INTEGRATED TECHNICAL EDUCATION CLUSTER
AT ALAMEERIA

E-716-A
Mobile Communications Systems

Lecture #9
3G & 4G Mobile Systems

Instructor:

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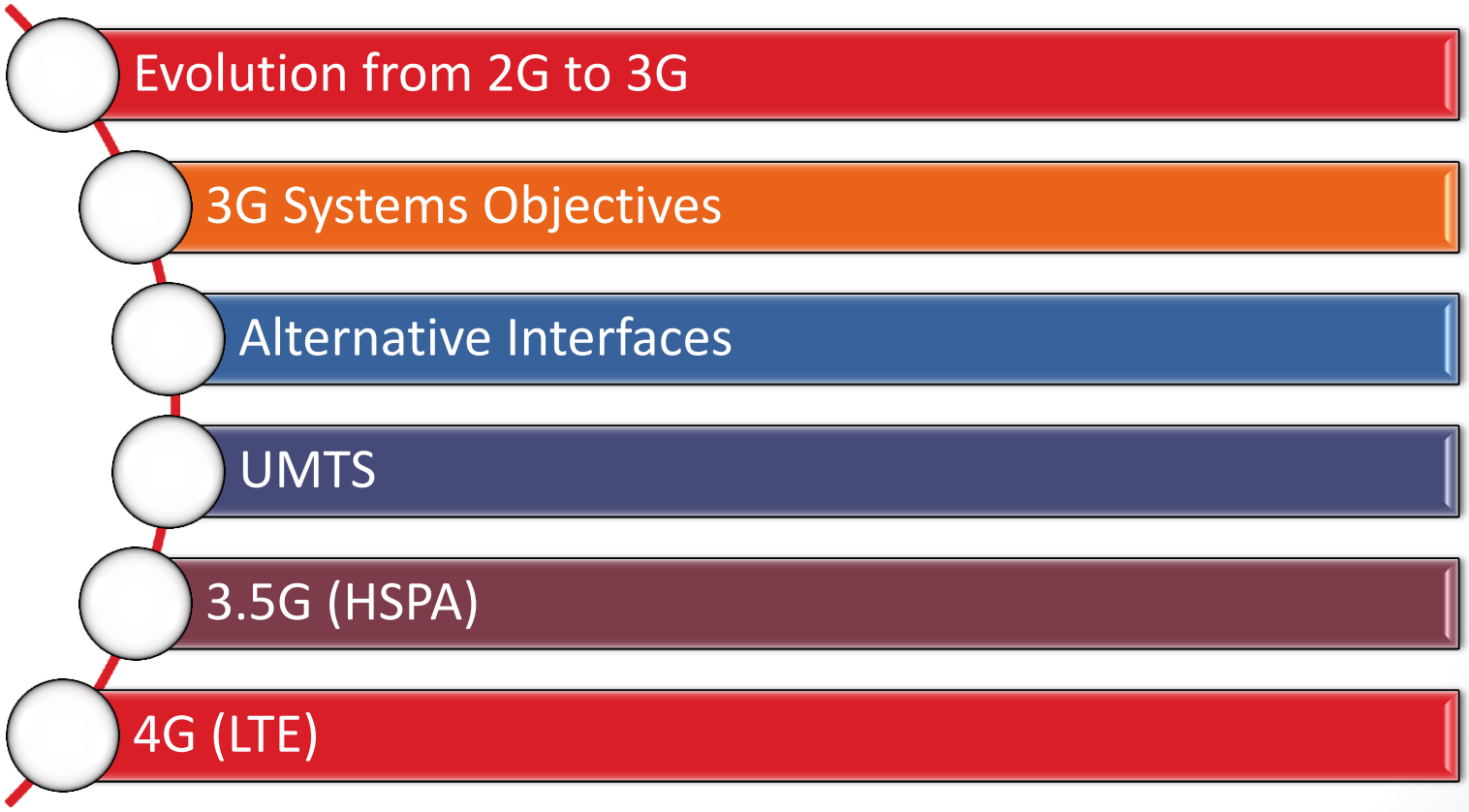
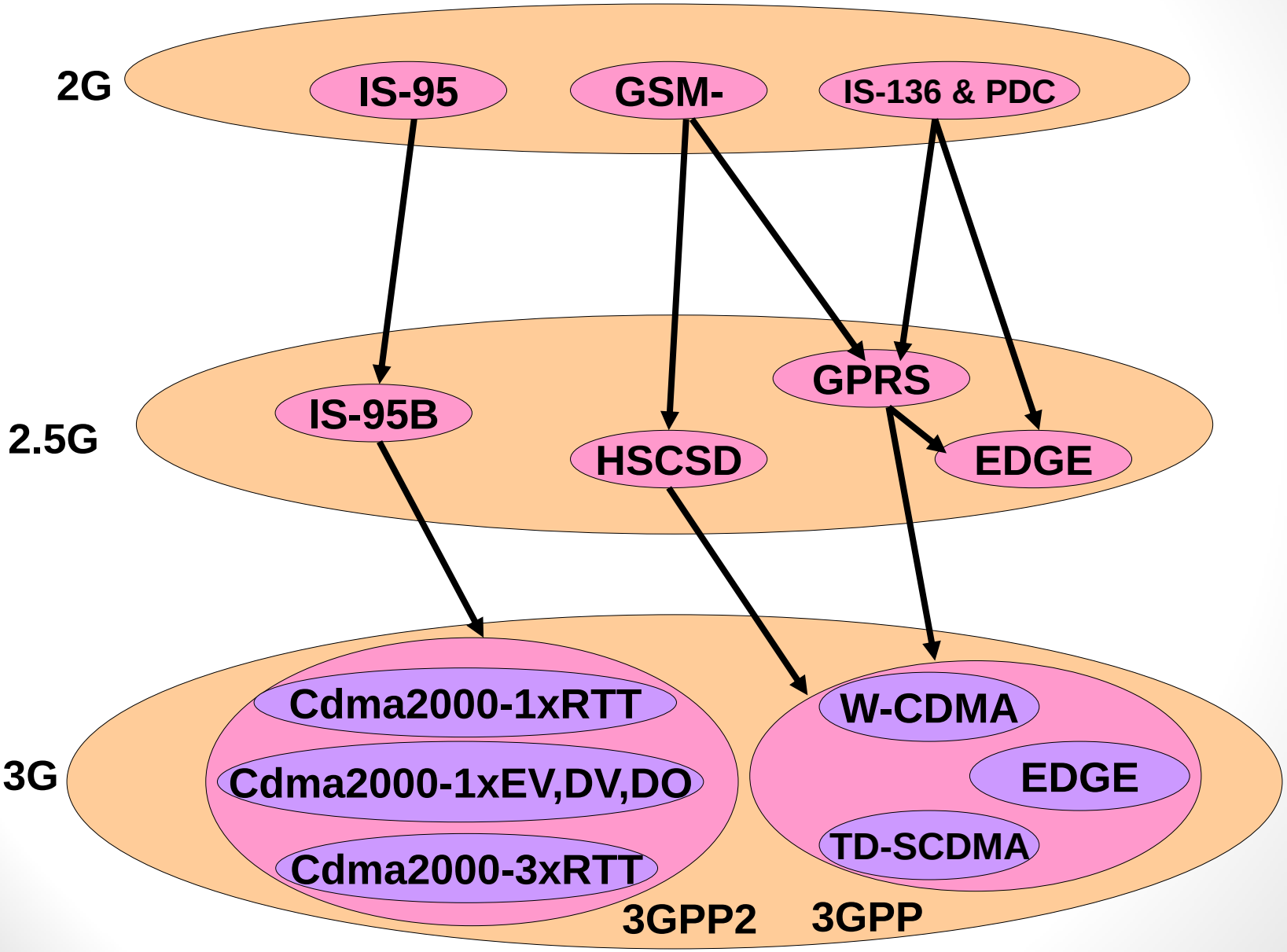
Ok, let’s change !

Agenda



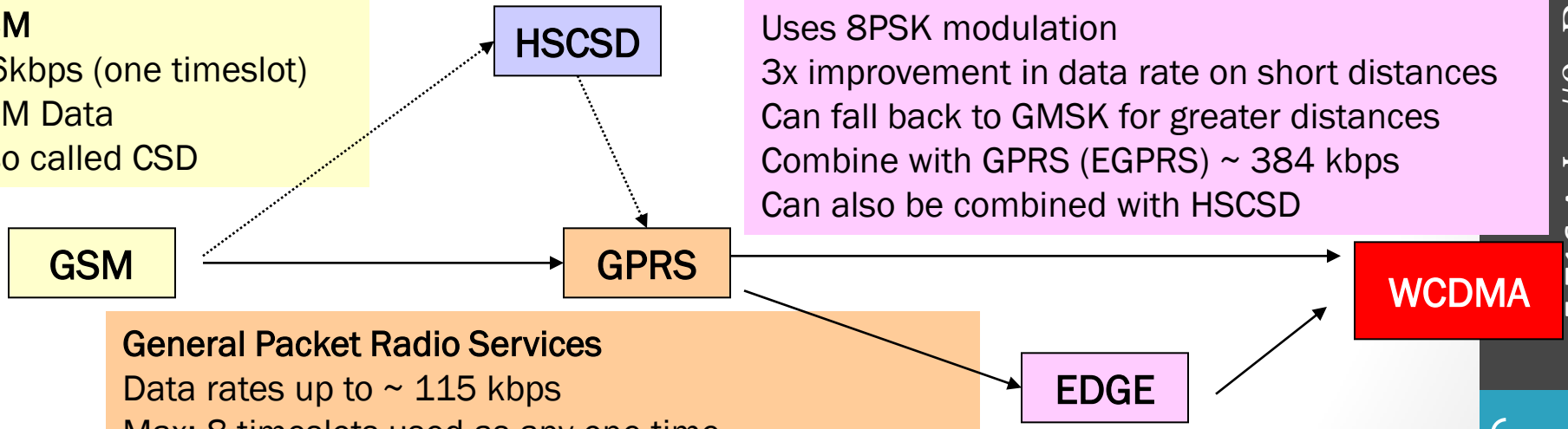
Evolution from 2G



GSM to 3G

High Speed Circuit Switched Data
Dedicate up to 4 timeslots for data connection ~ 50 kbps
Good for real-time applications c.w. GPRS
Inefficient -> ties up resources, even when nothing sent
Not as popular as GPRS (many skipping HSCSD)

GSM
9.6kbps (one timeslot)
GSM Data
Also called CSD



Enhanced Data Rates for Global Evolution
Uses 8PSK modulation
3x improvement in data rate on short distances
Can fall back to GMSK for greater distances
Combine with GPRS (EGPRS) ~ 384 kbps
Can also be combined with HSCSD

General Packet Radio Services
Data rates up to ~ 115 kbps
Max: 8 timeslots used as any one time
Packet switched; resources not tied up all the time
Contention based. Efficient, but variable delays
GSM / GPRS core network re-used by WCDMA (3G)

3G Systems Objectives

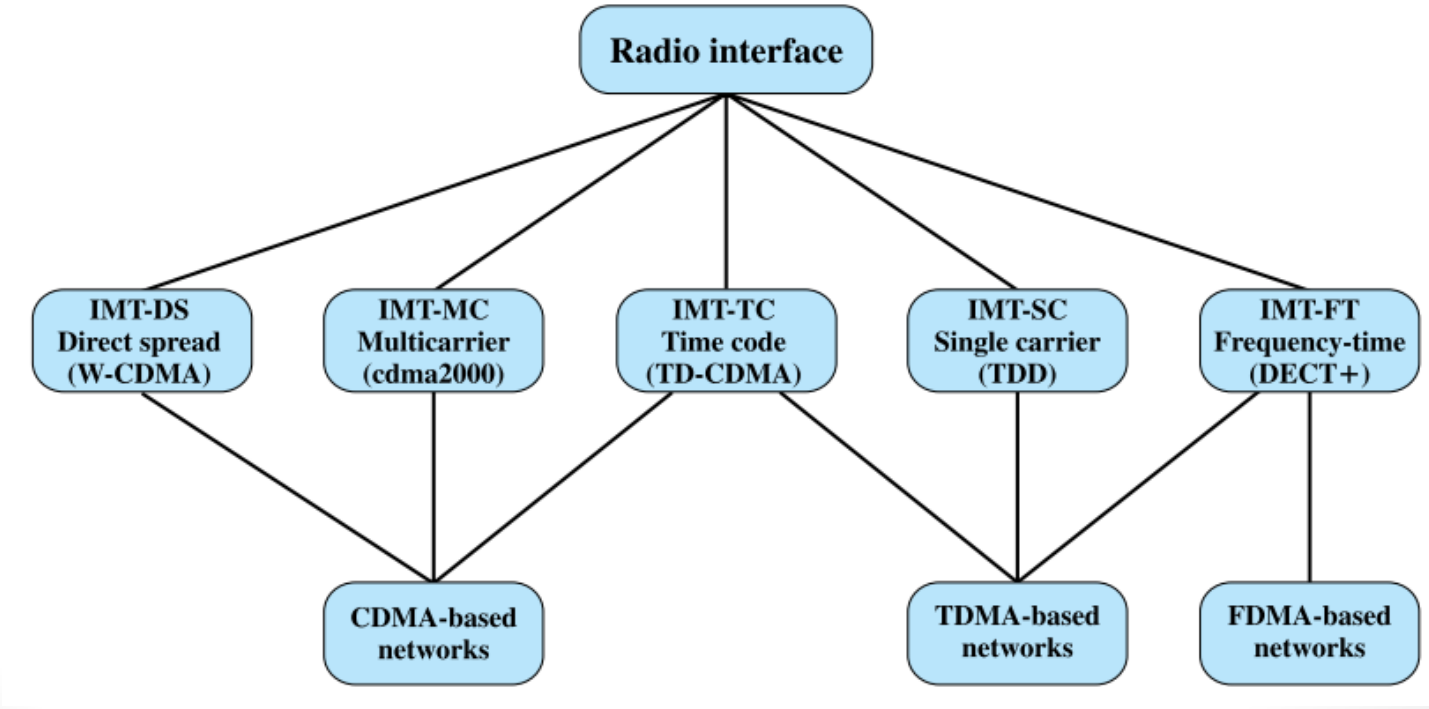
- Objective to provide fairly high-speed wireless communications to support multimedia, data, and video in addition to voice
- ITU's International Mobile Telecommunications for the year 2000 (IMT-2000) initiative defined ITU's view of third-generation capabilities as:
  - Voice quality comparable to PSTN
  - 144 kbps available to users in vehicles over large areas
  - 384 kbps available to pedestrians over small areas
  - Support for 2.048 Mbps for office use
  - Symmetrical and asymmetrical data rates
  - Support for packet-switched and circuit-switched services
  - Adaptive interface to Internet
  - More efficient use of available spectrum
  - Support for variety of mobile equipment
  - Flexibility to allow introduction of new services and technologies

Driving Forces

- Trend toward universal personal telecommunications
  - Ability of person to identify himself and use any communication system in globally, in terms of single account
- Universal communications access
  - Using one's terminal in a wide variety of environments to connect to information services
  - e.g. portable terminal that will work in office, street, and planes equally well
- GSM cellular telephony with subscriber identity module, is step towards goals
- Personal communications services (PCSs) and personal communication networks (PCNs) also form objectives for third-generation wireless
- Technology is digital using time division multiple access or code-division multiple access
- PCS handsets low power, small and light

Alternative Interfaces

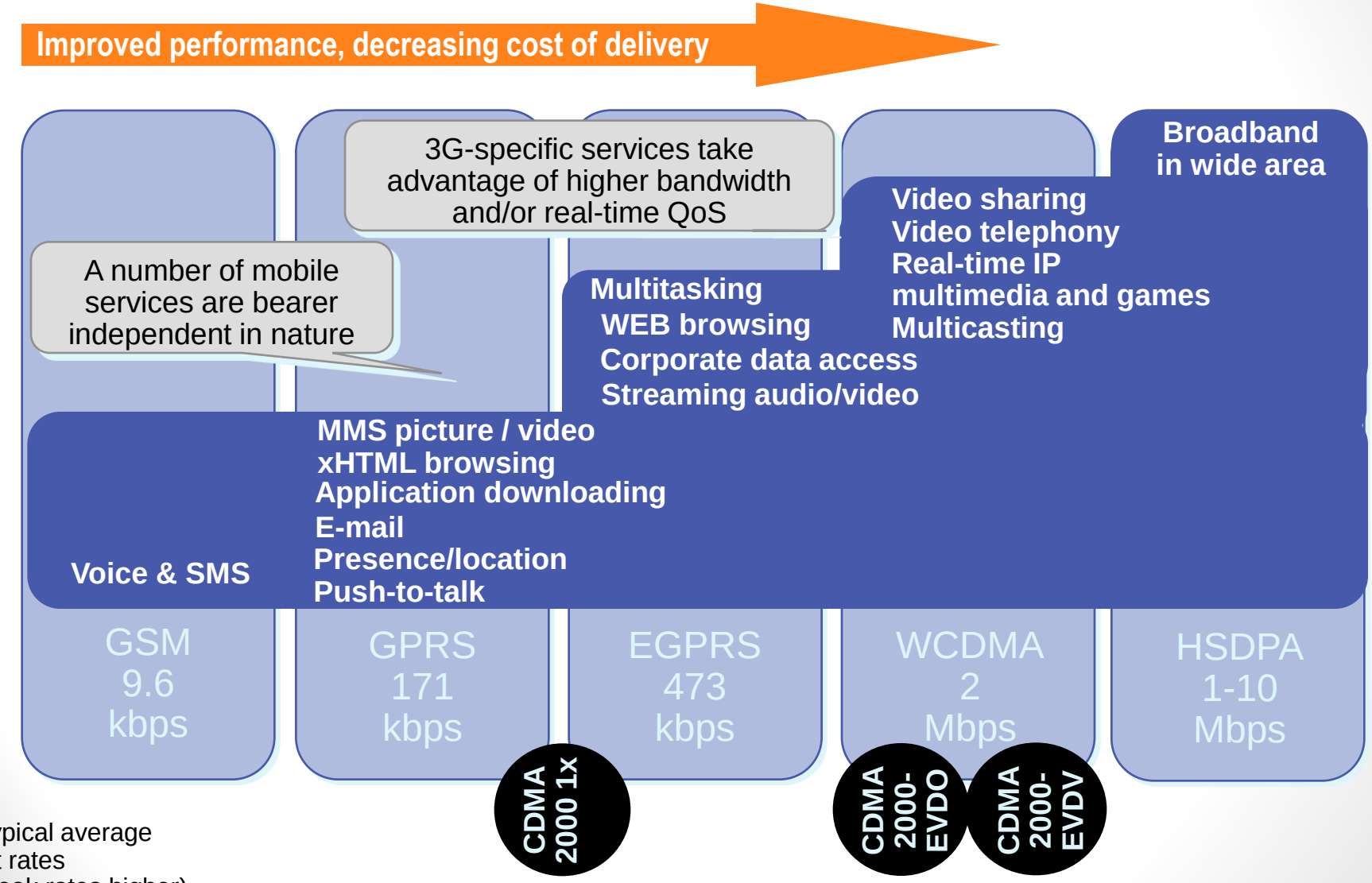
- IMT-2000 specification covers set of radio interfaces for optimized performance in different radio environments
- Five alternatives to enable smooth evolution from existing systems
- Alternatives reflect evolution from second generation



Alternative Interfaces..

- Two specifications grow out of work at European Telecommunications Standards Institute (ETSI)
  - Develop a UMTS (universal mobile telecommunications system) as Europe's 3G wireless standard
  - Includes two standards
    - Wideband CDMA, or W-CDMA
      - Fully exploits CDMA technology
      - Provides high data rates with efficient use of bandwidth
    - IMT-TC, or TD-CDMA
      - Combination of W-CDMA and TDMA technology
      - Intended to provide upgrade path for TDMA-based GSM systems
- CDMA2000
  - North American origin
  - Similar to, but incompatible with, W-CDMA
    - In part because standards use different chip rates
    - Also, cdma2000 uses multicarrier, not used with W-CDMA
- IMT-SC designed for TDMA-only networks
- IMT-FC can be used by both TDMA and FDMA carriers
  - To provide some 3G services
  - Outgrowth of Digital European Cordless Telecommunications (DECT) standard

Service Roadmap



Typical average bit rates (peak rates higher)

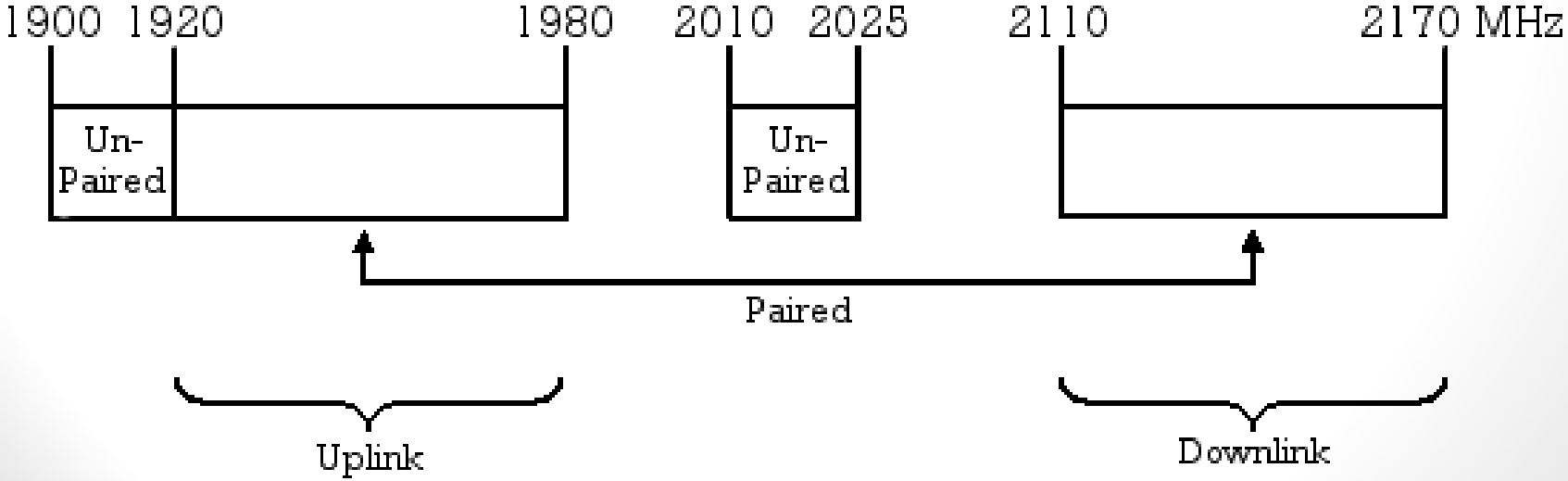
UMTS

- Universal Mobile Telecommunications System (UMTS)
- UMTS is an upgrade from GSM via GPRS or EDGE
- The standardization work for UMTS is carried out by Third Generation Partnership Project (3GPP)
- Data rates of UMTS are:
  - 144 kbps for rural
  - 384 kbps for urban outdoor
  - 2048 kbps for indoor and low range outdoor
- Virtual Home Environment (VHE)

  (VHE) is the concept that a network supporting mobile users should provide them the same computing environment on the road that they have in their home or corporate computing environment.

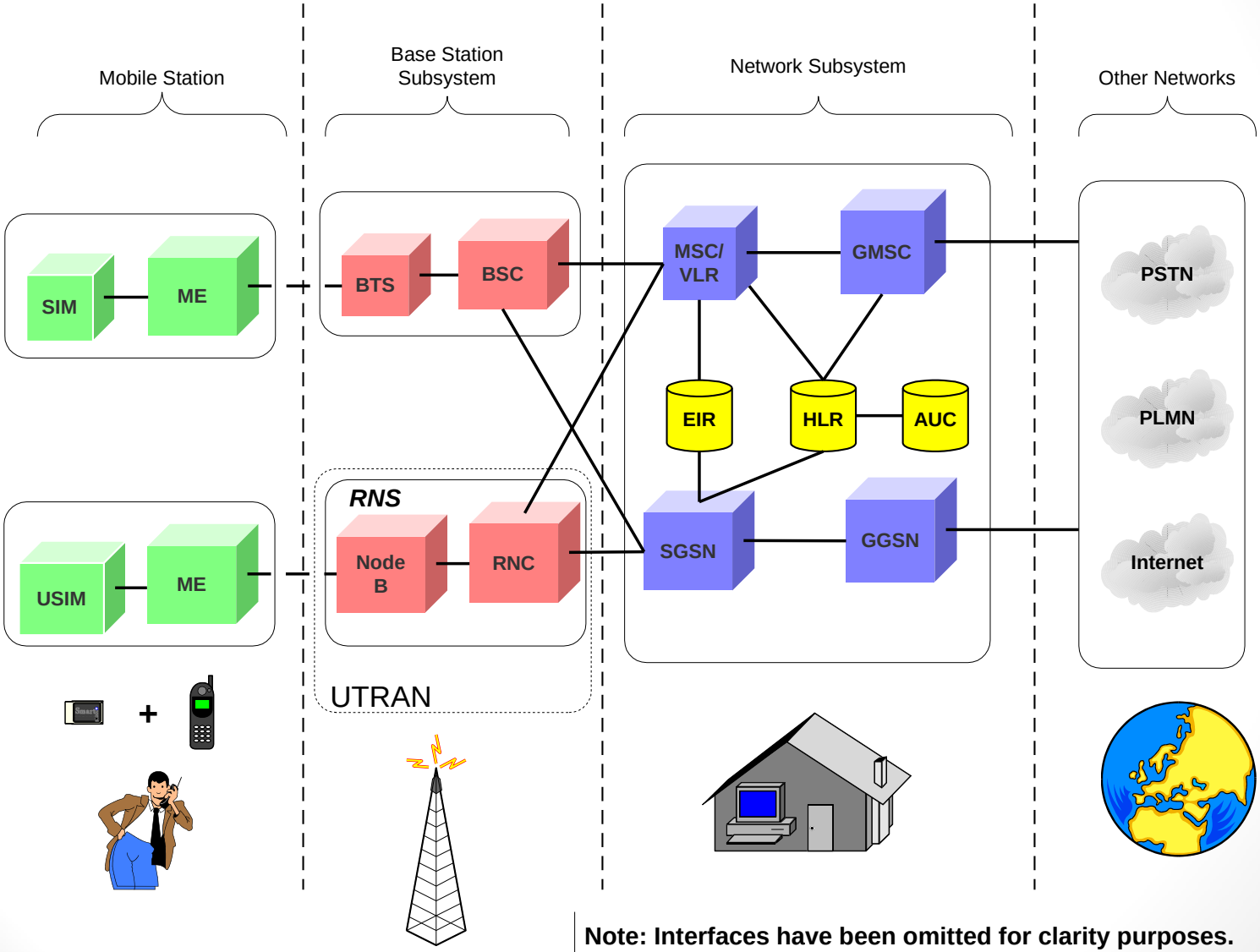
UMTS Frequency Spectrum

- UMTS Band
  - 1900-2025 MHz and 2110-2200 MHz for 3G transmission
  - In the US, 1710–1755 MHz and 2110–2155 MHz will be used instead, as the 1900 MHz band was already used.



UTRAN: Universal Terrestrial Radio Access Network
RNC: Radio Network Controllers
RNS: Radio Network Subsystem
SGSN: Serving GPRS Support Node
GGSN: Gateway GPRS Support Node
PLMN: Public Land Mobile Network

UMTS Architecture



Note: Interfaces have been omitted for clarity purposes.

UMTS Network Architecture

- UMTS network architecture consists of three domains
  - Core Network (CN): Provide switching, routing and transit for user traffic
  - UMTS Terrestrial Radio Access Network (UTRAN): Provides the air interface access method for user equipment.
  - User Equipment (UE): Terminals work as air interface counterpart for base stations. The various identities are: IMSI, TMSI, P-TMSI, TLLI, MSISDN, IMEI, IMEISV

UTRAN

- Wide band CDMA technology is selected for UTRAN air interface
  - WCDMA
  - TD-SCDMA
- Base stations are referred to as Node-B and control equipment for Node-B is called as Radio Network Controller (RNC).
  - Functions of Node-B are
    - Air Interface Tx/Rx
    - Modulation/Demodulation
  - Functions of RNC are:
    - Radio Resource Control
    - Channel Allocation
    - Power Control Settings
    - Handover Control
    - Ciphering
    - Segmentation and reassembly

3.5G (HSPA)

- High Speed Packet Access (HSPA) is an integration of two mobile telephony protocols, High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA), that extends and improves the performance of existing WCDMA protocols
- 3.5G introduces many new features that enhances the UMTS technology.
- 1xEV-DV already supports most of the features that is provided in 3.5G.
- These include:
  - Adaptive Modulation and Coding
  - Fast Scheduling
  - Backward compatibility with 3G
  - Enhanced Air Interface

4G (LTE)

- LTE stands for Long Term Evolution
- Next! Generation mobile broadband technology
- Promises data transfer rates of 100 Mbps
- Based on UMTS 3G technology
- Optimized for All-IP traffic

- Specification managed by 3GPP organization
  - 3rd Generation Partnership Project
  - Scope to create global 3G spec based on GSM architecture
  - UMTS (Universal Mobile Telephone System) Rel 99
  - HSPDA (High Speed Download Packet Access) Rel 5
  - HSPUA (Upload Access) Rel 6
  - HSPA+ Rel 7, enhancements in Rel 8-10
- New LTE specification in Release 8, 4G Scope

LTE Releases

- Release 8
  - Initial LTE release
  - Up to 4x4 MIMO
- Release 9
  - Minor enhancements
  - Currently built out by VZ, ATT & S
- Release 10, LTE Advanced
  - 2013 Commercial Availability
  - Channel bonding up to 5X
  - 8x8 MIMO, SON

Advantages of LTE

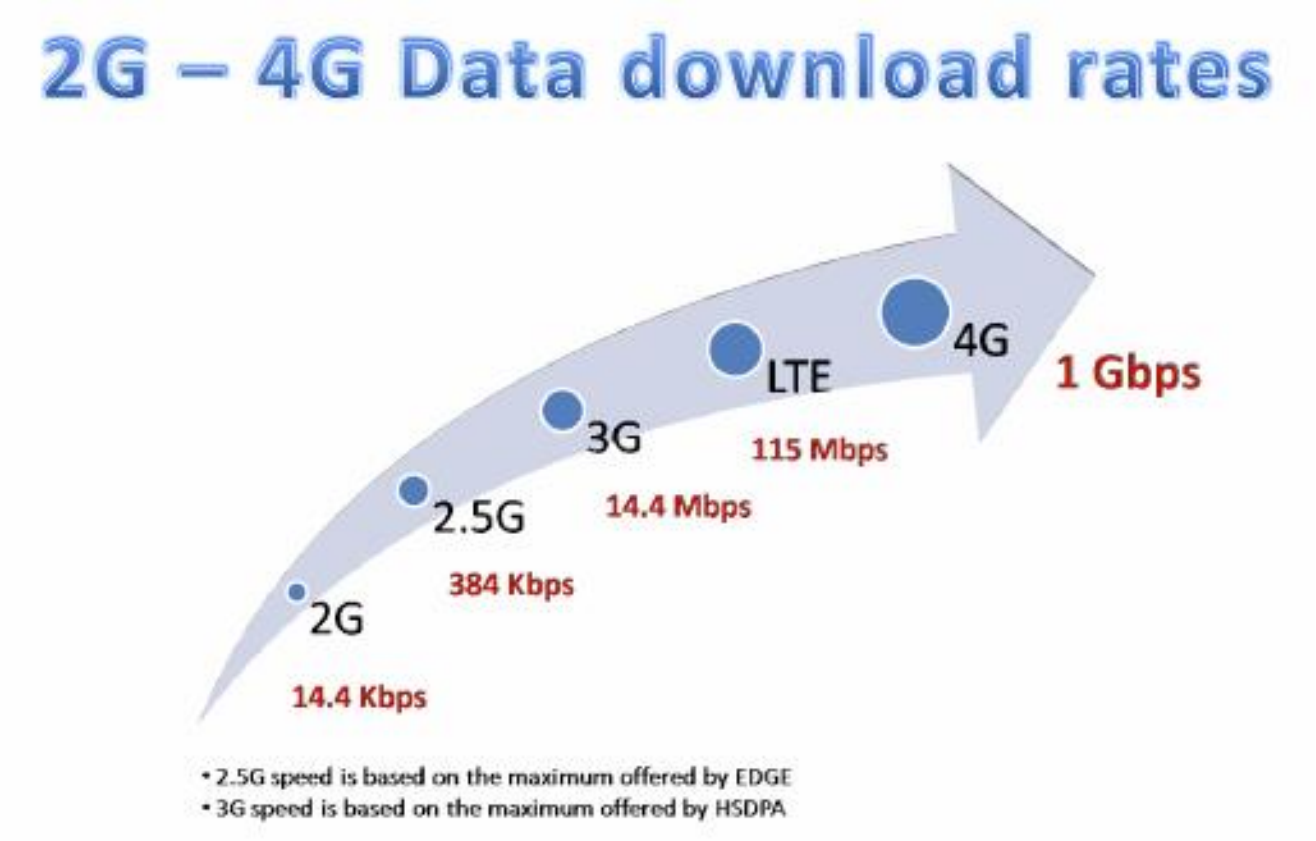
- High network throughput
- Low latency
- Plug & Play architecture
- Low Operating Costs
- All-IP network
- Simplified upgrade path from 3G networks

for Network Operators

- Faster data downloads/uploads
- Improved response for applications
- Improved end-user experience

for End Users

Comparison of LTE Speed



Major LTE Radio Technogies

- Uses Orthogonal Frequency Division Multiplexing (OFDM) for downlink
- Uses Single Carrier Frequency Division Multiple Access (SC-FDMA) for uplink
- Uses Multi-input Multi-output(MIMO) for enhanced throughput
- Reduced power consumption
- Higher RF power amplifier efficiency (less battery power used by handsets)

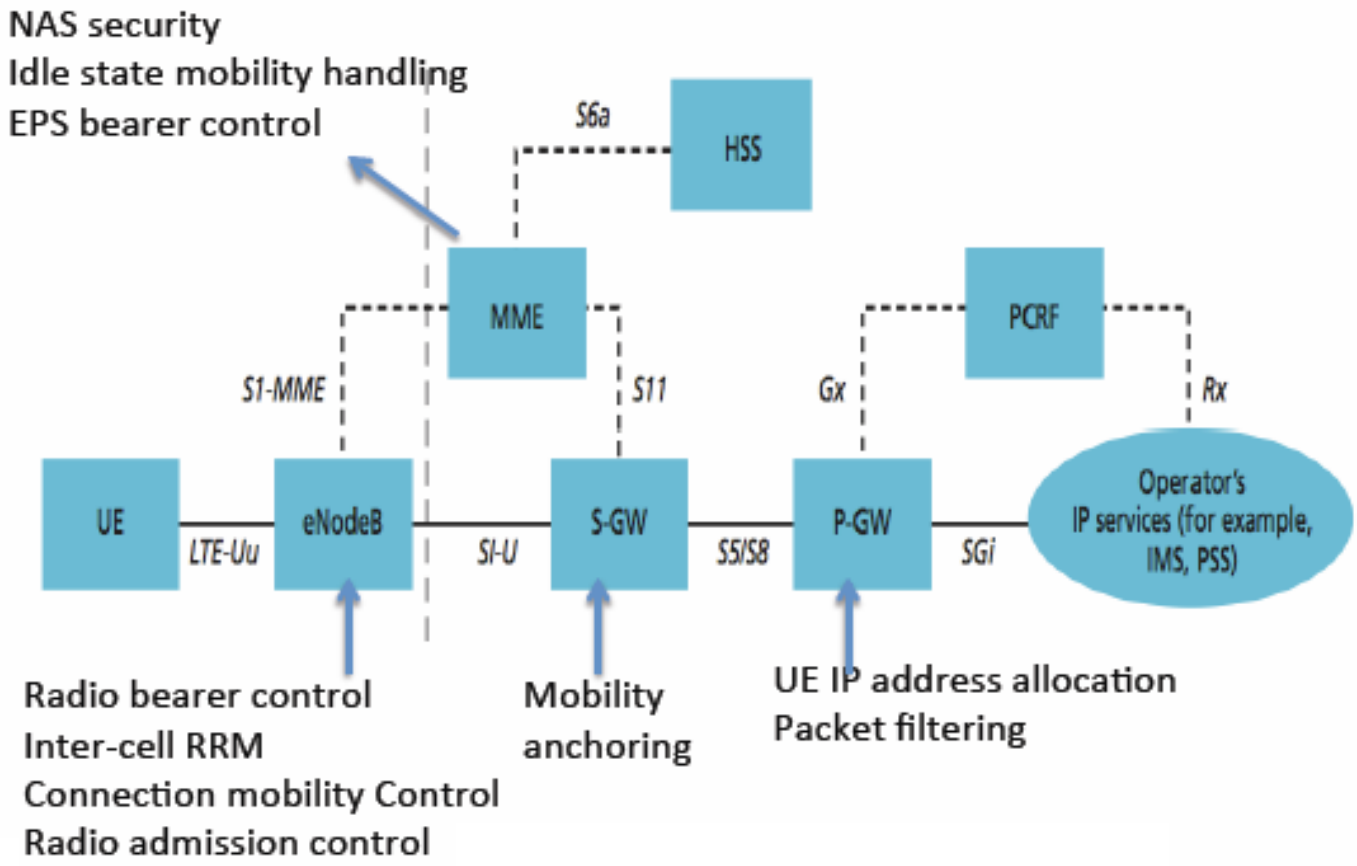
LTE Multiplexing

- 1G: FDMA 1 user, 1 channel, 30kHz, add channels for more users
- 2G: CDMA or TDMA, 200 kHz to 1.25 MHz
- 3G: CDMA & TDMA hybrid
  - 1.25 to 5 MHz channels
  - 1.2288 to 3.84 MSps
- 4G: LTE & WiMax = OFDM
  - Slow down symbol rates, use multiple orthogonal frequencies
  - 15kHz channels Orthogonally spaced. 15 kSps
  - 802.11 A,G,N & HDTV all use OFDM

LTE Channel sizes

- 2G; GSM= 200 kHz, 1xRTT = 1.25 MHz
- 3G; HSPA = 5 MHz, EVDO = 1.25 MH
- Wasted spectrum
  - Guard bands between carriers or left
  - Leftover spectrum unused Holdings
- LTE is Flexible Channel Size
  - 1.4, 3, 5, 10, 15 or 20 Mhz
  - ~100 subcarriers per MHz (128, 256, 512, 1024, 1536 or 2048)
  - Subcarriers are 15 kHz

LTE Architecture



- For more details, refer to:
  - Chapter 10, W. Stallings, Wireless Communications and Networks, 2005.
  - 3G online tutorials
- The lecture is available online at:
  - https://speakerdeck.com/ahmad_elbanna
- For inquires, send to:
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