Briefing session

Wireless Network and Mobile Communication

BITS 3533

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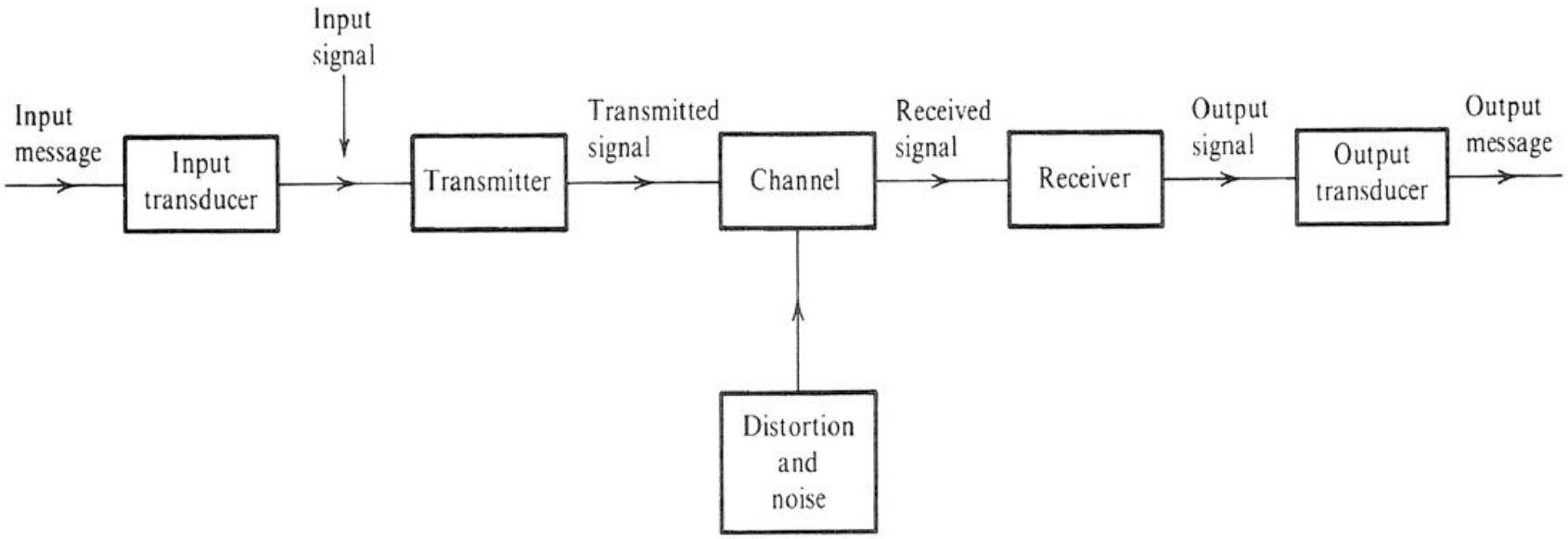
Evaluation

- Assignments 10% (1 x)
- Quiz 10% (2 x)
- Lab Assessment 20 % (5 x)
- Project 15% (1 x)
- Mid-term test 15%
- Final Exam 30%

Components of Communication System



Components of Communication System

- Source could be voice/picture/data that converted by an input transducer into a baseband/message signal (electrical waveform)
- Transmitter modifies the signal for efficient transmission. It consists of sampler, quantizer, coder and ect.
- Channel is a medium to transfer data from transmitter to receiver.
  - Wireline communication - coaxile cable, fiber optic
  - Wireless Communication - radio link, LED, bluetooth, infrared

Components of Communication System

- Receiver reprocessed the signal from the channel by undoing the signal modifications made at transmitter and the channel. Task of the receiver includes demodulator, decoder, filter ect.

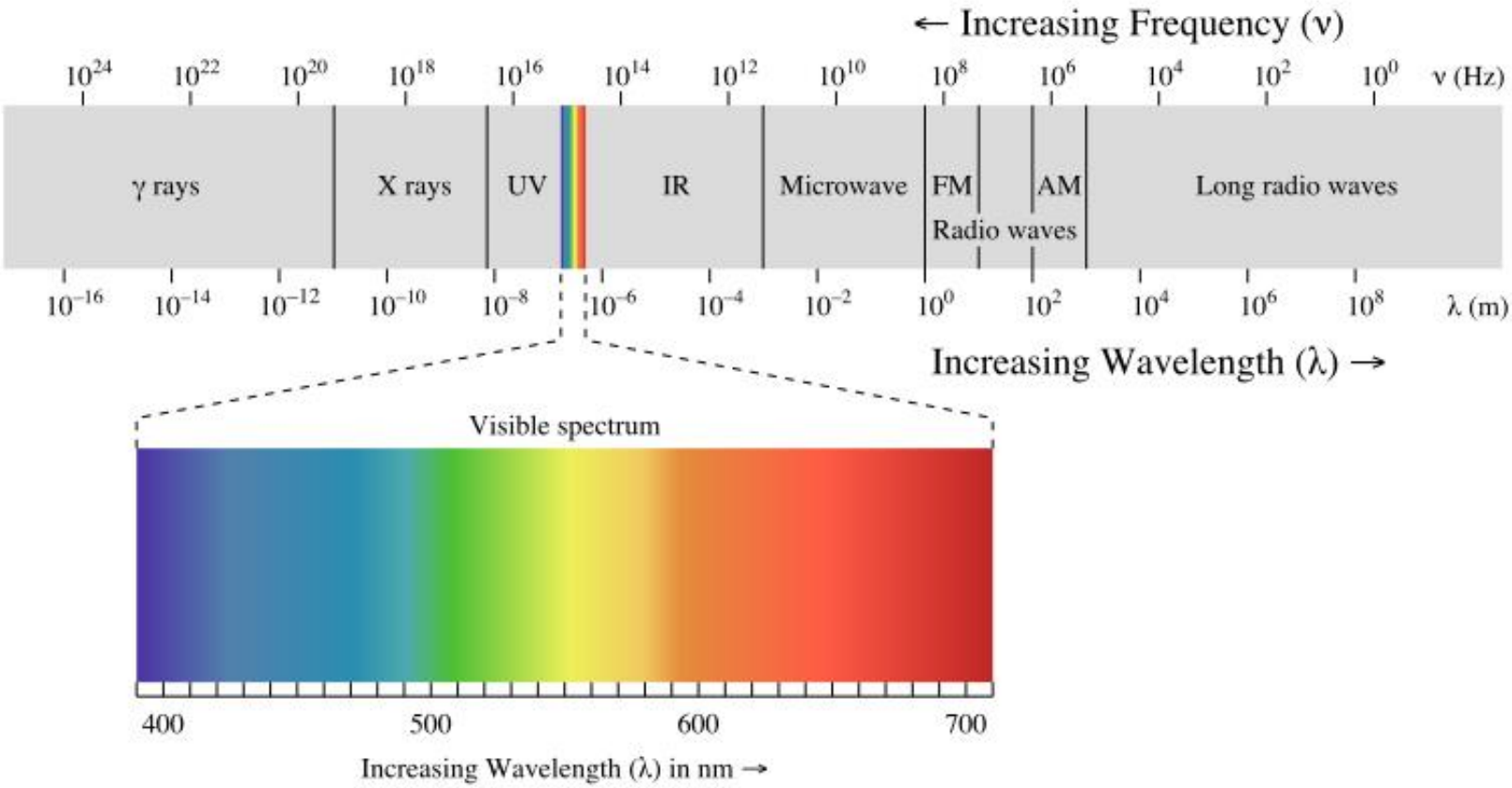
- The receiver output is fed to the output transducer, which converts the electrical signal to original form

- Transmitter and receivers are designed to overcome distortion and noise. Goal of communication – to transit information accurately and use spectrum efficiently

Wireless Communication

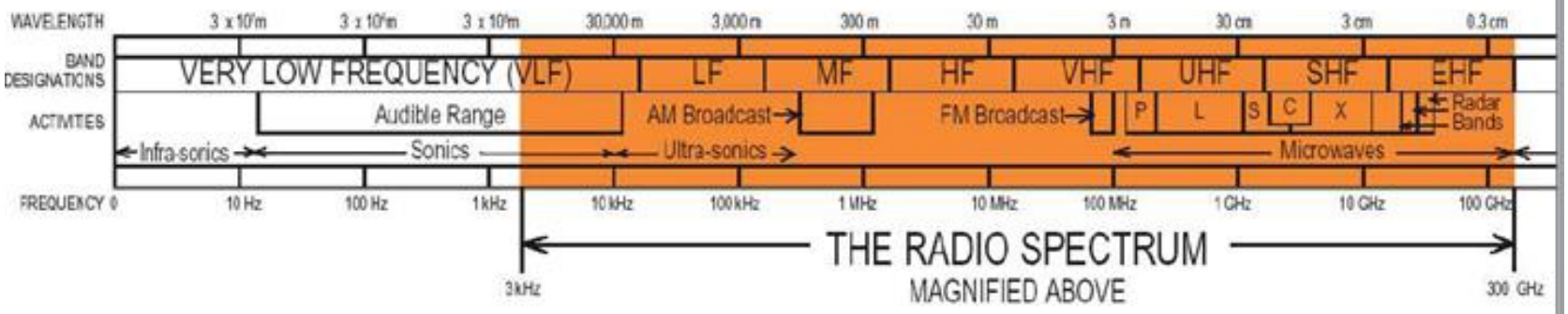
- Transmitting voice and data using electromagnetic waves in open space (atmosphere)
- Electromagnetic waves
  - Travel at speed of light ($c = 3x10^8$ m/s)
  - Has a frequency (f) and wavelength (λ)
    - $c = f \times \lambda$
  - Higher frequency means higher energy photons
  - The higher the energy photon the more penetrating is the radiation

Electromagnetic radiation spectrum



Radio Frequency

Radio Frequency is an electromagnetic signal with a frequency between 3 kHz and 300 Ghz



RF signals carry analog or digital information

- Analog: Information content varies continuously over time
  - *Example: radio and TV stations*
- Digital: Information content consists of discrete units (e.g., 0s and 1s)
  - *Example: Cell phones and wireless networks*

Types of Electromagnetic Carrier

- When the distance between the sender and receiver is short (e.g. TV box and a remote control) infrared waves are used
- for long range distances between sender and receiver (e.g. TV broadcasting and cellular service) both microwaves and radio waves are used

  - *Radio waves (*300 GHz to 3 kHz*)* are ideal when large areas need to be covered and obstacles exist in the transmission path
    - 3 Hz – 300 KHz - low frequency
    - 300 KHz – 30 MHz – high frequency
    - 30 MHz – 300 MHz – very high frequency
    - 300 MHz – 300 GHz – ultra high frequency

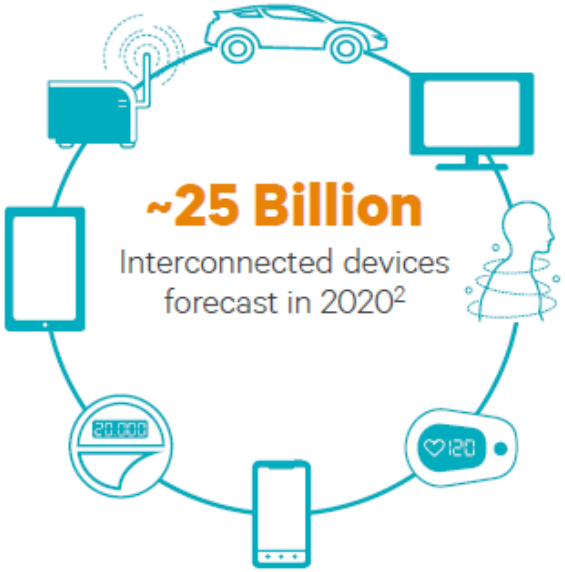
  - *Microwaves* (300GHz to 300MHz) are good when large areas need to be covered and no obstacles exist in the transmission path

Trend in Wireless Communication

Billions of Mobile Connections

~7 Billion

Mobile connections, almost as many as people on Earth[1]



~25 Billion

Interconnected devices forecast in 2020[2]

Billions of Mobile Experiences

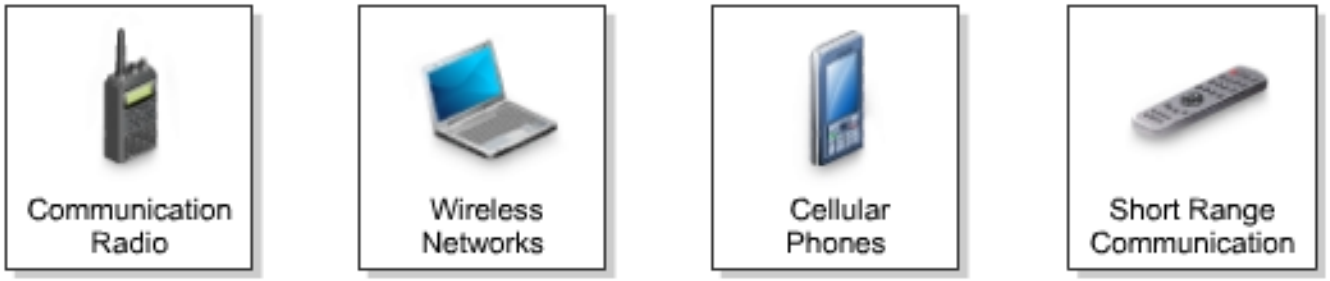
>100 Billion

App downloads completed in 2013[3]

~270 Billion

App downloads expected in 2017[3]

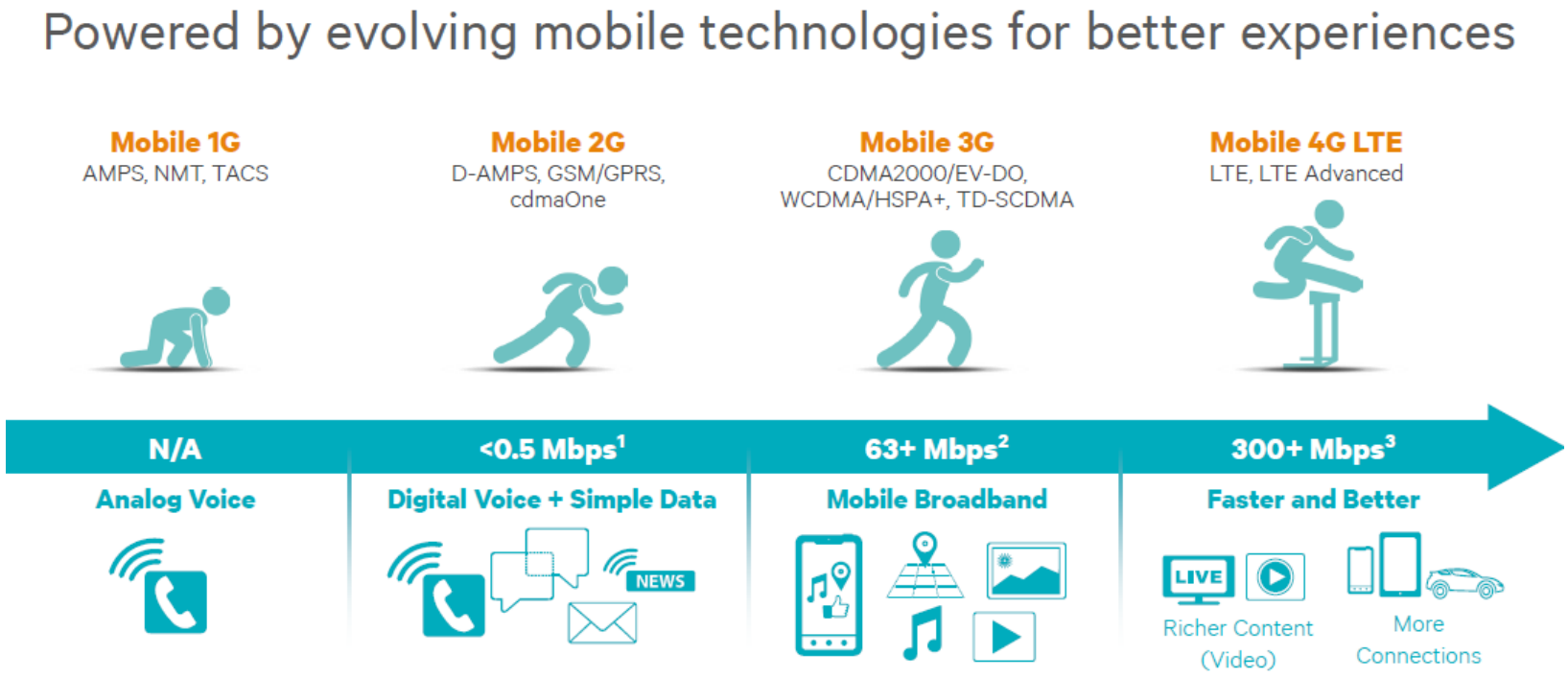
Wireless Application



- Communication radio – AM,FM
- Wireless network- WLAN, WiFi
- Cellular phone – UMTS, LTE. LTE-Advanced
- Short range communication - Bluetooth (2.45 GHz) , Zigbee, Infrared(430 THz-300 GHz, 700nm-1mm)

Cellular Communication

- Evolution of cellular communcation- 1G to 5G



Evolution from 1G to 5Gc

Mobile 4G LTE is evolving to provide more data capacity

Delivering faster and better mobile broadband experiences

Mobile 1G
AMPS, NMT, TACS

Foundation of Mobile
Seamless Mobility

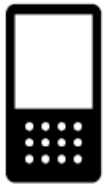
Mobile 2G
D-AMPS, GSM/GPRS, cdmaOne

Mobile for the Masses
More Voice Capacity

Mobile 3G
CDMA2000/EV-DO, WCDMA/HSPA+, TD-SCDMA

Mobile Broadband
Data Optimized

3GPP
A GLOBAL INITIATIVE
3G 3RD GENERATION PARTNERSHIP PROJECT 2 "3GPP2"

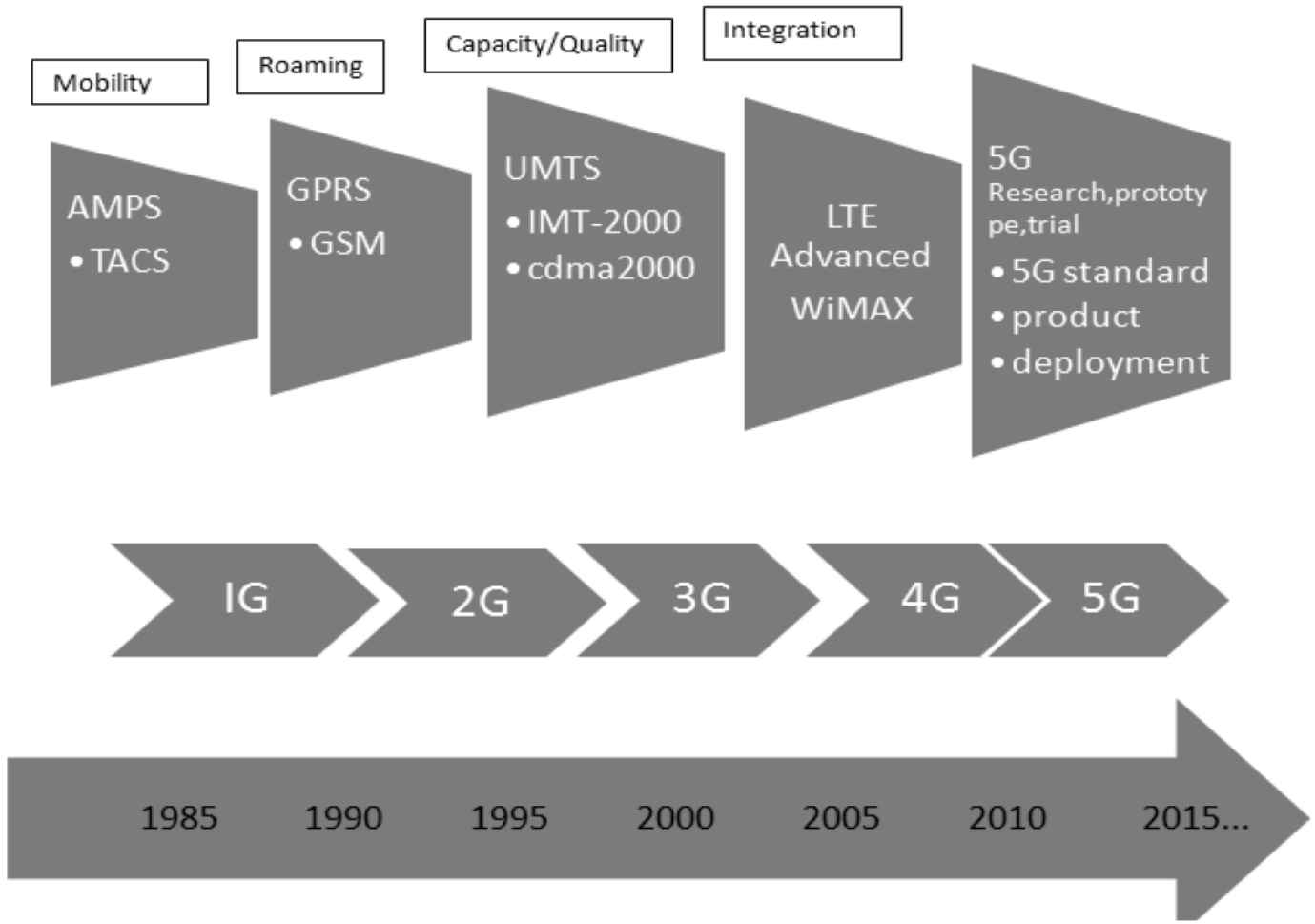


Mobile 4G LTE
LTE, LTE Advanced

Faster and Better Mobile Broadband
More Data Capacity

1980s 1990s 2000s 2010s

Evolution from 1G to 5G



1G cellular communication system

- Appeared in late 1970s and deployed in early 1980s.
- All based on analog techniques, all used FDMA and FM modulation.
- System capacity is low. Data rate: 8~10 kbps
- Representative Standards:
  - **AMPS:** Advanced Mobile Phone System, developed by AT&T Bell Labs in late 1970s. First deployed in 1983. The first AMPS system **used large cells and omni-directional base station antennas, therefore, the number of users that can be supported was quite limited.** AMPS is used all over the world and is esp. popular in US, South America, China and Australia.
  - **ETACS:** European Total Access Communication Systems. Almost identical to AMPS except that the channel bandwidth is scaled to 25kHz instead of 30 kHz as in AMPS.

2G cellular communication system

- Deployed in mid 1990s, 2G wireless systems all use digital voice coding and digital modulation.
- Can provide advanced call capabilities and at least a 3-times increase in overall system capacity.
- Was designed before the widespread of the Internet, mainly supported voice-centric services and limited date-service, like short messages, FAX,etc.
- Date rate: on the order of 10 kbps

2G cellular communication system

- **GSM** (Global Systems for Mobile communications)
  - A TDMA system, serves as the pan-European cellular service, provides a wide range of network service, including phone service, FAX, short message service. Support 24.7kbps data rate.
- **USDC IS-136** (United States Digital Cellular)
  - A TDMA system which is compatible with AMPS, it supports more users (6 times) with improved performance. It shares the same frequencies, frequency reuse plan and base stations as AMPS. Provides access to VPN, supports short messages. Support 48.6kbps data rate.
- **IS-95** (United States Digital Cellular Standard)
  - A CDMA standard also designed to be compatible with AMPS through using of CDMA/AMPS dual mode phones and base stations. Capacity is 8~10 times that of AMPS. Support 14.4kbps data rate.

2.5G cellular communication system

Compared to 2G systems, 2.5G systems enables high speed data communications, provides continuous connection to internet.

- **CDPD** (Cellular Digital Packet Data), a data service for 1st and 2nd generation US cellular systems without additional bandwidth requirement, packet channels are dynamically assigned to idle voice channels. Support 48.6kbps data rate as in IS-136.
- **GPRS** (General Packet Radio Service), based on GSM by allowing multiple slots of a GSM radio channel be dedicated to an individual user, promises data rate from 56 kbps to 114kbps--- continuous connection to the Internet for mobile phone and computer users, easy access to VPN (Virtual Private Network).
- **EDGE** (Enhanced Data Rates for GSM Evolution), providing 384kbps rate by using improved modulation (8-PSK instead of GMSK in GSM) and relaxed error control. Also referred to as EGPRS.
- **CDMA one (IS-95B)**: Providing high speed data access on a common CDMA radio channel by dedicating multiple orthogonal user channels for specific users or specific purposes. Support 115.2kbps.

3G cellular communication system

- **3GPP UMTS** (Universal Mobile Telecommunications System) A wideband CDMA (5MHz) standard based on the network fundamentals of GSM/EDGE, is designed to provide backward compatibility with GSM, IS-136, GPRS and EDGE. Can support 2Mbps data rate. New RF equipment needed.

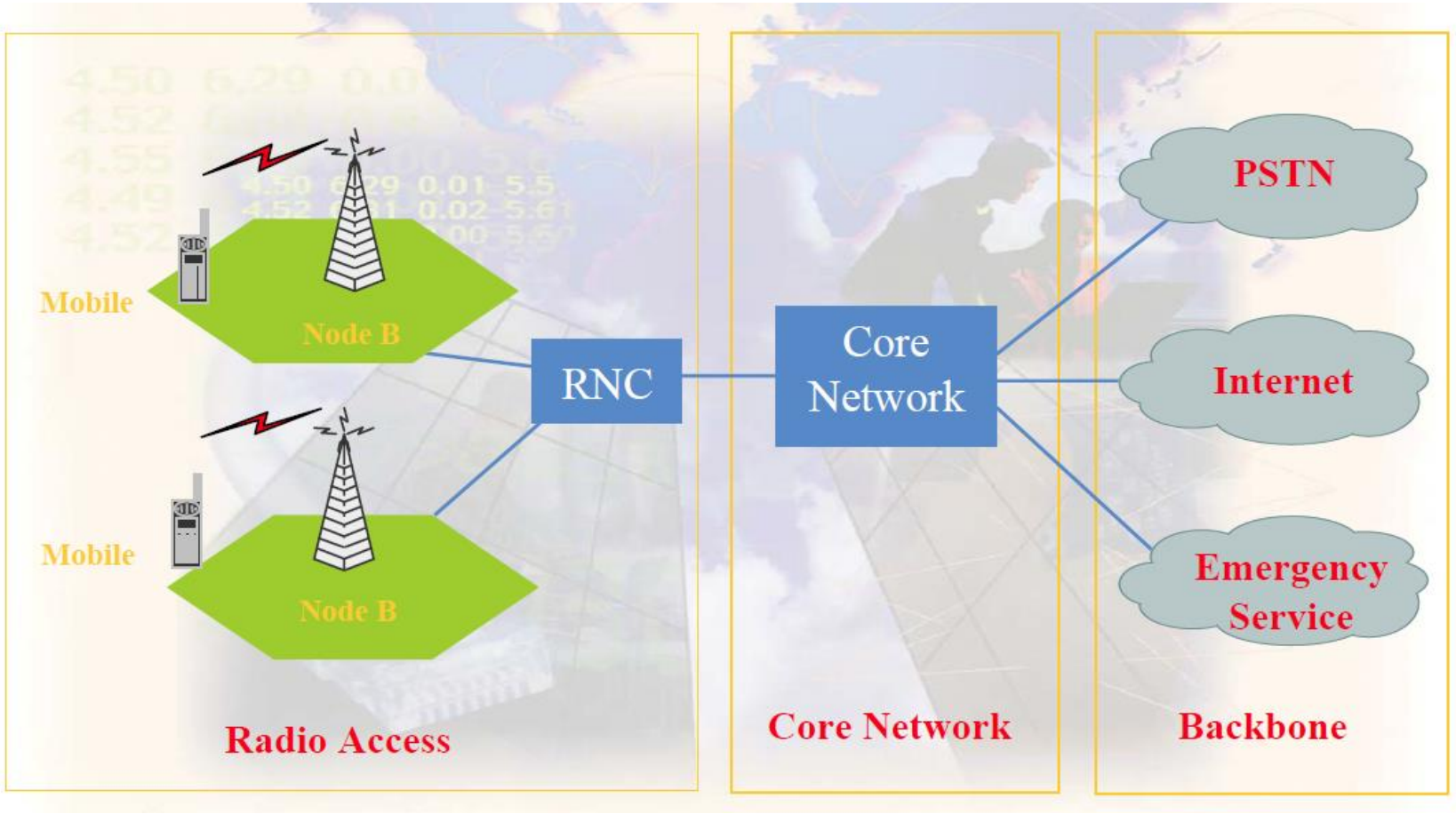
- **3GPP2 CDMA 2000 3G 1X-3X** Use one (same bandwidth as IS-95) or three adjacent 1.25MHz channels (3-times bandwidth as that of IS-95) to provide instantaneous packet data access at 144kbps or 2Mbps. No additional RF equipment needed, changes are all made in software or baseband hardware.

- **TD-SCDMA** (Time-division Synchronous CDMA) A standard proposed by CATT (China Academy and Telecommunications Technology) and Siemens Corporation. Relies on the existing GSM infrastructure and allows 3G data access by adding high data rate equipment (smart antennas) at each GSM station. Support up to 384kbps of packet data.

4G cellular communication system

- **4G**, the planned successor to the 3G standard. The peak speed for the 4G standard are to be 100Mbps for a mobile connection and 1Gbps for stationary connections
- 4G services that meet these requirements are not publically available yet (as of June 2011) but telecommunications providers are looking to upgrade their infrastructure to cater for 4G services in the not too distant future.
- The 4G service is set to offer a fast and secure all-IP, roaming mobile broadband solution to devices such as laptops with wireless 4G modems, 4G smartphone mobile phones and other 4G mobile devices that require internet access with speed intensive facilities being made available, including on-demand HD television, IP telephony, on-demand gaming and, of course, high speed internet access.

Cellular System Architecture



Advantages and Disadvantages of Wireless Communication

- advantages:
  - mobility
  - a wireless communication network is a solution in areas where cables are impossible to install (e.g. hazardous areas, long distances etc.)
  - easier to maintain
- disadvantages:
  - has security vulnerabilities
  - high costs for setting the infrastructure
  - unlike wired comm., wireless comm. is influenced by physical obstructions, climatic conditions, interference from other wireless devices