3G WCDMA

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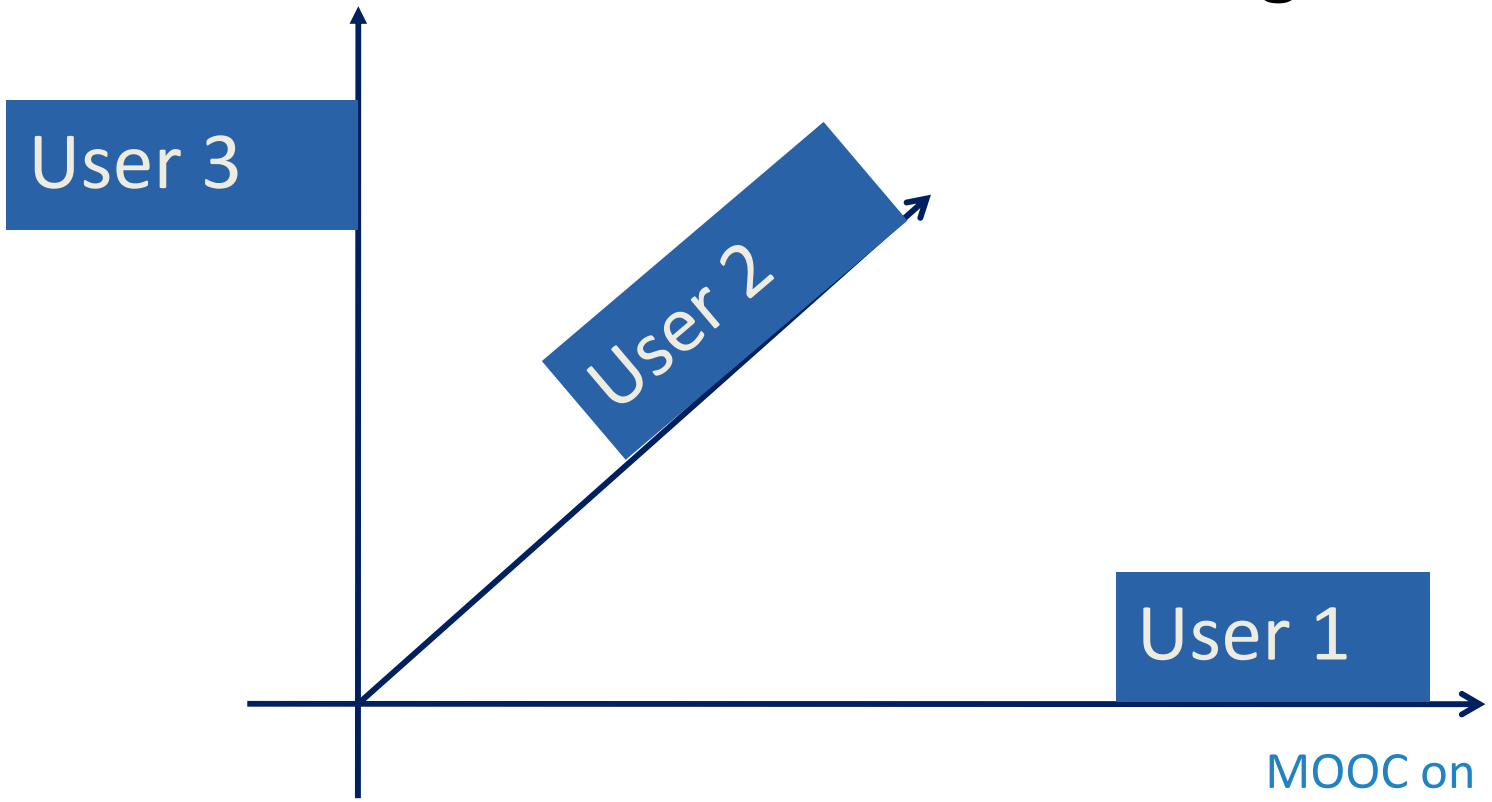
Multiple Access Technologies

- CDMA – Code Division for Multiple Access.
- Each user is allocated a certain “code” sequence on which he transmits his data.
- The codes of different users are **orthogonal**.



CDMA Cocktail Party

- CDMA Communication is analogous to a "Cocktail party" scenario.
- Imagine several conversations going on in a room but softly.
  - Different groups are talking in different language
- Unless you know the language, you cannot understand the conversation
  - This is the principle of code
- Rest of the conversations will appear as noise
  - This is interference

Introduction 3G UMTS

UMTS Overview

- 2G Wireless Systems.
  - GSM, CDMA One (IS-95).
  - Wireless voice communications, SMS, Basic Data (EDGE, GPRS)
- UMTS (Universal Mobile Telecommunication System).
  - Widely adopted 3G wireless cellular standard.
  - WCDMA (Wideband CDMA) is the air interface for UMTS.

UMTS Overview

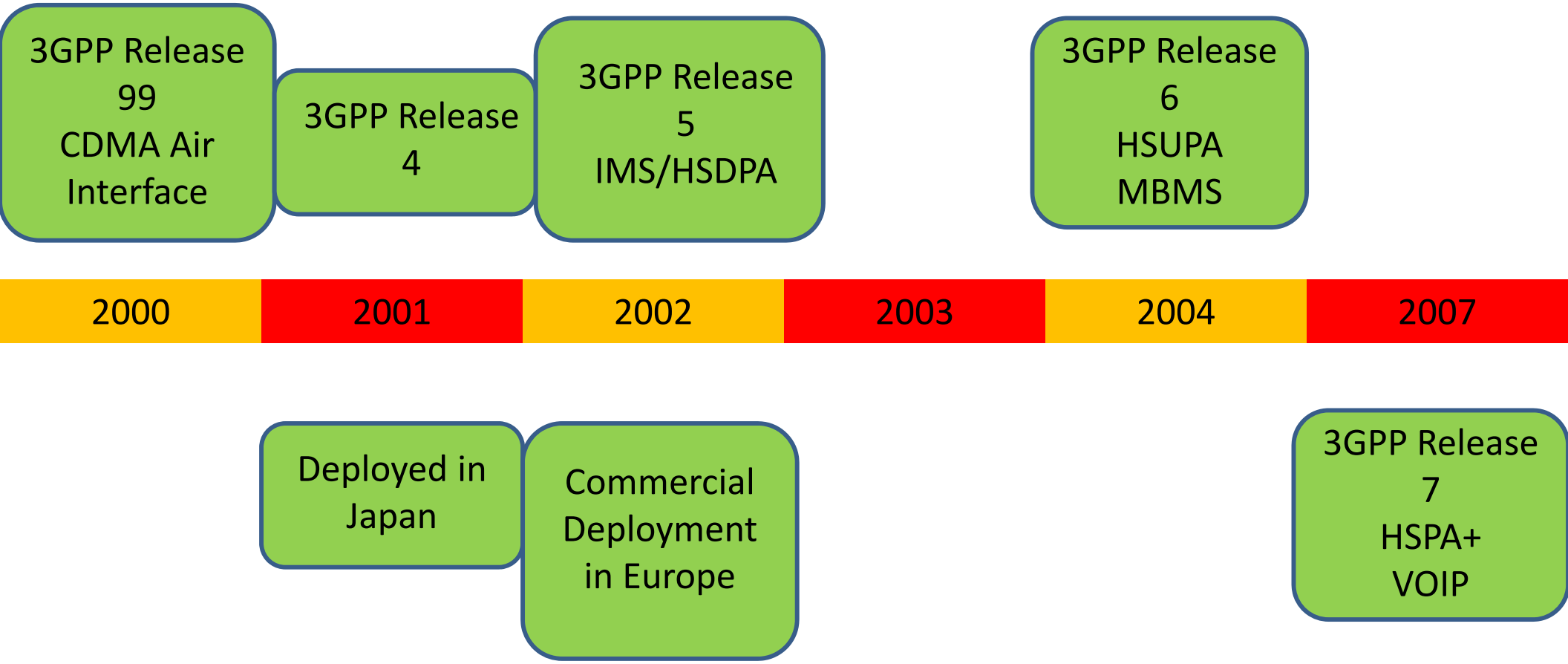
- Created by **3GPP** (3rd Generation Partnership Project).
- Designed for Multimedia Communication.
  - High quality images and video.
  - Access to information and services.

UMTS History

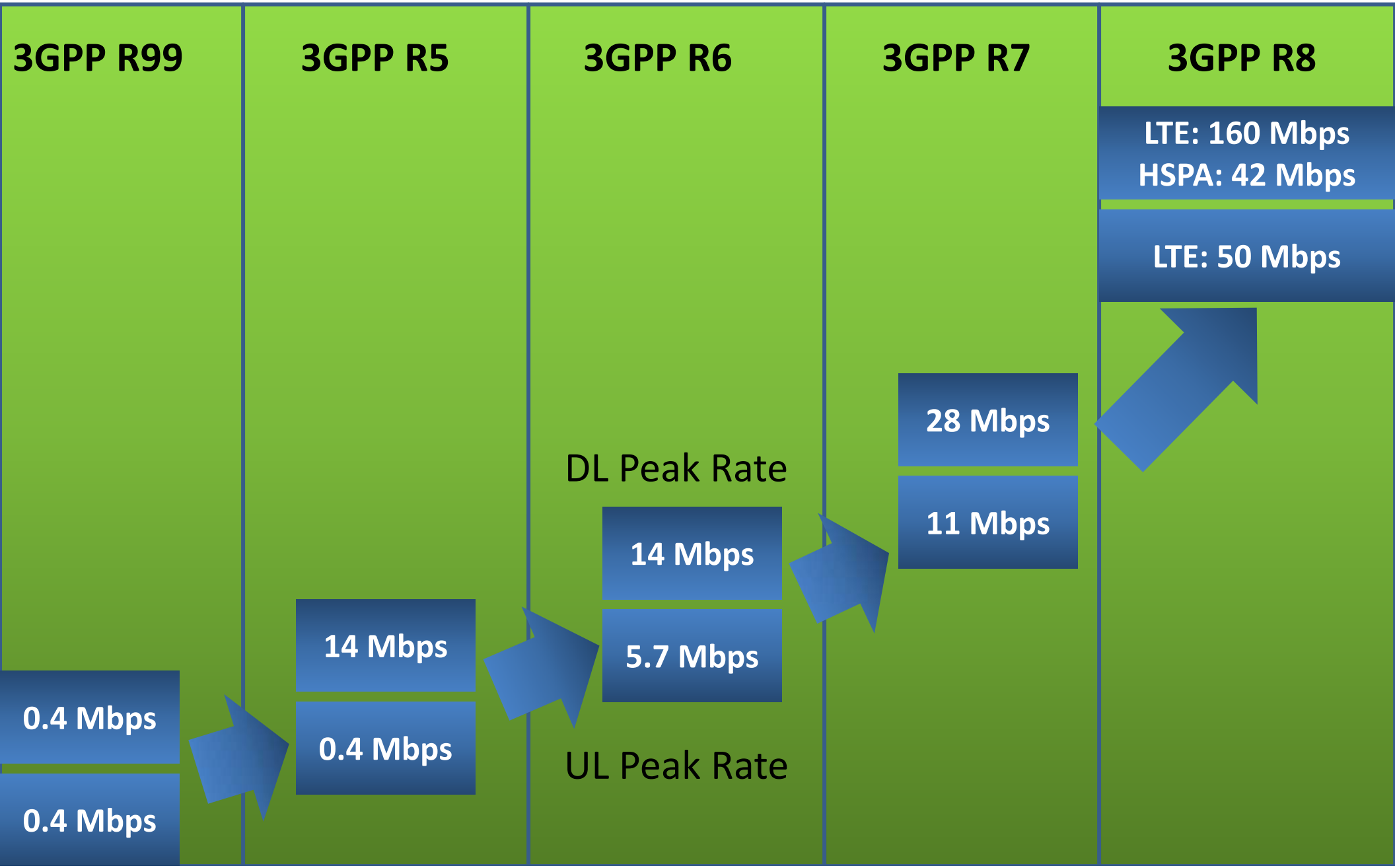
- 3G effort initiated in the 1992 meeting of ITU WARC. (World Administrative Radio Conference).
  - Identified frequencies around 2GHz for 3G.
- Original target – Single 3rd generation air interface.
- In 1998 ETSI adopted WCDMA.
- First commercial networks – Japan ‘01, Europe ‘02.

UMTS Timeline

- UMTS Development and Deployment timeline.



Cellular Data Rate Evolution



UMTS Peak Data Rate Evolution

- R99 in theory enabled 2 Mbps, but in practice gave 384 Kbps.
- HSPA in Release 5 and Release 6 pushes the peak rates to 14 Mbps in downlink and 5.7 Mbps in uplink.
- HSPA evolution in Release 7 brings a maximum 28 Mbps in downlink and 11 Mbps in uplink.
- LTE will then further push the peak rates beyond 100 Mbps in downlink and 50 Mbps in uplink.
  - It employs a 20 MHz bandwidth.

Salient features of WCDMA

- Bit rates up to 2 Mbps.
- Variable bit rate to offer bandwidth on demand.
- Multiplexing of speech, video, data on a single link.
- Capability to handle variable delay requirements.
  - From delay sensitive to best effort packet data.
- Variable quality requirements.
  - 10% FER to 10^{-6} BER.

Salient features of WCDMA

- Coexistence of 2G and 3G with inter-system handovers for enhanced coverage.
  - Backward compatibility
- High spectrum efficiency.
- Support of asymmetric uplink and downlink.
  - For asymmetric apps such as web browsing.
- Coexistence of FDD and TDD modes.

WCDMA vs. GSM Air Interfaces

	WCDMA	GSM
Carrier spacing	5 MHz	200 KHz
Frequency reuse factor	1	1-18
Frequency diversity	Multipath diversity with Rake combining.	Frequency hopping.
Packet data	Load based packet scheduling.	Time slot based scheduling with GPRS.
Downlink transmit diversity	Supported.	Not supported.

WCDMA vs IS-95 Air Interfaces

	WCDMA	IS-95
Carrier spacing	5 MHz	1.25 MHz
Base station synchronization	Not needed.	Yes, obtained via GPS.
Efficient radio resource management algorithms	Yes, provides QOS. For voice and video	Not needed for speech only networks.
Packet data	Load based packet scheduling.	Packet data transmitted on circuit switched calls.
Downlink transmit diversity	Supported.	Not supported.

Services and Applications

Introduction

- 2nd Generation systems like GSM, were originally designed for efficient delivery of voice services.
- UMTS networks are, on the contrary, designed from the beginning for flexible delivery of any service.
  - High bit rates theoretically up to 2 Mbps in 3GPP Release ’99.
  - Beyond 10 Mbps in 3GPP Release 5.
  - Practical bit rates are up to 384 kbps initially, and beyond 2 Mbps with Release 5.
  - Low delays with packet RTTs below 200 ms.

Types of Services

- Services are divided into
- Person-to-Person
  - Peer-to-peer or intermediate server based connection between two persons or a group of persons.
  - Example: AMR Speech, Push-To-Talk etc.

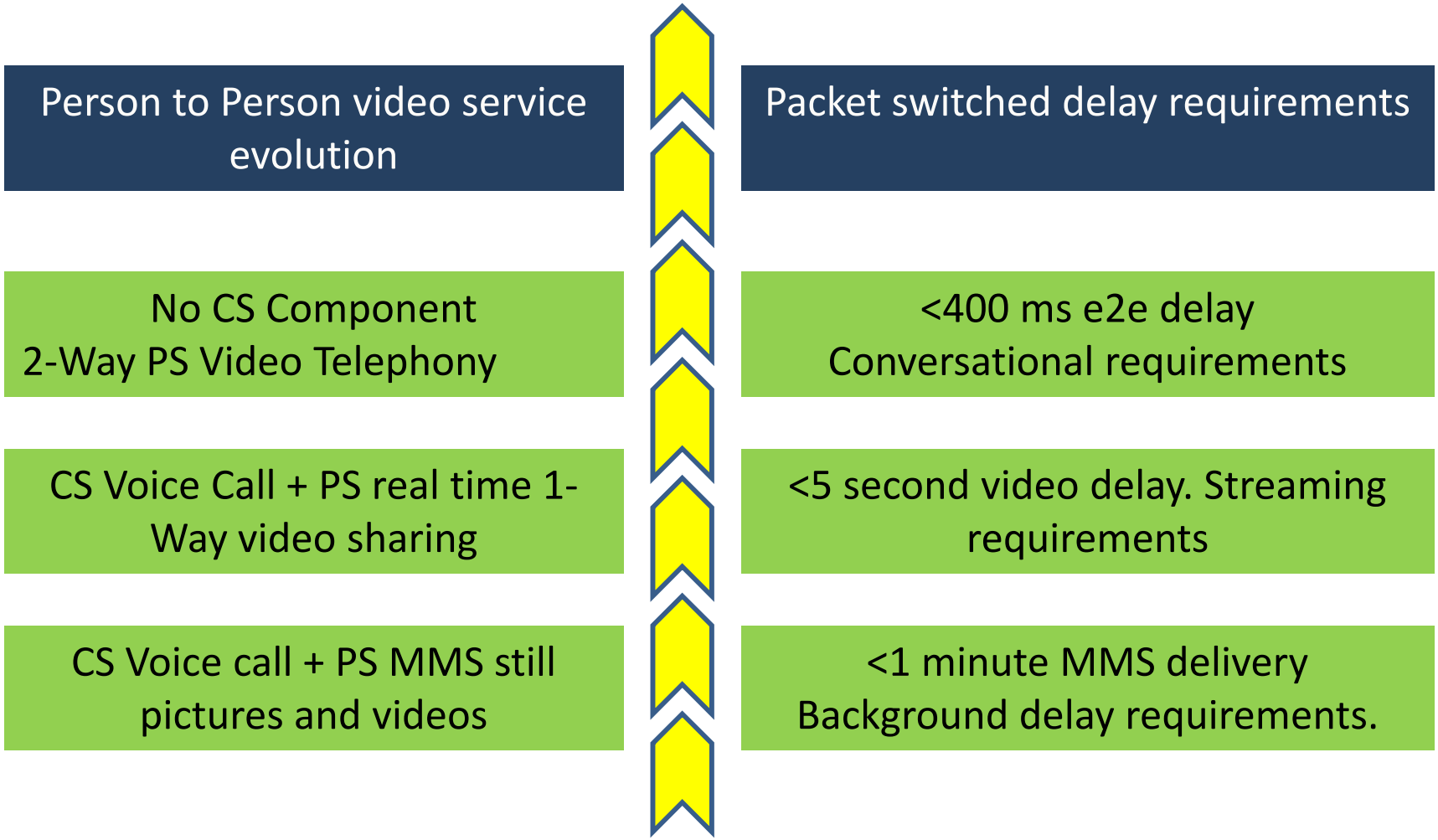
Types of Services

- Content-to-Person
  - Characterized by the access to information or download of content – UDP Based.
  - Example: Audio/Video Streaming.
- Business/ Enterprise Connectivity
  - Laptop (Data Cards) access to internet or intranet using WCDMA as the radio modem.

Images and Multimedia

- The end user performance requirements for the real time video sharing service are that
  - Image quality and update rates should be high enough to enable ‘scanning’ the environment with the camera.
  - Delay between taking a picture and showing it to the other side is low enough to enable true interactivity.

Evolution of P-to-P video service



Content-to-person Services
Audio and Visual Streaming

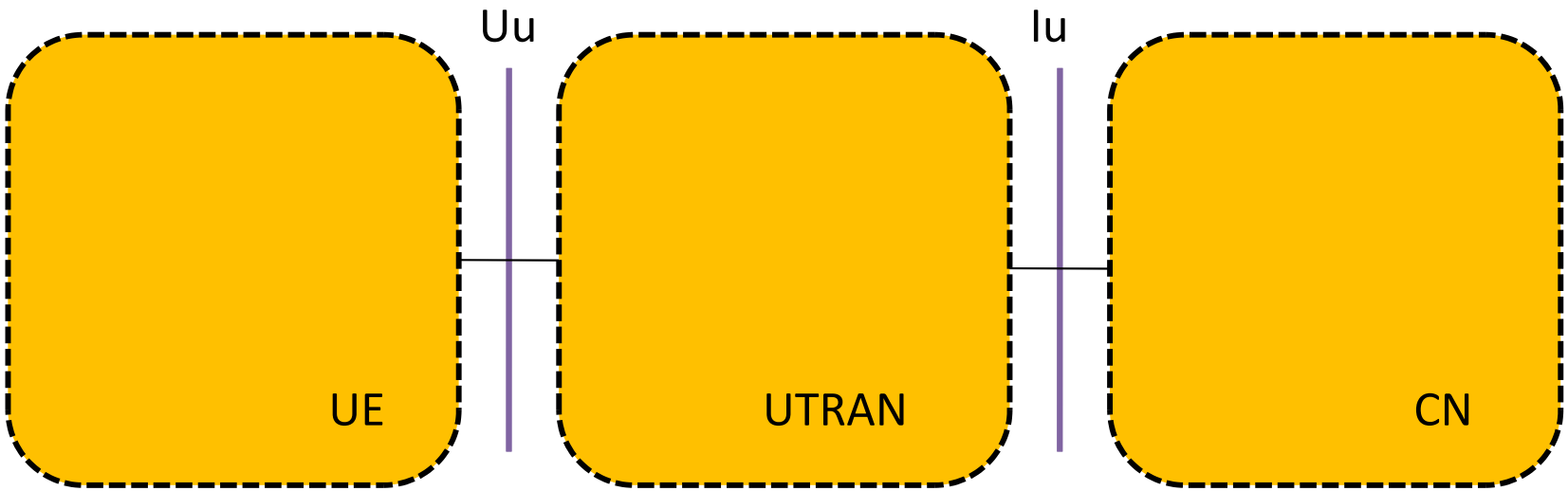
- Streaming applications are very asymmetric.
  - Withstand more delay than conversational services.
  - Jitter has to be smoothed out.
- *Web broadcast*
  - Usually target very large audiences that connect to a media server
  - Offer their core products for 28.8 kbps market.
- *Video streaming on demand.*
  - Video clips or lectures to a server connected to a higher bandwidth local intranet .
  - Bandwidth variation sensitive. Streaming in the 100 Kbps to 7.300 Mbps intranet market

Radio Access Network Architecture

System Architecture

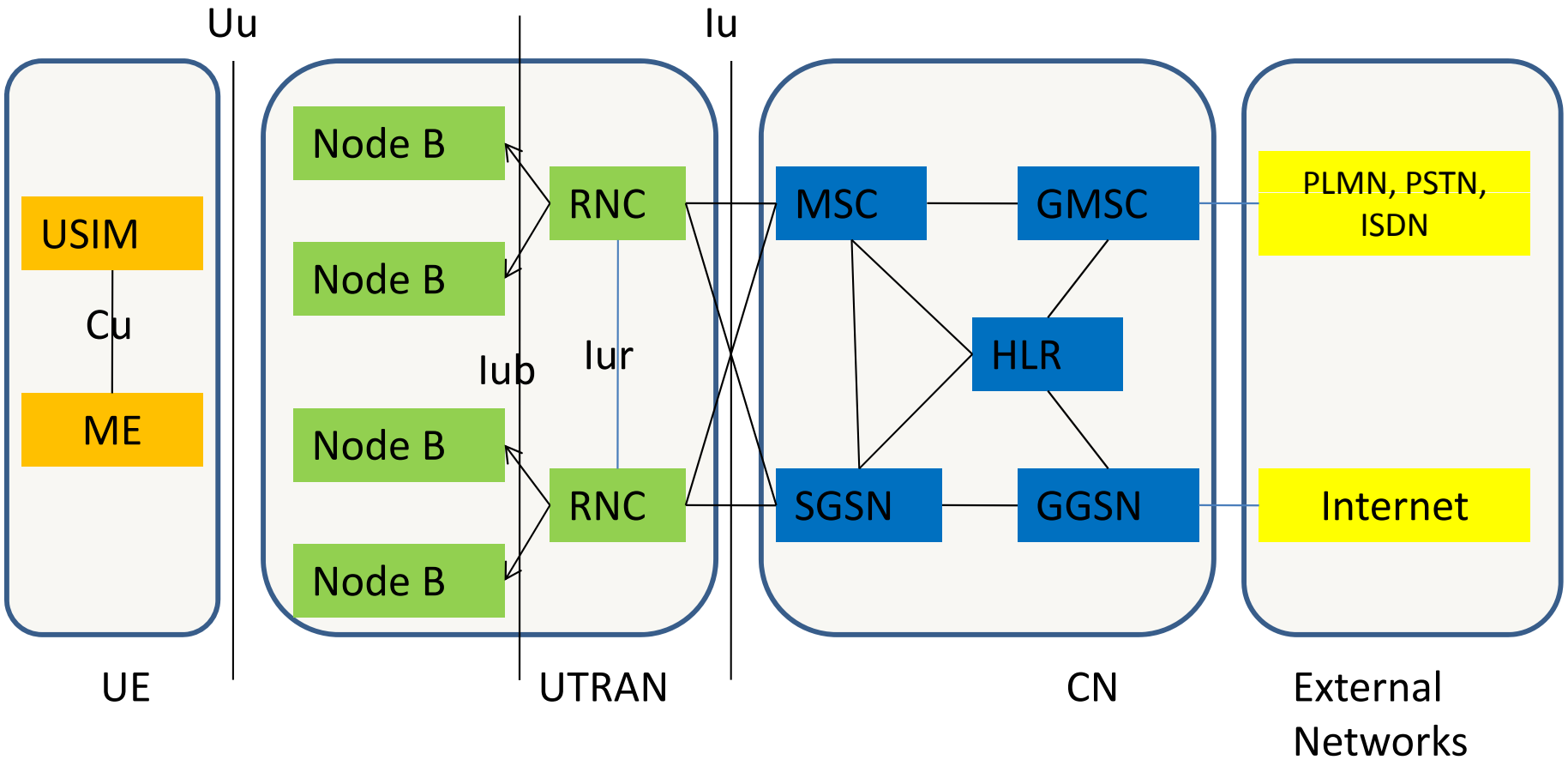
- Network elements are grouped into
  - User Equipment (UE) that interfaces with the user.
  - UMTS Terrestrial RAN (UTRAN) that handles all radio-related functionality.
  - Core Network responsible for switching and routing calls and data connections to external networks.

System Architecture



UMTS High Level System Architecture

Sub-Networks based modular UMTS



Network elements in a PLMN

UMTS Architectural Elements

- User Equipment (UE) consists of two parts:
  - Mobile Equipment (ME)
    - The terminal used for radio communication.
    - Communicates over the air interface.
  - UMTS Subscriber Identity Module (USIM)
    - Smartcard that holds the subscriber identity.
    - Stores authentication algorithms.
    - Stores authentication and encryption keys.
    - Subscription information that is needed at the terminal.

UMTS Architectural Elements

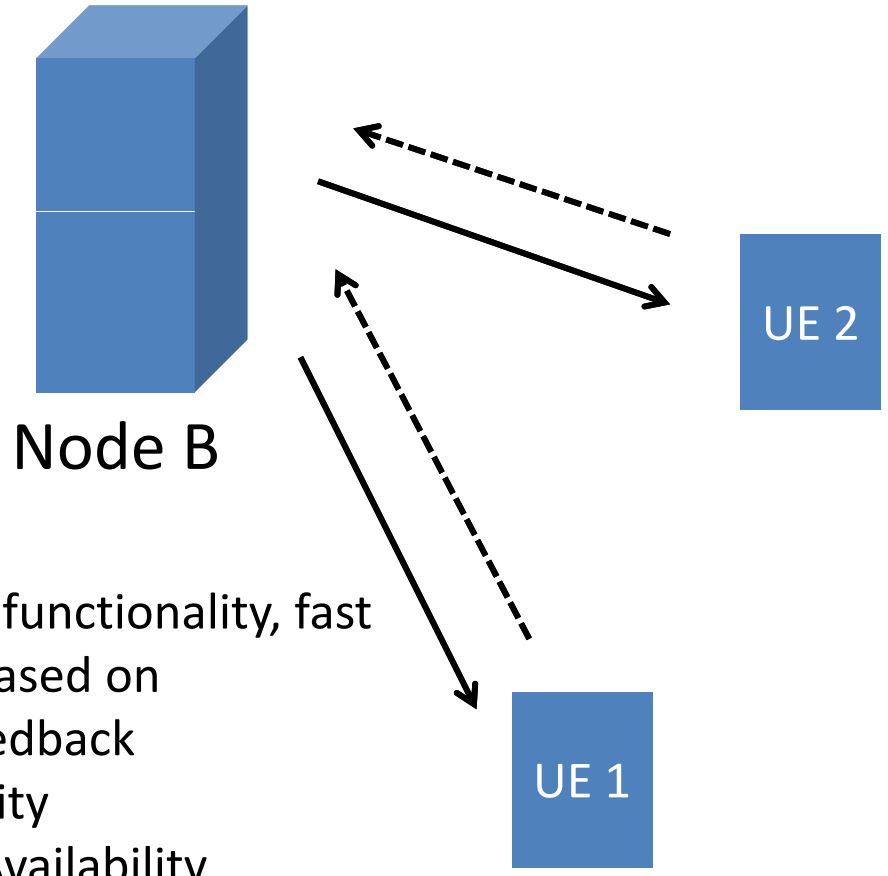
- UMTS Terrestrial RAN (UTRAN)
  - Node B
    - Converts the data flow between the wired and wireless interfaces.
    - Generically termed the ‘Base Station’.
  - Radio Network Controller (RNC)
    - Controls the radio resources in its domain.
    - Similar to BSC in GSM.

High-Speed Downlink Packet Access (HSDPA)

HSDPA Introduction

- HSDPA (High Speed Downlink Packet Access) concept has been designed to increase downlink packet data throughput (5-30 Mbps) by means of
  - Fast PHY (L1) retransmission and transmission combining for packet drops.
  - Fast link adaptation controlled by the Node B (Base Transceiver Station (BTS)) – to efficiently use wireless channel.

HSDPA Features



New Node B functionality, fast scheduling based on

- Quality Feedback
- UE Capability
- Resource Availability
- Buffer Status
- Qos and Priority

HSDPA Features

- Adaptive modulation and coding (AMC)
- Extensive multi-code operation.
  - A Single user may simultaneously utilize up to 15 multi-codes in parallel.
- A fast and efficient retransmission strategy.
- Scheduling decisions are done in the Node B.

HSDPA vs WCDMA Features - Comparison

Feature	WCDMA	HSDPA
Soft Handover	Yes	No
Fast Power Control	Yes	No
AMC	No	Yes
Multi-Code	Yes	Yes, Extended
Fast Retransmission	No	Yes
BTS Scheduling	No	Yes