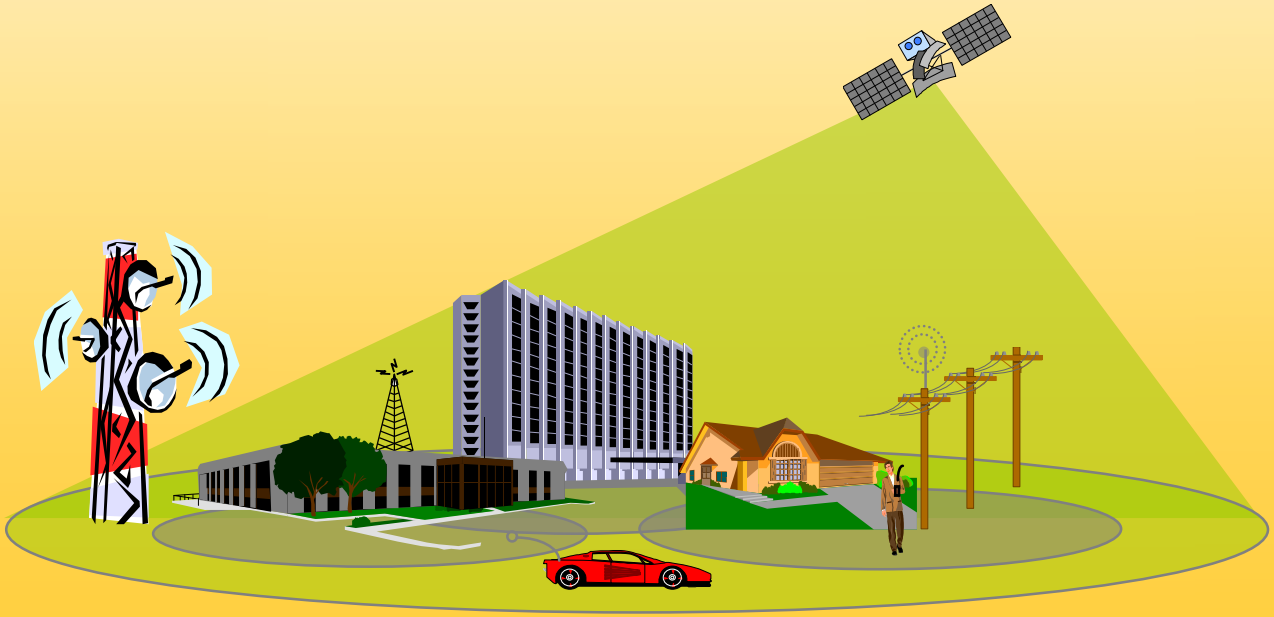
Cihan University Sulaimaniya
Department: Computer Science
Subject: Networking 2

Lecture (1): Wireless



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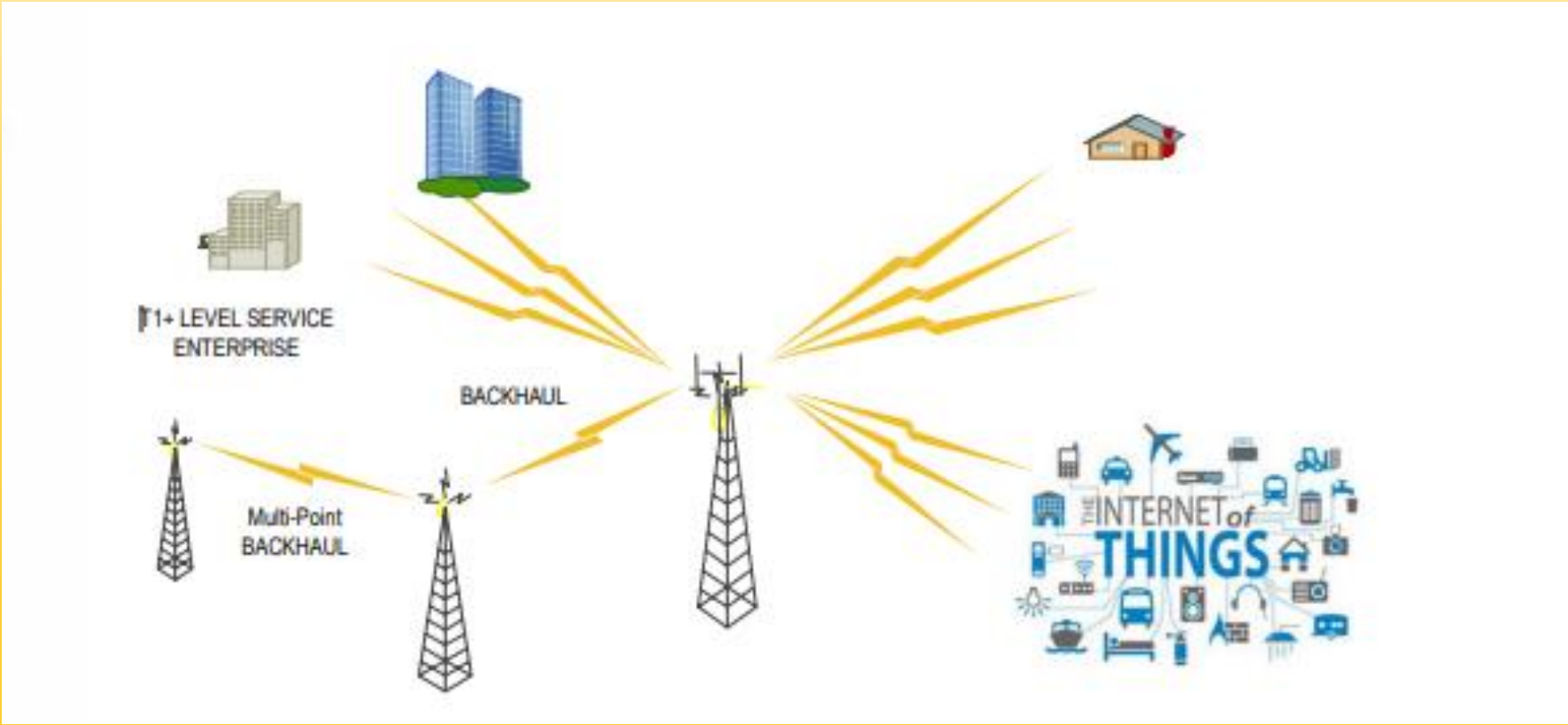
Outlines of Lecture 1

- **Introduction**
- **Mobile Generations**



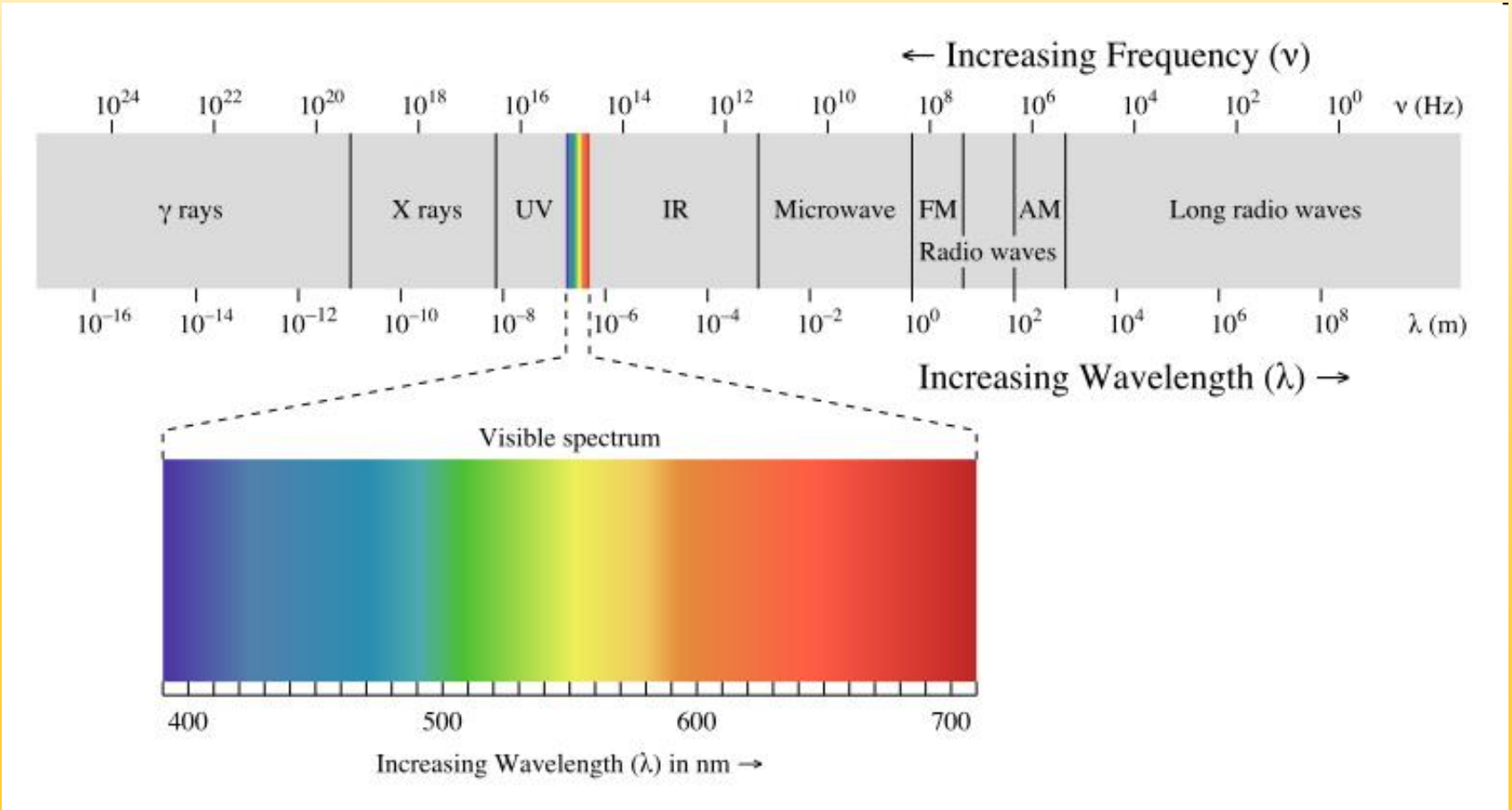
Introduction

Wireless Communications History

- Marconi invented the wireless telegraph in 1896 and sent telegraphic signals across the Atlantic Ocean in 1902.
- 1914 – first voice communication over radio waves.
- Communications satellites launched in 1960s.
- In 1964, Motorola invented first mobile phone, In 1973, 1st man held device came from Motorola.
- Cellular has enjoyed exponential growth since 1988, with more than 6 billion users worldwide today.

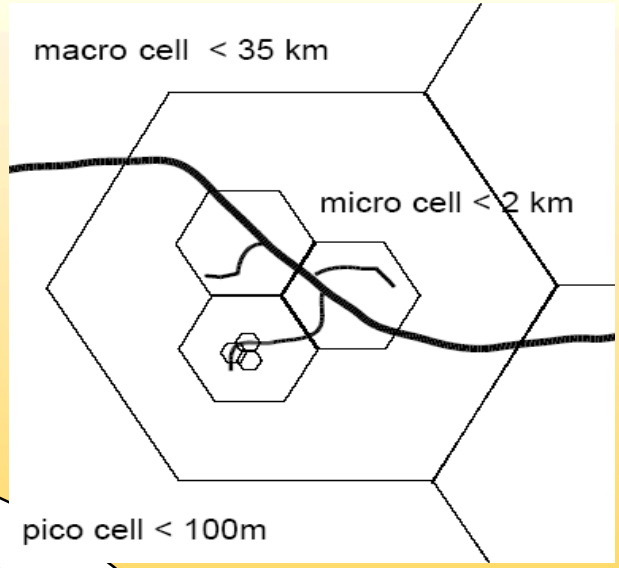
Introduction… Cont.

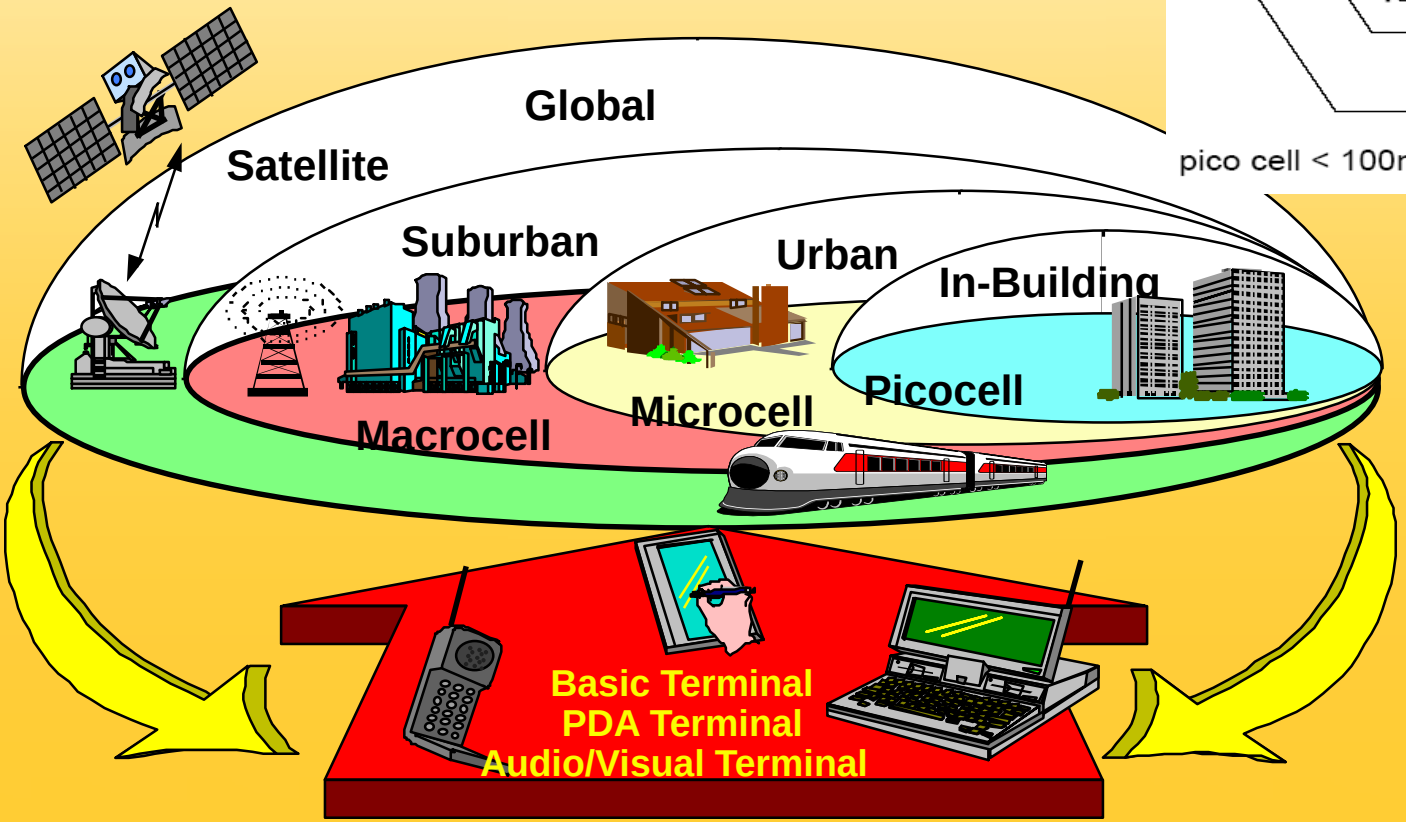
Electromagnetic radiation spectrum



Introduction… Cont.

Type of Cells:





Introduction… Cont.

Wireless LAN Standards

- 802.11b (Current Generation)
  - Standard for 2.4GHz ISM band (80 MHz)
  - Frequency hopped spread spectrum
  - 1.6-10 Mbps, 500 ft range
- 802.11a (Emerging Generation)
  - Standard for 5GHz NII band (300 MHz)
  - OFDM with time division
  - 54 Mbps, variable range
  - Similar to HiperLAN in Europe
- 802.11g (New Standard)
  - Standard in 2.4 GHz and 5 GHz bands
  - OFDM
  - Speeds up to 54 Mbps

Since 2008, all WLAN Cards have all 3 standards

	Frequencies	Maximum allowable streams	Maximum theoretical throughput (per stream)	Maximum theoretical throughput (total)
802.11a	5 GHz	1	54 Mbit/s	54 Mbit/s
802.11b	2.4 GHz	1	11 Mbit/s	11 Mbit/s
802.11g	2.4 GHz	1	54 Mbit/s	54 Mbit/s
802.11n	5 GHz and/or 2.4 GHz	4	150 Mbit/s	600 Mbit/s
802.11ac	5 GHz	8	866.7 Mbit/s	6,934 Mbit/s

ZigBee Radios/ IEEE 802.15.4

- Low-rate low-power low-cost secure radio
  - Complementary to WiFi and Bluetooth
- **Frequency bands:** 784, 868, 915 MHz, 2.4 GHz
- **Data rates:** 20Kbps, 40Kbps, 250 Kbps
- **Range:** 10-100m line-of-sight
- Support for large mesh networking or star clusters
- Support for low latency devices
- CSMA-CA channel access

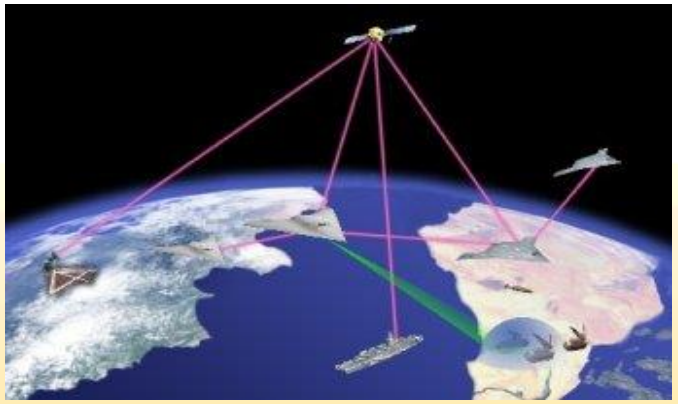
Bluetooth IEEE 802.15

Bluetooth®
version 5.2
2020

- Cable replacement RF technology (low cost)
- Short range (10m, extendable to 100m)
- 2.4 GHz band (crowded)
- 1 Data (700 Kbps) and 3 voice channels, up to 3 Mbps

Satellite Systems

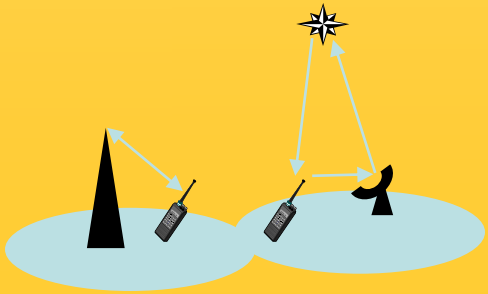
- Different orbit heights
  - GEOs (39000 Km)
  - MEOs (5000-12000Km)
  - LEOs (2000 Km)



- High cost relative to terrestrial networking
  - 15 Mbit/s down, 2 Mbit/s up
  - Remote sites, difficult-to-network sites
- High latency
  - 250 ms up, 250 ms down
- High frequencies - 2 GHz
  - Line of sight, rain fade

Paging Systems

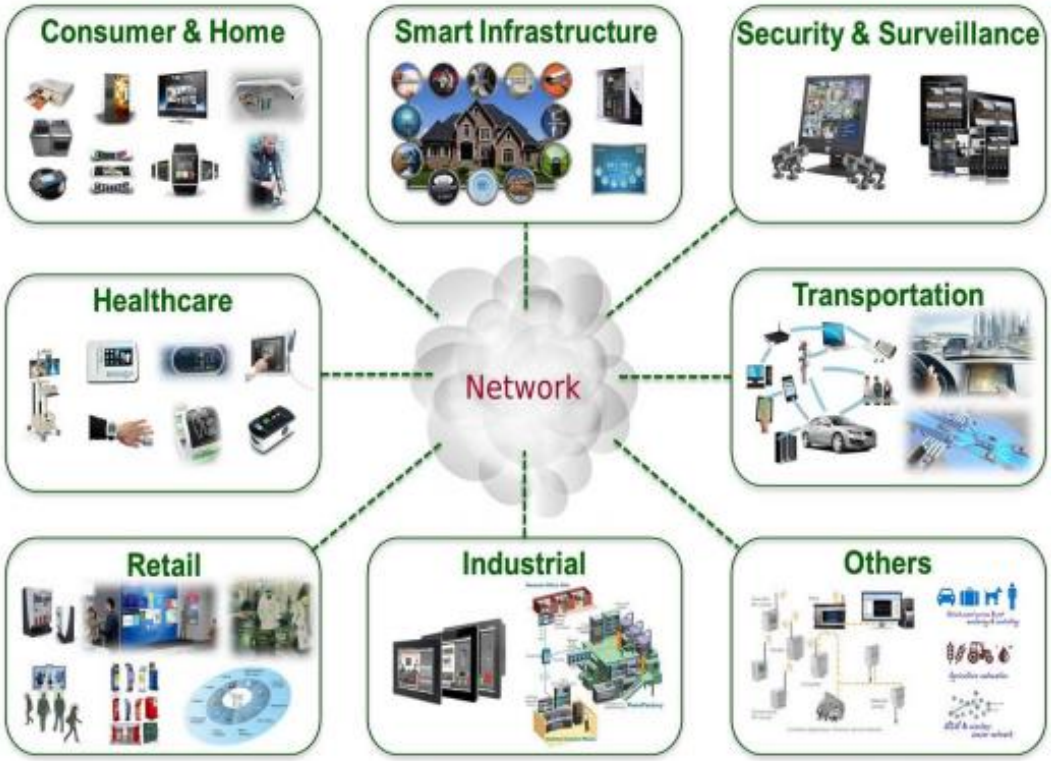
- Broad coverage for short messaging
- Message broadcast from all base stations



What is the Internet of Things?

Different requirements than smartphones: low rates/energy consumption

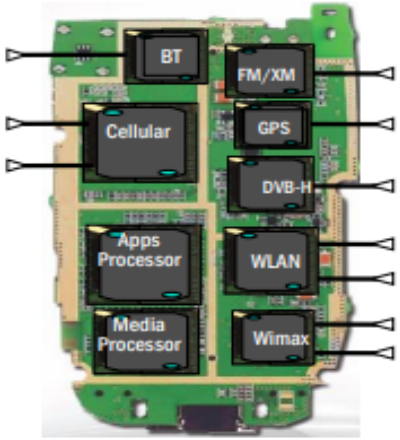
- Enabling every electronic device to be connected to each other and the Internet
- Includes smartphones, consumer electronics, cars, lights, clothes, sensors, medical devices,…
- Value in IoT is data processing in the cloud

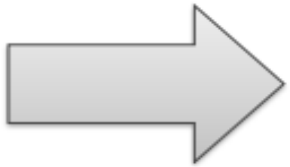


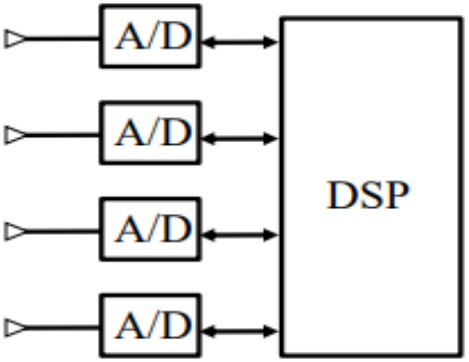
Green Communications

- Energy-efficient communication technologies primarily developed for addressing the environmental impact of traditional communication systems and networks
- Also knows as *Energy-Constrained Radios*

Software-Defined (SD) Radio

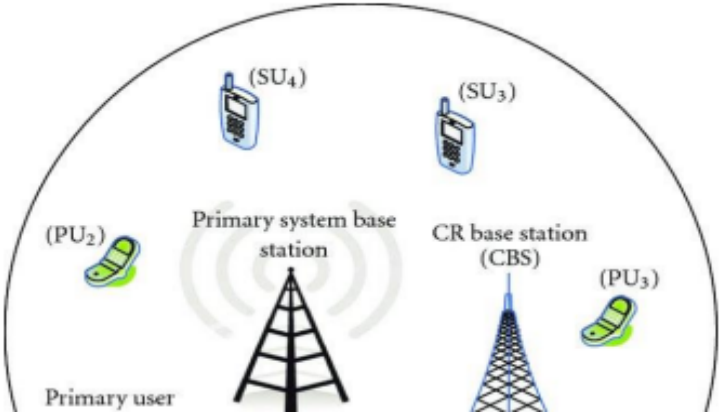






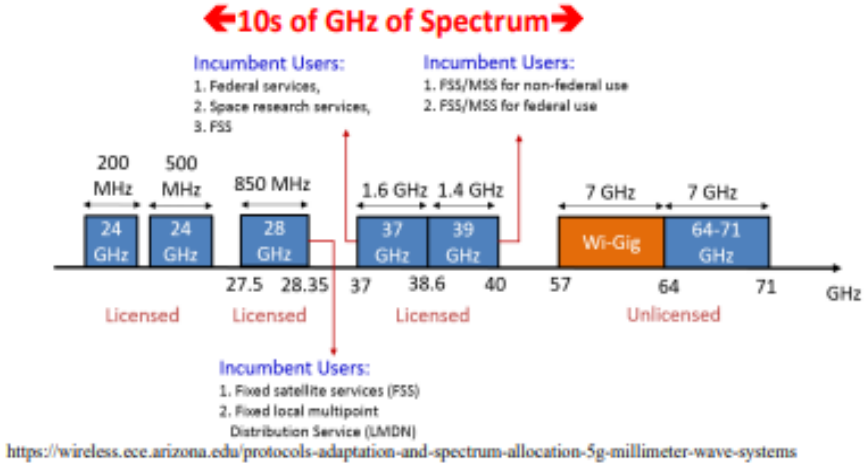
- Wideband antennas and A/Ds span BW of desired signals
- DSP programmed to process desired signal: no specialized HW

Cognitive Radios

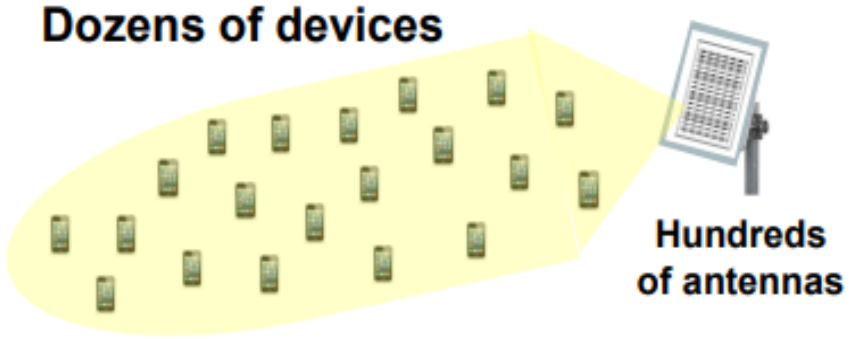


- Cognitive radios support new users in existing crowded spectrum <u>without degrading licensed users</u>
  - Utilize advanced communication and DSP techniques
  - Coupled with novel spectrum allocation policies
- Multiple paradigms
  - (MIMO) **Underlay** (interference below a threshold)
  - **Interweave** finds/uses unused time/freq/space slots

mmWave Massive MIMO



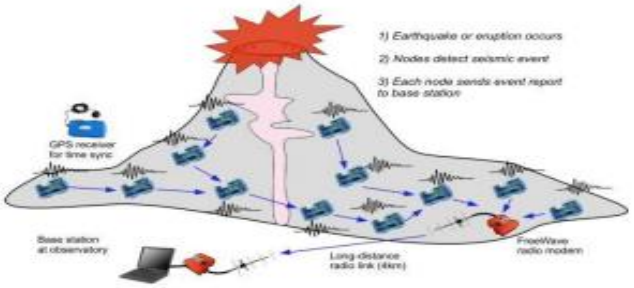
https://wireless.ece.arizona.edu/protocols-adaptation-and-spectrum-allocation-5g-millimeter-wave-systems



- mmWaves have large non-monotonic path loss
  - Channel model poorly understood
- mmWave antennas are small: perfect for massive MIMO

Wireless Sensor Networks

Data Collection and Distributed Control

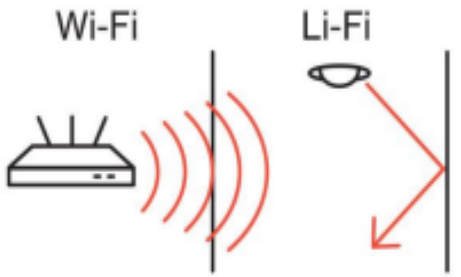


Applications:

- Smart homes/buildings
- Smart structures
- Search and rescue
- Homeland security
- Event detection
- Battlefield surveillance
- Seismic Surveys

LiFi

LiFi is a wireless optical networking technology that uses light-emitting diodes (LEDs) for data transmission. **LiFi** is designed to use LED light bulbs similar to those currently in use in many energy-conscious homes and offices



- ADSL (Asymmetric Digital Subscriber Line)
  - Uses telephone lines
  - Download speed is faster than the upload speed (asymmetric)
  - ~10,000 foot limitation from the central office
  - 24 Mbit/s downstream / 3.3 Mbit/s upstream

- VDSL (Very-high-bit-rate DSL)
  - 3 Mbit/s through 100 Mbit/s

Line-of-sight services

- Line-of-sight
  - Visual path between antennas
  - High frequencies
- Common in metropolitan areas
  - Cover many homes simultaneously
- Also options for non-line-of-sight
  - Lower frequencies
- WiMAX networking
  - Worldwide Interoperability for Microwave Access
  - Wireless high-speed Internet access

Current and Emerging Wireless Systems

Current

- Cellular Systems
  - 4G Cellular Systems (LTE-Advanced)
  - 5G Cellular
- 6G Wireless LANs/WiFi (802.11ax)
- Satellite Systems
- Bluetooth
- Zigbee
- Internet of Things

- What is WiGig ? Find out
- **Much room for innovation**

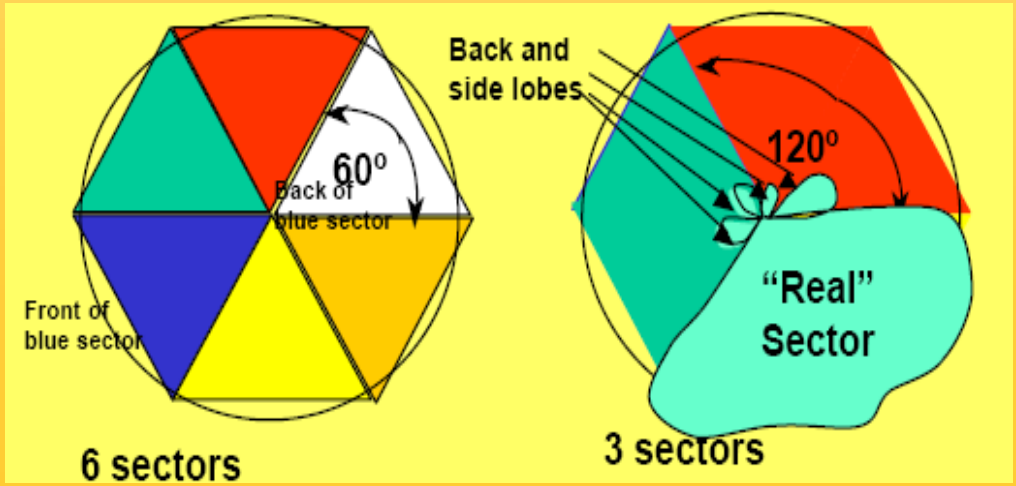
Emerging

- Green Communications
- Software-Defined (SD) Radio
- Cognitive Radio
- mmWave Massive MIMO
- Wireless Sensor Networks
  - AdHoc Networks
  - Self Organizing Networks
  - Distributed Control over Wireless
- LiFi
- Applications in Health, Biomedicine and Neuroscience
- Energy-Harvesting Systems
- WiGig

Introduction… Cont.

Benefits of cellular technology

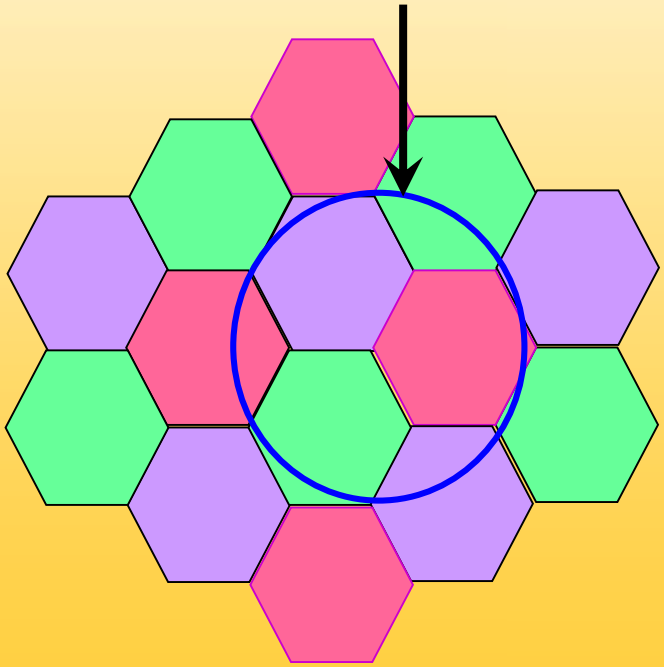
- Group of cells called cluster.
- Smaller cells = frequency reuse = more number of users
- As demand increases (more channels needed)
  - Number of base stations is increased (by reducing cell size)
  - Transmitter power is decreased correspondingly to avoid interference.
- Adjacent cells assigned different frequencies.
- The same frequency is reused in different areas.
- In GSM networks a frequency reuse with k = 3, 4, 7,12 or 21.



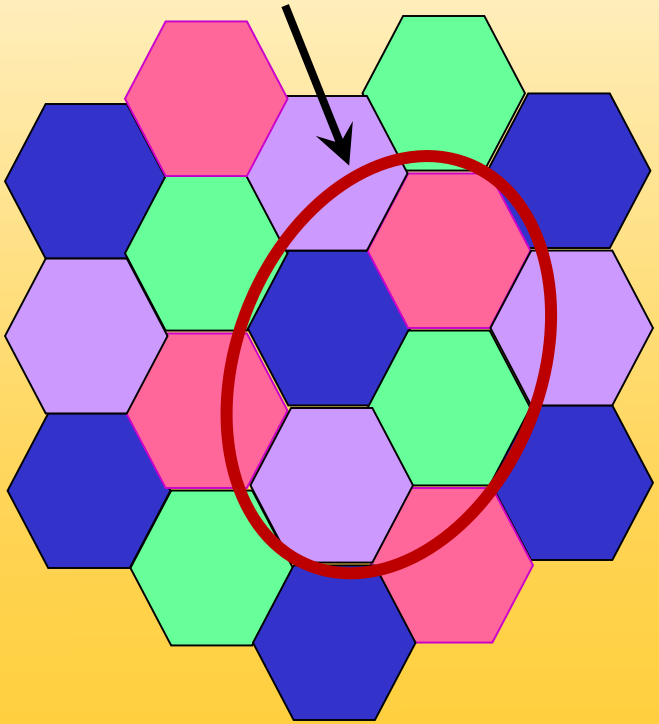
Introduction… Cont.

Frequency reuse:

>Reuse factor = 3



>Reuse factor = 4

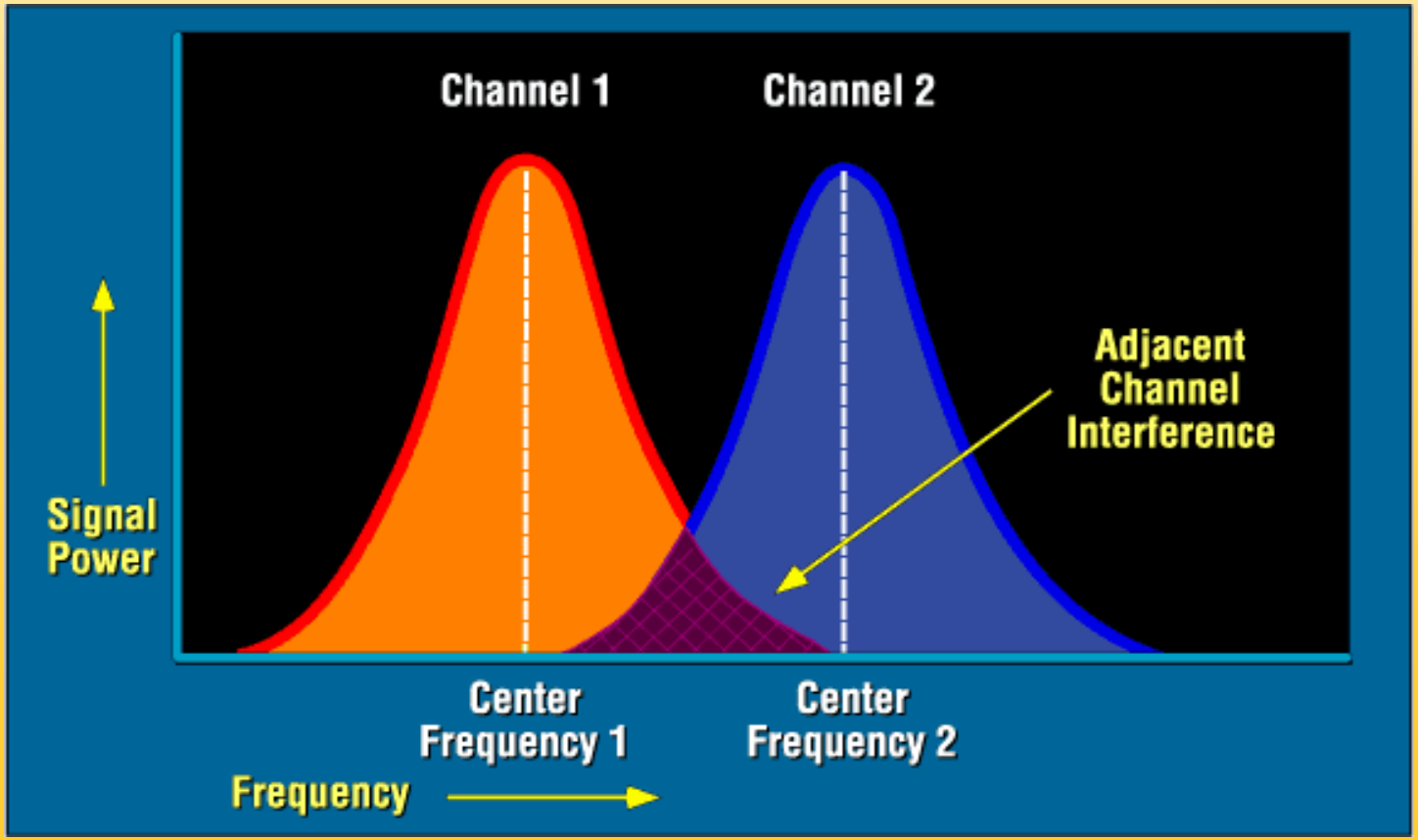


Handoff : It depends on signal strength (90dBm- 100dBm)
RSSI: Reduced signal strength indicator

Introduction… Cont.

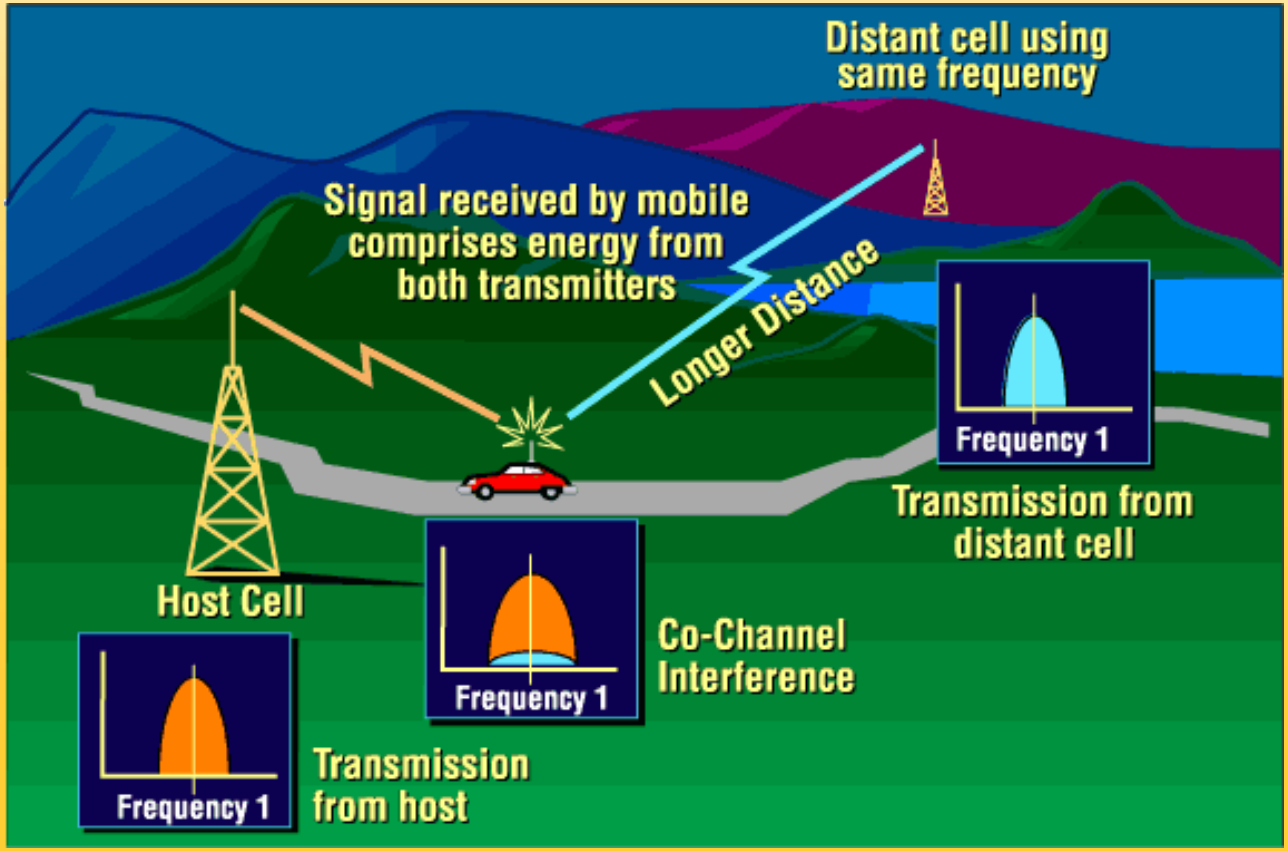
Frequency Reuse Problems:

1. Adjacent-Channel Interference: Comes from imperfect filters that allow frequency leakage into the band.



Introduction… Cont.

2. Co-Channel Interference: occurs when the same carrier frequency reaches the same receiver from two separate transmitters. Seperation distance is the solution.



Introduction… Cont.

Reasons for interference

Environmental factors:

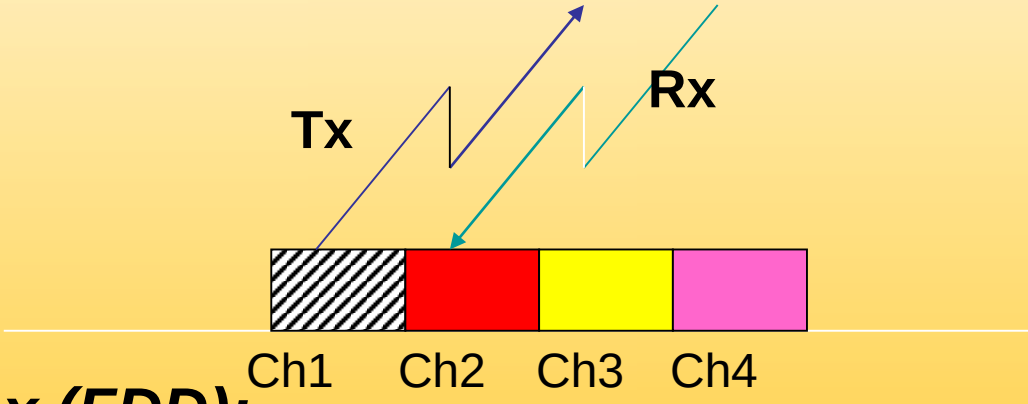
- Terrain (mountains, hills, plains, water bodies, etc.);
- The quantity, heights, distribution and materials of buildings;
- The vegetation and weather conditions;
- Natural and artificial electromagnetic noises;

Solution -Anti-interference:

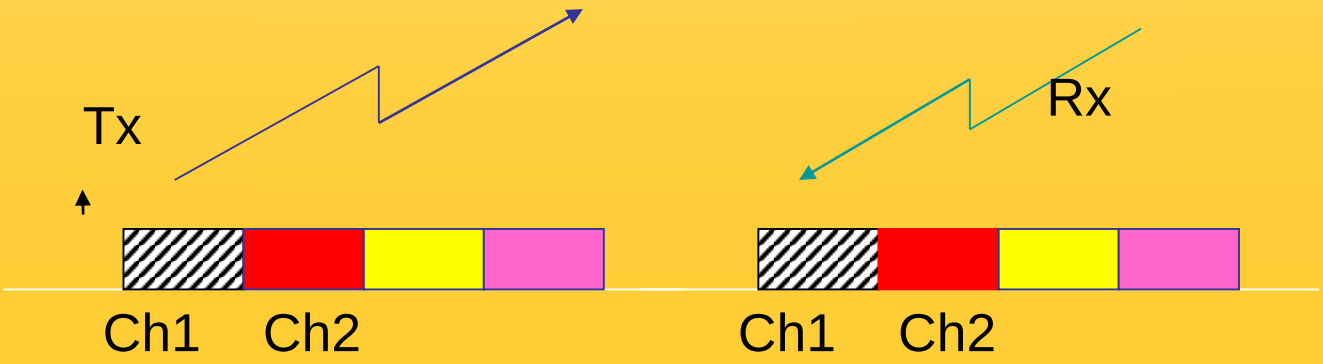
- ✓ Frequency Hopping Technology
- ✓ Dynamic power control (DPC)
- ✓ Discontinuous Transceiving (DTX)
- ✓ Diversity receiving technique

Introduction… Cont.

- ***Time Division Duplex (TDD):***
  - Transmit and receive using same set of channel

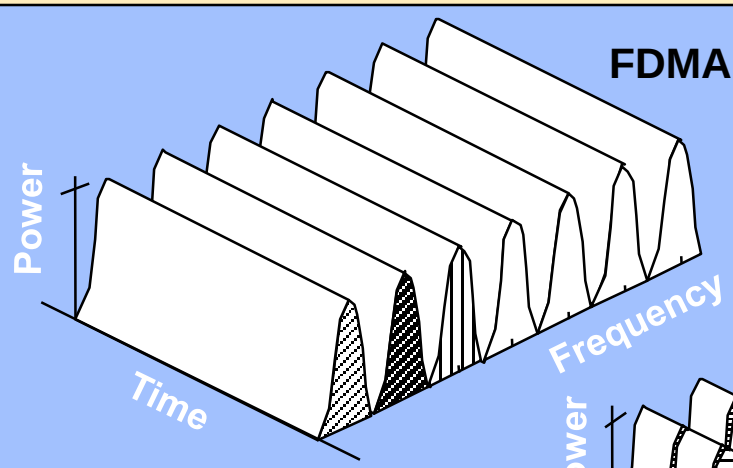


- ***Frequency Division Duplex (FDD):***
  - Transmit and receive using different set of channel.



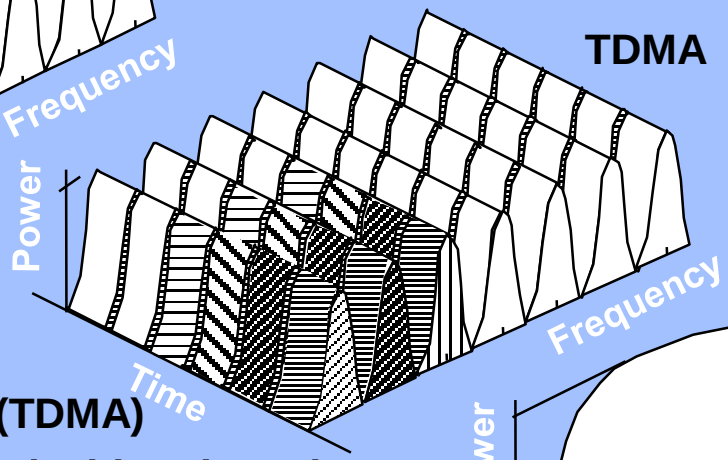
Introduction… Cont.

Fundamentals of Multiple Access Schemes



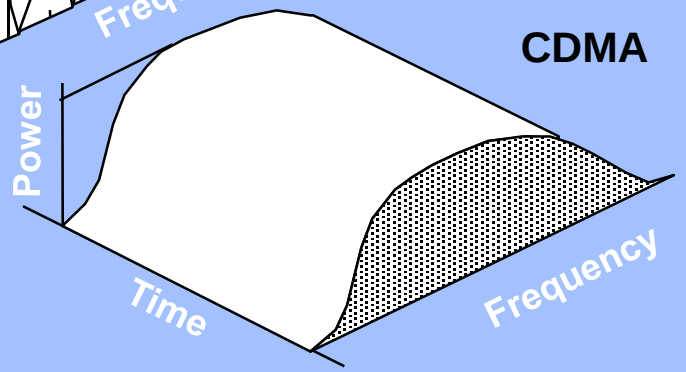
-Frequency Division Multiple Access (FDMA)

- **One channel per user.**
- **Used in analog system only.**



-Time Division Multiple Access (TDMA)

- **Example 3 users per channel with 3 time slot**
- **Used in Digital System**



Mobile Generations

1st Generation:
Introduced in 1980's.
Analog cellular mobile
Data speed 2.4kbps
Uses FDMA techniques with 30KHz .

2nd Generation :
First digital mobiles-1990's
Data support : 9.6-19.2Kbps
Used for voice transmission.
2.5G representing handsets with data capabilities over GPRS.

3rd Generation :
Introduced in 2000 by IMT-2000
3G is arrived Data rates are 128Kbps for mobile stations For fixed applications 2Mbps. Universal global roaming multimedia video calling accommodate web-based applications

4th Generation :
High-speed data access, 100Mb for Mobile and 1GB for Stationary.
High-quality video streaming
IMT-Advanced

5th Generation :
It is a packet based, High speed, high capacity, and low cost per bit. Support interactive multimedia, Scalability, voice, streaming video, Internet, more effective and more attractive.

Mobile Generations… Cont.

What is GSM ?

Global System for Mobile (GSM) is a second generation cellular standard developed for voice services and data delivery using digital modulation.

- Developed by Group Spéciale Mobile, which was an initiative of CEPT (Conference of European Post and Telecommunication)
- Presently the responsibility of GSM standardization resides with special mobile group under ETSI (European telecommunication Standards Institute)

• GSM 900 uses 25 MHz frequency spectrum with 124 channels Each channels have 200 KHz bandwidth. Each two channels are separated by 1.6 KHz guard band. Each channel have 8 time slots which allows 8 subscribers to use same frequency by TDMA.

GSM 900

Mobile to BTS (uplink): 890-915 Mhz

BTS to Mobile (downlink):935-960 Mhz

Bandwidth : 2* 25 Mhz

GSM 1800

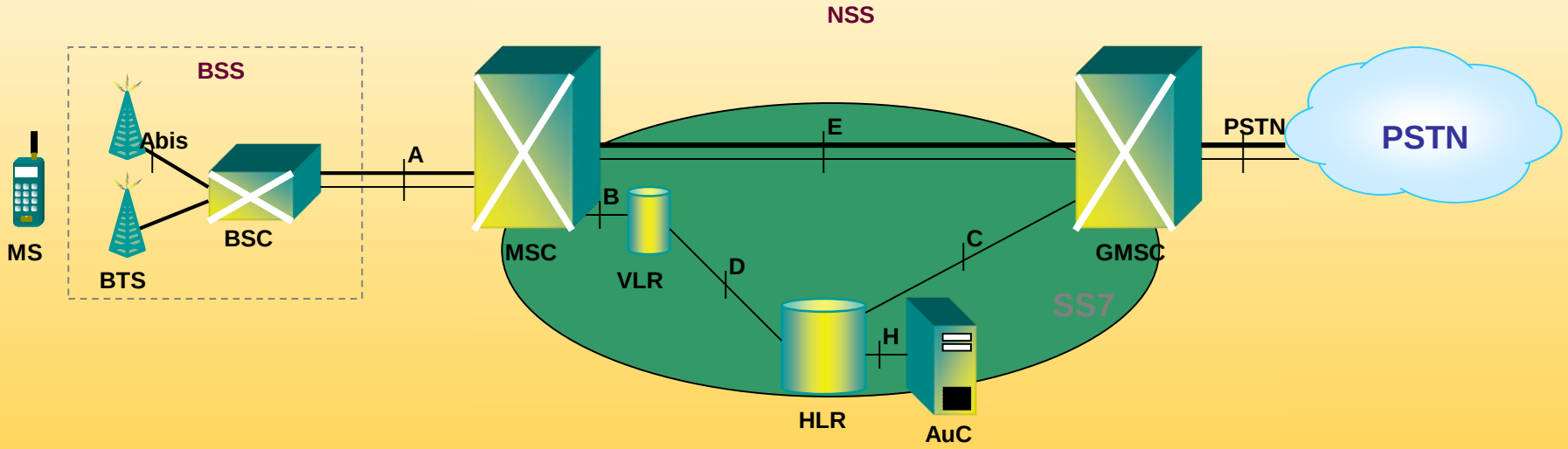
Mobile to BTS (uplink): 1710-1785 Mhz

BTS to Mobile(downlink) 1805-1880 Mhz

Bandwidth : 2* 75 Mhz

Mobile Generations… Cont.

GSM 2G Architecture



BSS — Base Station System

BTS — Base Transceiver Station

BSC — Base Station Controller

MS — Mobile Station

NSS — Network Sub-System

MSC — Mobile-service Switching Controller

VLR — Visitor Location Register

HLR — Home Location Register

AuC — Authentication Server

GMSC — Gateway MSC

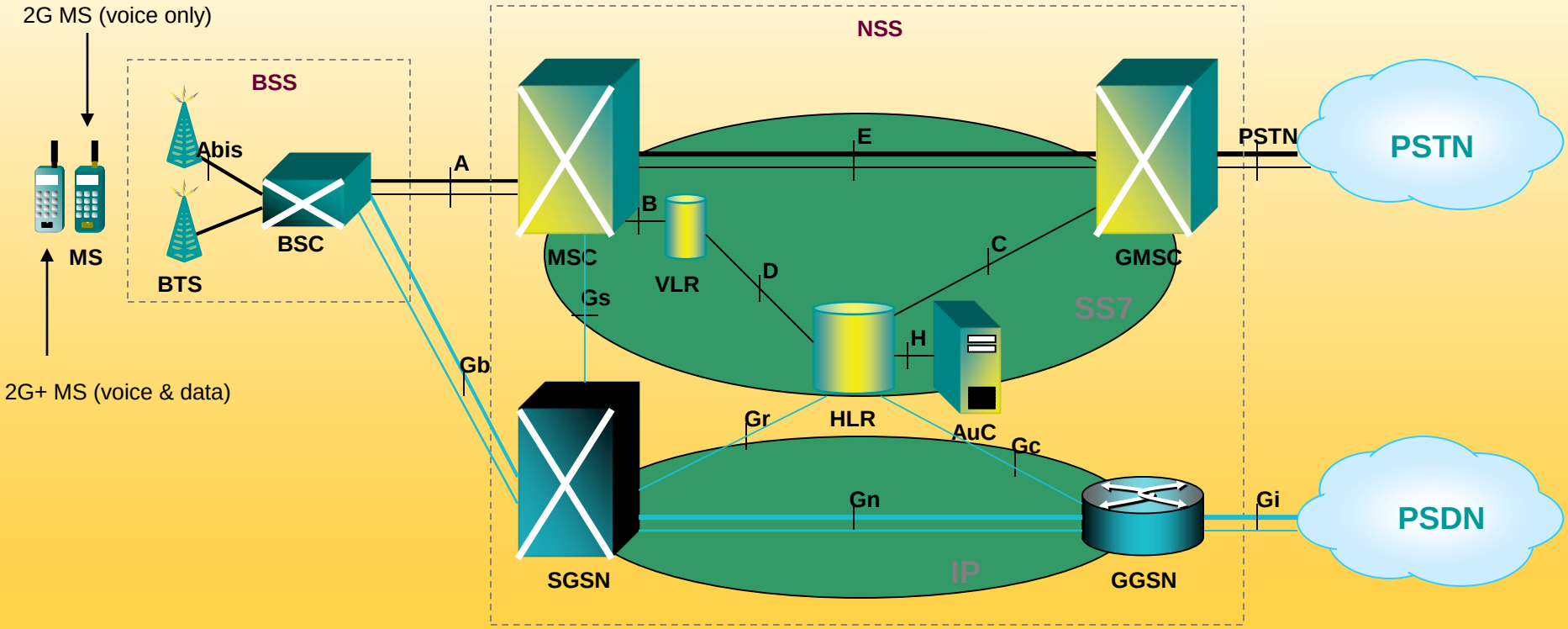
GSM — Global System for Mobile communication

Mobile Generations… Cont.

- 2.5 Generation (Future of GSM)
  - HSCSD (High Speed circuit Switched data)
    - Data rate : 76.8 Kbps (9.6 x 8 kbps)
  - GPRS (General Packet Radio service)
    - Data rate: 14.4 - 115.2 Kbps
  - EDGE (Enhanced data rate for GSM Evolution)
    - Data rate: 547.2 Kbps (max)

Mobile Generations… Cont.

2.5G Architectural Detail



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AuC — Authentication Server

GMSC — Gateway MSC

SGSN — Serving GPRS Support Node

GGSN — Gateway GPRS Support Node

GPRS — General Packet Radio Service

Mobile Generations… Cont.

GPRS features

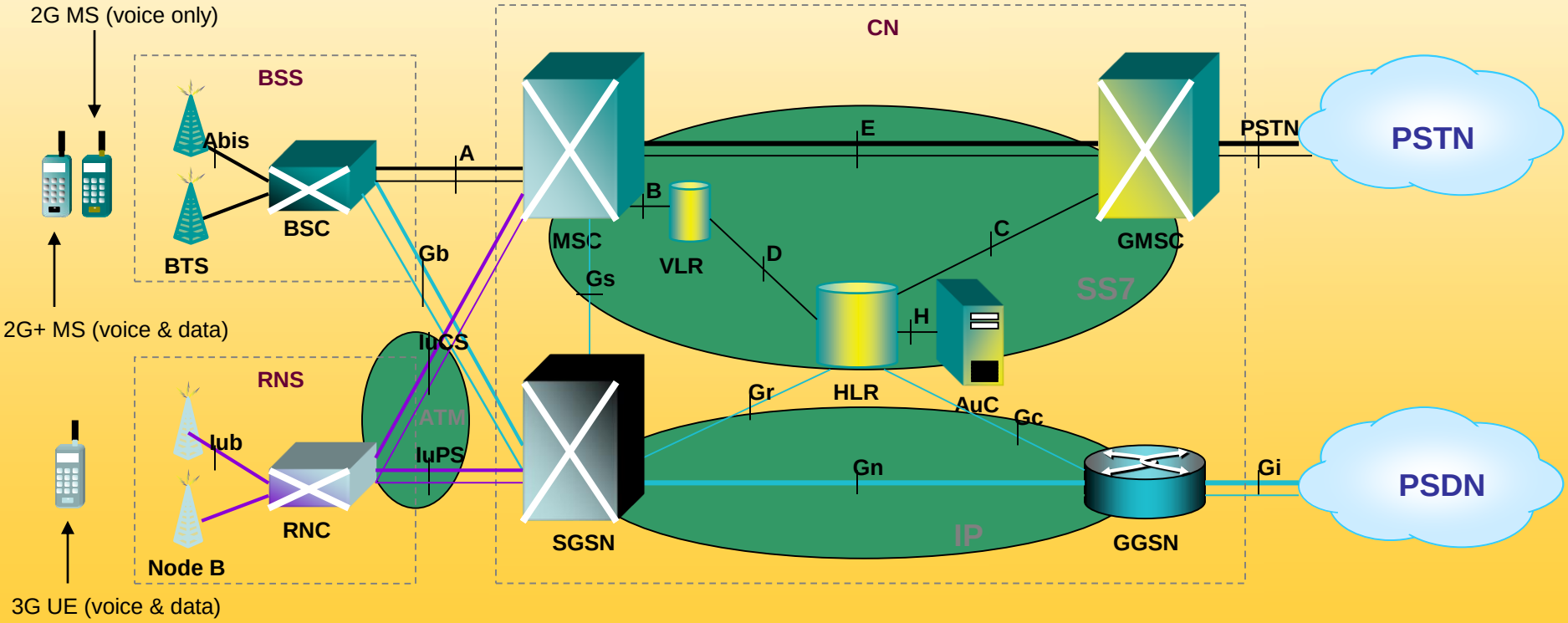
- Radio resources are allocated for only one or a few packets at a time, so GPRS enables:
  - many users to share radio resources, and allow efficient transport of packets
  - fast setup/access times
  - connectivity to external packet data networks
- GPRS also carries SMS in data channels rather than signaling channels as in GSM

EDGE

- Enhanced Data rates for Global Evolution
- Increased data rates with GSM compatibility
  - Still 200 KHz bands; still TDMA
  - 8-PSK modulation: 3 bits/symbol give 3X data rate
  - Shorter range (more sensitive to noise/interference)
  - New GSM/ EDGE radios but evolved ANSI-41 core network

Mobile Generations… Cont.

3G Architecture (UMTS) — *3G Radios*



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BTS — Base Transceiver Station

BSC — Base Station Controller

RNS — Radio Network System

RNC — Radio Network Controller

CN — Core Network

MSC — Mobile-service Switching Controller

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HLR — Home Location Register

AuC — Authentication Server

GMSC — Gateway MSC

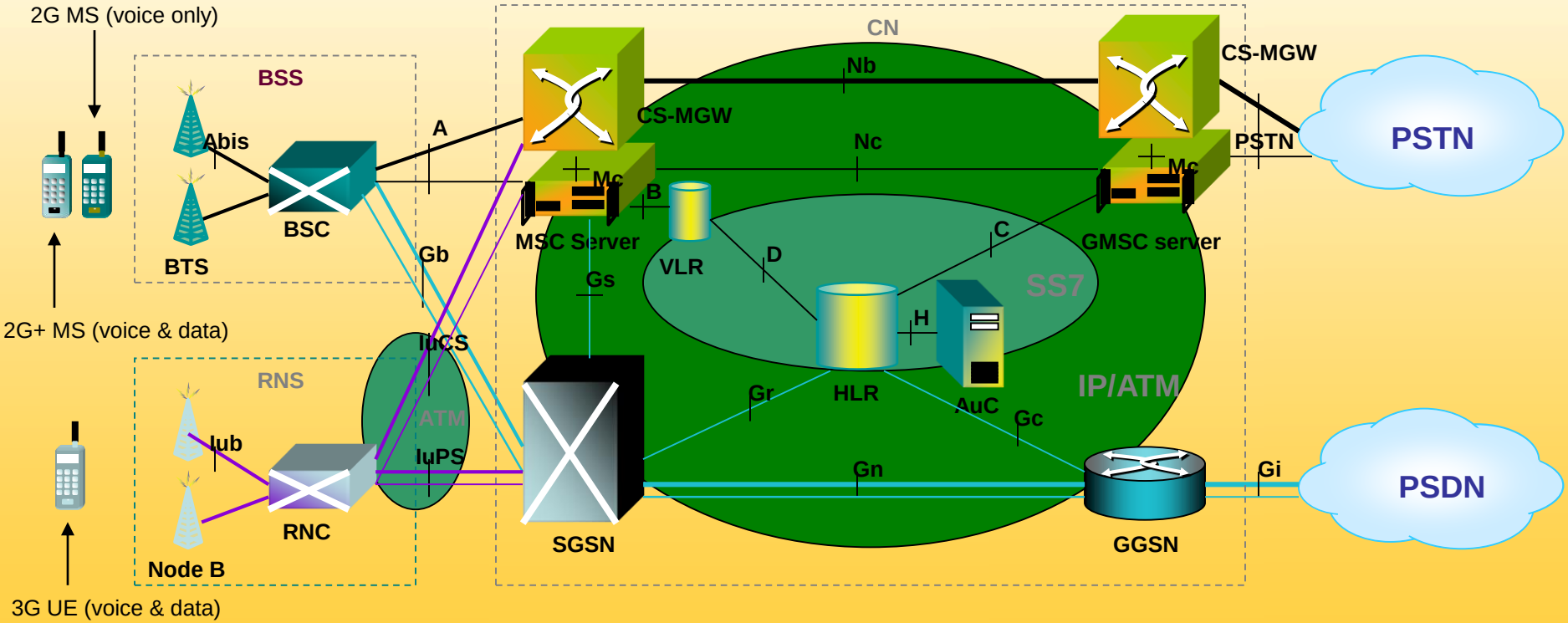
SGSN — Serving GPRS Support Node

GGSN — Gateway GPRS Support Node

UMTS — Universal Mobile Telecommunication System

Mobile Generations… Cont.

3G rel4 Architecture (UMTS) — *Soft Switching*



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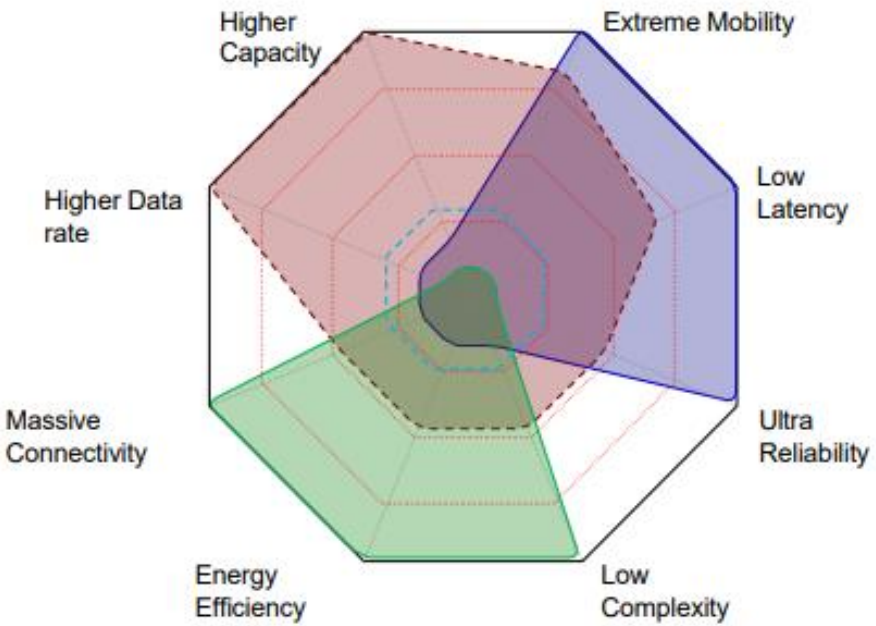
The 5G Cellular Networks

- Massive number of devices (things)
- Wide spatial existence
- Heterogenous types of devices and network elements
- High dynamic range of traffic
- Highly dynamic topology



Immersive Experience
1 Augmented reality
2 Online gaming
3 Video streaming

Instant Action
1 Public Safety
2 Autonomous Cars
3 Tactile Internet

Everything Connected
1- Internet of Things
2- Smart cities
3- Industrial automation

THANKS TO ALL