVDO	5-30Mbps

WCDMA: Wideband of CDMA

UMTS: Universal Mobile Telecommunications Standard

HSDPA: High-Speed Downlink Packet Access

HSUPA: High-Speed Uplink Packet Access

EVDO: Evolution-Data Optimized

Similar to what we made for the 2G scenario and we have 3G - one of the fundamental standards for; 3G is WCDMA or UMTS, which has a data rate of approximately 384 kbps. So, this is our technology and this is the approximate data rate capability. I have also 3G; another standard is CDMA 2000, which has a data rate of again approximately 384 kbps. And this evolved into a 3.5G standard that is, HSDPA/HSUPA which has a data rate capability of around 5 to 30 Mbps, and another 3.5G standard which was 1 x EVDO revision A, B, C; which has a data rate of around 5 to 30 Mbps. And if you look at the timeline for 3G, these were around the early 2000 and fully evolved and deployed in various countries around late 2000, that is expand the decade from 2000 to 2010. If you look at 3G, the lifetime of 3G was around 2000. There is 2000 to 2010 and of course, currently being also deployed in several countries and let us again. You can see that; these have data rates from several 100s of kilobit per second to a couple of 10s of megabits per second. Again, let us look at the different acronyms; we already seen CDMA stands for Code Division for Multiple Access and WCDMA, which is closely related to CDMA stands for Wideband CDMA or Wideband Code Division for Multiple Access. UMTS is the; Universal Mobile Telecommunication Standard. HSDPA is the High-Speed Downlink Packet Access and our EVDO stands for Evolution-Data Optimized alright. So, we have these different standards, WCDMA which is Wideband CDMA; UMTS which is the Universal Mobile Telecommunication Standard. HSDPA, High-Speed Downlink Packet Access, and the corresponding uplinks standard is HSUPA, which is High-Speed Uplink Packet Access. We have EVDO, which is Evolution-Data Optimized. And as we said these have data range span roughly that decade of the 2000 and data rates around 100s of kilobit per seconds to a couple of 10s of megabits per second. And these further give way to the 4th generation of the wireless communication system.

➢ The Fourth Generation 4G

2010- Today
Data Rate: 100-200Mbps
Applications: Online Gaming and HDTV

The Fourth Generation	Standards of Technology	Data Rate
4G	**LTE**	**100-200Mbps**
4G	**WIMAX**	**~100Mbps**

LTE: Long Term Evolution

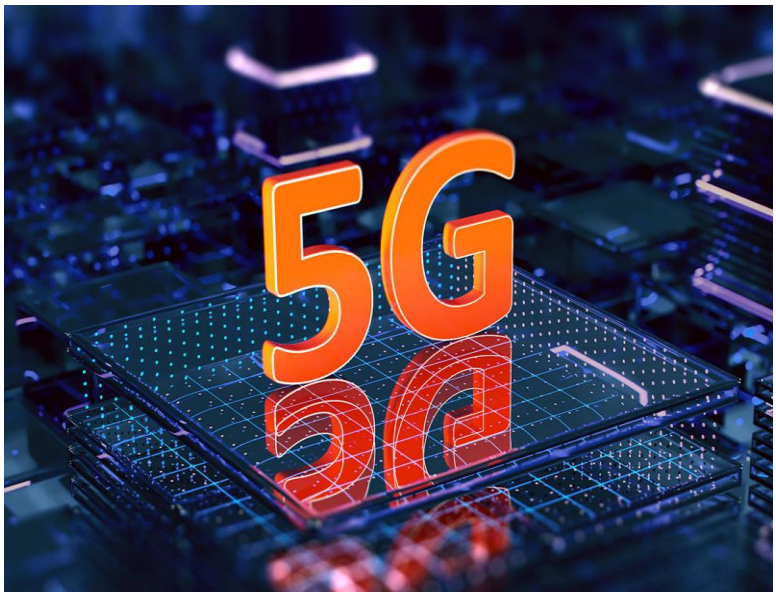
WiMAX: Worldwide Interoperability for Microwave Access

MIMO: Multiple Input Multiple Output

This is 4G or the 4th generation of what is also known, as the 4th generation of wireless communication standards, and in this, there are mainly 2, 4G standards. One is 4G is LTE, which has again 100 to 200 Mbps and another 4G standard is WiMAX, which has again a data rate of about 100 Mbps. And also, we have some other standards such as LTE advanced, which have a significantly higher data rate of about half Gbps to 1 Gbps and LTE again is rough spans the 2010s, the decade of 2010s that is roughly starting from 2000 years to 2010. It also currently in progress and its life cycle is expected to be around, the year 2020. Even 5G is supposed to progressively take over that is the fifth generation. And LTE stands for, Long Term Evolution.

WiMAX stands for, the Worldwide Interoperability for Microwave Access. We have 2 dominant standards or technologies; that is LTE and WiMAX alright.

➢ The Fifth Generation 5G



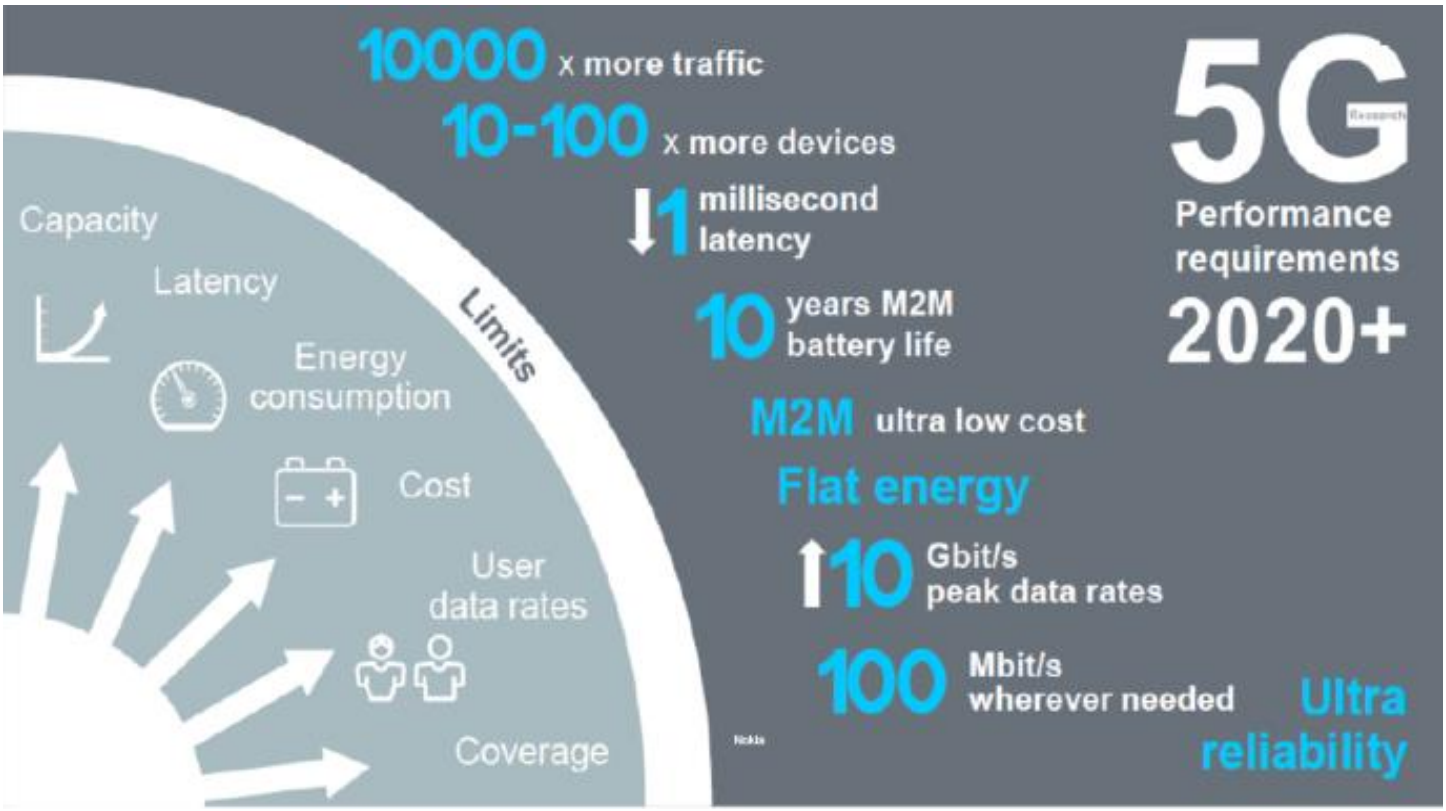
2020- Today

Data Rate: 10Gbps

5G (5th generation wireless systems) is the next major phase of mobile telecommunications standards. The scope of 5G will ultimately range from mobile broadband services to next-generation automobiles and connected devices. The initial 5G New Radio (NR) specification was completed in June 2018 and published in the 3GPP Release 15 specification. Now, a variety of industry players, including network equipment vendors, network operators, semiconductor vendors, and device manufacturers, are developing new products that implement the new standard.

Orthogonal Frequency Division Multiplexing (OFDM) is an efficient modulation format used in modern wireless communication systems including 5G. OFDM combines the benefits of Quadrature Amplitude Modulation (QAM) and Frequency Division Multiplexing (FDM) to produce a high-data-rate communication system.

5G performance Requirements:



Some Applications of 5G:

1. High-speed mobile network
2. Entertainment and multimedia
3. Internet of Things – Connecting everything
4. Smart Home
5. Logistics and shipping
6. Industrial IoT
7. Smart farming
8. Healthcare and mission-critical applications
9. Autonomous Driving
10. Drone Operation

Massive MIMO: More Antennas

Another key technology for achieving greater spectral efficiency is massive MIMO. Massive MIMO, sometimes referred to as large-scale MIMO, is a form of multiuser MIMO in which the number of antennas at the base station is much larger than the number of devices per signaling resource. A large number of base station antennas relative to user devices results in a channel response that is quasi-orthogonal and has the potential to yield huge gains in spectral efficiency. Designers face a challenge when scaling the number of antennas to hundreds:

• The simulation speed of traditional antenna design tools is slow for large antenna arrays.

• It is difficult to simulate the antenna coupling.

• Hybrid beamforming is needed to optimize the number of RF chains.