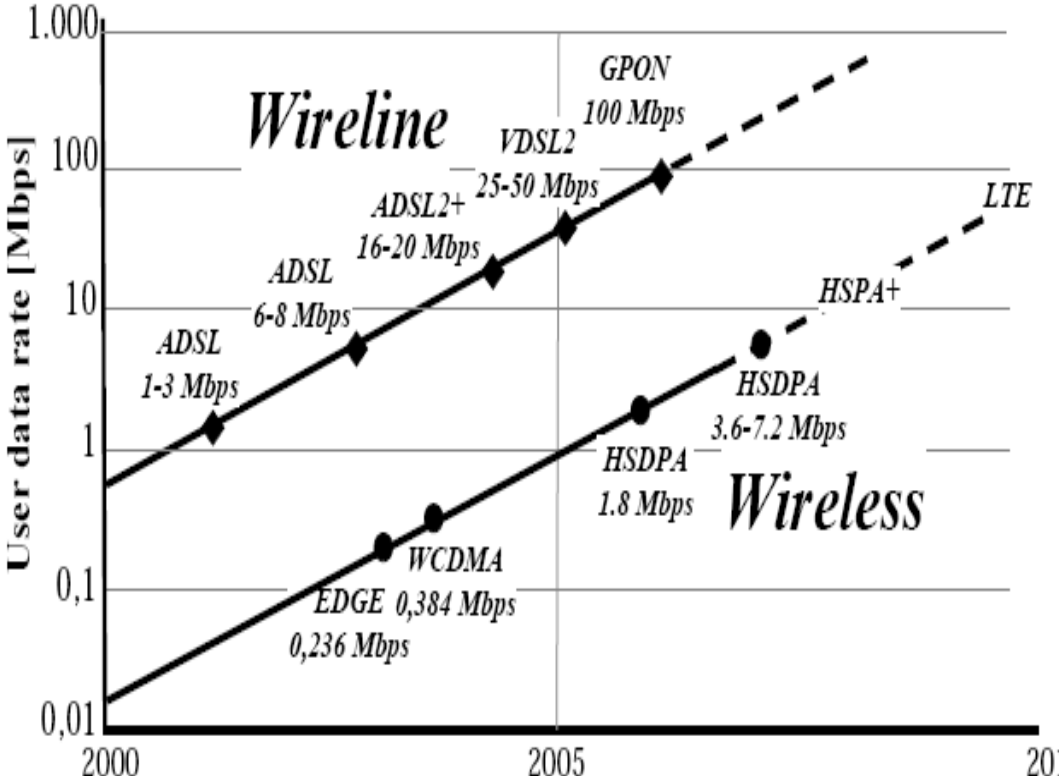
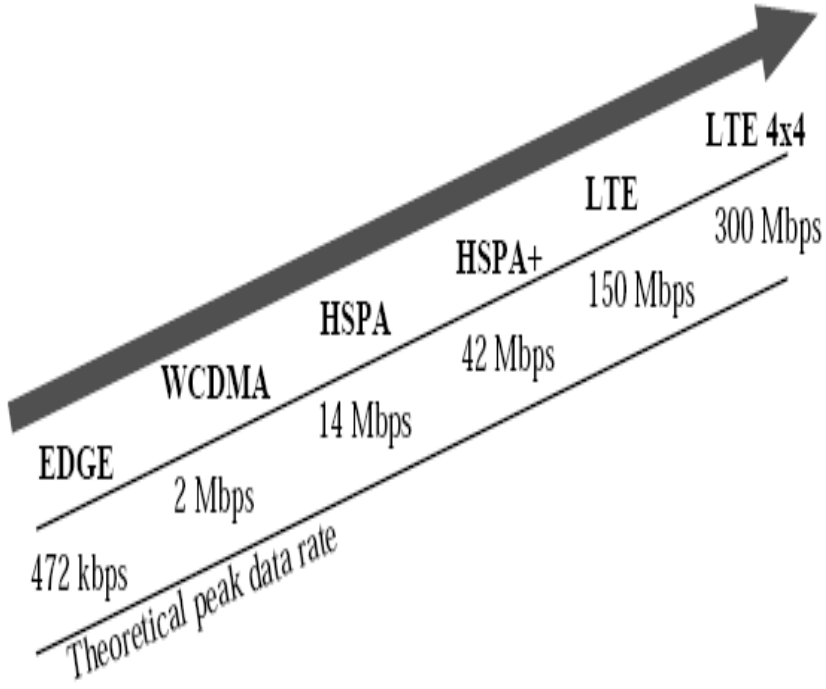
Wireless Communication Systems

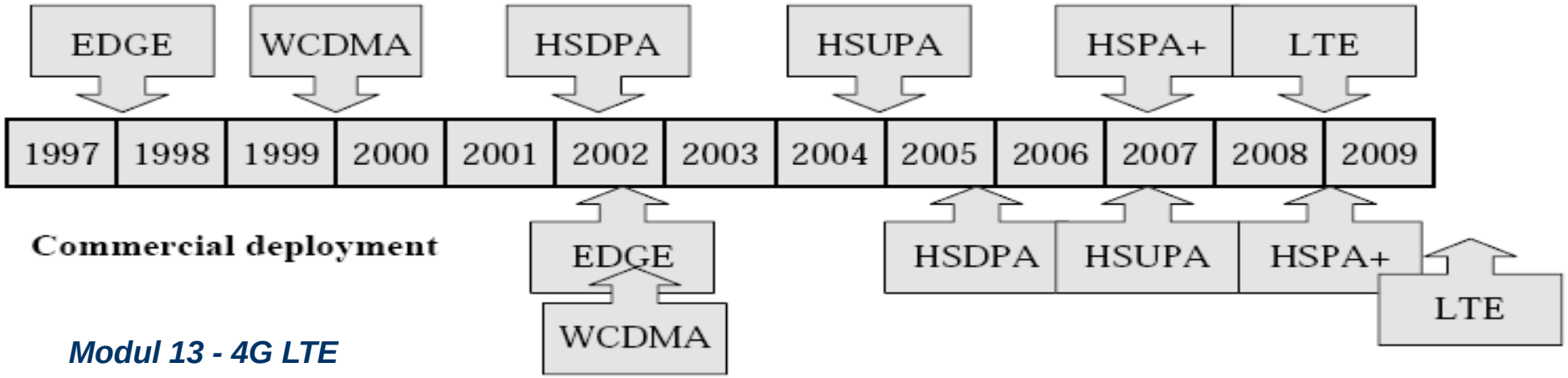
Modul 13 4G LTE / LTE – Advance for Mobile Broadband

Faculty of Electrical Engineering
Bandung – 2015

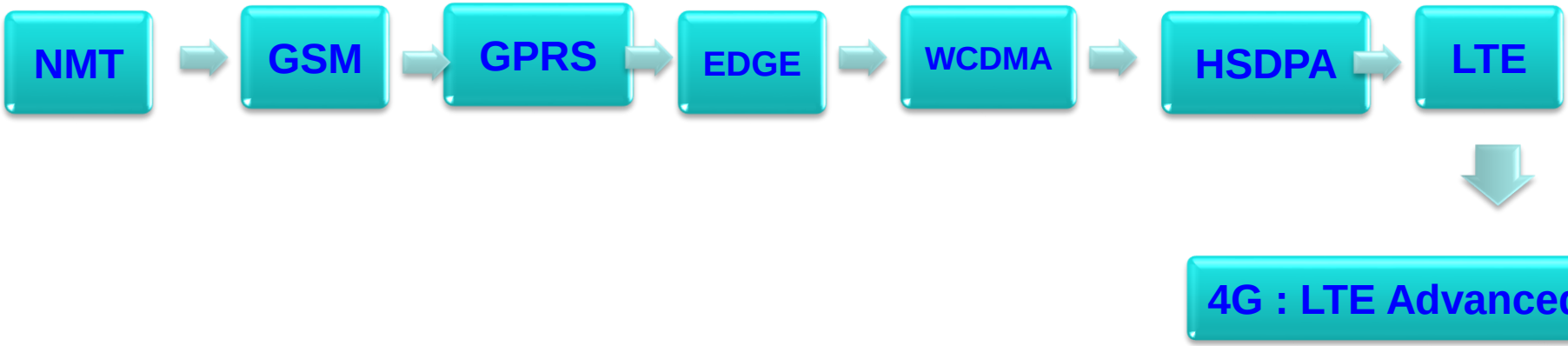
Evolution of Wireless and Wireless





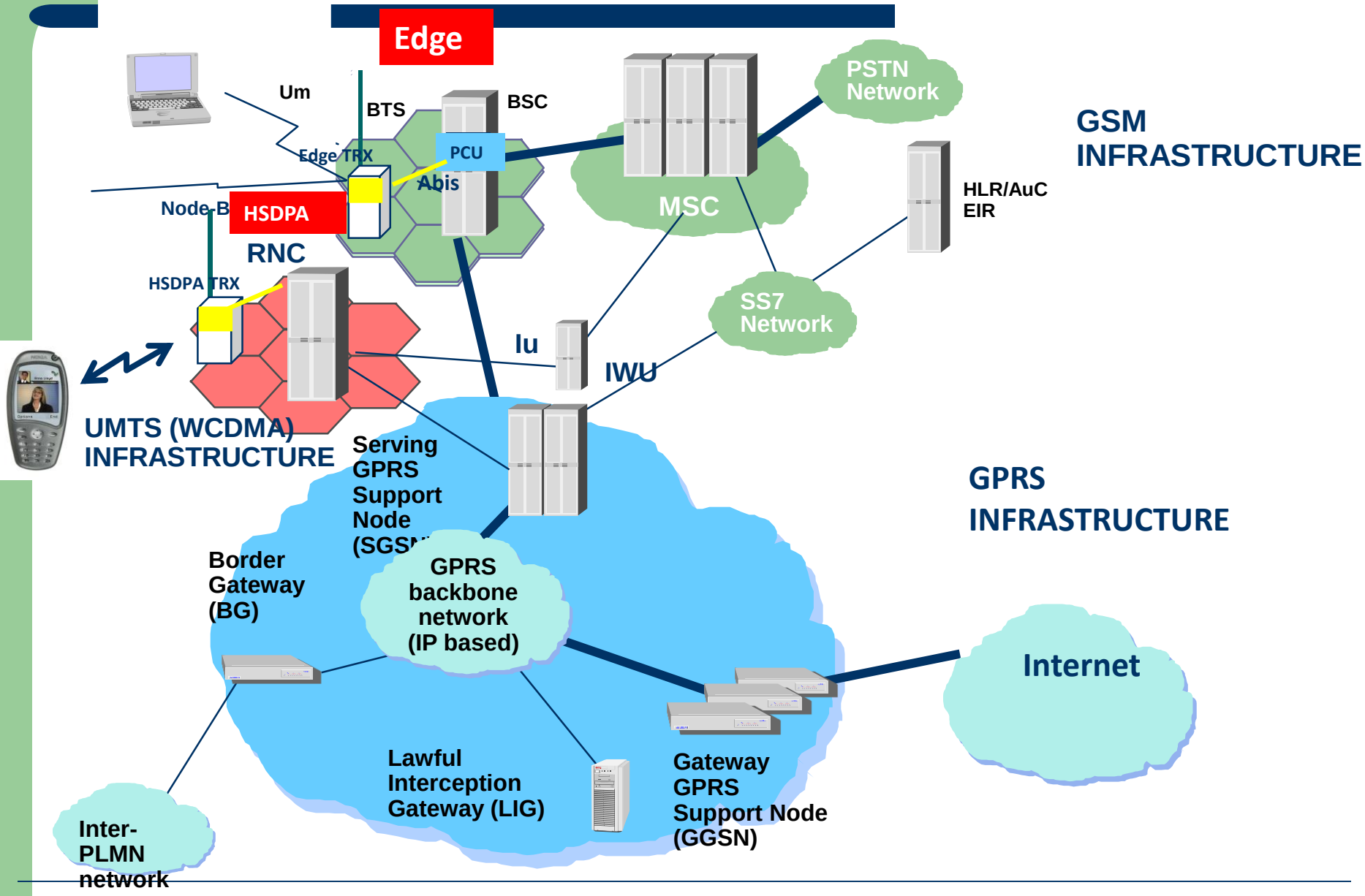


Evolution 1G to 3,9 G



	Peak Transfer Data Rate					
No packet data service	CSD : 9,6 Kbps HSCSD : 38,4 Kbps	56 – 114 Kbps	384 Kbps	2 Mbps	14,4 Mbps	50 Mbps (LTE) : 100 Mbps (LTE Advanced)

Evolution step GSM / GPRS / UMTS / HSDPA

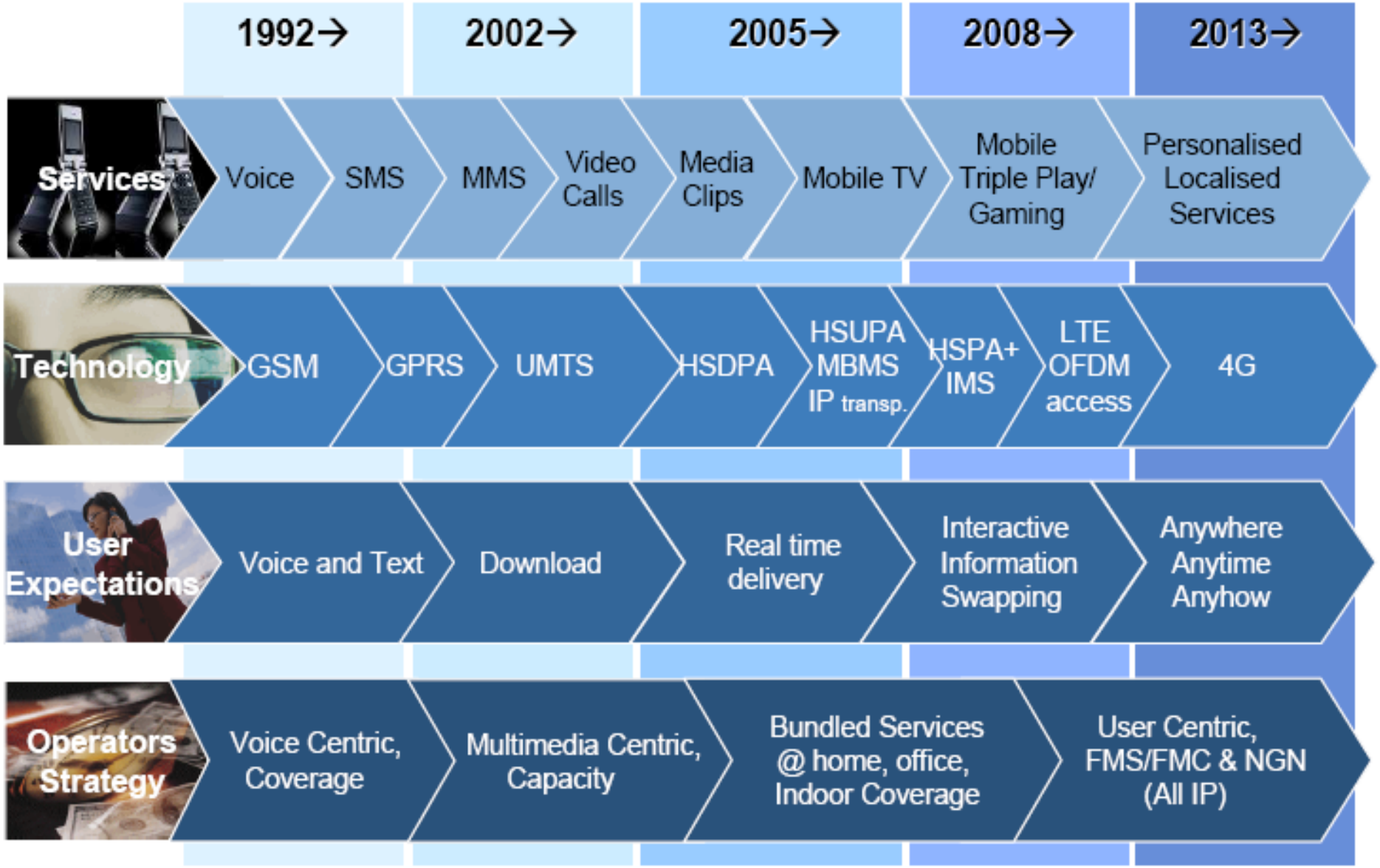


Evolusi Wireless

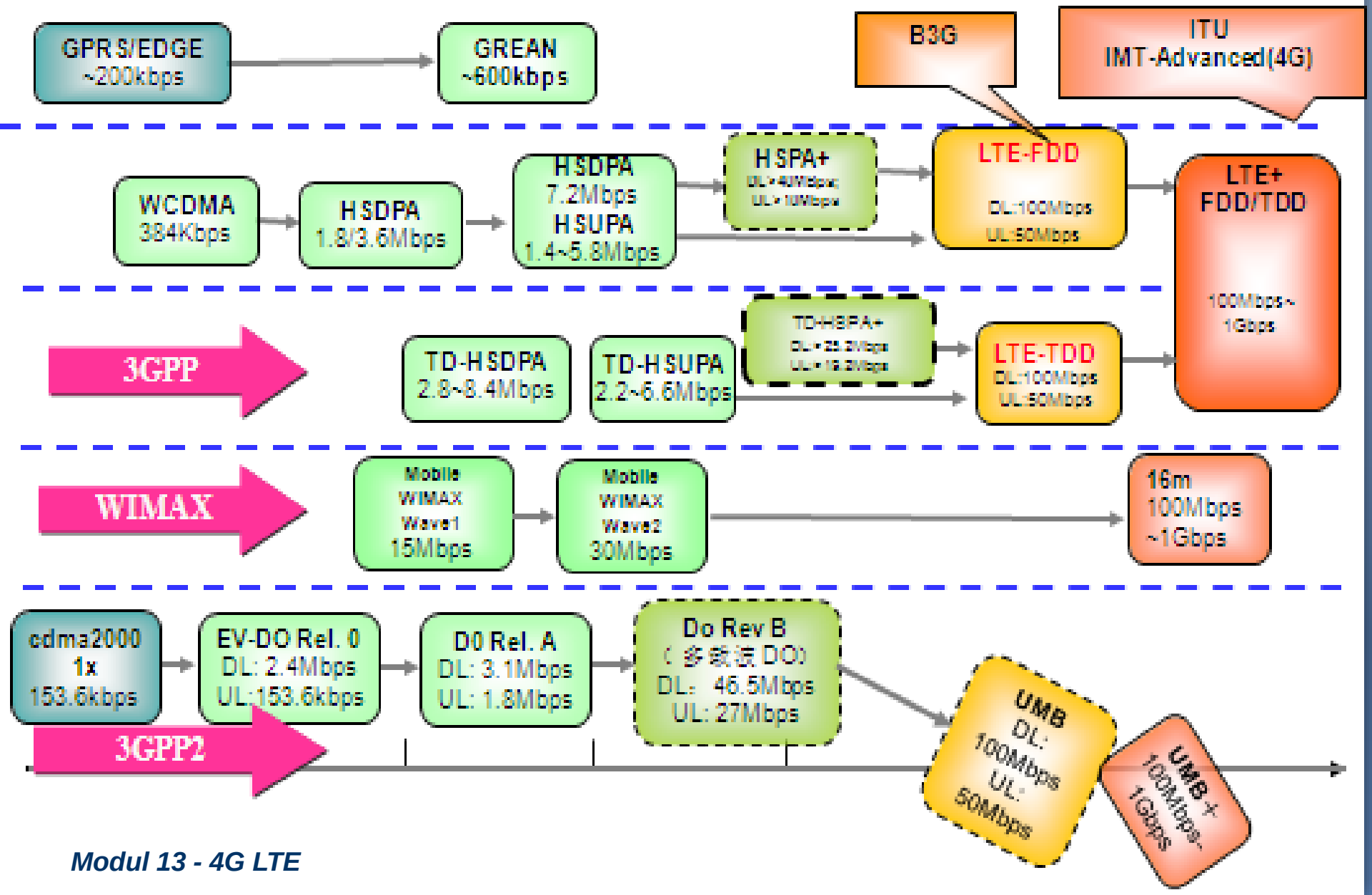
Generation	Family/Standardization body	Technologies	Features	Mobil./Roam	Throughput	Capacity	Services
1G (1981)		NMT, AMPS, TACS	Extended coverage, Bad quality, drops				
2G (1991 - 95)	ETSI/3GPP	GSM and GSM/CSD	Better mobility, Roaming, Better quality, SMS + low bitrate date				
	3GPP2	CdmaOne (IS-95 A and B)					
	Other	D-AMPS (IS-54 and IS-136), PDC, PHS					
2.5G (1999 - 00)	GSM/3GPP	GPRS, HSCSD	PS data				
2.75G (2000)	3GPP	EDGE/EGPRS	Higher data rate, PS data				
	3GPP2	CDMA2000 1xRTT (IS-2000)					
3G (IMT-2000) (2002 – 03)	3GPP	UMTS : WCDMA, TD-CDMA, TD-SCDMA	Higher data rates, Global roaming				
	3GPP2	CDMA2000 1xEV-DO (IS-856)					

Generation	Family/Standard. body	Technologies	Features	Mobil./Roam	Throughput	Capacity	Services
3.5G (2005 – present)	3GPP	HSDPA, HSUPA	Higher data rates, less latency, more capacity				
	3GPP2	EV-DO Rev. A					
3.75G (2007 – present)	3GPP	HSPA+	Higher data rates, more capacity				
	3GPP2	CDMA2000 3x (EV-DO Rev. B)					
3.9G (2010)	3GPP	3GPP LTE	?				
	Other	IEEE 802.16e-2005, Flash-OFDM, IEEE 802.20					
4G (IMT-Advanced)	?	?	?				

Mobile Evolution



Trend of B3G


GPRS/EDGE
~200kbps
GREAN
~600kbps
B3G
ITU
IMT-Advanced(4G)
WCDMA
384Kbps
HSDPA
1.8/3.6Mbps
HSDPA
7.2Mbps
HSUPA
1.4~5.8Mbps
HSPA+
LTE-FDD
DL:100Mbps
UL:50Mbps
LTE+
FDD/TDD
100Mbps~
1Gbps
3GPP
TD-HSDPA
2.8~8.4Mbps
TD-HSUPA
2.2~6.6Mbps
TD-HSPA+
LTE-TDD
DL:100Mbps
UL:50Mbps
WIMAX
Mobile
WIMAX
Wave1
15Mbps
Mobile
WIMAX
Wave2
30Mbps
16m
100Mbps
~1Gbps
cdma2000
1x
153.6kbps
EV-DO Rel. 0
DL: 2.4Mbps
UL:153.6kbps
D0 Rel. A
DL: 3.1Mbps
UL: 1.8Mbps
Do Rev B
DL: 46.5Mbps
UL: 27Mbps
3GPP2
UMB
DL:
100Mbps
UL:
50Mbps
UMB+
100Mbps~
1Gbps

3 Kelemahan 3G

1. Bit rate maksimum masih 1/20 dari sistem 802.11n dan 802.16e/m.
2. Latency dari user plane traffic (UMTS: >30 ms)

   dan prosedur penugasan resource (UMTS: >100 ms) terlalu besar untuk menangani trafik dengan variansi tinggi secara efisien
3. Kompleksitas terminal sistem WCDMA /MC-CDMA sehingga menyebabkan perangkat menjadi mahal

1G to 4G

Generation	Requirements	Comments
1G	No official requirements. Analog technology.	Deployed in the 1980s.
2G	No official requirements. Digital Technology.	First digital systems. Deployed in the 1990s. New services such as SMS and low-rate data. Primary technologies include CDMA2000 1xRTT and GSM.
3G	ITU's IMT-2000 required 144 kbps mobile, 384 kbps pedestrian, 2 Mbps indoors	Primary technologies include CDMA2000 EV-DO and UMTS-HSPA. WiMAX now an official 3G technology.
4G	ITU's IMT-Advanced requirements include ability to operate in up to 40 MHz radio channels and with very high spectral efficiency.	No technology meets requirements today. IEEE 802.16m and LTE Advanced being designed to meet requirements.

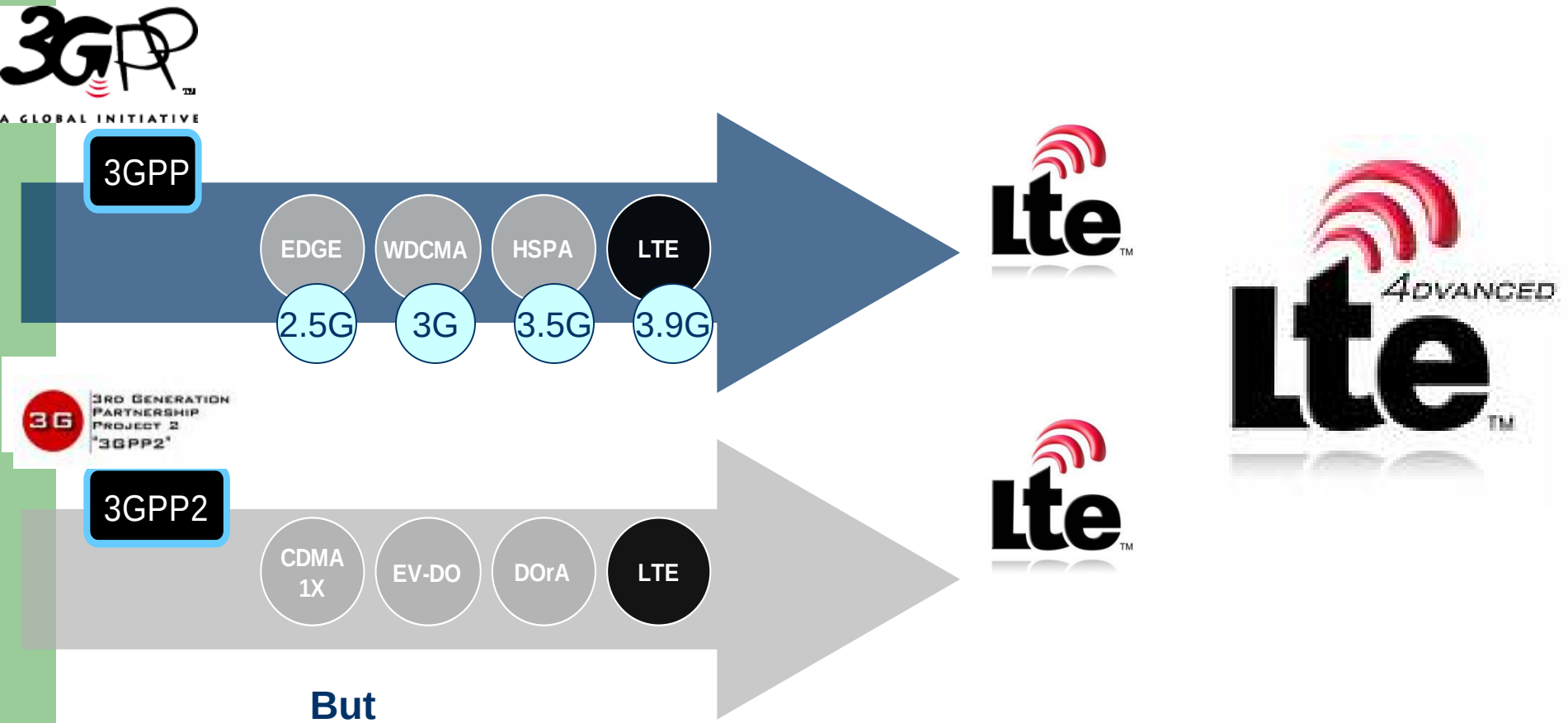
Characteristics of 3GPP Technol

Technology Name	Type	Characteristics	Typical Downlink Speed	Typical Uplink Speed
GSM	TDMA	Most widely deployed cellular technology in the world. Provides voice and data service via GPRS/EDGE.		
EDGE	TDMA	Data service for GSM networks. An enhancement to original GSM data service called GPRS.	70 kbps to 135 kbps	70 kbps to 135 kbps
Evolved EDGE	TDMA	Advanced version of EDGE that can double and eventually quadruple throughput rates, halve latency and increase spectral efficiency.	175 kbps to 350 kbps expected (Single Carrier) 350 kbps to 700 kbps expected (Dual Carrier)	150 kbps to 300 kbps expected
UMTS	CDMA	3G technology providing voice and data capabilities. Current deployments implement HSPA for data service.	200 to 300 kbps	200 to 300 kbps
HSPA	CDMA	Data service for UMTS networks. An enhancement to original UMTS data service.	1 Mbps to 4 Mbps	500 kbps to 2 Mbps
HSPA+	CDMA	Evolution of HSPA in various stages to increase throughput and capacity and to lower latency.	1.5 Mbps to 7 Mbps	1 Mbps to 4 Mbps
LTE	OFDMA	New radio interface that can use wide radio channels and deliver extremely high throughput rates. All communications handled in IP domain.	4 Mbps to 24 Mbps (in 2 x 20 MHz)	
LTE-Advanced	OFDMA	Advanced version of LTE designed to meet IMT-Advanced requirements.		

2G
2.5G
2.5G
3G
3.5G
3.5G
3.9G
4G

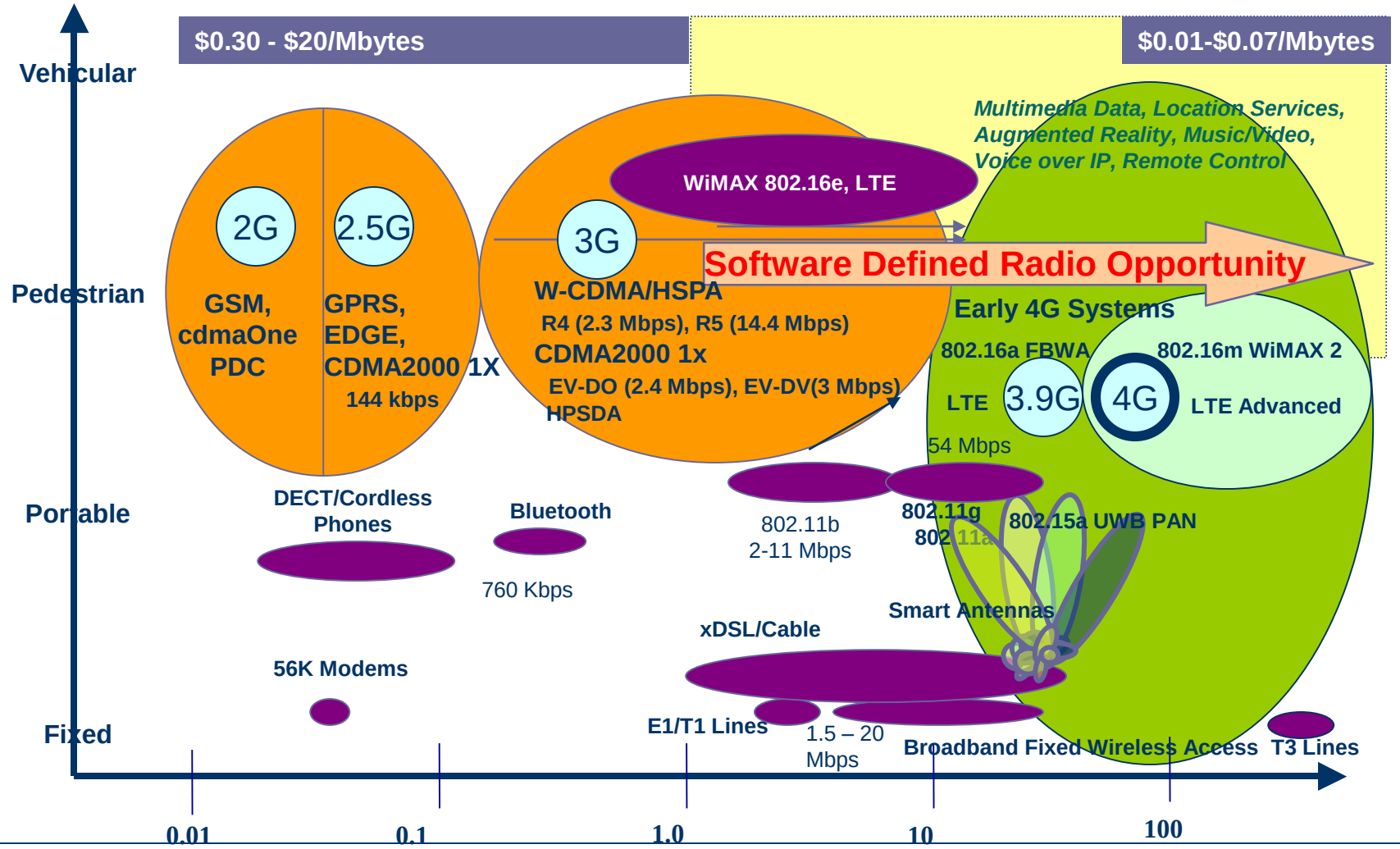
Background of LTE: Access Network Evolution

The Driver for LTE is Data…

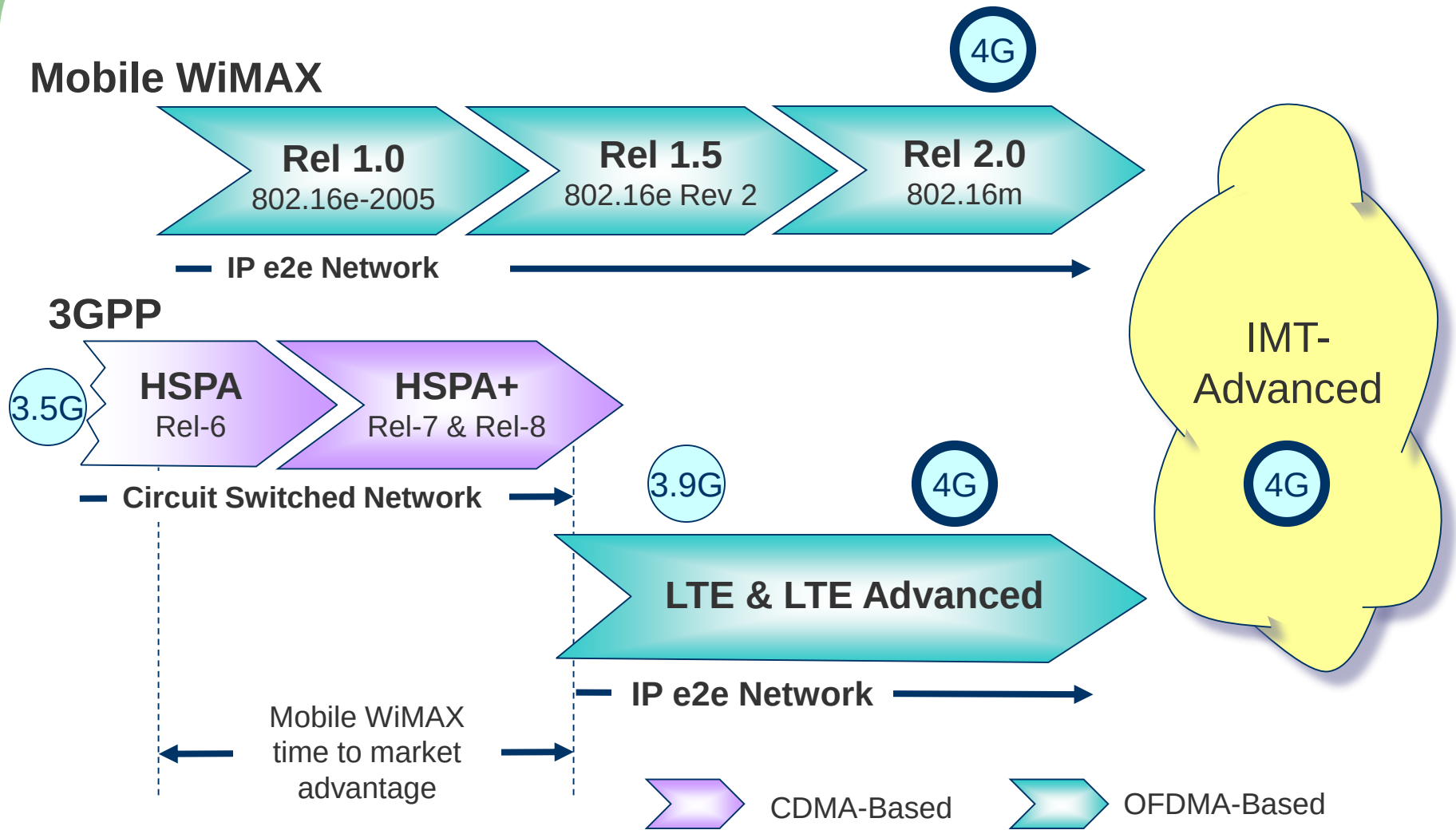


But
Voice and SMS:
Still the leading Mobile Applications today…

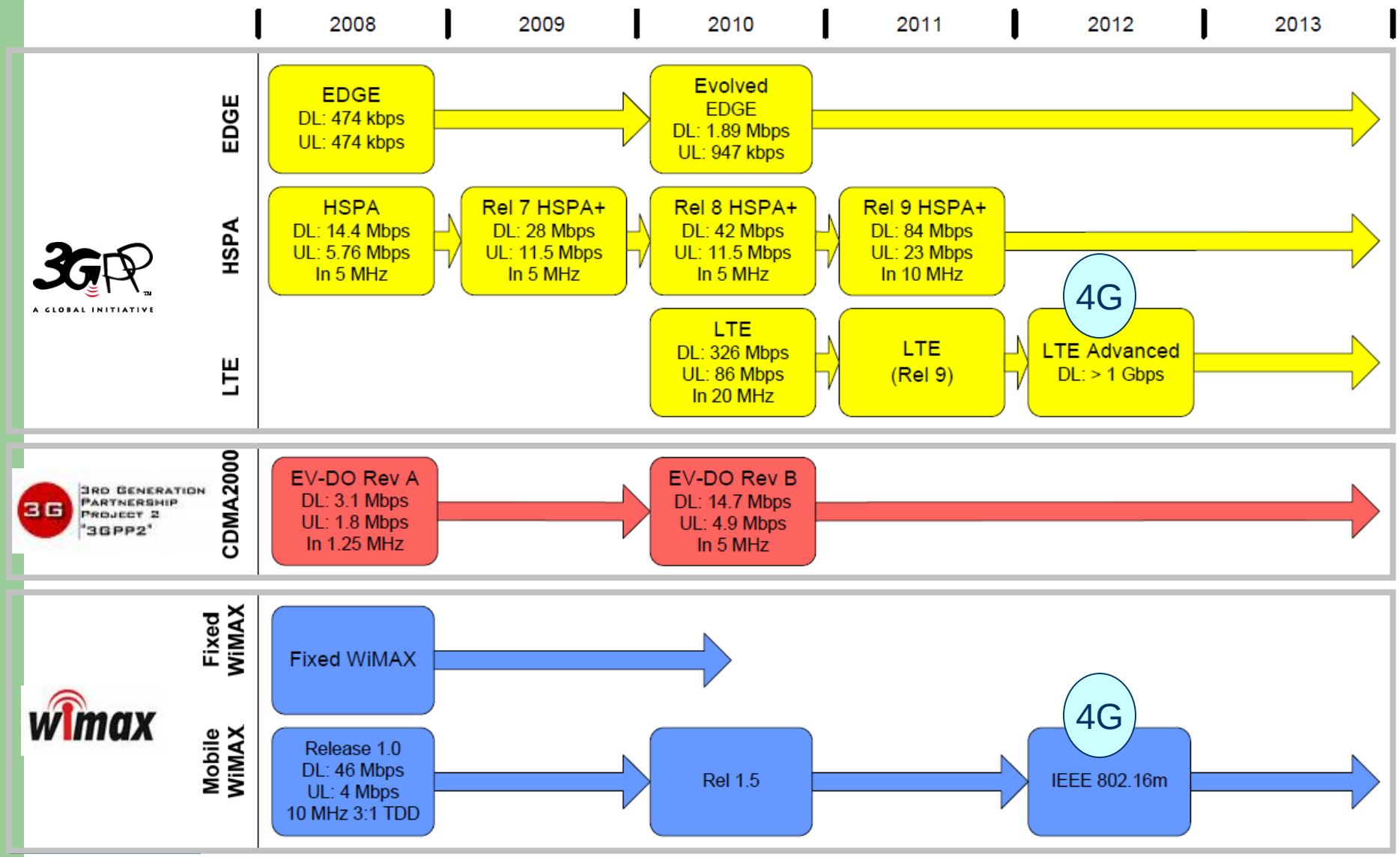
Wireless Access Roadmap



3GPP & Mobile WiMAX Timeline



Evolution of TDMA, CDMA and OFDMA Systems



Notes: Throughput rates are peak theoretical network rates. Radio channel bandwidths indicated.
Dates refer to expected initial commercial network deployment except 2008, which shows available technologies that year.

Radio Spektrum UMTS

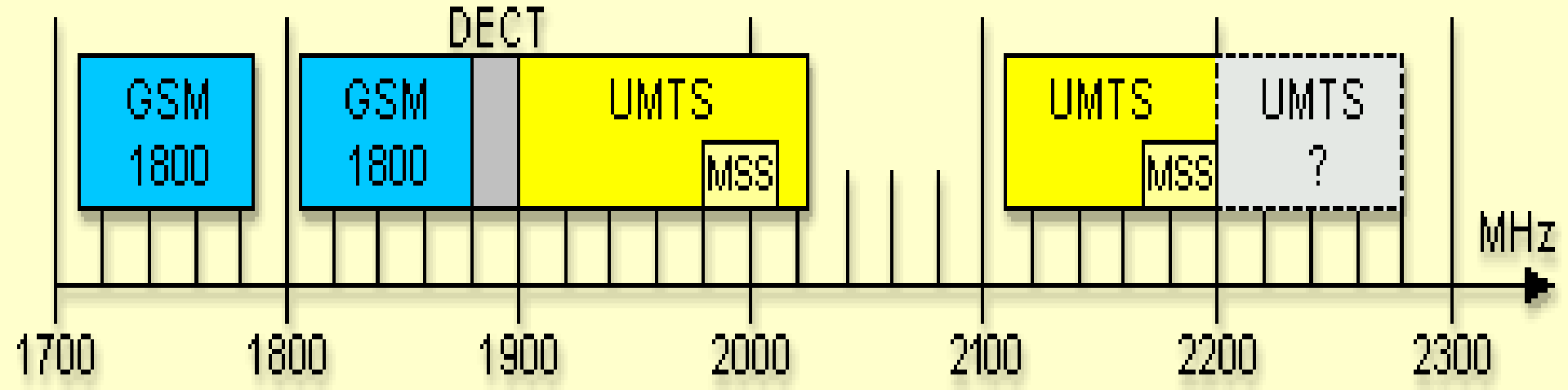
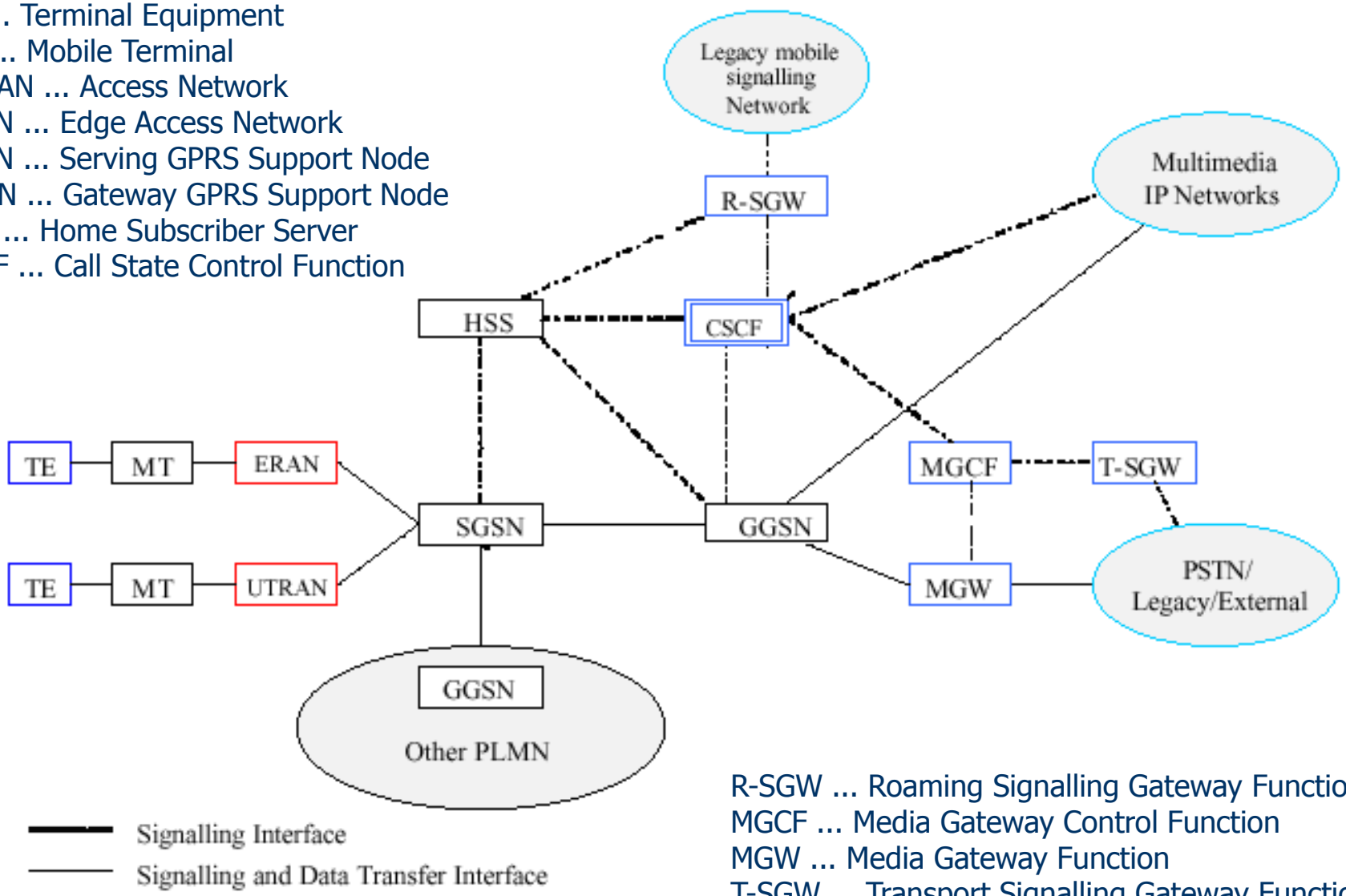


fig. 3: Spectrum for UMTS -

1920 MHz - 1980 MHz	FDD Uplink
2110 MHz - 2170 MHz	FDD Downlink
1900 MHz - 1920 MHz	*TDD*
2010 MHz - 2025 MHz	
1980 MHz - 2010 MHz	MSS (Mobile Satellite Service) Uplink
2170 MHz - 2200 MHz	MSS Downlink

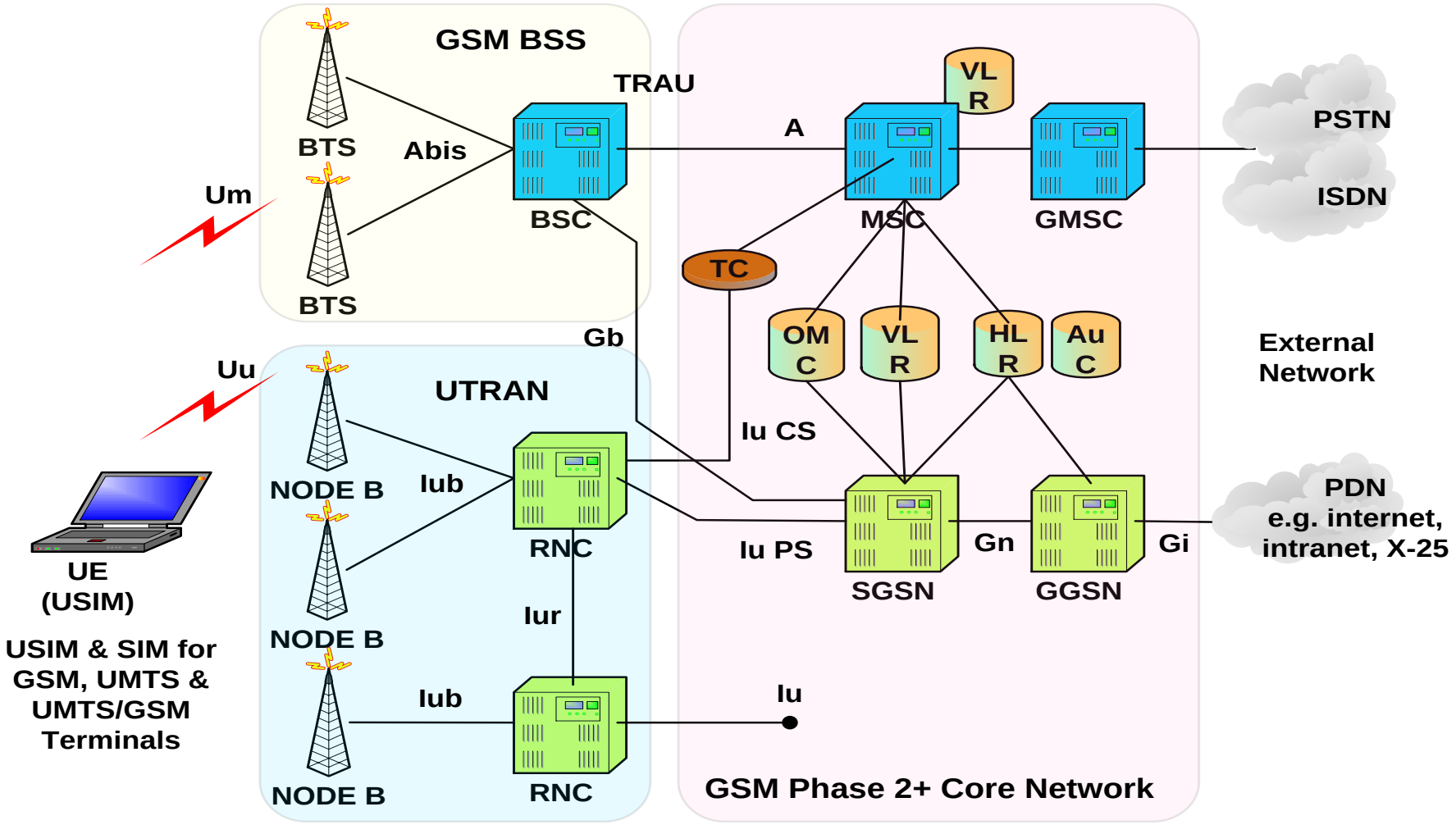
Core Network Architecture UMTS

TE ... Terminal Equipment
MT ... Mobile Terminal
UTRAN ... Access Network
ERAN ... Edge Access Network
SGSN ... Serving GPRS Support Node
GGSN ... Gateway GPRS Support Node
HSS ... Home Subscriber Server
CSCF ... Call State Control Function



R-SGW ... Roaming Signalling Gateway Function
MGCF ... Media Gateway Control Function
MGW ... Media Gateway Function
T-SGW ... Transport Signalling Gateway Function

Arsitektur Jaringan UMTS



Gambar 2.4 Arsitektur Jaringan UMTS

W-CDMA Parameters

Parameters	3GPP (W-CDMA)
Carrier Spacing	5 MHz. (nominal) 4.2-5.4 MHz. On 200 kHz. raster
Downlink RF Channel Structure	Direct Spread
Chip Rate	3.84 Mcps
Roll-off factor for chip shaping	0.22
Frame Length	10 ms.
Number of slots/frame	15
Spreading modulation	Balanced QPSK (downlink) Dual channel QPSK (uplink) Complex spreading circuit
Data modulation	QPSK (downlink) BPSK (uplink)
Coherent Detection	Pilot Symbols/channel
Channel multiplexing in uplink	Control and pilot channel time multiplexed. For the data and control channels I and Q multiplexing
Multirate	Variable spreading and multicode
Spreading Factors	4-256
Power Control	Open and fast closed loop (1.5 kHz.)
Spreading (downlink)	Variable length orthogonal sequences for channel separation. Gold sequences 2^{18} for user separation (different time shifts in I and Q channel, truncated cycle 10 ms.)
Spreading (uplink)	Variable length orthogonal sequences for channel separation. Gold sequences 2^{18} for user separation (different time shifts in I and Q channel, truncated cycle 10 ms.)
Handover	Soft handover; Interfrequency Handover

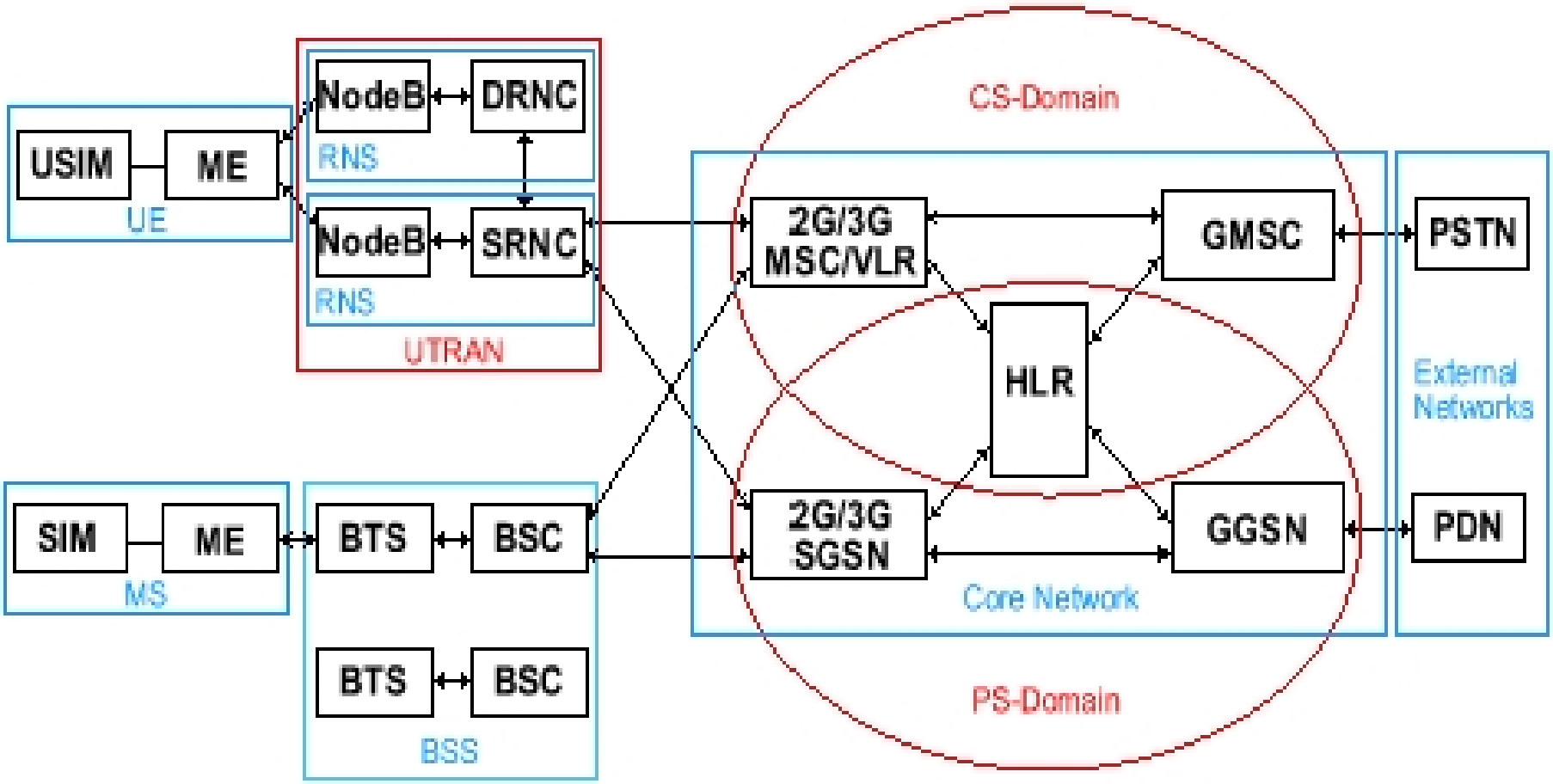
W-CDMA Spreading

- W-CDMA uses long spreading codes
  - One set of codes are used for cell separation on downlink
  - One set of codes are used for user separation on uplink
- Downlink
  - Gold Codes of length 2^{18} are used
  - Truncated to same length as the 10 ms frames
  - Total number of scrambling codes is 512
  - Divided into 64 code groups with 8 codes in each group, to allow fast cell search (recently revised)
- Uplink
  - Short codes can be used to ease implementation of advanced multi-user receiver techniques
    - VL-Kasami Codes of length 256 chips
  - Otherwise long codes are used
    - Gold sequences of length 2^{41} chips, truncated to 10 ms

W-CDMA Channelization

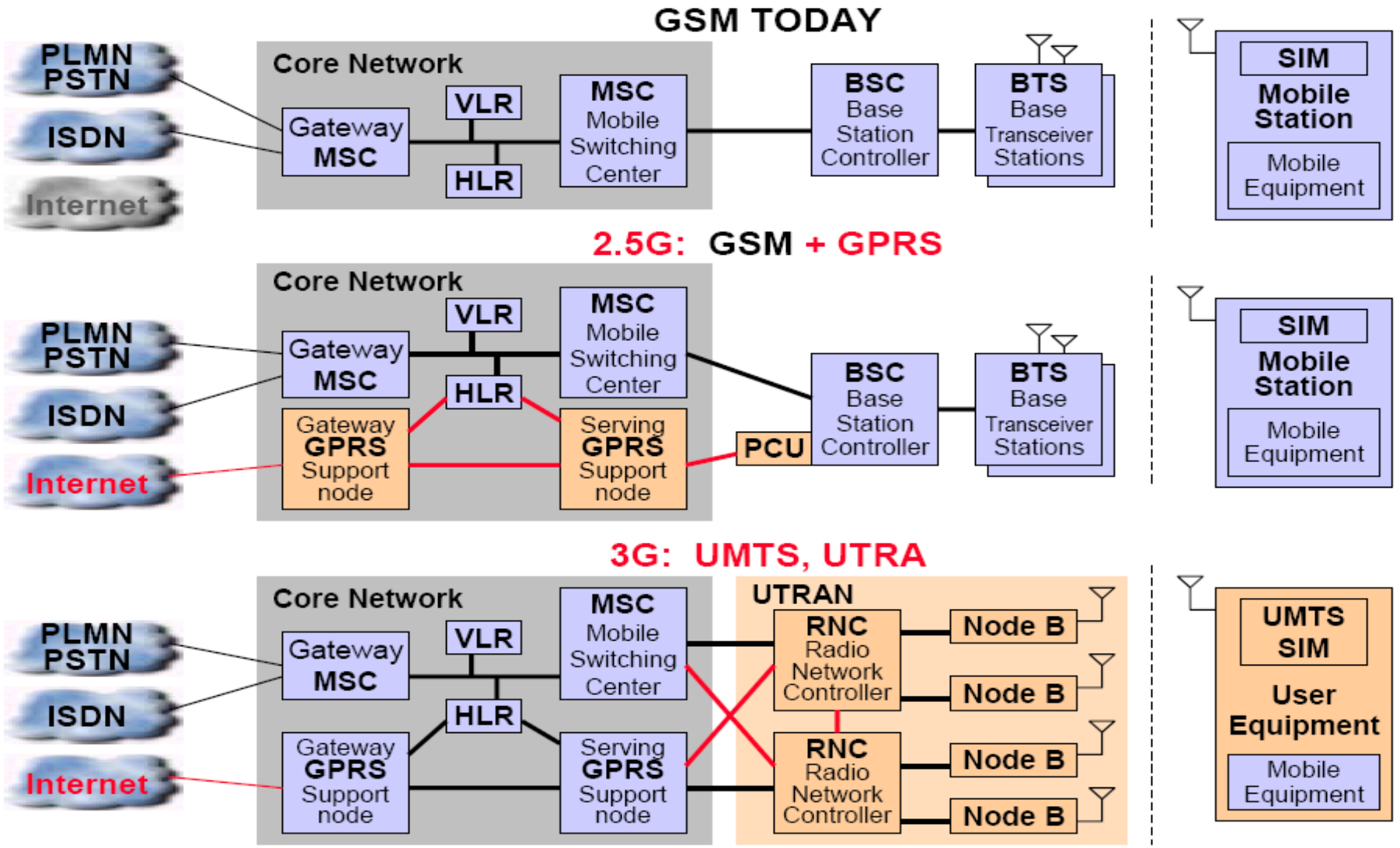
- Orthogonal OVSF codes are used for channelization
- OVSF codes are used from a tree structure
  - This ensures that only orthogonal codes are used

W-CDMA Network

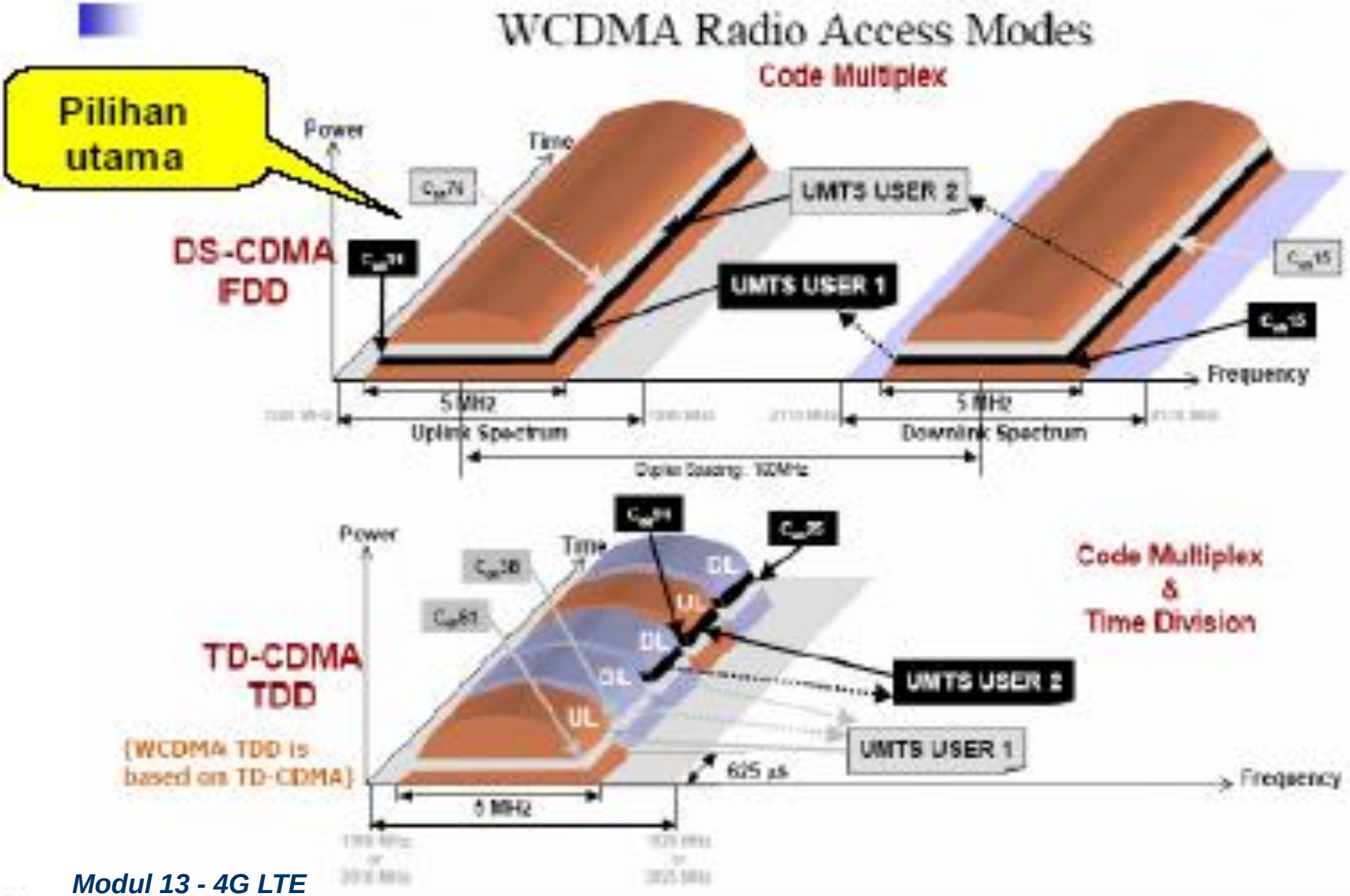


UMTS R99 Architecture

3 Steps to 3G: The GSM Network Transition



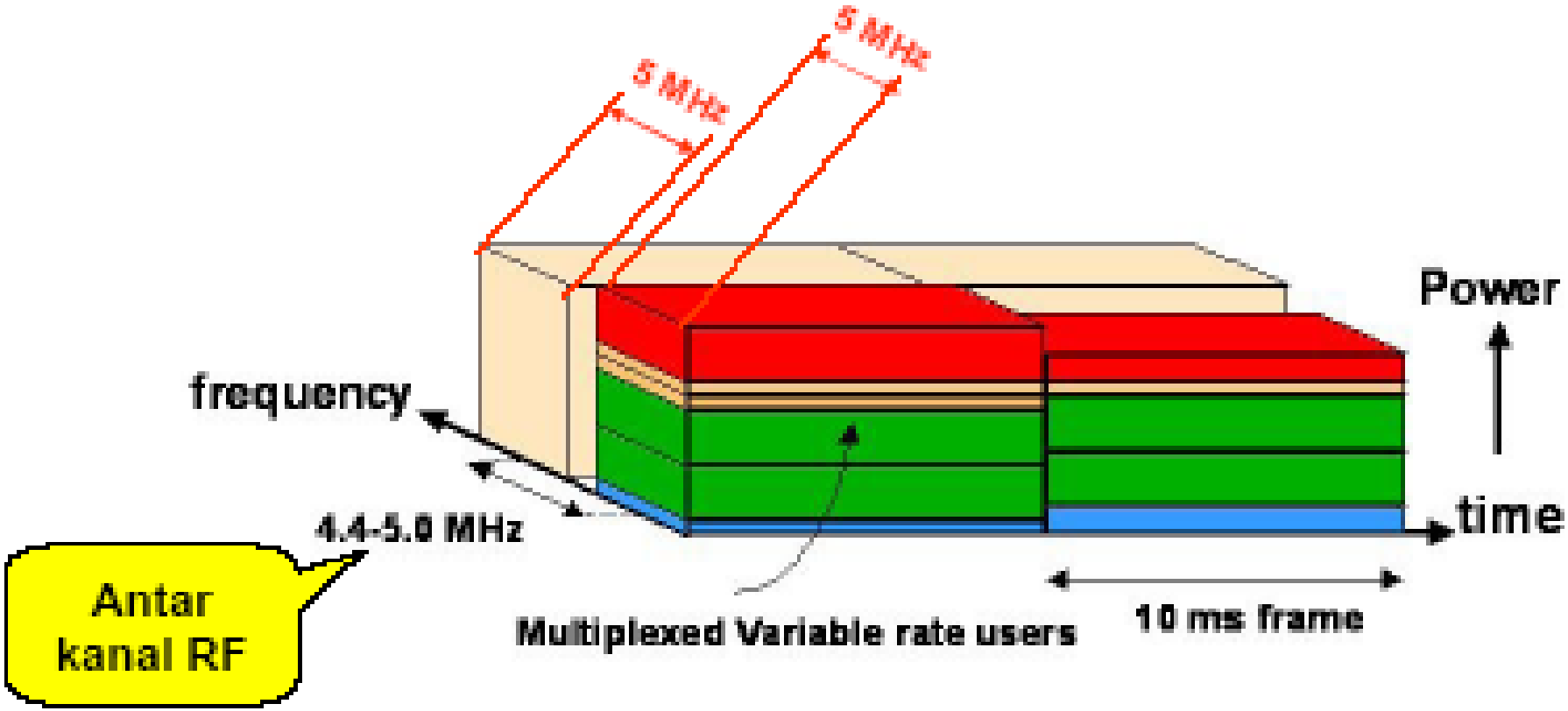
Model Radio Access W-CDMA



Spesifikasi W-CDMA (UMTS)

Channel Bandwidth	5 MHz
Duplex Mode	FDD and TDD
Downlink RF Channel Structure	Direct Spread (DS)
Chip Rate	3.84 Mcps
Frame Length	10 ms
Spreading Modulation	Balanced QPSK (downlink), Dual-channel QPSK (uplink) Complex spreading circuit
Data Modulation	QPSK (downlink), BPSK (uplink)
Channel Coding	Convolutional and turbo codes
Coherent detection	• User dedicated time multiplexed pilot (downlink and uplink) • common pilot in downlink
Channel Multiplexing in Downlink	Data and control channel are multiplexed
Channel Multiplexing in Uplink	• Control and pilot channel time multiplexed • I&Q multiplexing for data and control channel
Multirate	Variable spreading and multicode
Spreading Factors	4-256 (uplink), 4-512 (downlink)
Power Control	Open and fast closed loop (1.6 kHz)
Spreading (downlink)	OVSF sequences for channel separation. Gold sequences 2^{18}-1 for cell and user separation (truncated cycle 10 ms)
Spreading (uplink)	OVSF sequences. Gold sequence 2^{41} for user separation (different time shifts in I and Q channel, truncated cycle 10 ms)
Handover	Soft handover, Inter-frequency handover, etc.

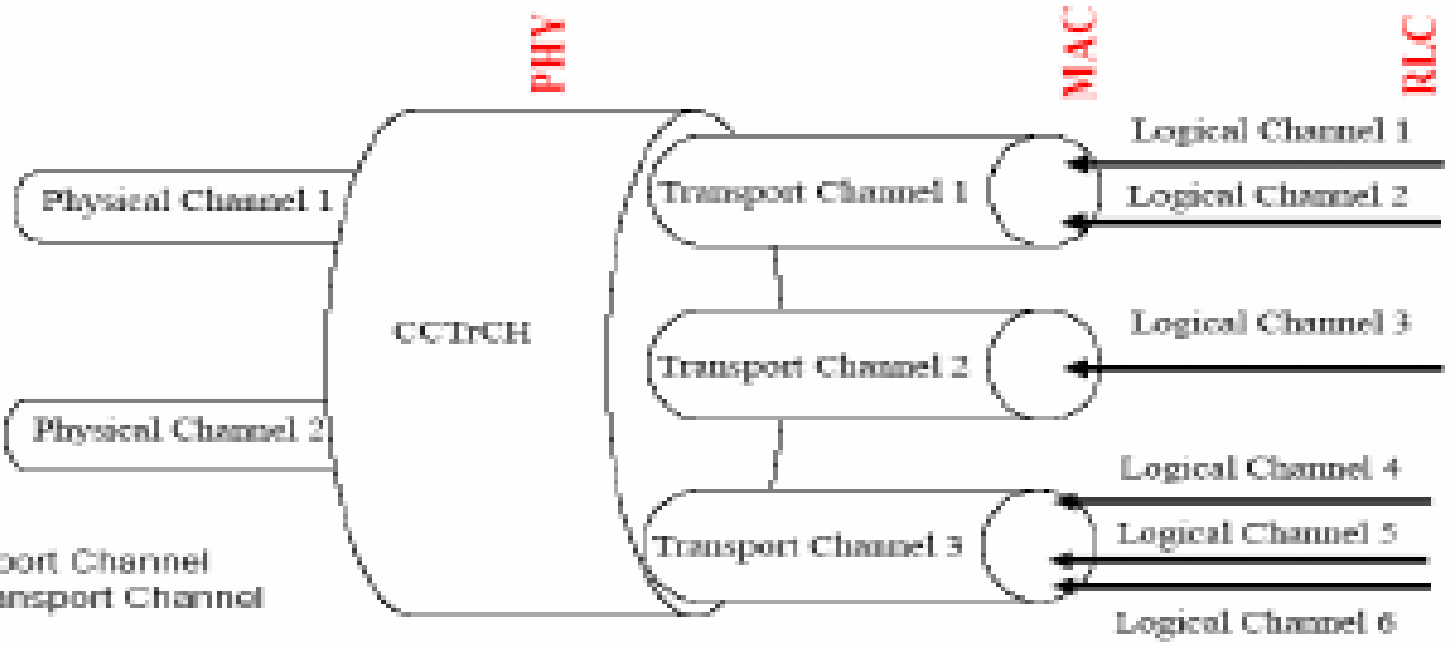
Kanal Fisik - UMTS



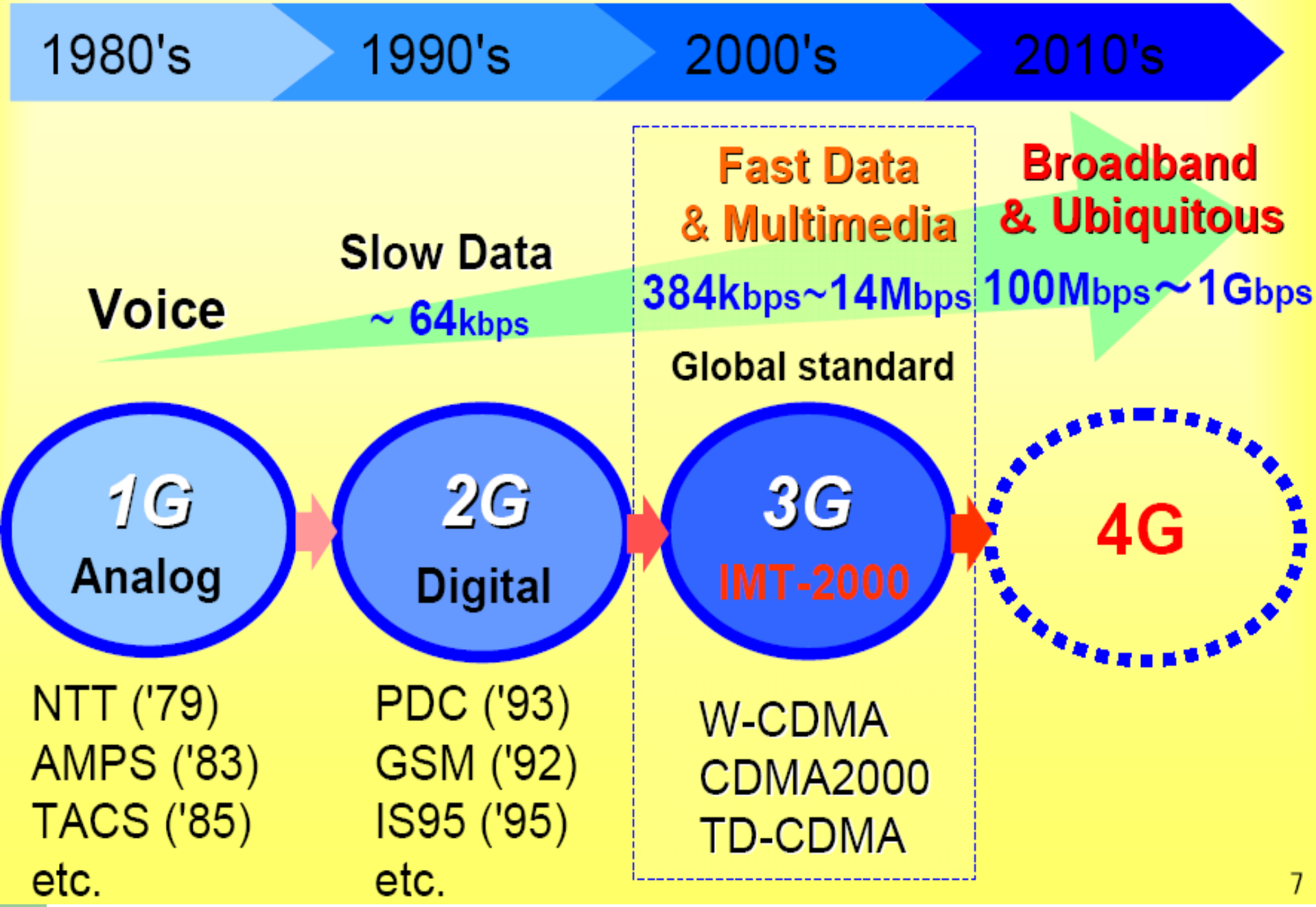
Chip rate = 3.84 Mcps
RF bandwidth = 5 MHz
Physical layer data rates = 15, 30, 60, 120, 240, 480, 960 and 1920 kbps
Payload data rates = 12.2, 64, 144, 384, 768 and 2048 kbps
Frame length = 10 ms
Fast power control = bi-directional, 1500 Hz

Type Kanal pada UMTS

- Kanal Logika (*Logical Channel*) antara RLC dan MAC
  - Spesifik untuk tipe-tipe informasi
- Kanal Transport (*Transport channel*) antara MAC dan PHY
  - Spesifik untuk "Bagaimana informasi ditransfer ?" (garansi kualitas)
- Kanal Fisik (Physical Channel)
  - Aktual transmisi pada *physical layer*

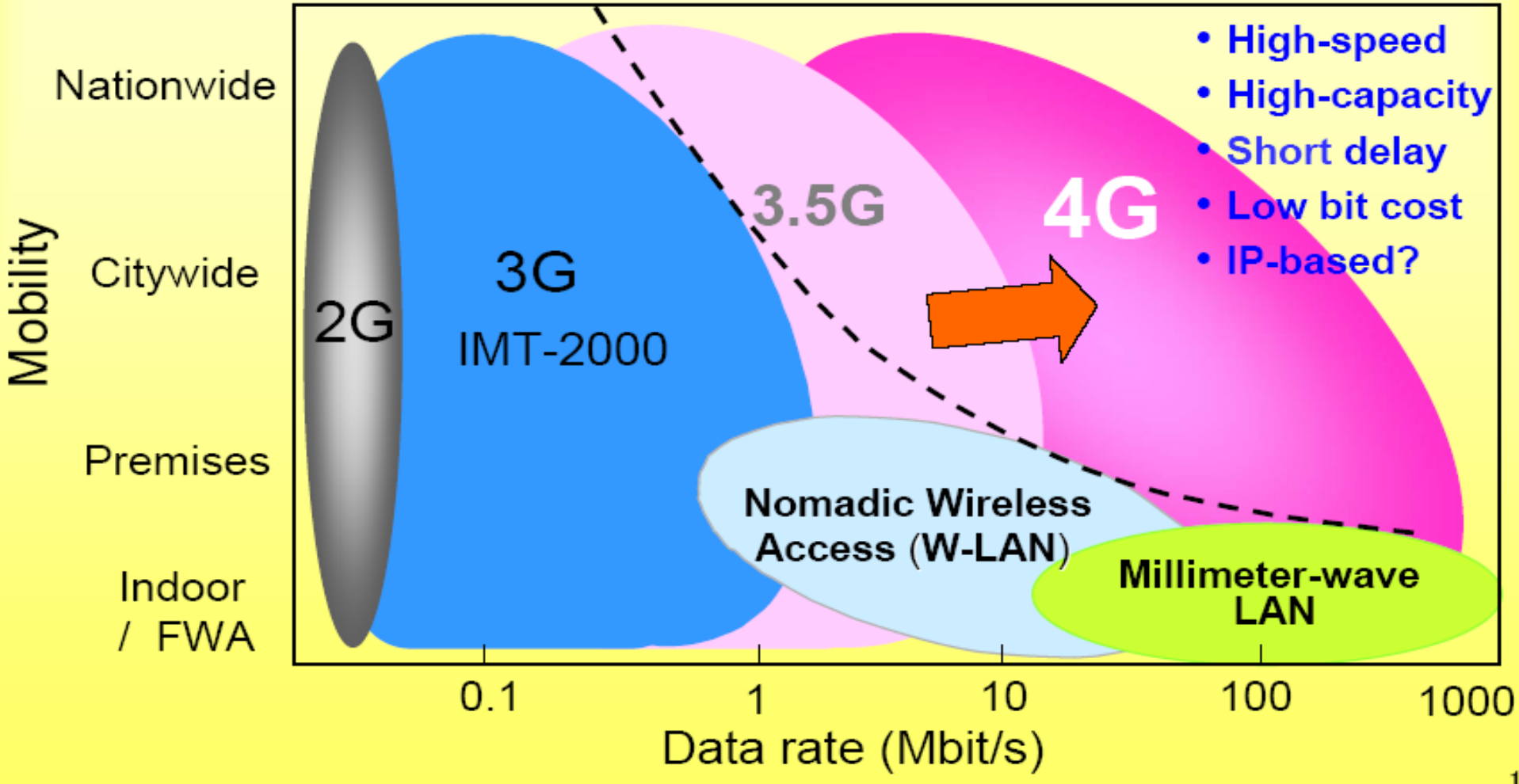


CCTrCH:
Coded Composite Transport Channel
(Connection between Transport Channel and Physical Channel)


1980's
1990's
2000's
2010's
Voice
Slow Data
~ 64kbps
Fast Data
& Multimedia
384kbps~14Mbps
Global standard
Broadband
& Ubiquitous
100Mbps~1Gbps
1G
Analog
2G
Digital
3G
IMT-2000
4G
NTT ('79)
AMPS ('83)
TACS ('85)
etc.
PDC ('93)
GSM ('92)
IS95 ('95)
etc.
W-CDMA
CDMA2000
TD-CDMA

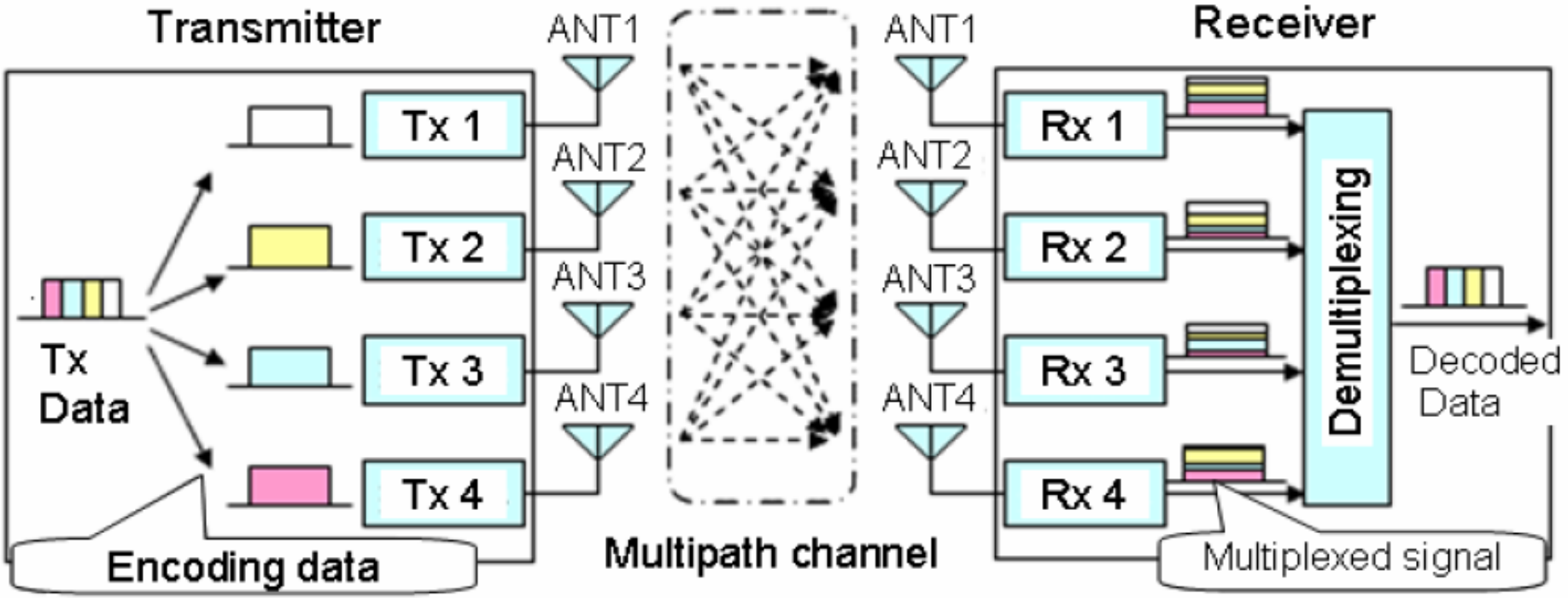
4G Enhancement in Transmission

- New **Broadband Packet Wireless Access Technology** will remarkably enhance system performance.



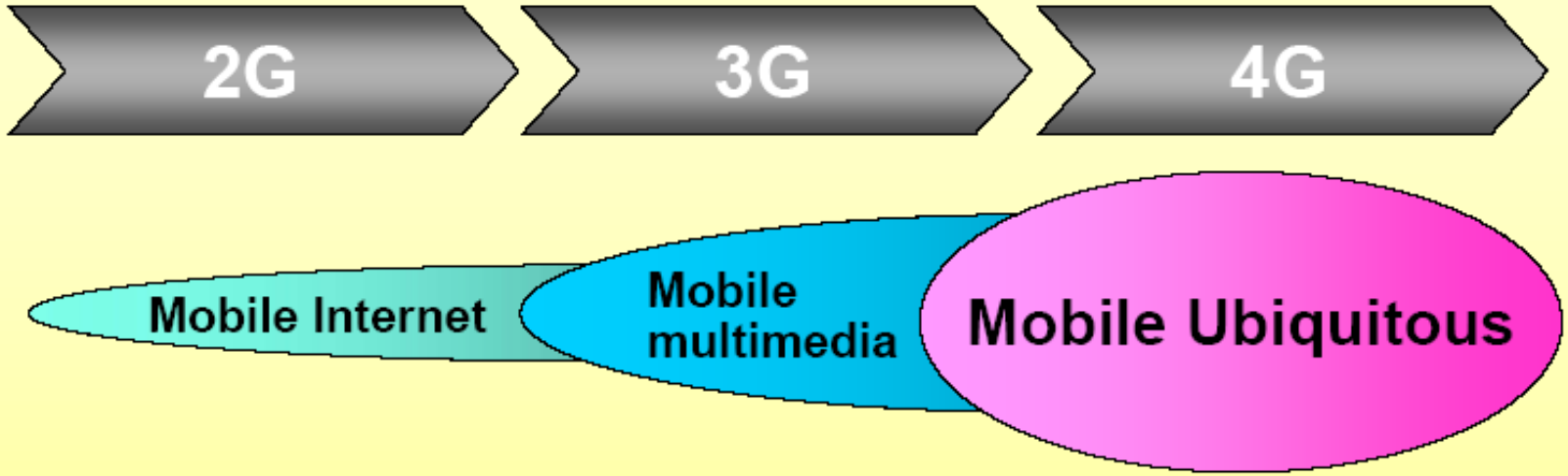
1Gbps Wireless Access

- **MIMO** (Multiple-Input Multiple-Output)



Spectrum efficiency target: 10bit/Hz
Demultiplexing method is the key.

4G Evolution Scenario



Services

- i-mode
  - E-mail
  - Web Access
- FOMA
  - Visual mail
  - TV conference
  - Video phone
- Ubiquitous Collaboration
  - Object-related application
  - Application based on real world info.

Systems

PDC PDC-P	ATM -> IP 3G RAN -> IP RAN	3G, 3.5G, 4G WLAN, Non-cellular

4G Technologies

Mobile WiMAX

Rel 1.0 802.16e-2005 | Rel 1.5 802.16e-2005 | Rel 2.0 802.16m

IP E2E Network

3GPP

HSPA Rel-6 | HSPA+ Rel-7 &Rel-8

CKT Switched Network

LTE & LTE Advanced

IP E2E Network

IMT-Advanced

2008	2009	2010	2011	2012

CDMA - Based

OFDMA - Based

From 3G to 4G

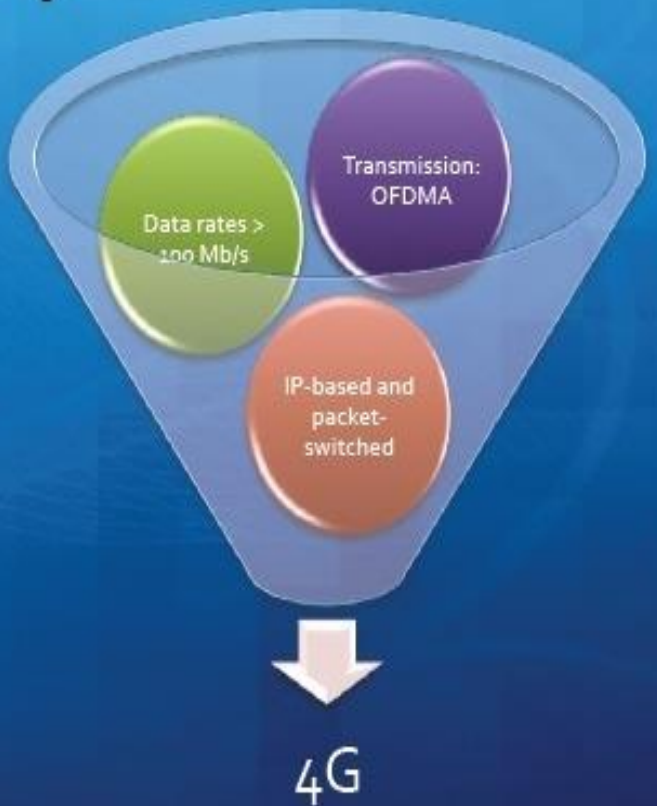
Coverage

- 3G → large area
- 4G → wide area & small-area (WiFi-like)
  - → wide- & narrow-area services from a single device, single network

Spectrum-Efficiency

- Researchers developed more spectrally efficient modulation schemes for encoding data onto carrier waves, such as 64 QAM
  - → Incompatible with 3G & 3.5G

ITU 4G Requirement



ITU 4G Schedule

2008-2009
- selecting candidate technologies

2009-2010
- developing detailed specification

2010-2012
- official implementation

2015
- wide deployment

Definisi 4G

- Generasi keempat dari standar nirkabel selular. Penerus standar 3G dan 2G.
  - 1G : analog
  - 2G : transmisi digital
  - 3G : mendukung multimedia support, transmisi *spread spectrum* minimal 200 kbps
  - 4G : jaringan seluruhnya berbasis *packet-switched*, *mobile ultra-broadband access, multi-carrier transmission*
- 4G secara standar merujuk ke *IMT Advanced* sebagaimana didefinisikan oleh ITU-R.
- LTE :
  - Long Term Evolution adalah teknologi pre-4G dari 3GPP sering dicap sebagai “4G”
  - LTE release pertama tidak memenuhi persyaratan the IMT Advanced

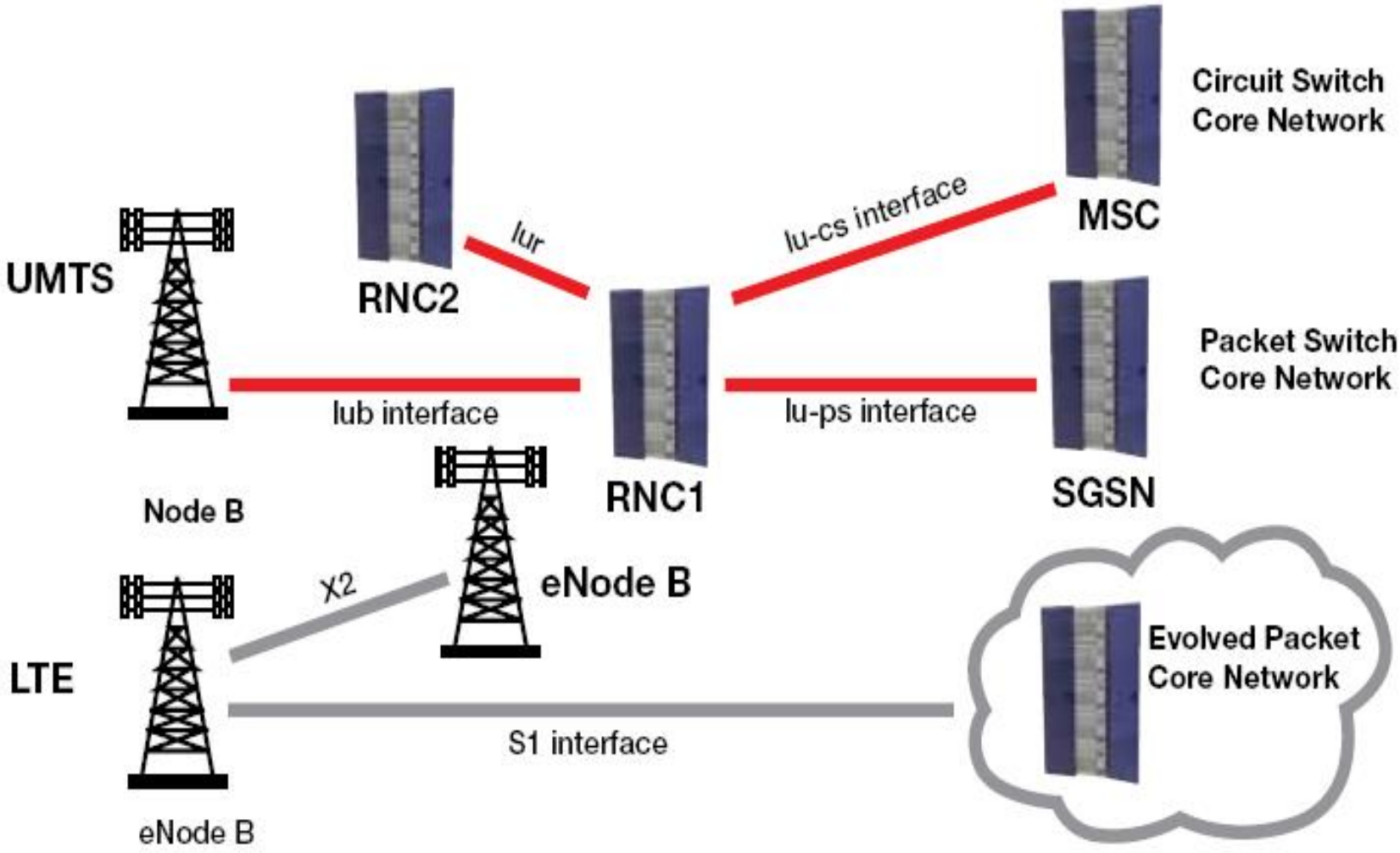
4G – Mobile Broadband Systems

- A variety of technology standards able to provide transmission rates beyond 3G (2 Mb/s)
- Advantages
  - Provides access to services and applications requiring these higher transmission rates
  - Extends capacity in zones where 3G is close to saturation
- Microwave and millimeter wave bands to be used mean smaller cell size (a few to 1000 meters); 5 GHz band will be first used with migration to higher carrier frequencies
- Coverage not continuous, necessitating mobile units to roam between different bands and standards

Alasan Munculnya Kebutuhan LTE

- Kebutuhan akan laju data yang lebih tinggi dan efisiensi spectral yang lebih baik
  * Demand layanan broadband yang meningkat
  * Mahalnya spektrum
- Kebutuhan sistem Packet Switched yang teroptimisasi
  * Evolusi ke all IP Network
- Kebutuhan akan QoS yang tinggi
  * Penggunaan licensed frequency untuk jamininan QoS
  * Minimum latency
- Kebutuhan akan infrastructure yang lebih murah
  * Penyederhanaan architecture dan pengurangan network element

Theory of LTE



Introduction to LTE

- 3GPP Long Term Evolution - the next generation of wireless cellular technology beyond 3G
- Initiative taken by the 3rd Generation Partnership Project in 2004
- Introduced in Release 8 of 3GPP
- Mobile systems likely to be deployed by 2010

LTE background story
the early days

- Work on LTE was initiated as a 3GPP release 7 study item "Evolved UTRA and UTRAN" in December 2004:
  - *"With enhancements such as HSDPA and Enhanced Uplink, the 3GPP radio-access technology will be highly competitive for several years. However, to ensure competitiveness in an even longer time frame, i.e. for the next 10 years and beyond, a long term evolution of the 3GPP radio-access technology needs to be considered."*
- Basic drivers for LTE have been:
  - Reduced latency
  - Higher user data rates
  - Improved system capacity and coverage
  - Cost-reduction.

About LTE/System Architercture Evolution (SAE)

- Packet Switched data is becoming more and more dominant
- VoIP is the most efficient method to transfer voice data

→ Need for PS optimised system

- Amount of data is continuously growing

→ Need for higher data rates at lower cost

- Users demand better quality to accept new services

→ High quality needs to be quaranteed

> Alternative solution for non-3GPP technologies (WiMAX) needed

- LTE will enhance the system to satisfy these requirements.

LTE Overview

- 3GPP R8 solution for the next 10 years.
- Peaks rates: DL 100Mbps with Orthogonal Frequncy Division Multiple Access (OFDMA), UL 50Mbps with Single Carrier Frequncy Division Multiple Access (SC-FDMA).
- Latency for Control-plane < 100ms, for User-plane < 5ms.
- Optimised for packet switched domain, supporting VoIP.
- Scaleable RF bandwidth between 1.25MHz to 20MHz.
- 200 users per cell in active state.
- Supports Mobile Broadband Multimedia Services.
- Uses MIMO multiple antenna technology.
- Optimised for 0-15km/h mobile speed and support for up-to 120-350 km/h.
- No soft handover, Intra-RAT handovers with UTRAN.
- Simpler E-UTRAN architecture: no RNC, no CS domain, no DCH.

LTE technical objectives

- **User throughput [/MHz]:**
  - **Downlink: 3 to 4 times Release 6 HSDPA**
  - **Uplink: 2 to 3 times Release 6 Enhanced Uplink**
- **Downlink Capacity: Peak data rate of 100 Mbps in 20 MHz maximum bandwidth**
- **Uplink capacity: Peak data rate of 50 Mbps in 20 MHz maximum bandwidth**
- **Latency: Transition time less than 5 ms in ideal conditions (user plane), 100 ms control plane (fast connection setup)**

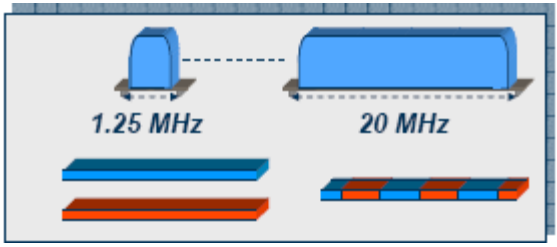
- **Mobility: Optimised for low speed but supporting 120 km/h**
  - ***Most data users are less mobile!***
- **Simplified architecture: Simpler E-UTRAN architecture: no RNC, no CS domain, no DCH**
- **Scalable bandwidth: 1.25MHz to 20MHz: Deployment possible in GSM bands.**

- LTE
  - Higher data rate than legacy
  - Better coverage and performance
  - Flexible and scalable deployment
  - Designed from both, system and mobile terminal perspective
- SAE
  - Inter-operability between more RATs than LTE even non-3GPP
  - Simplified from predecesors (redundant features removed)
  - More secure than legacy
  - Faster than legacy
  - Better performance than legacy

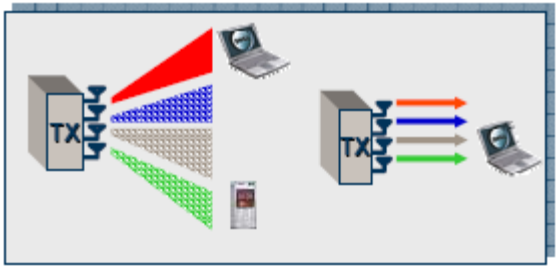
LTE agreements

- 2 main issues have been investigated:
  - The physical layer
  - The access network internal architecture
- Physical layer
  - Downlink based on OFDMA
    - OFDMA offers improved spectral efficiency, capacity etc
  - Uplink based on SC-FDMA
    - SC-FDMA is technically similar to OFDMA but is better suited for uplink from hand-held devices
    - (battery power considerations)
  - For both FDD and TDD modes (User Equipment to support both)
    - With Similar framing + an option for TD SCDMA framing also
- Access Network consideration
  - For the access network it was agreed to get rid of the RNC which minimized the number of nodes

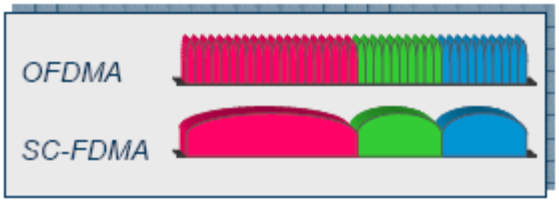
- **Spectrum flexibility**
  - *Flexible bandwidth*
  - *Duplex flexibility*



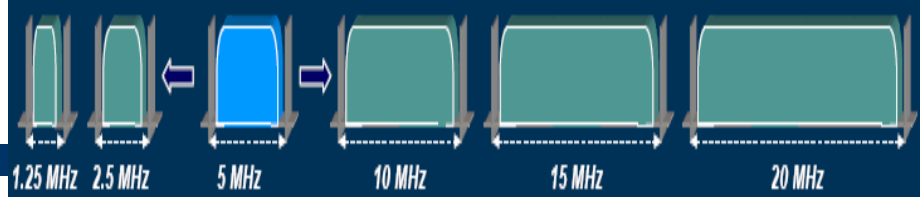
- **Advanced antenna solutions**
  - *Diversity*
  - *Beam-forming*
  - *Multi-layer transmission (MIMO)*



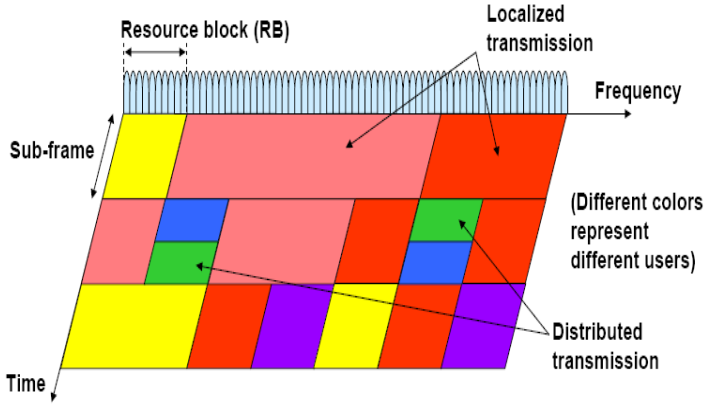
- **New radio access**
  - *Downlink: OFDM*
  - *Uplink: SC-FDMA*



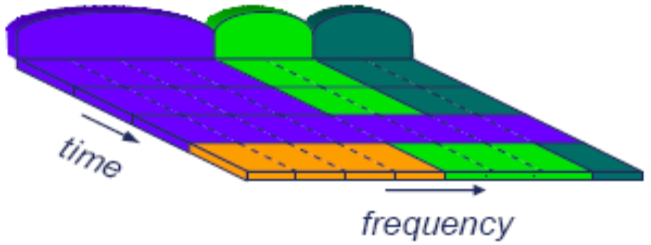
LTE radio interface



- New radio interface modulation: SC-FDMA UL and OFDMA DL
  - Frequency division, TTI 1 ms
  - Scalable bandwidth 1.25-20MHz
  - TDD and FDD modes
    - UL/DL in either in same or in another frequncy
  - OFDMA has multiple orthogonal subcarries that can be shared between users
    - quickly adjustable bandwith per user
  - SC-FDMA is technically similar to OFDMA but is better suited for uplink from hand-held devices
    - Single carrier, time space multiplexing
    - Tx consumes less power



From Ericsson, H. Djuphammar



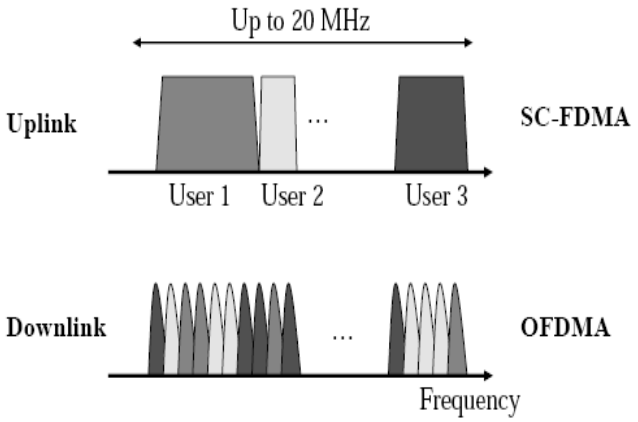


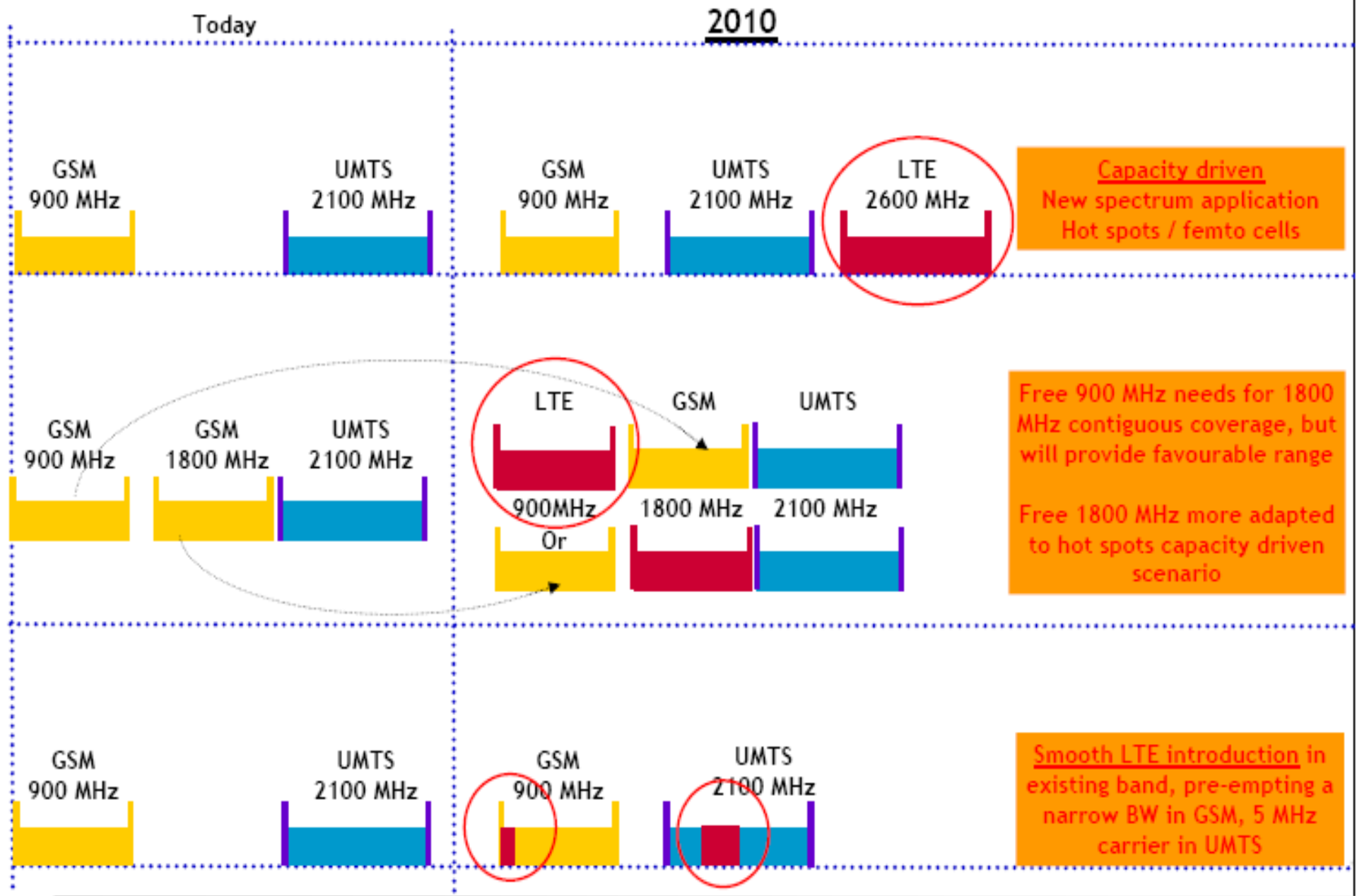
Figure 1.7 LTE multiple access schemes

FDD (left) and TDD (right) frequency bands defined in the 3GPP (May 2009)

Operating band	3GPP name	Total spectrum	Uplink [MHz]	Downlink [MHz]
Band 1	2100	2x60 MHz	1920-1980	2110-2170
Band 2	1900	2x60 MHz	1850-1910	1930-1990
Band 3	1800	2x75 MHz	1710-1785	1805-1880
Band 4	1700/2100	2x45 MHz	1710-1755	2110-2155
Band 5	850	2x25 MHz	824-849	869-894
Band 6	800	2x10 MHz	830-840	875-885
Band 7	2600	2x70 MHz	2500-2570	2620-2690
Band 8	900	2x35 MHz	880-915	925-960
Band 9	1700	2x35 MHz	1750-1785	1845-1880
Band 10	1700/2100	2x60 MHz	1710-1770	2110-2170
Band 11	1500	2x25 MHz	1427.9-1452.9	1475.9-1500.9
Band 12	US700	2x18 MHz	698-716	728-746
Band 13	US700	2x10 MHz	777-787	746-756
Band 14	US700	2x10 MHz	788-798	758-768
Band 17	US700	2x10 MHz	704-716	734-746
Band 18	Japan800	2x30 MHz	815-830	860-875
Band 19	Japan800	2x30 MHz	830-845	875-890

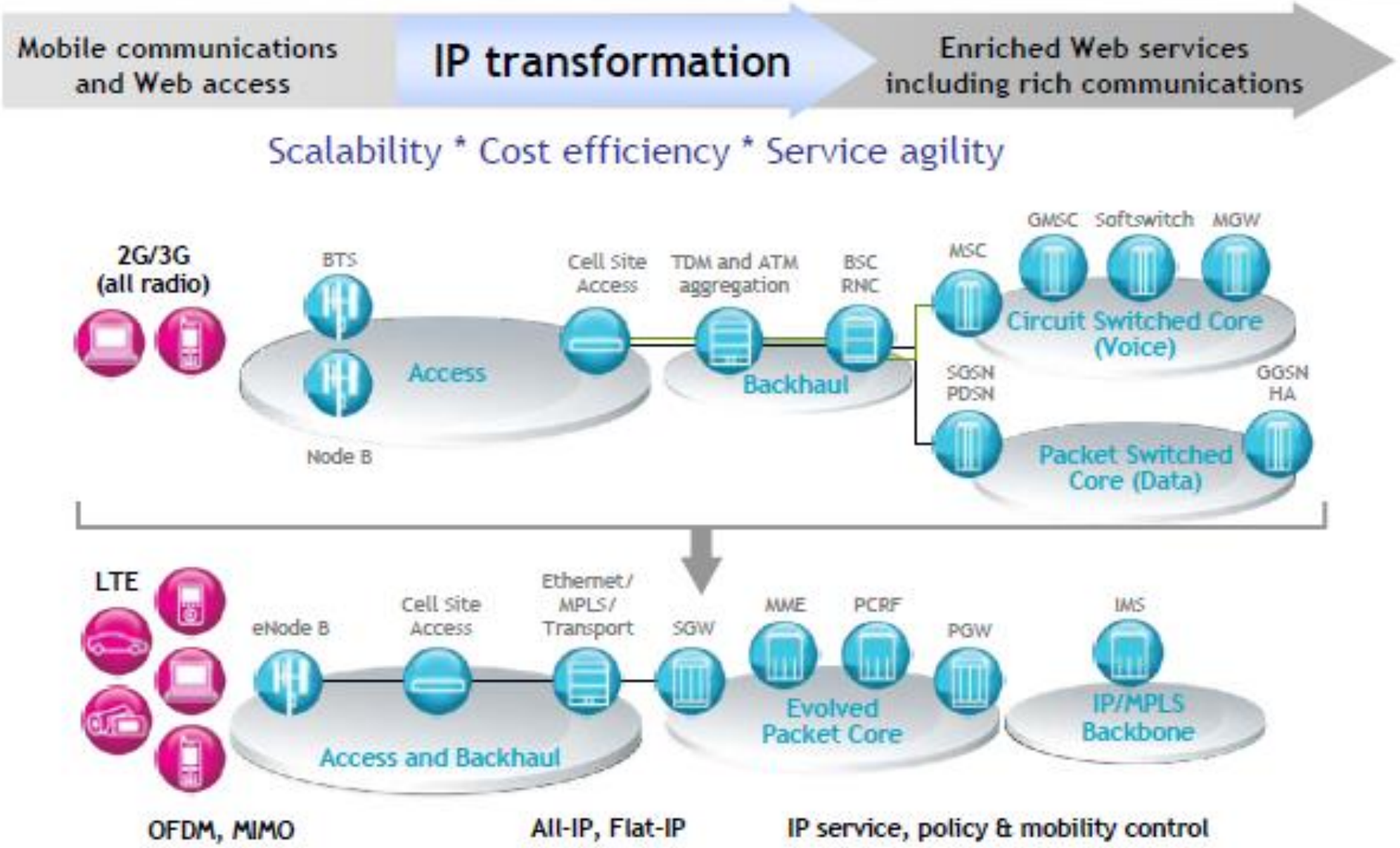
Operating band	3GPP name	Total spectrum	Uplink and downlink [MHz]
Band 33	UMTS TDD1	1x20 MHz	1900-1920
Band 34	UMTS TDD2	1x15 MHz	2010-2025
Band 35	US1900 UL	1x60 MHz	1850-1910
Band 36	US1900 DL	1x60 MHz	1930-1990
Band 37	US1900	1x20 MHz	1910-1930
Band 38	2600	1x50 MHz	2570-2620
Band 39	UMTS TDD	1x40 MHz	1880-1920
Band 40	2300	1x50 MHz	2300-2400

LTE Spectrum - New or Re-use : Main Trends



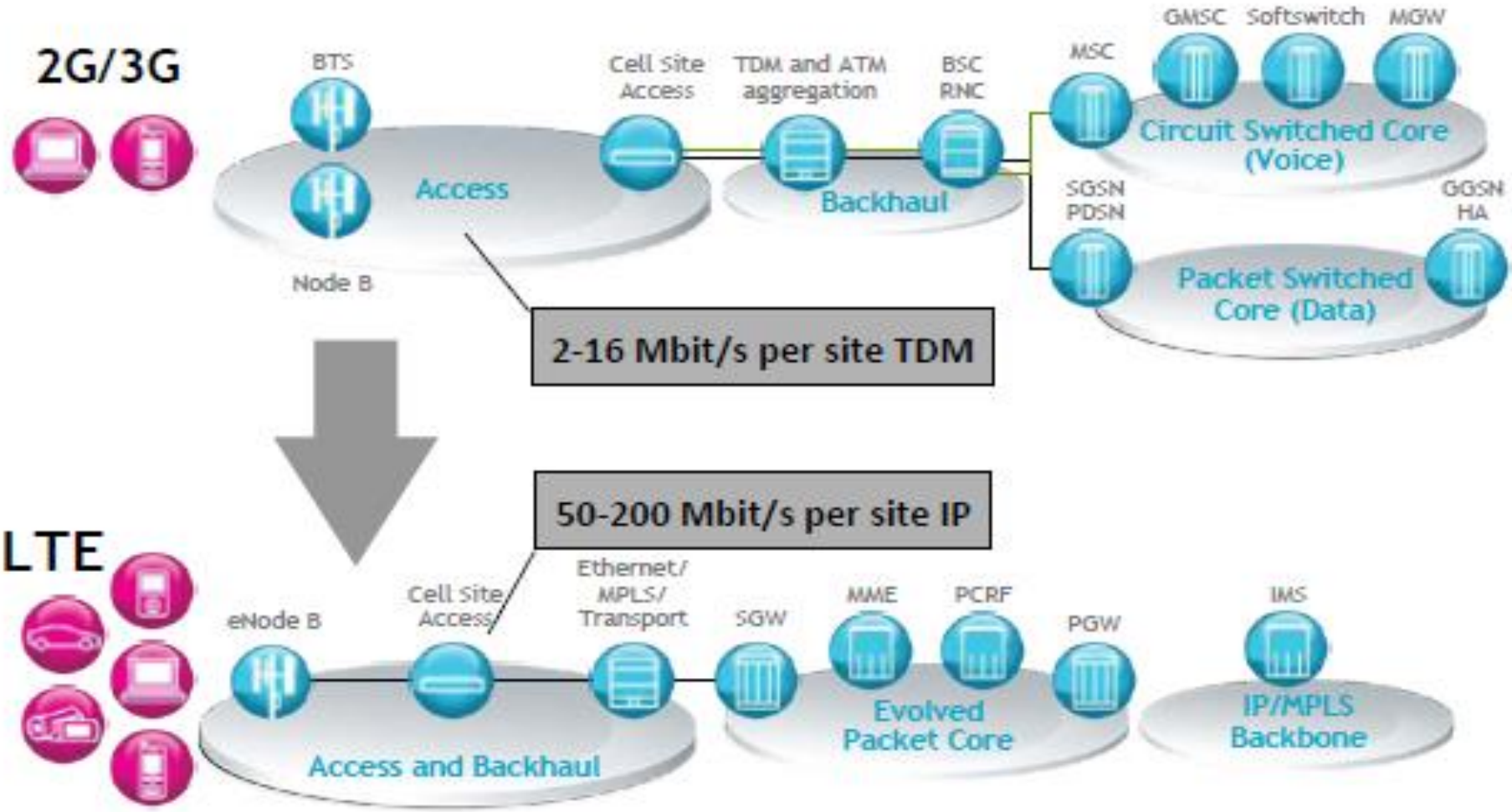
LTE network

...is an end-to-end IP network – migration already underway



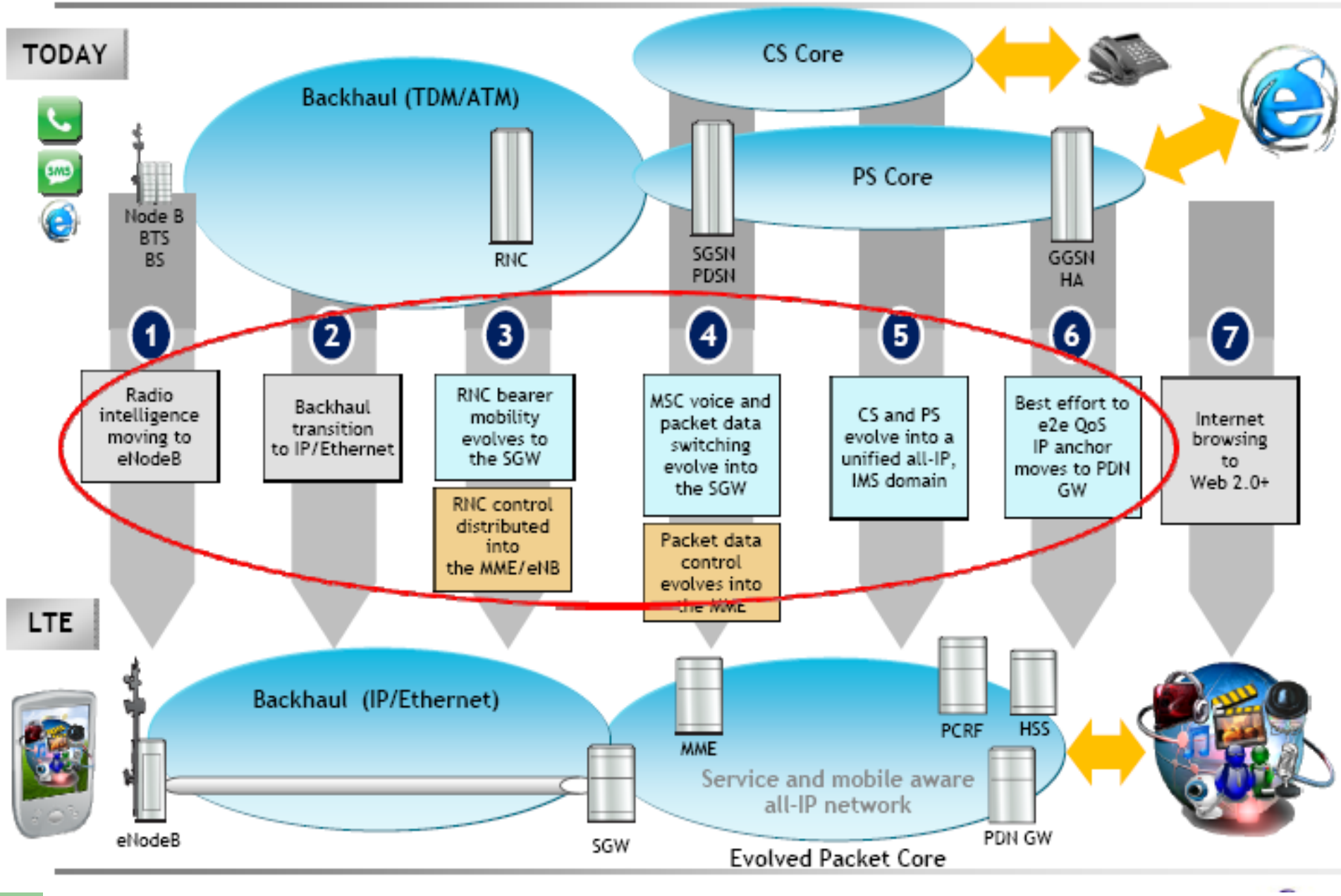
LTE network

...is an end-to-end IP network – migration already underway



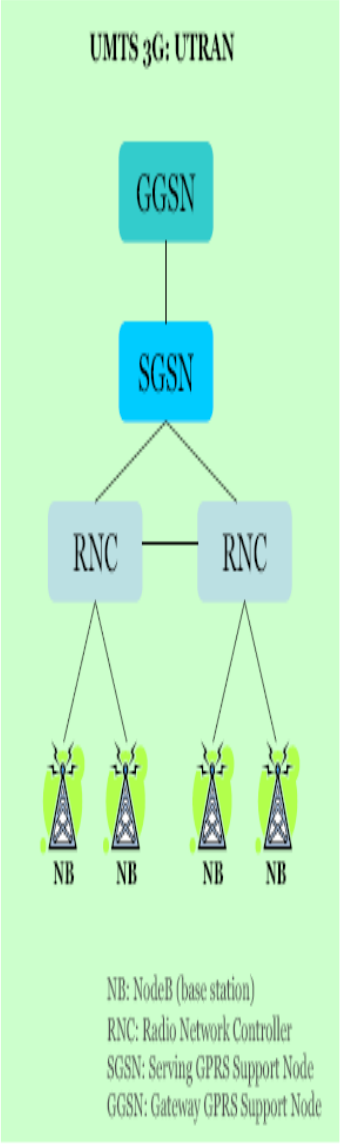
Transmission networks need to be prepared for LTE capacities

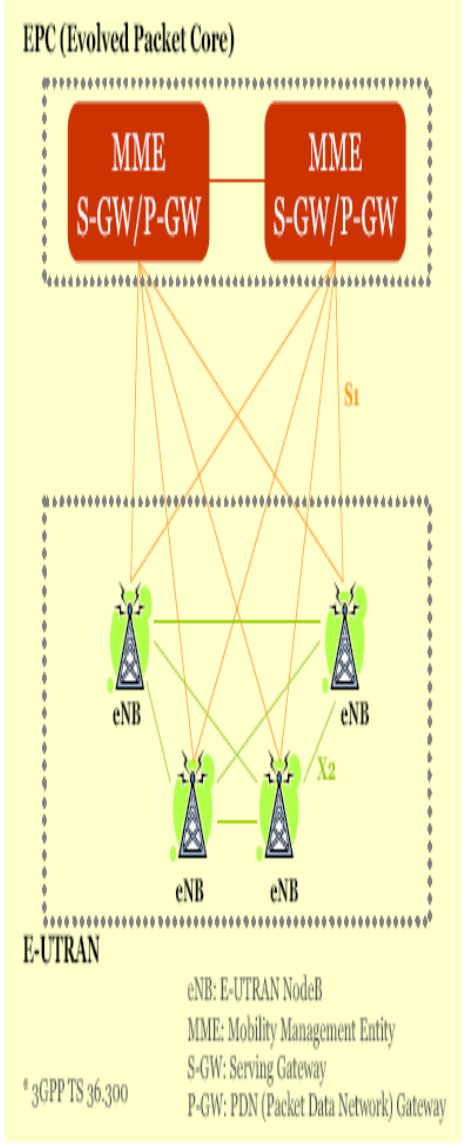
All-IP mobile transformation: What happens?



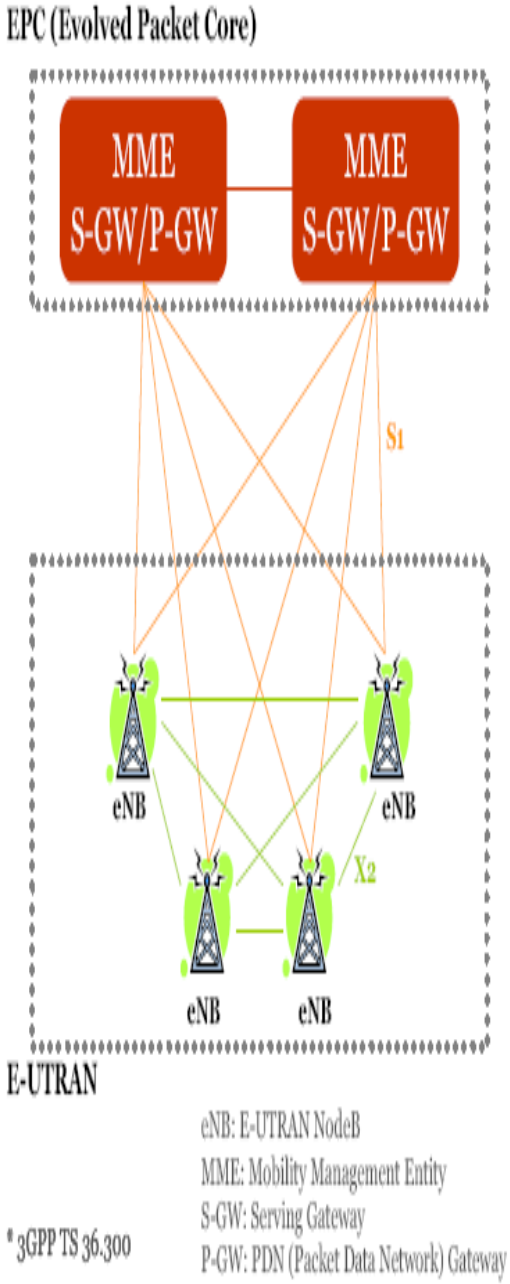
LTE Network Architecture

- E-UTRAN (Evolved Universal Terrestrial Radio Access Network)



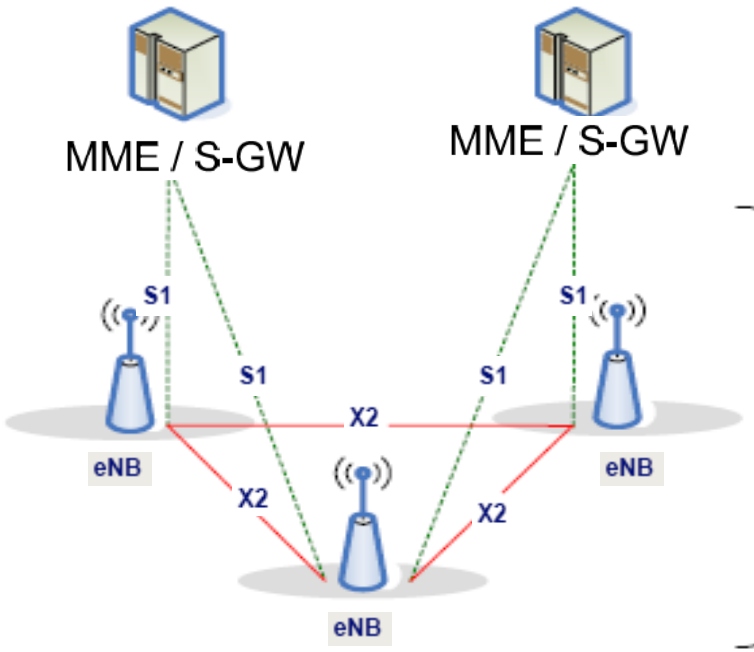


- eNB
  - All radio interface-related functions
- MME
  - Manages mobility, UE identity, and security parameters.
- S-GW
  - Node that terminates the interface towards E-UTRAN.
- P-GW
  - Node that terminates the interface towards PDN.



Simplified LTE network elements and interfaces

3GPP TS 36.300 Figure 4: Overall Architecture

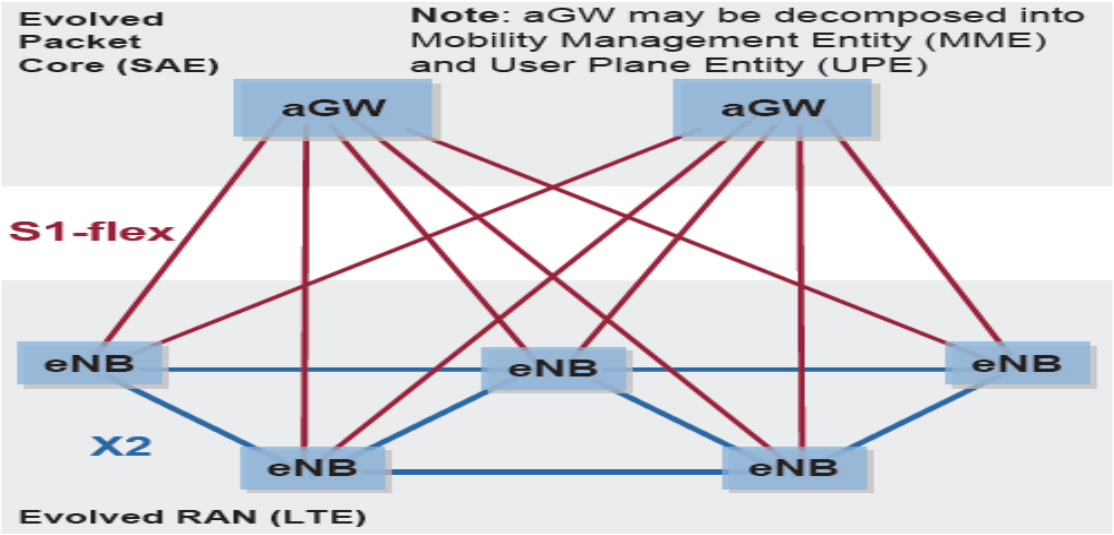


eNB = **E-UTRAN Node B**
All radio interface-related functions

MME = **Mobile Management entity**
— Manages mobility, UE identity, and security parameters.

S-GW = **Serving Gateway**
— Node that terminates the interface towards E-UTRAN.

P-GW = PDN (Packet Data Network) Gateway
— Node that terminates the interface towards PDN.



Two types of interfaces:

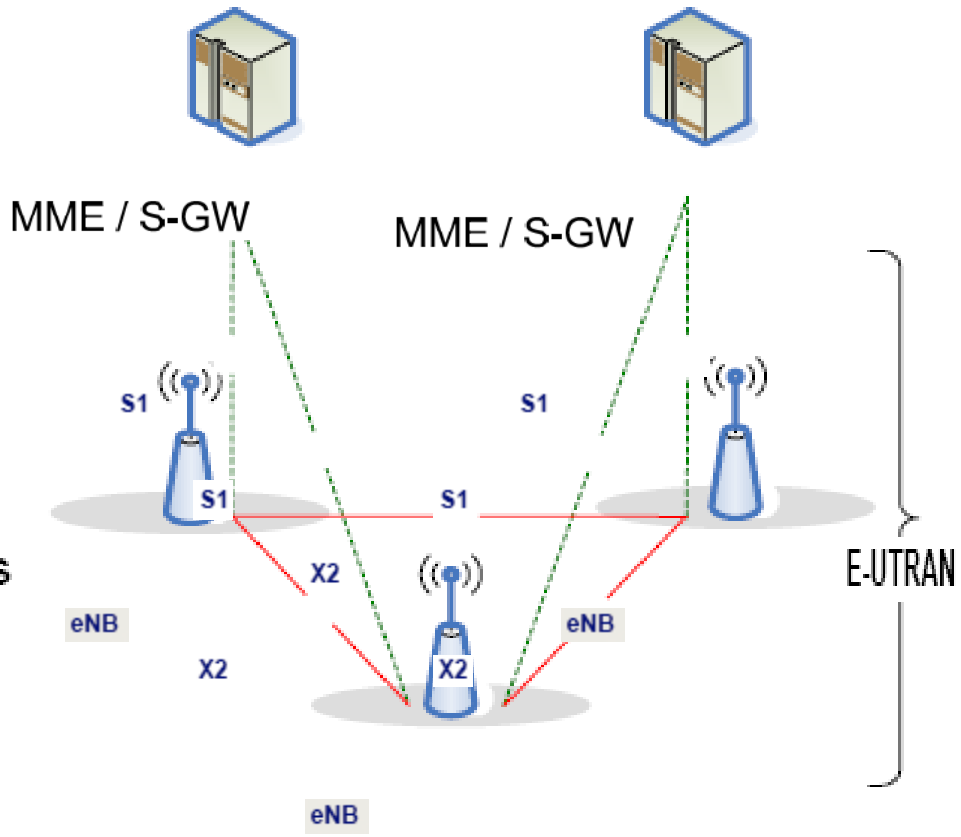
- **S1-flex:** Many-to-many relationship between "**enhanced NodeBs**" (eNB) and core network nodes (**Access Gateways**, aGW)
- **X2:** Direct interfacing between adjacent eNBs for handover and RRM

Advantages:

- Minimises single points of failure above eNBs
- All radio-related issues are handled in the RAN
- Allows RAN Sharing

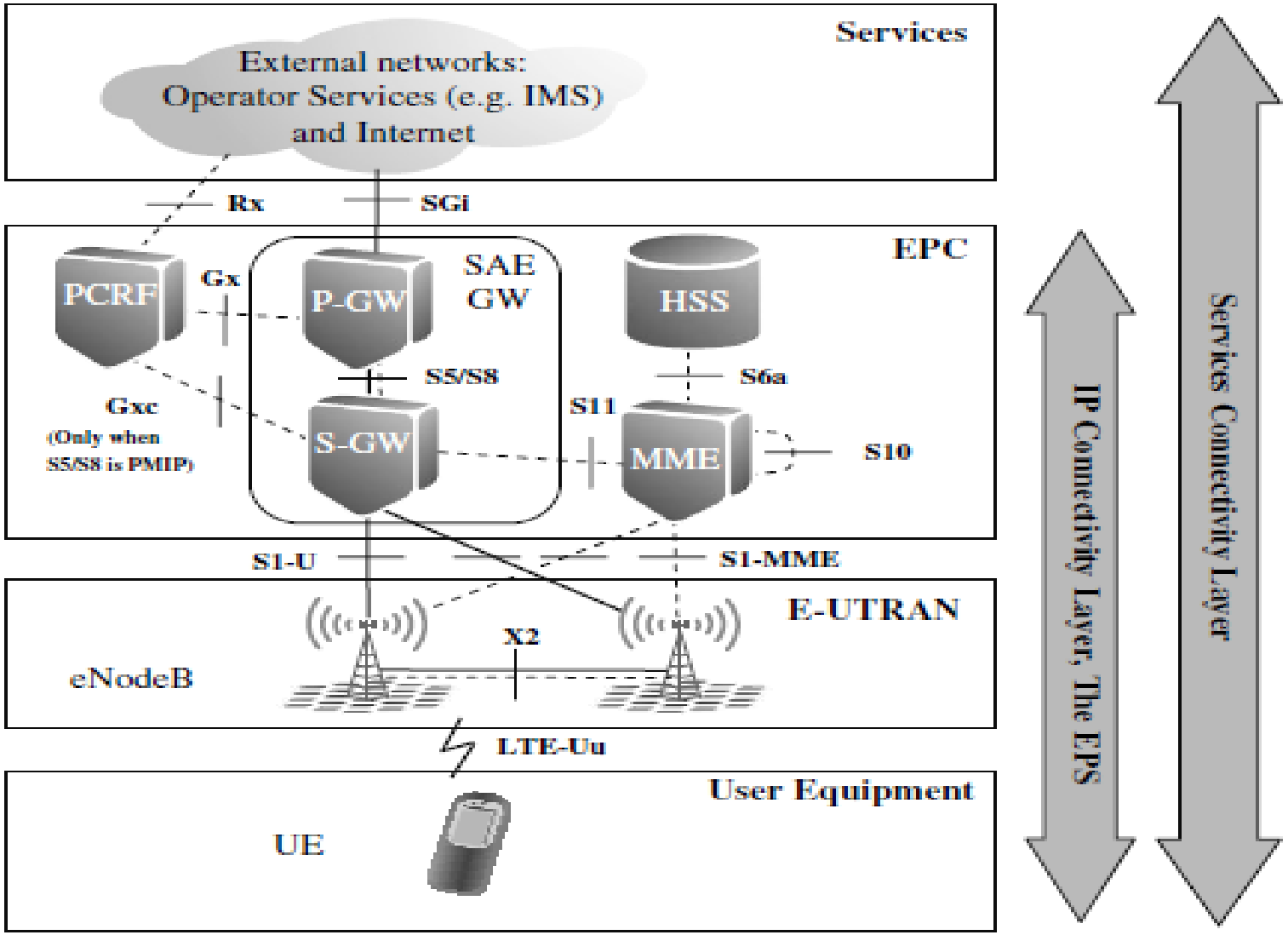
LTE Network Architecture

- Simple Architecture
- Flat IP-Based Architecture
- Reduction in latency and cost
- Split between EPC and E-UTRAN
- Compatibility with 3GPP and non-3GPP technologies
- eNB-radio interface-related functions
- MME-manages mobility, UE identity and security parameters
- S-GW-node that terminates the interface towards E-UTRAN



- EPC = Evolved Packet Core
- E-UTRAN = Evolved Universal Radio Access Network
- MME = Mobile Management entity
- S-GW = Serving Gateway
- SAE = System Architecture Evolution
- eNB = E-UTRAN Node B

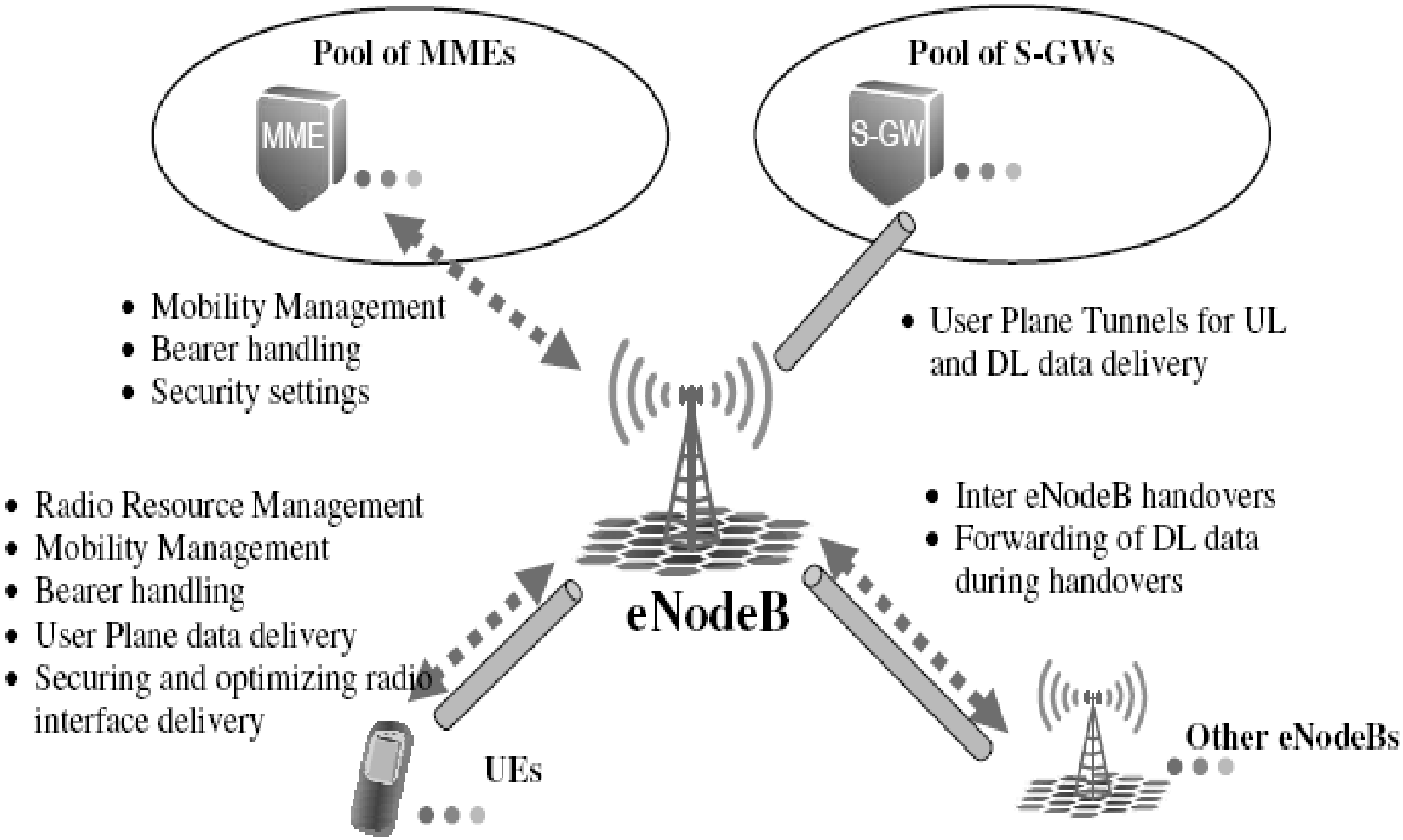
Empat Level Jaringan LTE



Interface X2

- Interface X2 is a interface structure protocol which has been used for moblity occurs between 2 eNodeB near handover process
- On data process handover which is transfered through this interface X2 is specific data from user
- Fungction of Interface X2 are :
  - Intra-handover mobility management
  - Coordination of Resource status information, and traffic overload situation
  - Setting up and Resetting of Interface X2
  - The handling of error cases

E-UTRAN Node B (eNodeB)



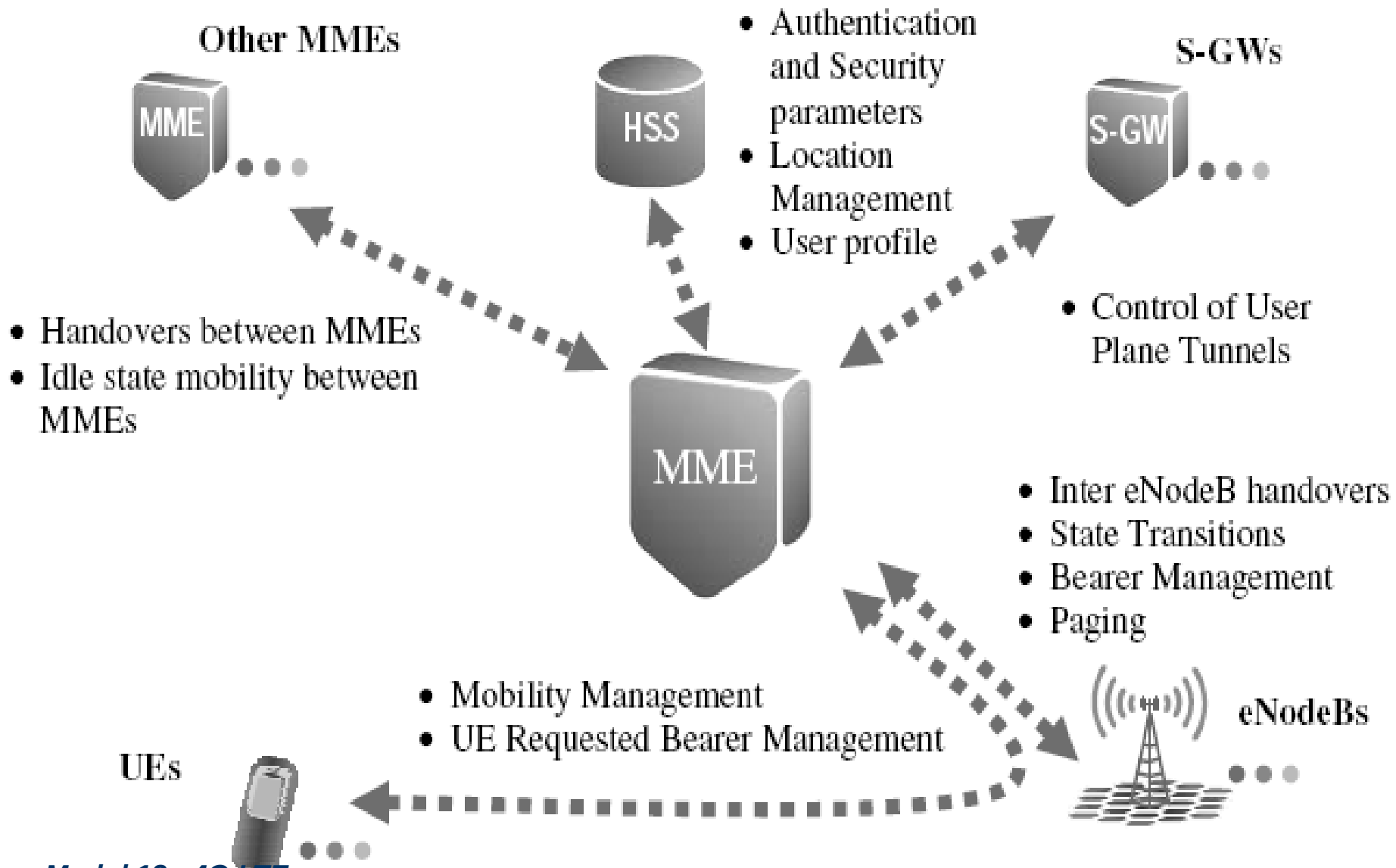
Functions of eNodeB

- Terminates RRC, RLC and MAC protocols and takes care of Radio Resource Management functions
  - Controls radio bearers
  - Controls radio admissions
  - Controls mobility connections
  - Allocates radio resources dynamically (scheduling)
  - Receives measurement reports from UE
- Selects Mobility Management Entity (MME) at UE attachment
- Schedules and transmits paging messages coming from MME
- Schedules and transmits broadcast information coming from MME & O&M
- Decides measurement report configuration for mobility and scheduling
- Does IP header compression and encryption of user data streams

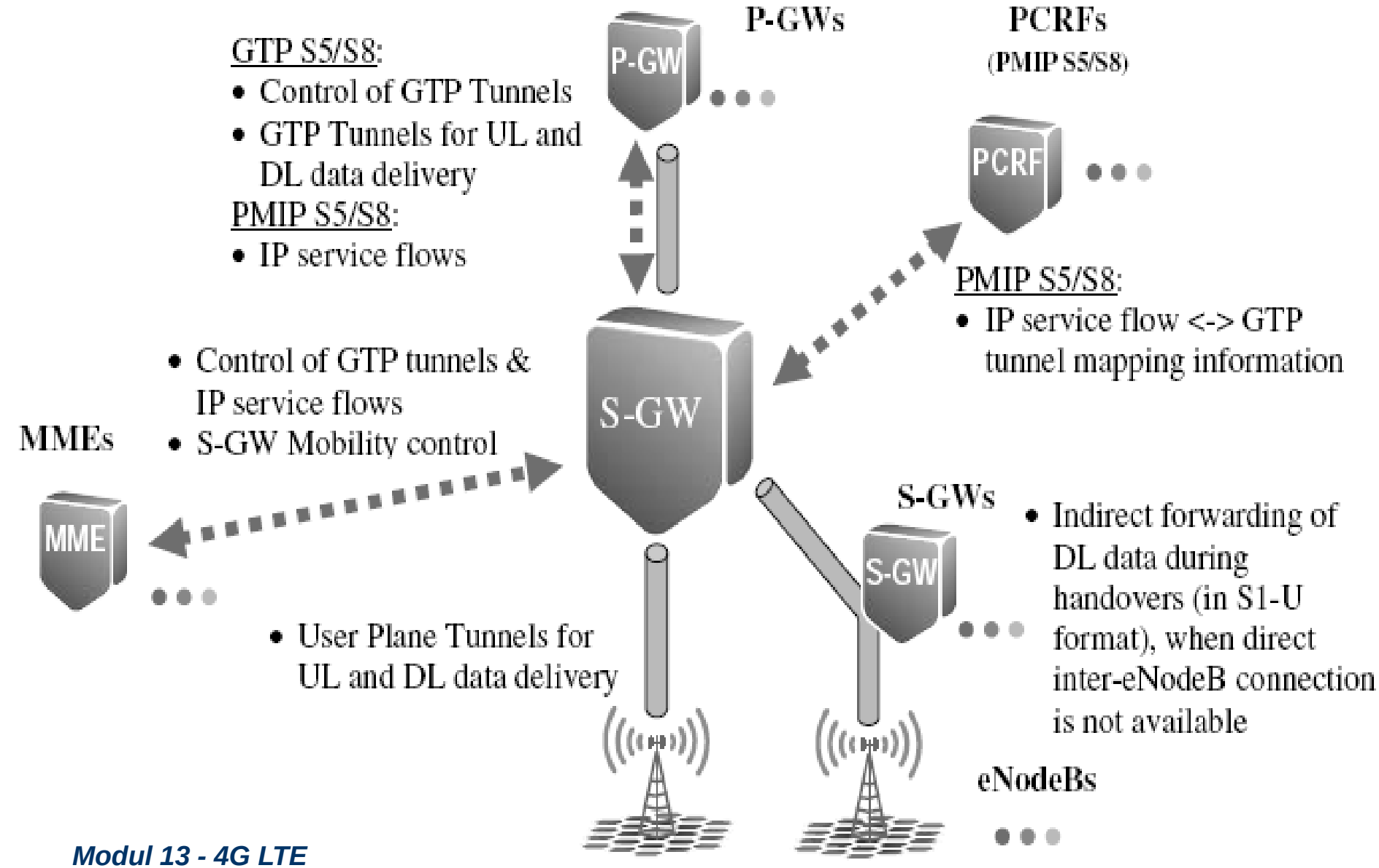
Functions of aGateWay

- Takes care of Mobility Management Entity (MME) functions
  - Manages and stores UE context
  - Generates temporary identities and allocates them to UEs
  - Checks authorization
  - Distributes paging messages to eNodeBs
  - Takes care of security protocol
  - Controls idle state mobility
  - Control SAE bearers
  - Ciphers & integrity protects NAS signaling

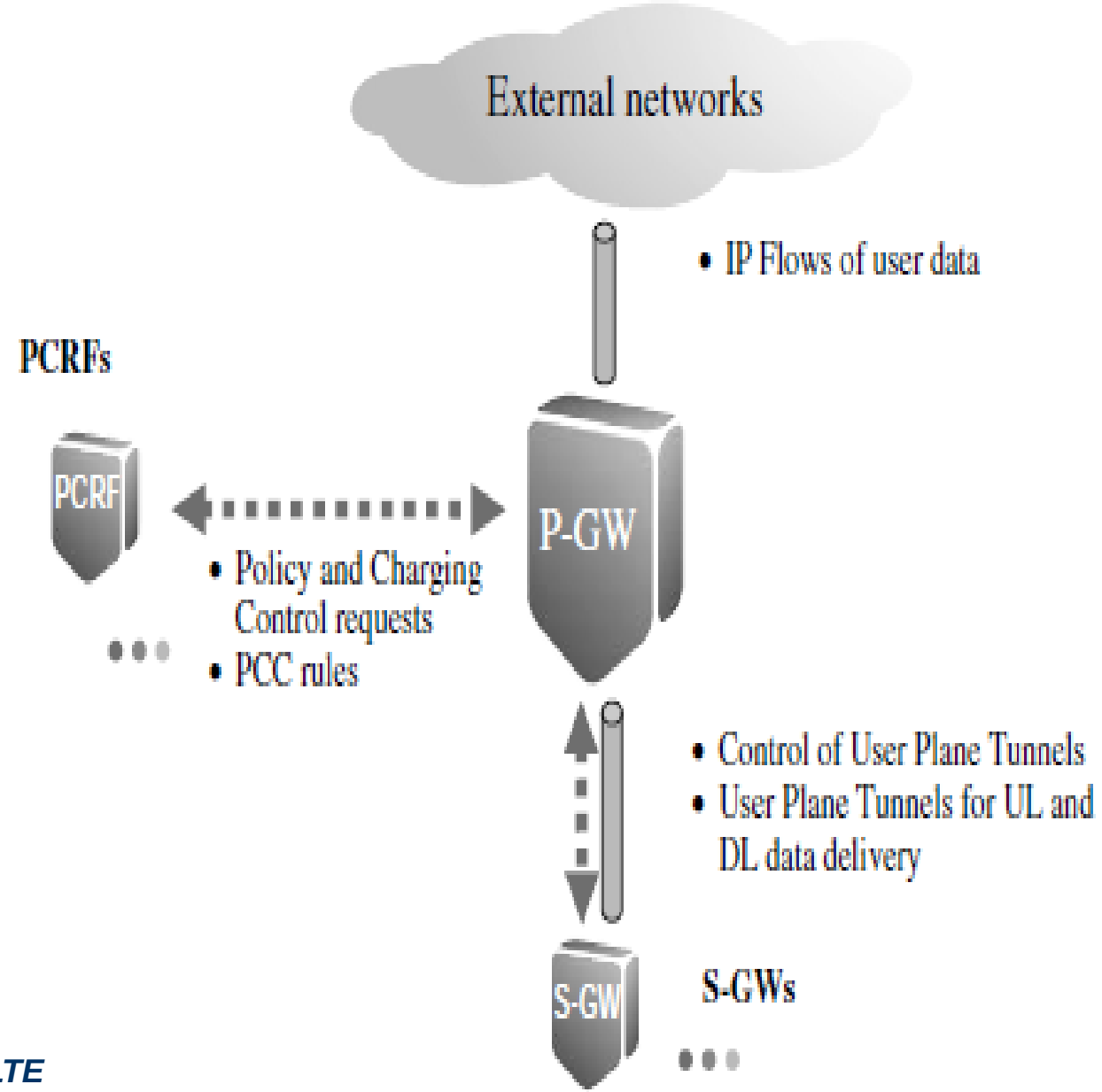
Mobilty Management Entity (MME)



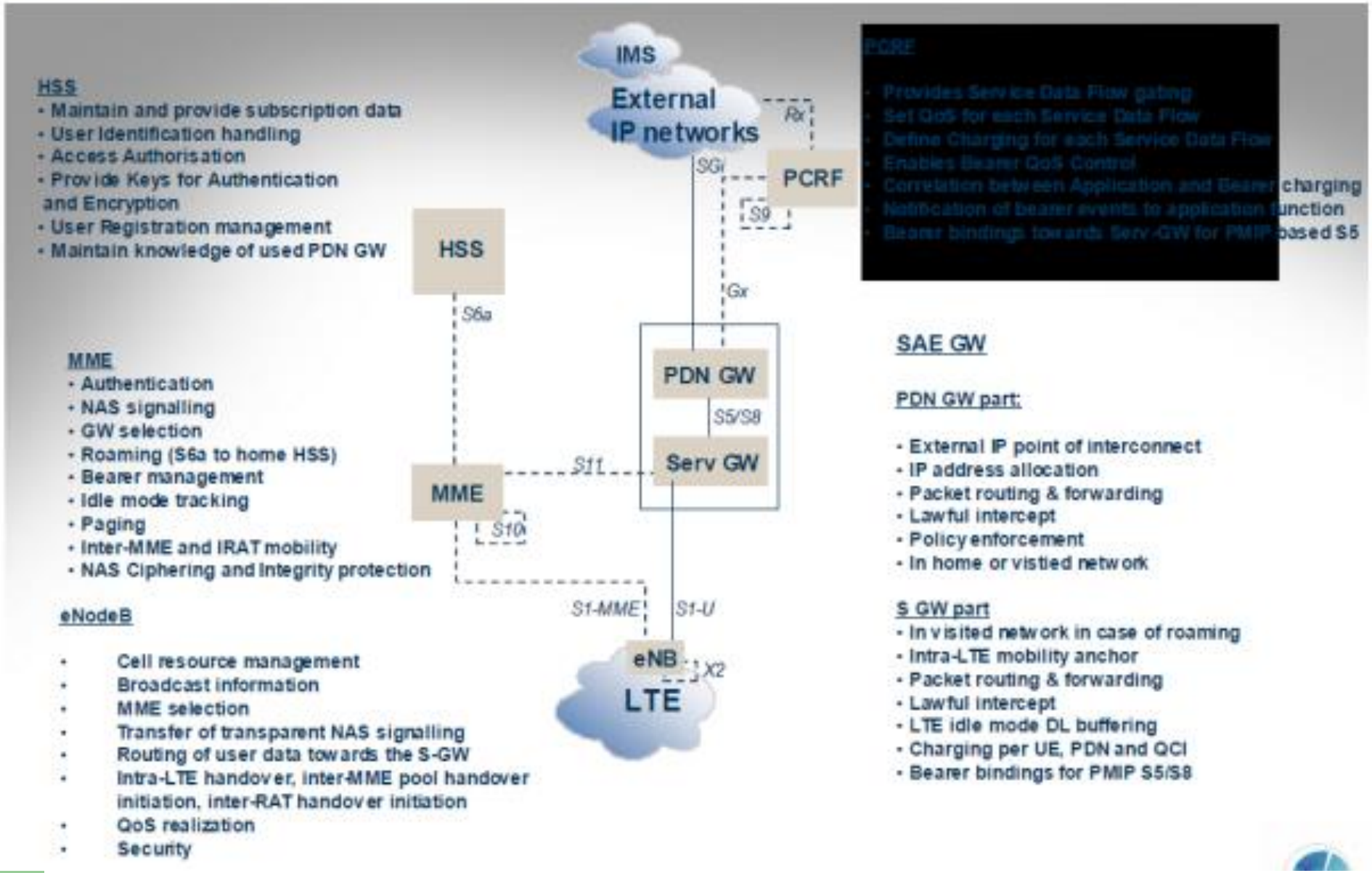
Serving Gateway (S-GW)



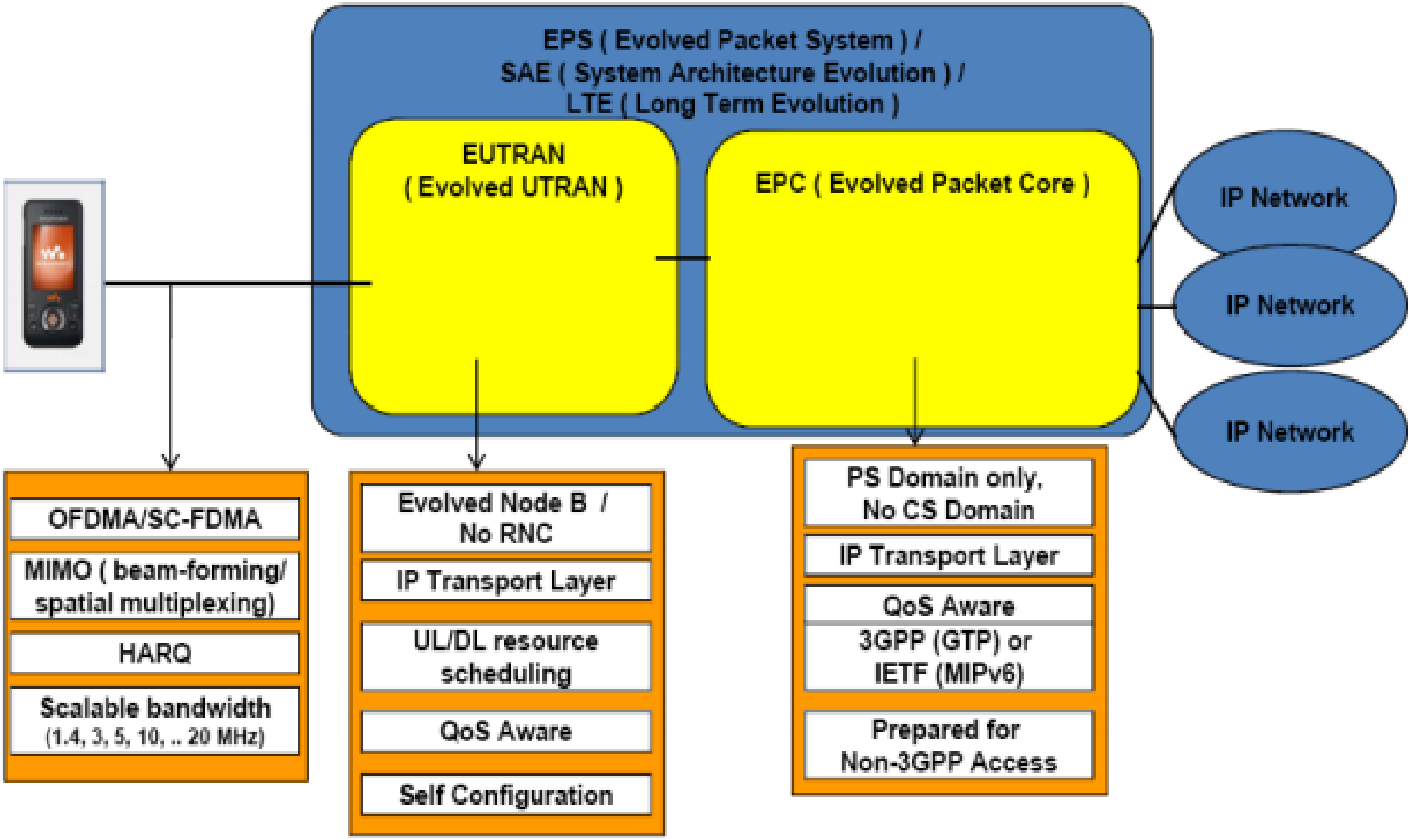
Packet Data Network Gateway (P-GW)



Aristektur LTE



Fitur LTE/SAE

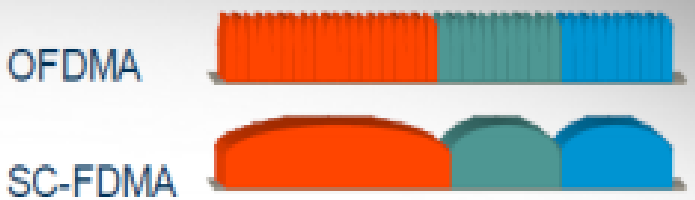


Fitur LTE/SAE

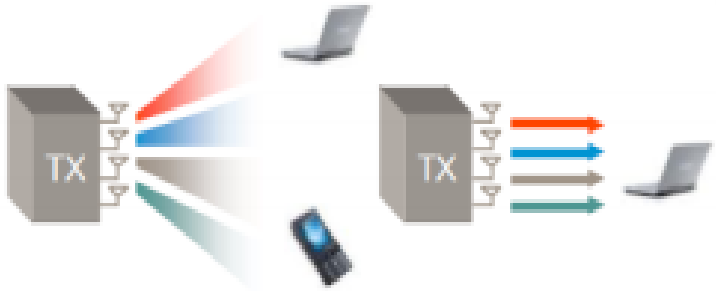
- Evolved NodeB
  - Tidak diperlukan RNC lagi
  - Evolved Node B mengambil alih semua fungsi managemen radio
  - Hal ini memungkinkan managemen sumberdaya radio menjadi cepat dan arsitektur jaringan menjadi lebih sederhana
- IP transport layer
  - EUTRAN menggunakan IP sebagai transport layer
- UL/DL resource scheduling
  - Sumber daya pada UMTS msih berupa sumberdaya yang di-shared atau dedicated
  - Evolved Node B menangani semua sumberdaya dengan melalui suatu scheduler dan melakukan penugasan secara dinamis ke pengguna dan kanal
  - Hal ini memungkinkan LTE memiliki fleksiblitas yang lebih baik

Teknologi Kunci LTE

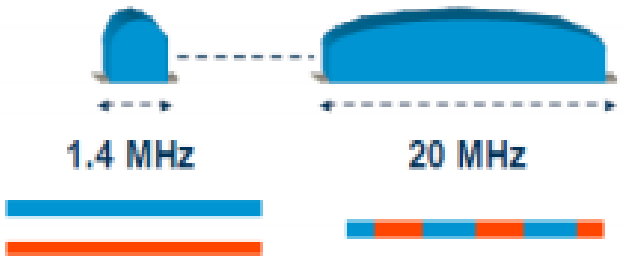
- **LTE radio access**
  - Downlink: OFDM
  - Uplink: SC-FDMA



- **Advanced antenna solutions**
  - Diversity
  - Beam-forming
  - Multi-layer transmission (MIMO)

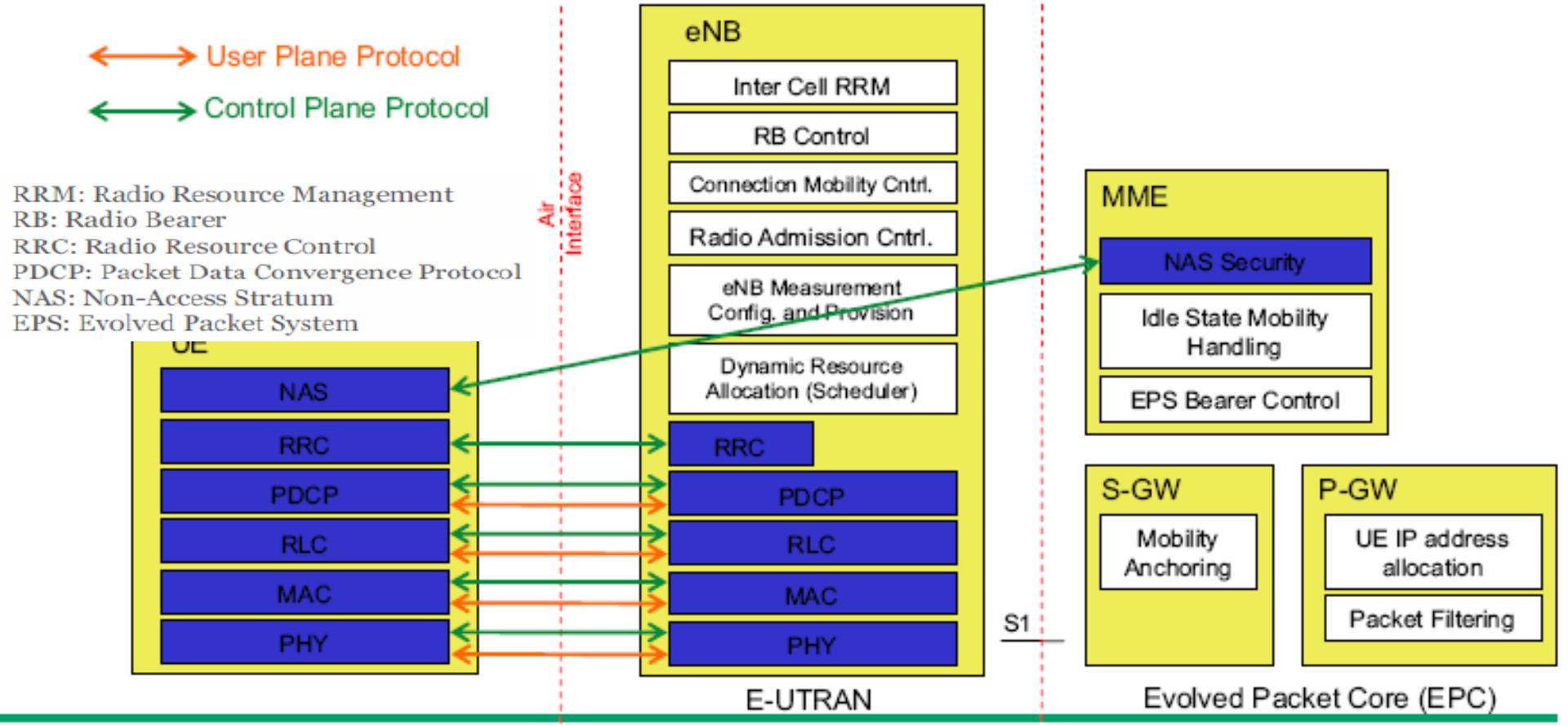


- **Spectrum flexibility**
  - Flexible bandwidth
  - New and existing bands
  - Duplex flexibility: FDD and TDD

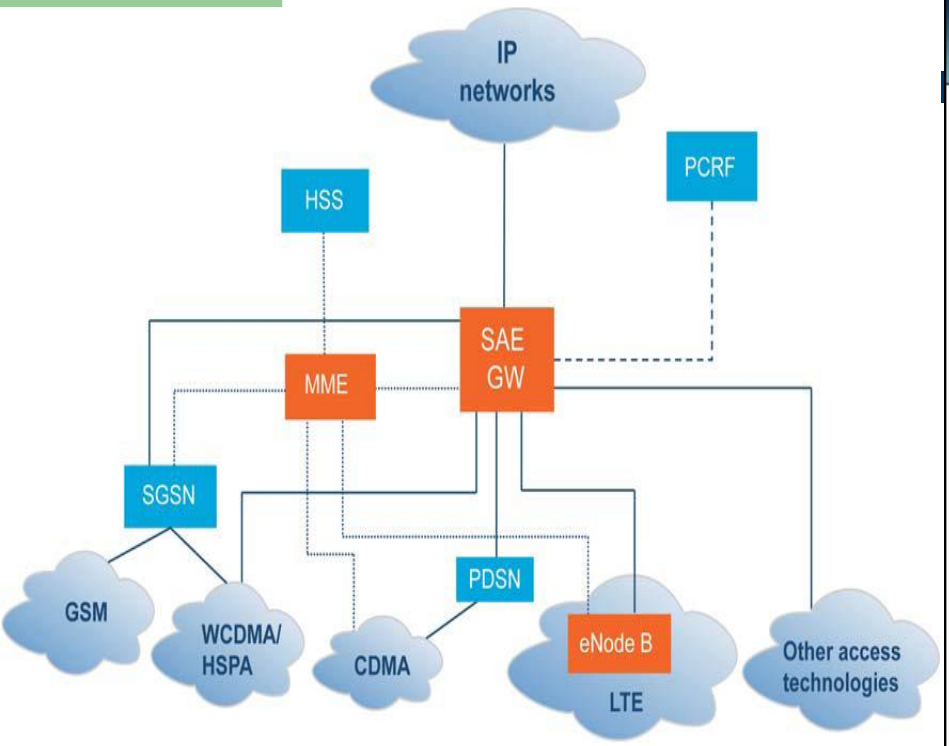


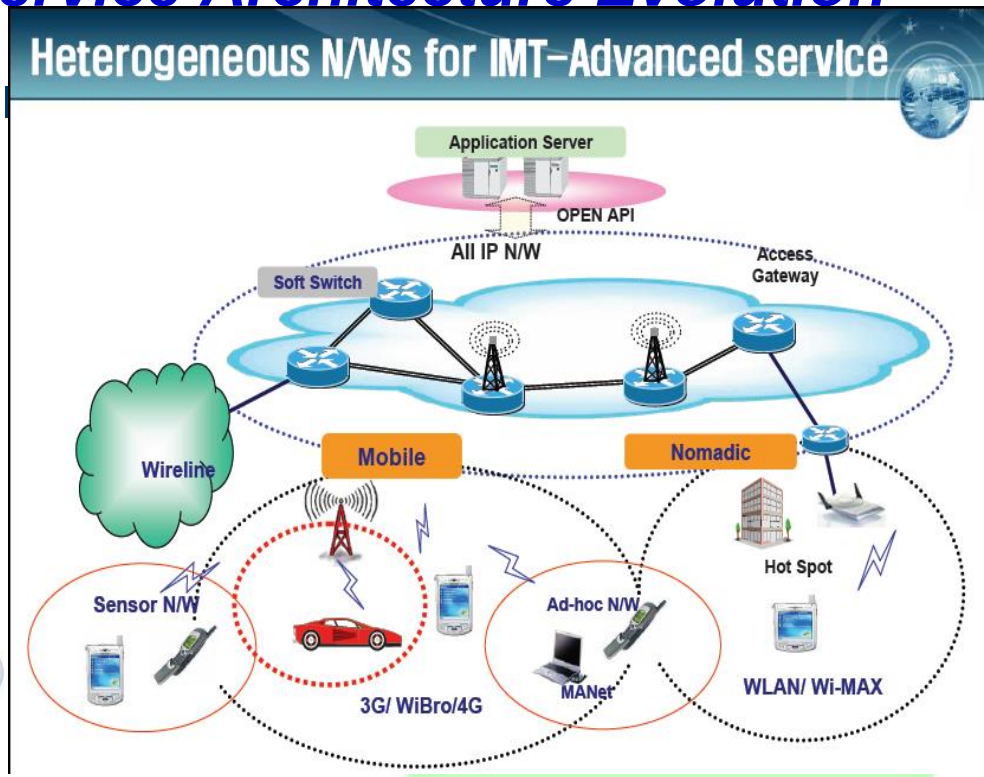
LTE Radio Access Network – Physical Elements

- E-UTRAN Architecture
  - Evolved NodeB (eNB) now has most of the Node B and RNC functionality in a single entity.
  - MME & GateWay (xGW) has most of the SGSN and GGSN functionality.



Flat architecture of LTE and Service Architecture Evolution





- **Evolusi lanjutan dalam standar jaringan selular yang ditentukan oleh 3GPP (*Third Generation Partnership Project*).**
- **Teknologi lanjutan dari generasi 1xEV-DO.**
- **Berbeda dengan Wimax yang awalnya dikembangkan untuk komunikasi data.**

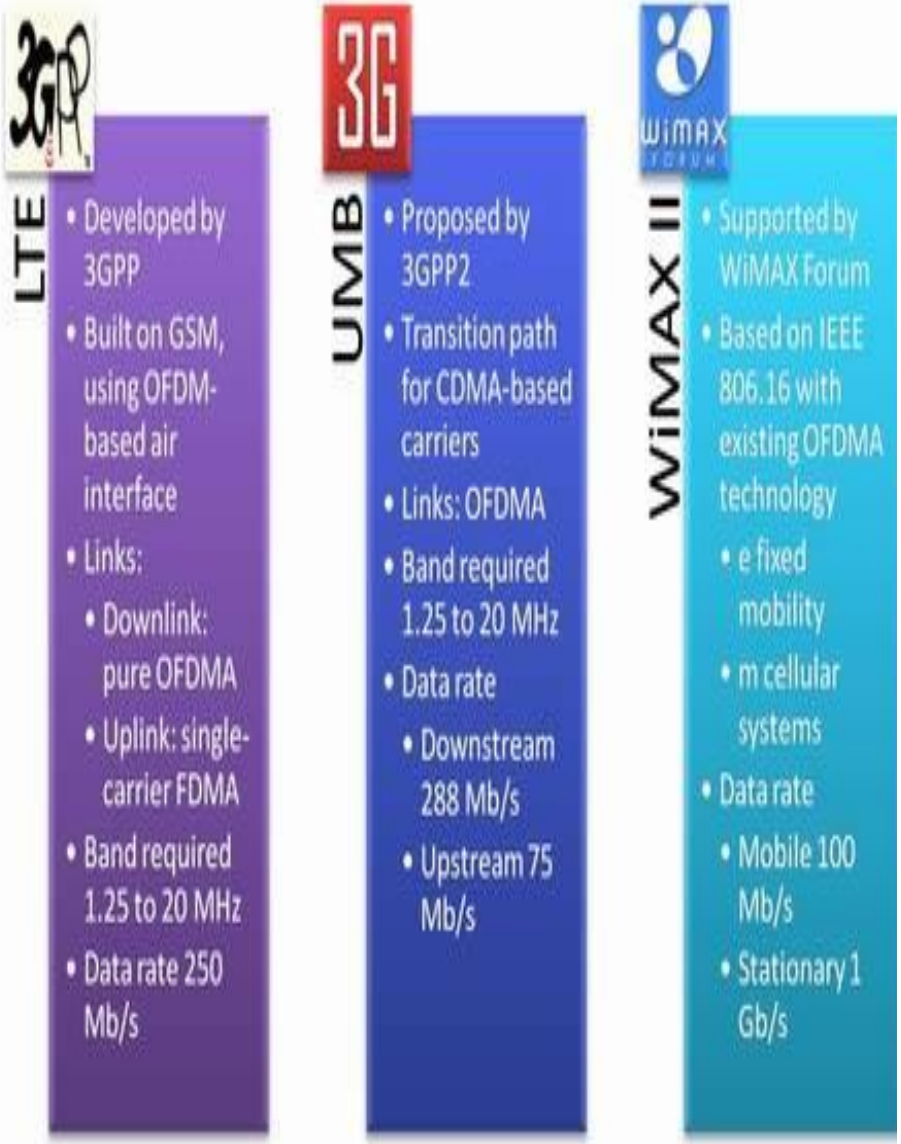
Roadmap evolusi teknologi selular di dunia yaitu :

(1)GSM(2G)→GPRS(2.5G)→EDGE→WCDMA(3G) →HSDPA (3.5G) → LTE (4G).

(2) CDMA (2G)→CDMA 2000→EV-DO (3G)→UMB (4G).

(3) Wi-Fi→Fixed WiMAX→Mobile WiMAX→WiMAX II (4G).

LTE,UMB,WIMAX II



	3GPP LTE	3GPP2 UMB	Mobile WiMAX
Channel bandwidth	1.4, 3, 5, 10, 15, and 20 MHz	1.25, 2.5, 5, 10, and 20 MHz	5, 7, 8.75, and 10 MHz
DL multiple access	OFDMA	OFDMA	OFDMA
UL multiple access	SC-FDMA	OFDMA and CDMA	OFDMA
Duplexing	FDD and TDD	FDD and TDD	TDD
Subcarrier mapping	Localized	Localized and distributed	Localized and distributed
Subcarrier hopping	Yes	Yes	Yes
Data modulation	QPSK, 16QAM, and 64QAM	QPSK, 8PSK, 16QAM, and 64QAM	QPSK, 16QAM, and 64QAM
Subcarrier spacing	15 kHz	9.6 kHz	10.94 kHz
FFT size (5 MHz)	512	512	512
Channel coding	Convolutional coding and turbo coding.	Convolutional coding, turbo coding, and LDPC coding	Convolutional coding and convolutional turbo coding. Block turbo coding and LDPC coding optional.
MIMO	Multi-layer precoded spatial multiplexing space-time/frequency block coding, switched transmit diversity, and cyclic delay diversity	Multi-layer precoded spatial multiplexing, space-time transmit diversity, spatial division multiple access, and beamforming.	Beamforming, Space-time coding, and spatial multiplexing