EVOLUTION OF WIRELESS COMMUNICATIONS TOWARDS 5G AND BEYOND (2020-2030)

DR. LWAA FAISAL AL-TIMIMY

lwaa@kecbu.uobaghdad.edu.iq

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بسم الله الرحمن الرحيم


وقل رب زدني علما

OUTLINE

- HISTORY OF CELLULAR TELEPHONY
- ✓IMT-1990 (2G)
- ✓IMT-2000 (3G)
- ✓IMT-Advanced (4G)
- ✓IMT-2020 (5G)
- Requirements of 5G
- Growth in IMT traffic
- 5G scenarios
- 5G usage scenarios for 2020 and beyond

Introduction

- Mobile communications is now intricately tied to socio-economic fabric of the modern generation human beings
- The tight coupling between mobile communication systems and socio-technical trends are expected to continue beyond 2020
- Also it is foreseen that, there will be

❖ More traffic volume

❖ More devices with diverse service requirements

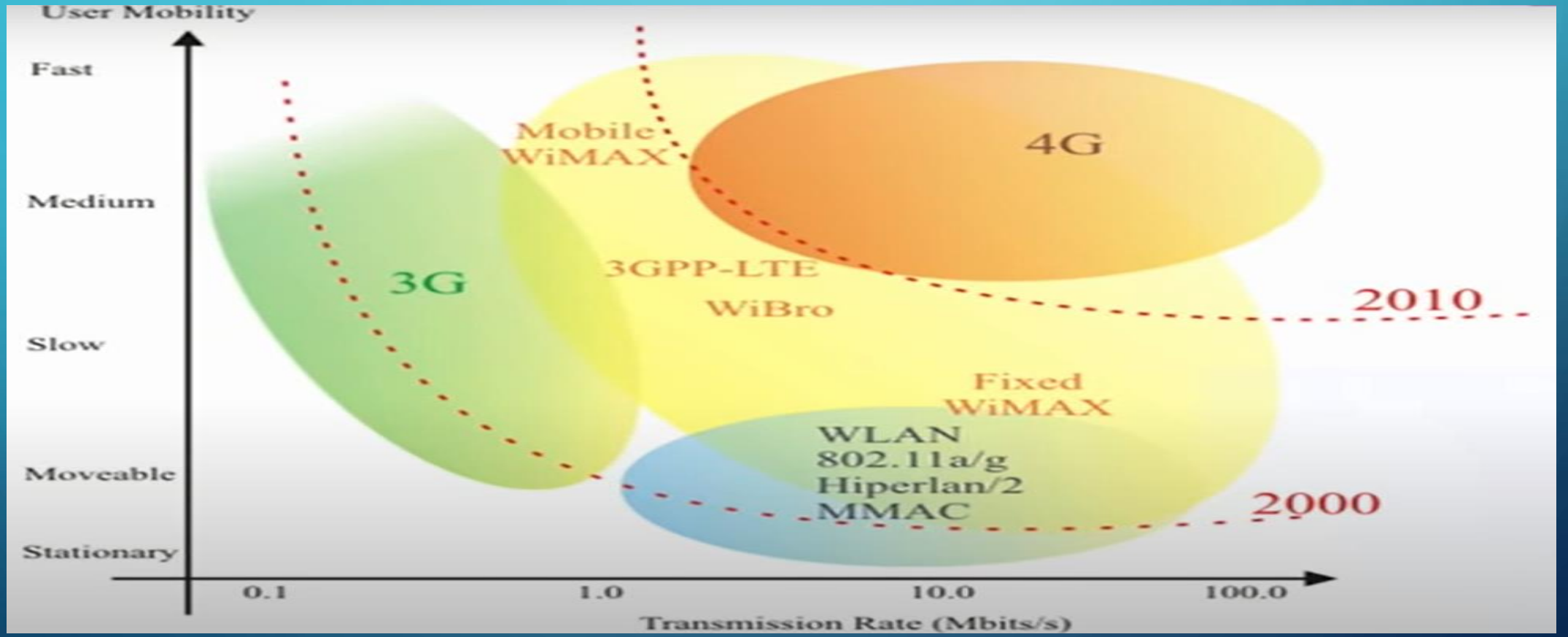
❖ Better quality of user experience (QoE)

❖ will require an increasing number of innovative solutions

HISTORY OF CELLULAR TELEPHONY

1G	2G	2.5G	3G	Beyond 3G	4G
Analog voice	Digital voice	Voice + data	Multimedia services	Broadband multimedia	Ubiquitous networks
NMT AMPS	GSM PDC IS-95A IS-136	GPRS HSCSD EDGE IS-95B	WCDMA CDMA 2000	HSPA WiMAX UMTS-LTE CDMA 2000 1xEV	IMT-A
FM modulation Analog switching Cellular concept Hard handover	Digital modulation Error control Data compression Soft handover High quality voice	Voice + data Higher rate than 2G	'Any time any where' multimedia Packet based data Dynamic RRM Increased capacity	Broadband multimedia High data rate High QoS support broadband wide area	Heterogeneous networks Adaptive air interface Guaranteed QoS Real broadband at wide-area
FDMA	TDMA/CDMA	TDMA/CDMA	WCDMA	WCDMA/OFDMA	OFDMA
very low rate	9.6-28.8kbps	57-115kbps	0.144~2Mbps	~10's of Mbps	~100's of Mbps
1970s/1980s	**1982/1992**		**1992/2001**	**..../2007**	**2010**

RECENT PAST WIRELESS COMMUNICATION SYSTEMS



EVOLUTION OF WIRELESS COMMUNICATION STANDARDS FROM 2G TO 5G

- **2G: GSM (Global System for Mobile Communication)**

✓ The European Conference of Post and Telecommunication Administration (CEPT).

✓ Group Special Mobile

○ To provide digital mobile communications across Europe with objectives

❑ Better and efficient wireless communication than analog.

❑ Single standard for all Europe.

✓ After several proposals

❑ TDMA was agreed upon by several organizations because of common agreement.

- **IMT-2000 (3G) (Objectives To):**

✓Make voice and non-voice telecommunication services available to users who are

❑Mobile

❑Roaming

✓Accommodate variety of mobile terminals

❑Small: carried on person

❑are mounted in vehicles

- **Technologies introduced in 3G++**
- Variable Data Rates
  - Multiple code word assignment (variable spreading factor)
  - Modulation (QPSK, 16 QAM)
  - Code Rate (not only ½ but also different code rates)
- Coverage/ Improvement
  - Turbo code
  - Hybrid ARQ
  - Link Adaption
- Capacity Improvement
  - Multiantenna Transmission

- **IMT-Advanced (support) (ITU-R-M 2134)**

➢ Low to high mobility applications

➢ Wide range of data rates

- Peak data rats: 100 Mbps for high mobility and 1 Gbps for low mobility

➢ High quality multimedia applications

➢ Worldwide roaming

- **Minimum Requirements for IMT-Advanced**

➢ **Cell Spectral Efficiency**

❑ Let x_i denote the number of correctly received bits by user i (downlink) in a system comprising of

- N users
- M cells
- W channel bandwidth
- T time over which the data bits are received

❖ The cell spectral efficiency is given by

$$\xi = \sum_{i=1}^{N} \frac{x_i}{T.W.M}$$

- **Cell Spectral Efficiency (Cont.)**

Test environment	Downlink (bit/s/Hz/cell)	Uplink (bit/s/Hz/cell)
Indoor	3	2.25
Microcell	2.6	1.80
Base coverage urban	2.2	1.4
High speed	1.1	0.7

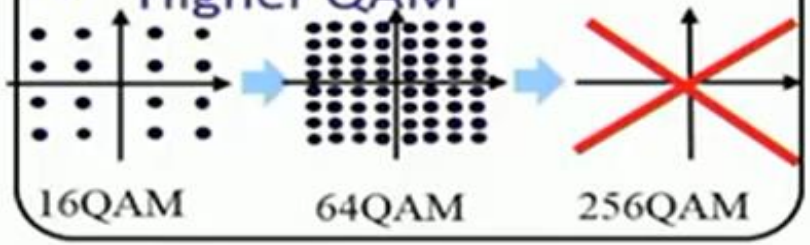
These values were defined assuming antenna configuration of downlink 4×2 and uplink 2×4

- **Peak Spectral Efficiency**
- Peak spectral efficiency is defined as the highest theoretical data rate normalized by B.W., which is the received data bits assuming error free conditions assignable to a single MS.
- **Minimum requirements for peak spectral efficiency:**
- Downlink peak spectral efficiency is 15 bit/s/Hz
- Uplink peak spectral efficiency is 6.75 bit/s/Hz

These values were defined assuming antenna configuration of downlink 4×4 and uplink 2×4

Main Components OF 4G Systems

- Higher QAM



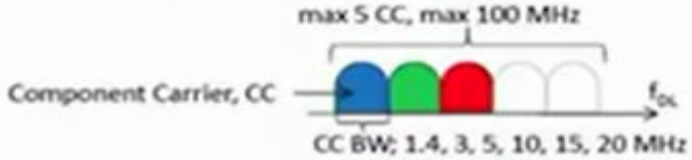
- MAC optimization

Packet Switching

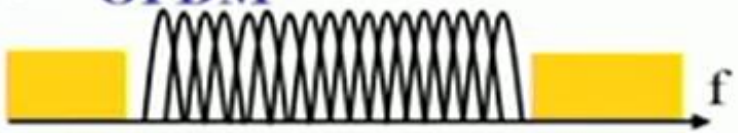
Packet Scheduling

Radio Resource Allocation.

Carrier Aggregation



- OFDM



Increasing the number of sub-carriers; 1.25times (IEEE 802.11)

Turbo Encoder & Decoder

HARQ

Link Adaptation

- MIMO

Channel capacity becomes N times for SISO

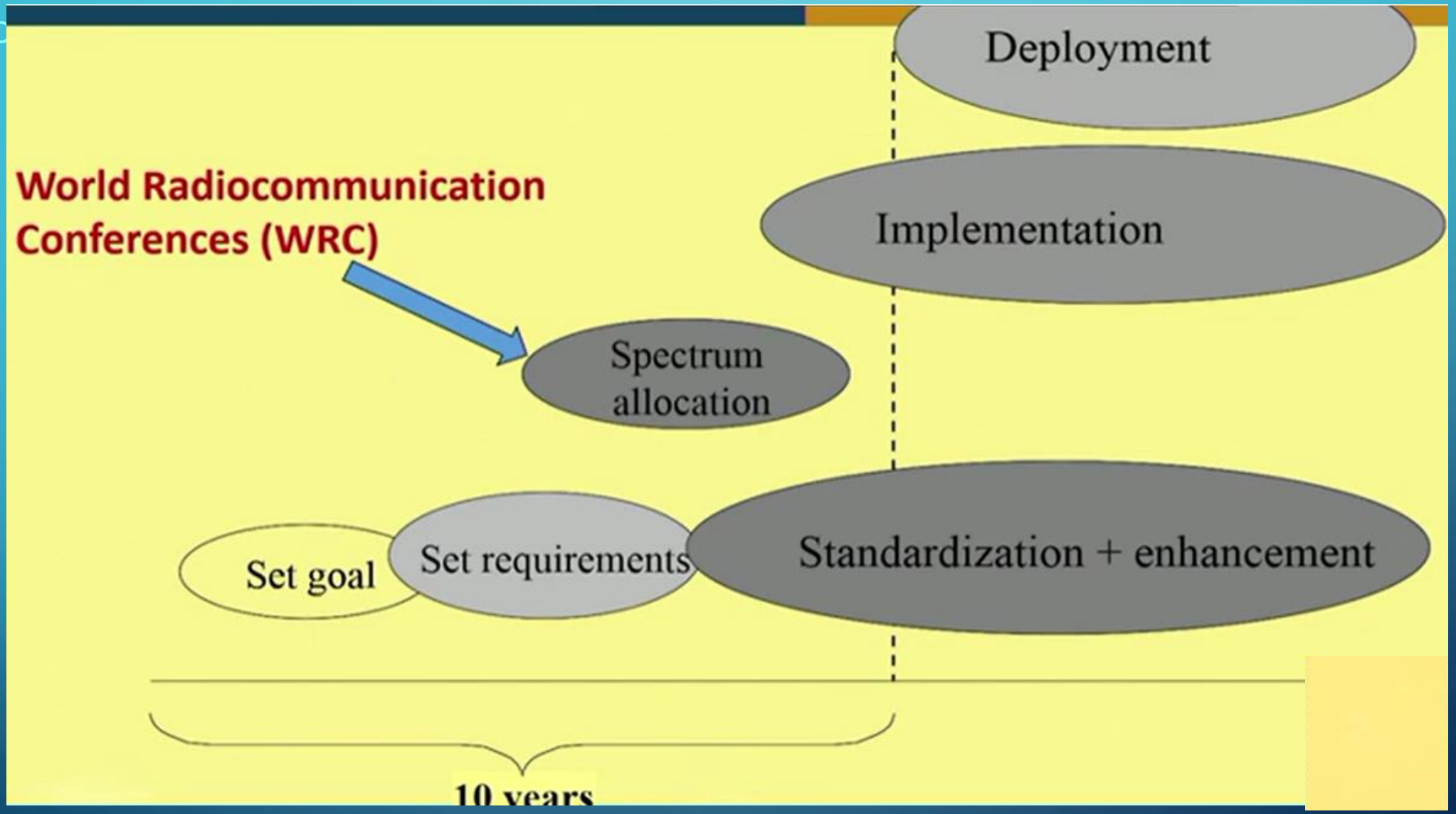
IMT-2020 (5G)

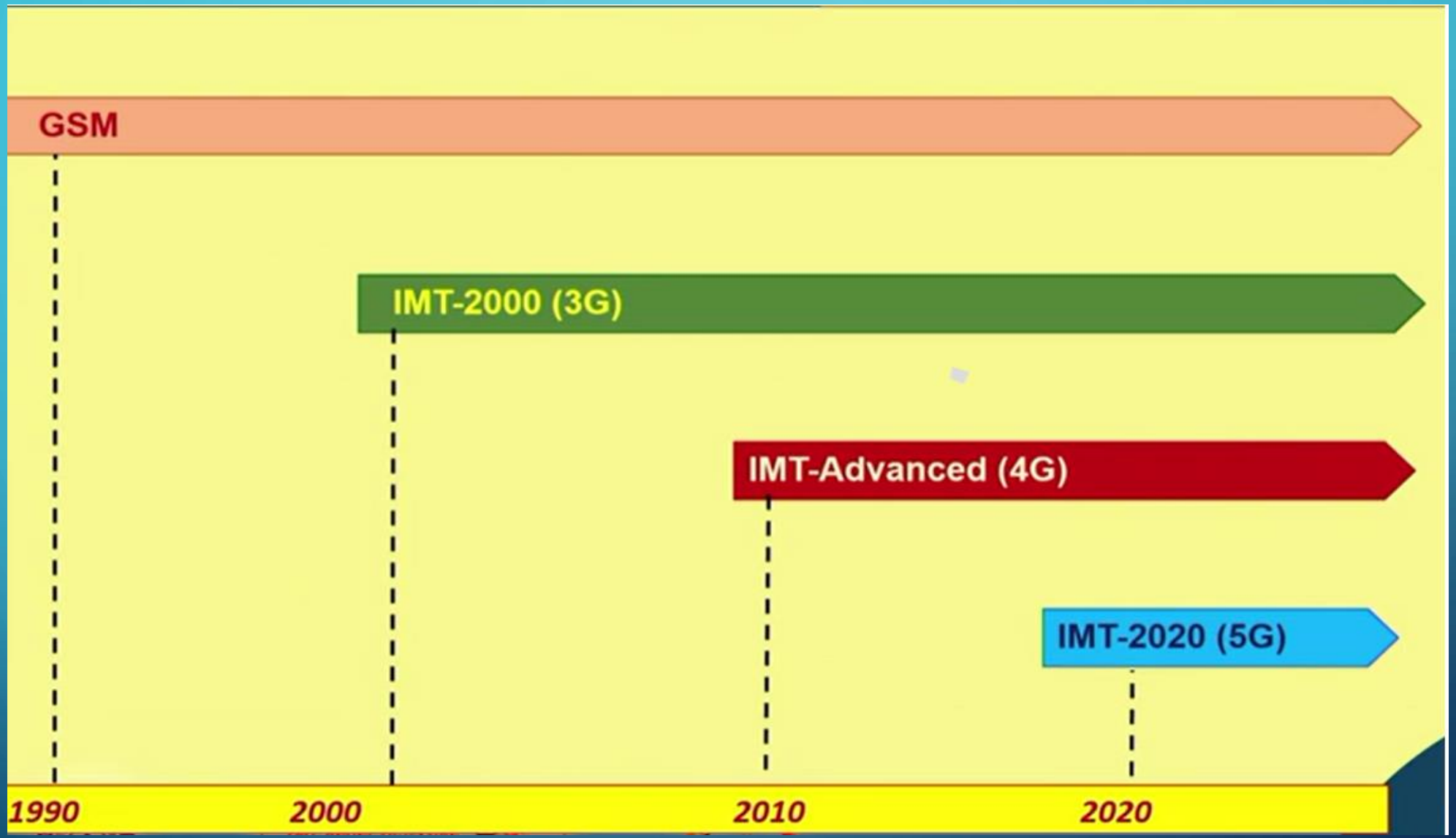
- **Concepts Covered**

✓ **Requirements of IMT-2020**

✓ **Traffic Prediction**

✓ **Operating Scenarios**


Deployment
World Radiocommunication Conferences (WRC)
Implementation
Spectrum allocation
Set goal
Set requirements
Standardization + enhancement
10 years


GSM
IMT-2000 (3G)
IMT-Advanced (4G)
IMT-2020 (5G)
1990
2000
2010
2020

Requirements of 5G/IMT-2020

- High level network architecture
- End-to-end QoS framework
- Emerging network technologies, and
- Network softurazation

Requirements of IMT-2020

- IMT-2020 [b-ITU-RM-2083-0] system that support to provide far more enhanced capabilities than those described in Recommendation ITU-R-M.1645]
- There is a reference ITU-R Recommendation ITU-RM-2083-0 “IMT vision-framework and overall objectivities of the future deployment of [IMT for 2020 and beyond]
- The term IMT-2020 is commonly referred to “fifth generation mobile networking” or simply 5G
- IMT-2020 and 5G are synchronous

Observations

- Wireless communication applications are expected to facilitate
  - ❑ The digital economy, ex. Smart grid, e-health, intelligent transport systems and traffic control
  - ➢ Which would bring requirements beyond what can be addressed in ITM application areas
- Rapid adoption of smart phones and mobile applications
  - ➢ Cause a tremendous increase in the volume of mobile data traffic
- Number of devices accessing the network are expected to increase due to
  - ○ Proliferation of Internet of Things (IoT)

Technologies Such as

- Beamforming and massive MIMO
- are aligned with higher frequencies
- Wide contiguous bandwidth would
- Enhance data delivering efficiency and case of hardware implementation
- Reduced cell size (the order of some tens of meters)
- Provide larger area-traffic capacity in dense area

User and Application Trends

- **Future IMT systems should support emerging new user cases, including applications requiring**

➢ Very high data rate communications,

➢ A large number of connected devices

➢ Ultra-low latency

➢ High reliability applications

Very Low Latency and High Reliability Human-Centric Communication

- Flash behavior is

❑A key factor for the success of:

➢ cloud services

➢Virtual reality and

❑Low latency and high reliability communications are enabler for

➢E-health

➢Safety

➢Office

➢Entertainment and other sectors

THANKS FOR YOUR ATTENTION

Email: lwaa@kecbu.uobaghdad.edu.iq

Mobile: 07723708900