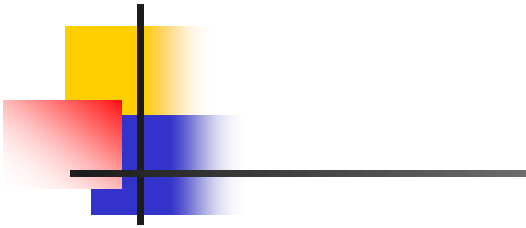
Chapter 11

Existing Wireless Systems

Outline

- AMPS
  - Characteristics of AMPS
  - Operation of AMPS
  - General working of AMPS phone system
- IS-41
- GSM
  - Frequency Bands and Channels
  - Frames in GSM
  - Indentity numbers used by a GSM system
  - Interfaces, planes, and layers of GSM
  - Handoff
  - Short message service (SMS)
- Personal Communication Services (PCS)
- IS-95
- IMT-2000
  - International Spectrum Allocation
  - Services provided by Third Generation Cellular Systems
  - Harmonized 3G Systems
  - Multimedia Messaging Service (MIMS)
  - Universal Mobile Telecommunications System (UMTS)



Advanced Mobile Phone System

(AMPS)

Design Goals of AMPS

- The very first cellular phone technology **conceived** by Bell Labs
- High voice quality (near wire line)
- Small coverage area (cell radius: 1-16 miles)
- Large cells thermal noise limited and small cells interference limited
- Frequency reuse planned in system design
- 666 channels (later increased to 832 channels)
- Large trunk mounted unit (now very small under dash units)
- Low power mobile (handheld) transmitters (4 watts or less)
- Medium power base stations (10's of watts)
- Low blocking (2%) during busy hour
- Immediate service (1-5 business days; now 1-5 hours)
- System capacity for 100,000 or more customers per city
- Mobile (handheld) can place and receive calls

Characteristics of AMPS

- Frequency range (45 MHz separation):
  - 824 MHz ~ 849 MHz for mobile stations to transmit (reverse)
  - 869 MHz ~ 894 MHz for base station to transmit (forward)
- 3 KHz analog voice channels modulated on to 30 KHz channels
- FM (frequency modulation) for voice
- MFM (Manchester frequency modulation) at 10 kbps for data
- Control channels
- Voice channels

AMPS Frequency Allocation

- **Band for A (other than Bell Companies)**
  - **Transmit:** 824 MHz ~ 835 MHz and 845 MHz ~846.48 MHz
  - **Receive:** 869 MHz ~ 880 MHz and 890 MHz ~ 891.5 MHz
- **Band for B (Bell Companies)**
  - **Transmit:** 835 MHz ~ 845 MHz and 846.5 MHz ~ 849 MHz
  - **Receive:** 880 MHz ~ 890 MHz and 891.5 MHz ~ 894 MHz

312 usable RF pairs divided by 7 (the reuse factor)
= roughly 45 channel pairs per cell

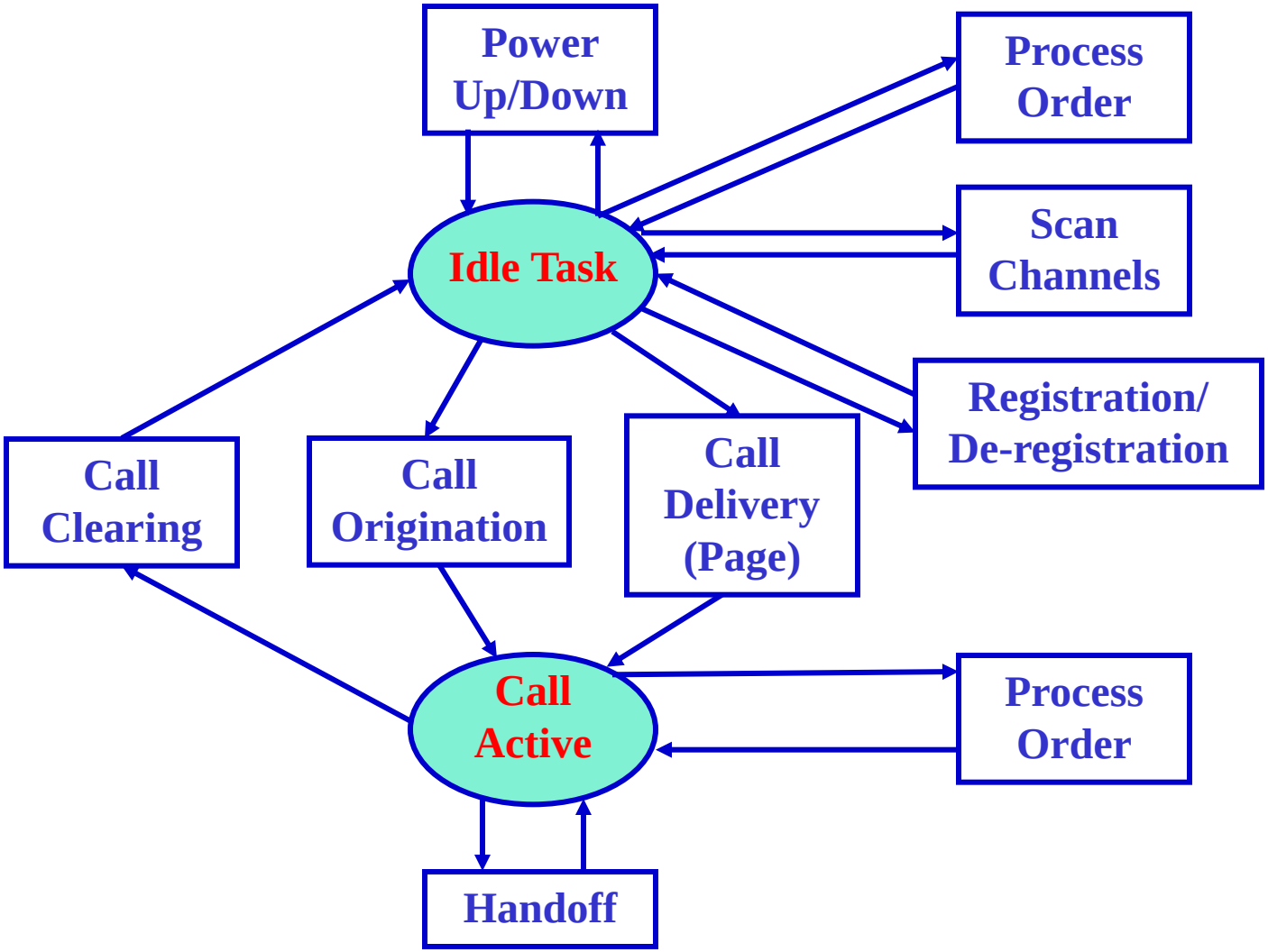
Frequencies for AMPS

- Two service providers:
  - A (non-wire line provider)
  - B (wire line provider: Bell Companies)

- Five band segments:

Band	MS-TX (MHz)	BS-TX (MHz)	Channel No.	No. of Channels
A	825.03-834.99	870.03-879.99	1-333	333
B	835.02-844.98	880.02-889.98	334-666	333
A’	845.01-846.48	890.01-891.48	667-716	50
B’	846.51-848.97	889.51-893.97	717-799	83
Not used	824.01	869.01	990	1
A”	824.04-825.00	869.04-870.00	991-1023	33

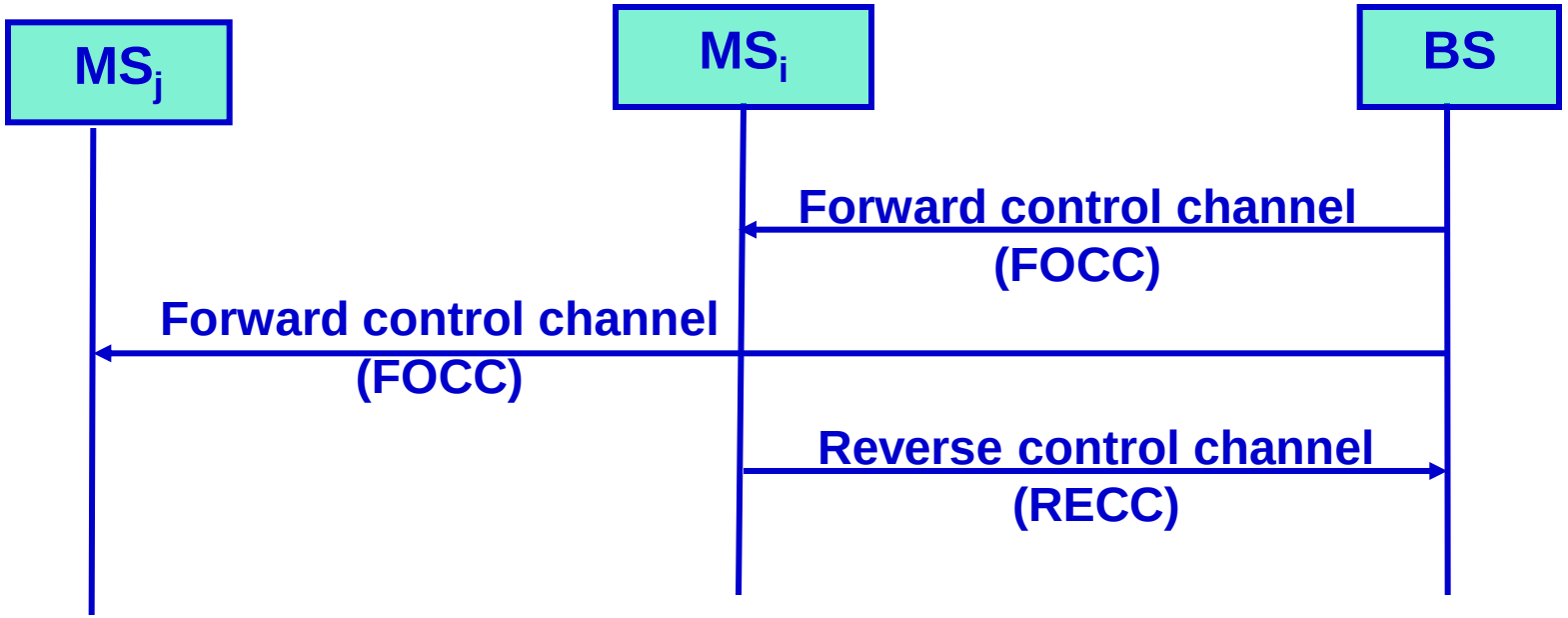
General Operation of AMPS



AMPS Identification Numbers

- Serial number (Electronic Serial Number [ESN])
  - Used for each MS transmitter in service in the cellular system
  - 32 bit binary number that uniquely identifies a cellular unit number established by the manufacture at the factory
  - Should not be easily alterable
- System Identification Number (SID)
  - 15 bit binary numbers assigned to cellular systems
  - MS in the cell must transmit the SID
  - FCC assigns one SID to each cellular system
  - Systems may transmit only their assigned SIDs or other SIDs, if the other SID user permits
- Mobile Identification Number (MIN)
  - Digital representation of MS's 10-digit directory telephone number

Forward and Reverse Channels



- The busy/idle stream indicates the current status of the RECC
- Stream A and B are identified with the least significant bit (LSB) of the MS's MIN, where a **0** signifies stream **A (lsb of user's MIN=0)** and a **1** signifies stream **B (lsb of user's MIN=1)**

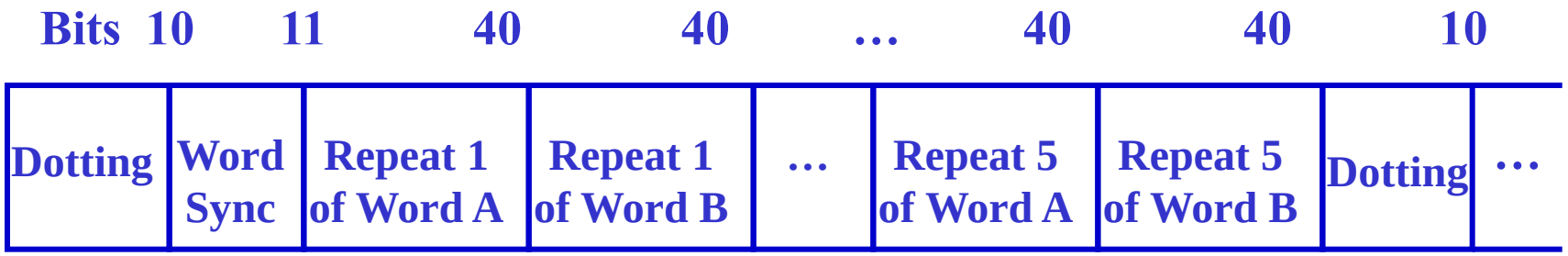
Where FOCC is a TDM channel of:

… Busy/idle stream … Stream A … Stream B …

Signaling on Control Channels

- Forward Control Channels (FOCCs)
  - Continuous data stream
  - Sends system information
  - Sends Pages, orders, voice channels assignments to MSs

Format

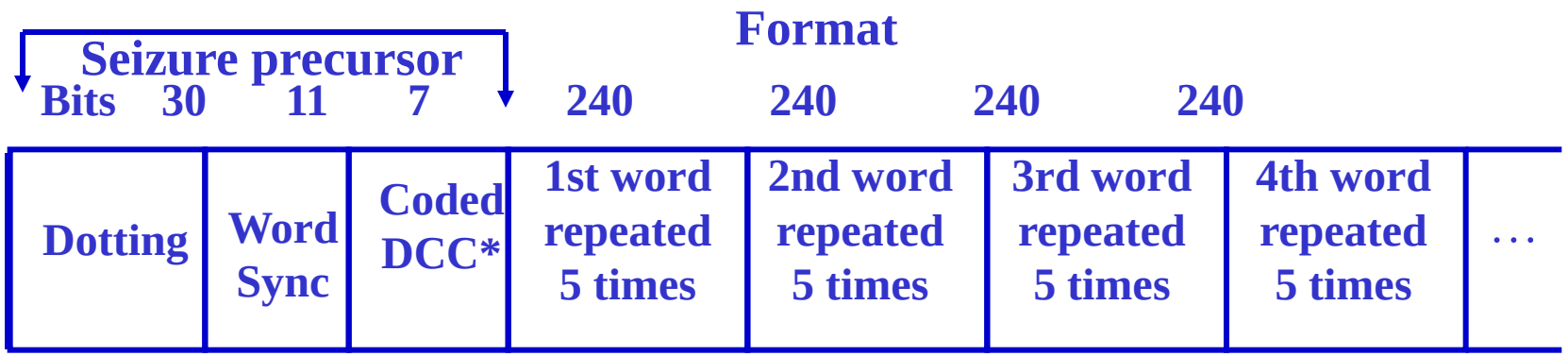


Dotting = 1010101010

Word Sync = 11100010010

Signaling on Control Channels

- **Reverse Control Channels (RECCs)**
  - Discontinuous, contention channel
  - Modeled after Slotted Aloha packet radio channel
  - MSs respond to pages
  - MSs make origination calls (with dialed digits)



Dotting = 1010…101

Word Sync = 11100010010

* DCC = Digital Color Code (indication of cochannel interference)

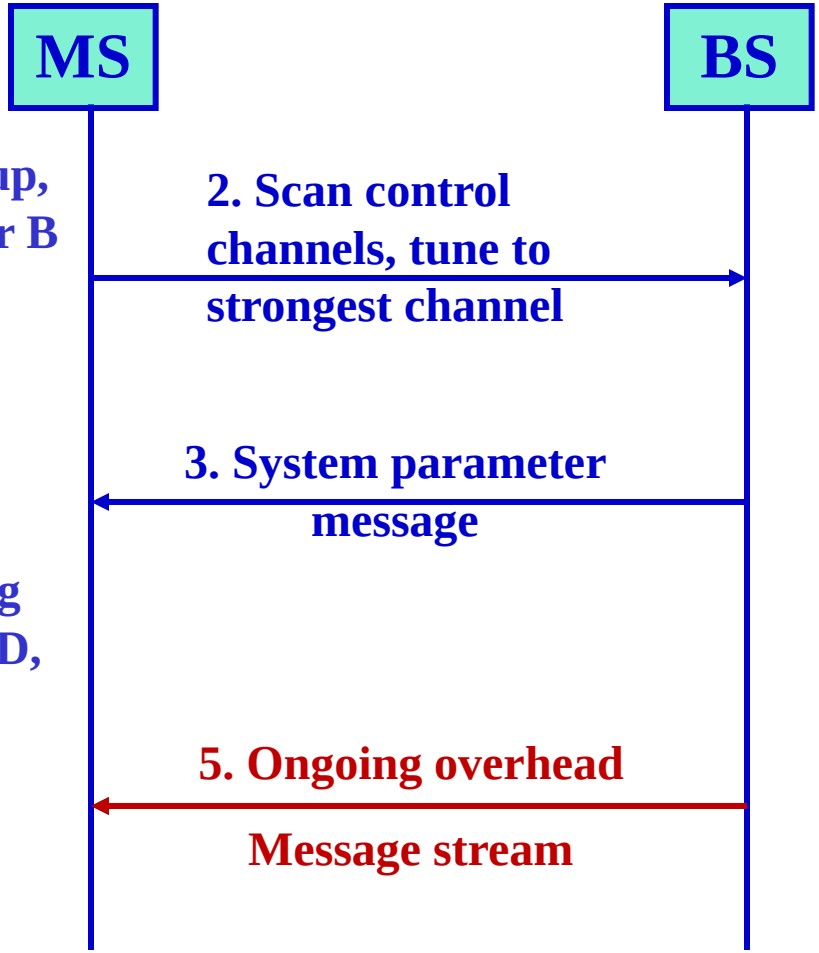
Signaling on Forward Voice Channel (FVC)

- Continuous supervisory audio tone (Beacons)
  - Transmitted by BS
  - Three tones at 6 kHz (5.97 kHz, 6.00 kHz, 6.03 kHz)
  - Received back at BS receiver
  - Lack of tone (or wrong tone) used to squelch receiver
  - Tone used to detect interference
  - Tone phase can be used for ranging
- Discontinuous data stream
  - Sends orders to MS
  - Sends new voice channels assignments (handoff)

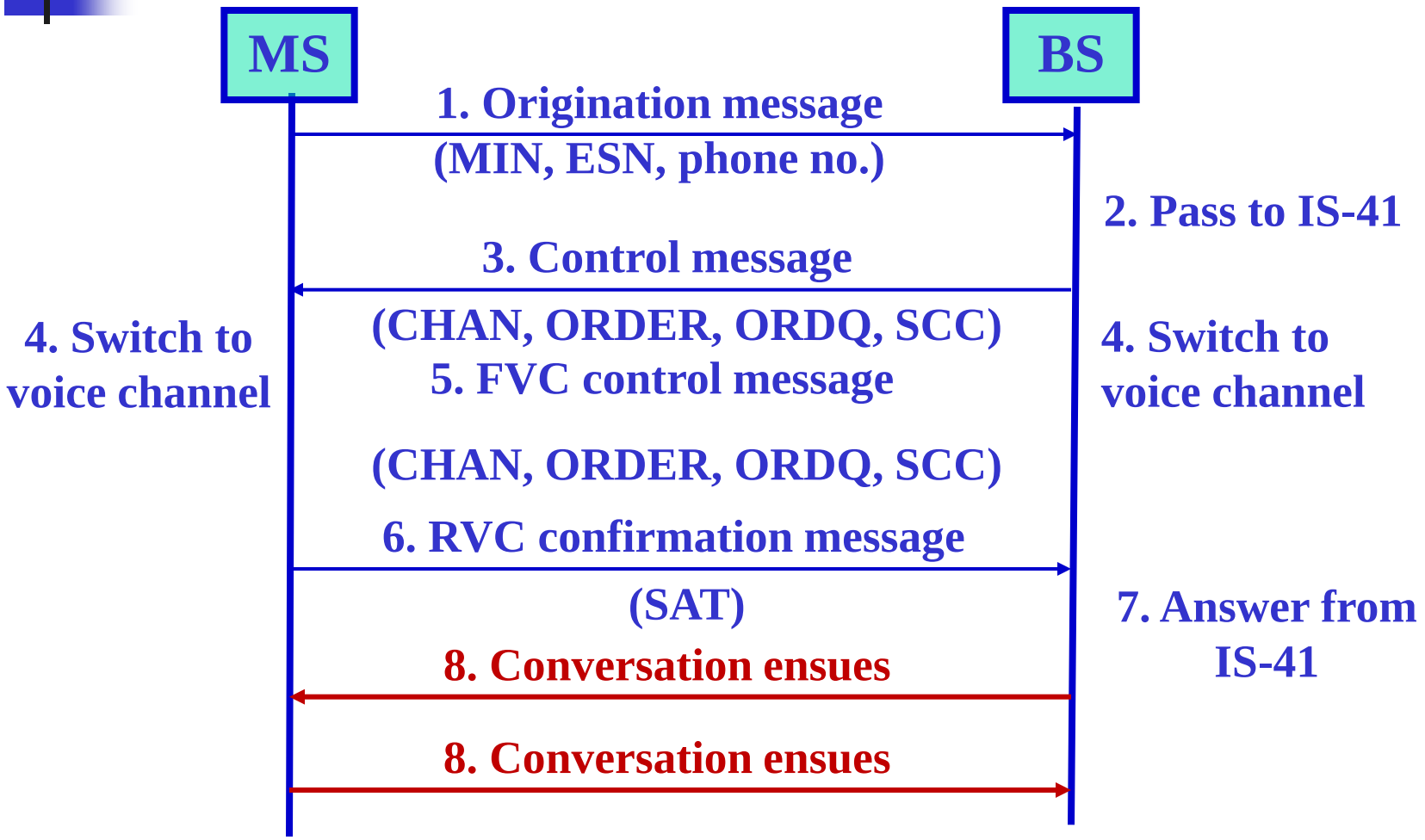
Signaling on Reverse Voice Channel (RVC)

- Continuous supervisory audio tone (**Beacons**)
  - MS regenerates tone
  - Lack of tone (or wrong tone) used to squelch receiver
  - Tone used to detect interference
- Discontinuous data
  - Confirms orders
  - MSs make 3-way calls (with dialed digits)
- Signaling tone (10 kHz)
  - Used to signal Disconnect (1.5 seconds)
  - Used to signal Flash (0.5 seconds)

Initialization Procedures

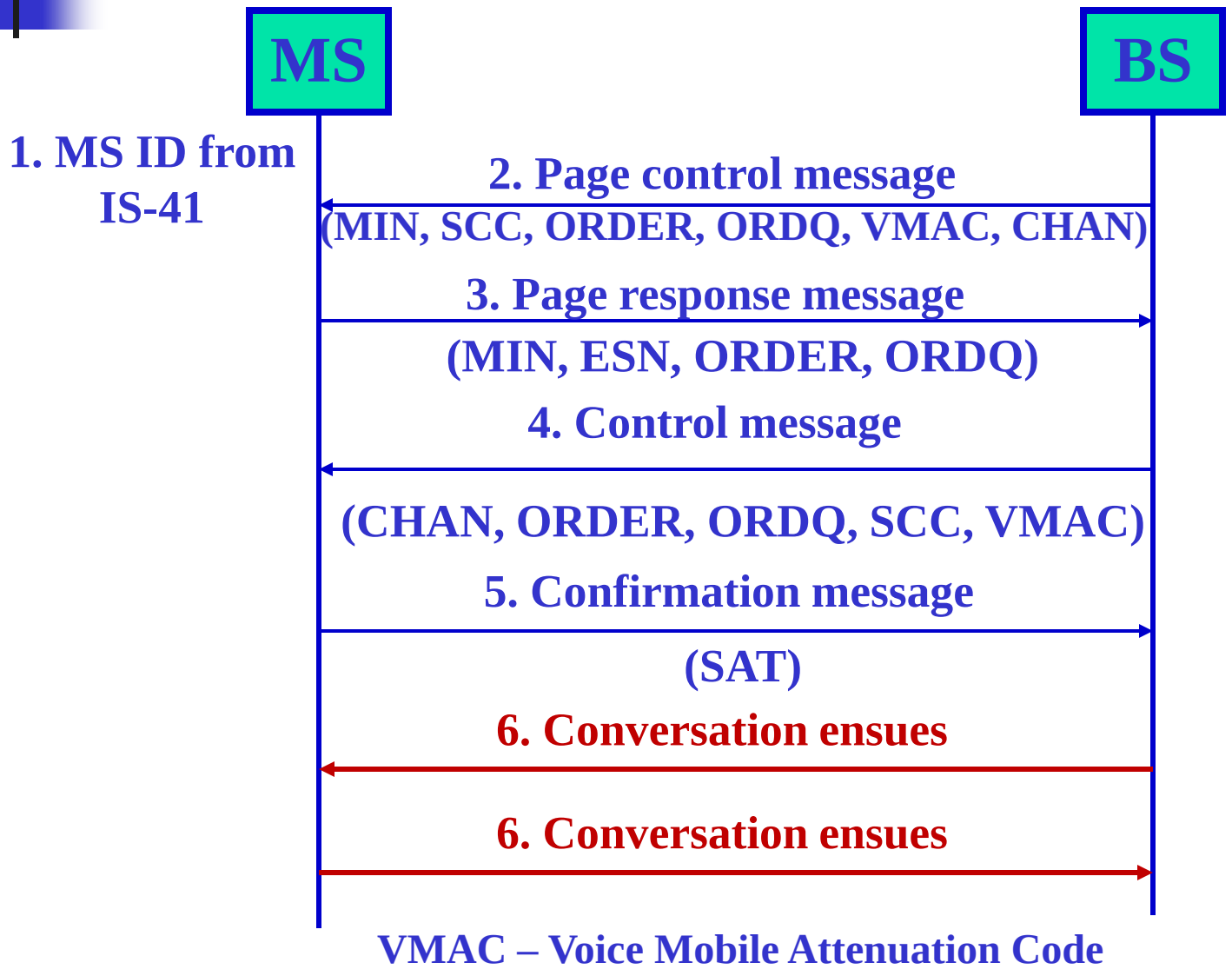


MS Originates the Call (System Access Task)

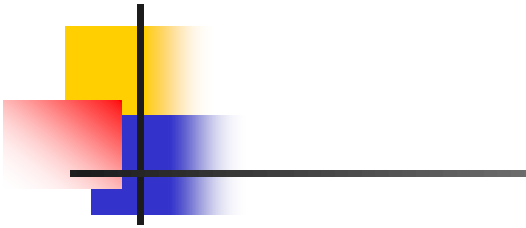


CHAN – Channel Number; ORDQ – Order Qualifier; SCC – Set Color Code

MS Receives the Call



VMAC – Voice Mobile Attenuation Code



Interim Standard

IS-41

IS-41 (Interim Standard 41, also known as ANSI (American National Standards Institute)-41)

- IS-41 model
- Support Operations
  - Registration in a new MSC
  - Calling an idle MS in a new system
  - Call with unconditional call forwarding
  - Call with no answer
  - Calling a bust MS
  - Handoff Measurements request
  - Recovery from failure at the HLR

IS-41 Entities and Reference Points

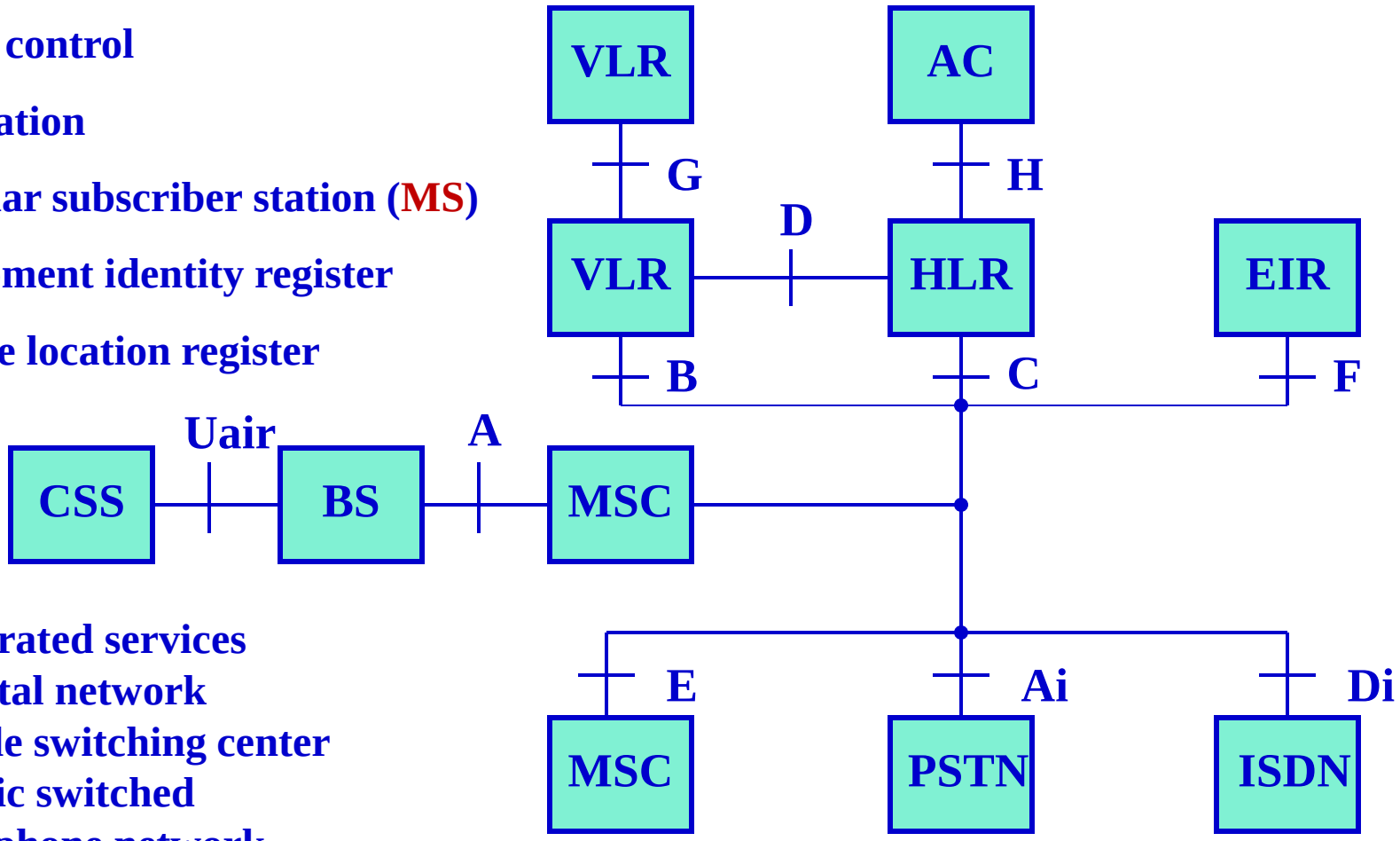
AC – Access control

BS – Base station

CSS – Cellular subscriber station (MS)

EIR – Equipment identity register

HLR – Home location register



ISDN – Integrated services digital network

MSC – Mobile switching center

PTSN – Public switched telephone network

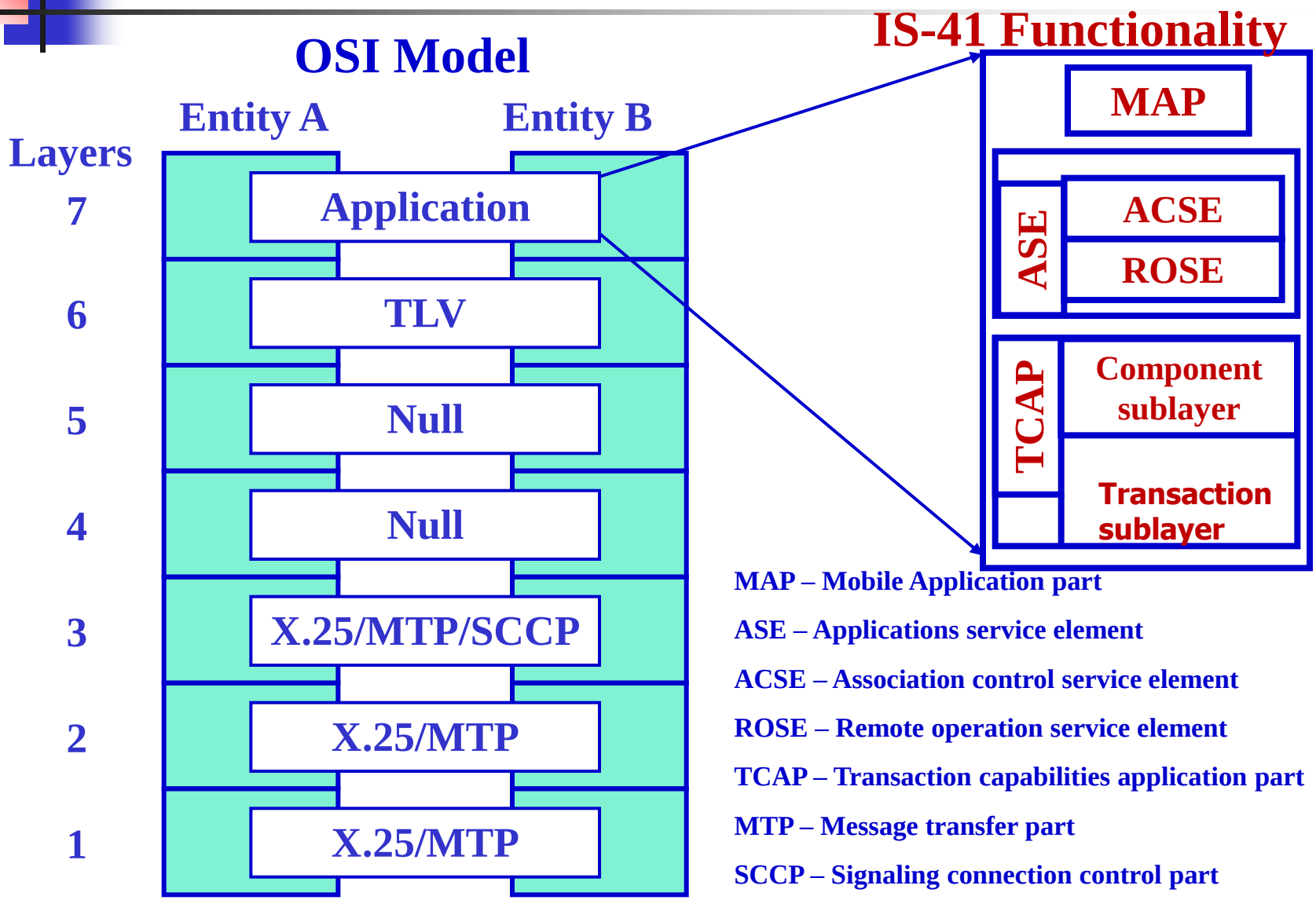
VLR – Visitor location register

Um, A, B, … H, Ai, Di -- Interfaces

Key Terms and Concepts

Term	Definition
Anchor MSC	This MSC is as the initial contact point when an originating call is initiated by the MS or when a terminating call (to the MS) is received from the fixed telephone network
Candidate MSC	This MSC is being requested to provide the next service during a handoff operation
Homing MSC	This MSC is the "owner" of the MS in the sense that it is the owner of the directory number from which the MS's MIN is derived
Serving MSC	This MSC is currently serving the MS at a cell site within a coverage area controlled by the MSC
Target MSC	This MSC is the MSC that was selected from a list of MSC's as having the cell site that can service the MS with the best signal quality

IS-41 and OSI

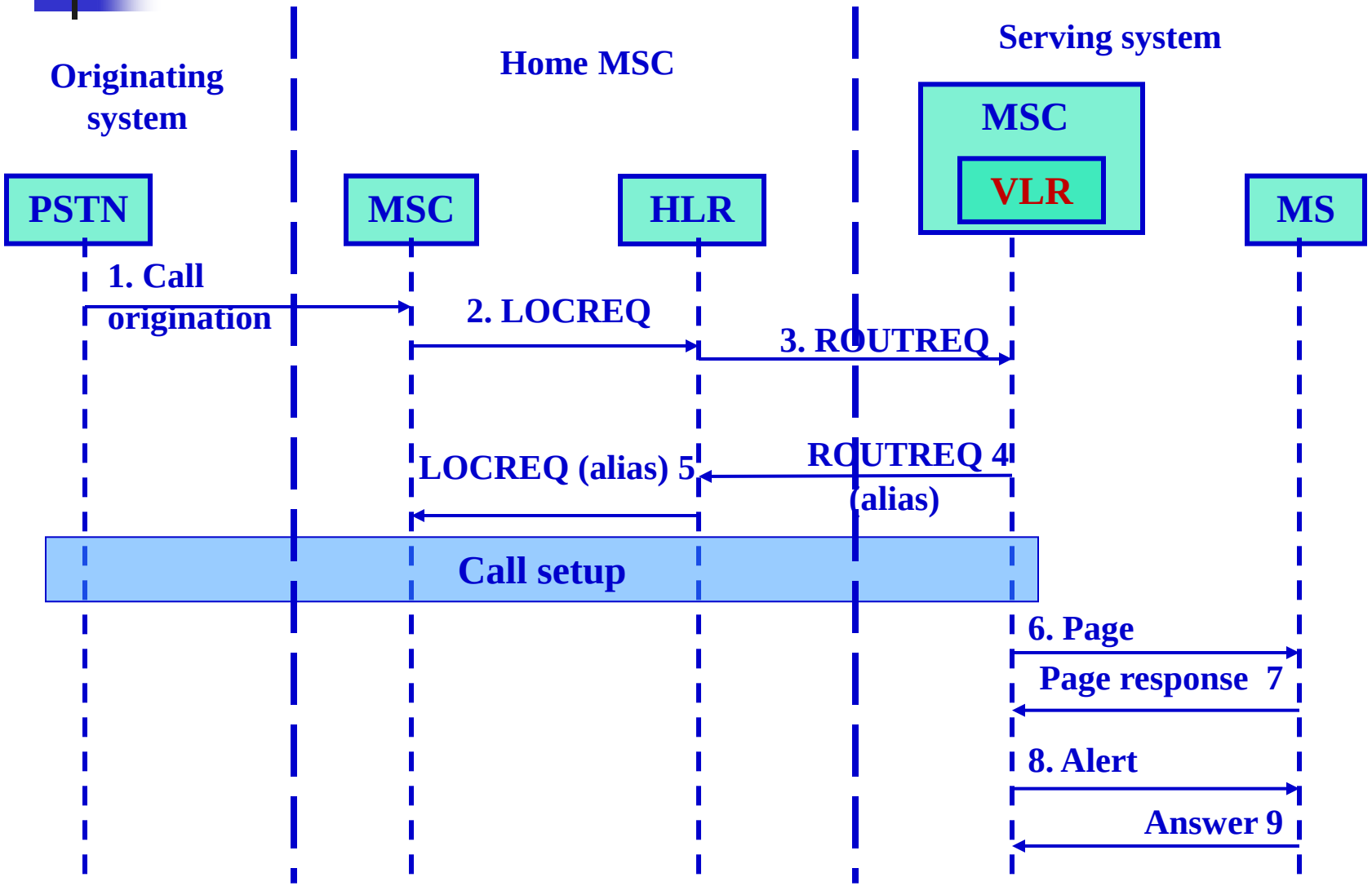


ROSE Operations

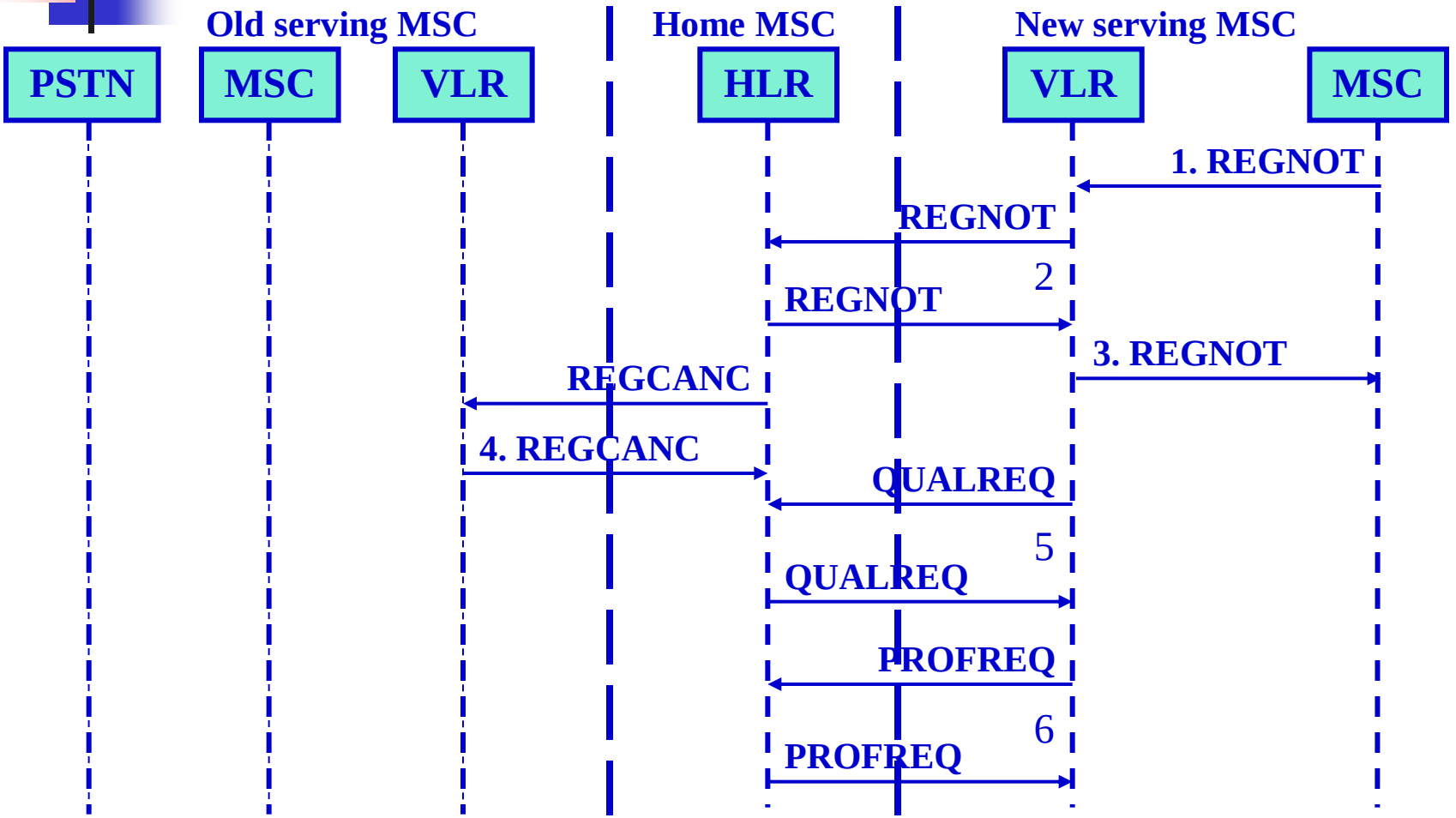
Result of Operation	Expected Report from Server
Success or failure	If successful, return a result. If a failure, return an error reply
Failure only	If successful, no reply. If a failure, return an error reply
Success only	If successful, return a result. If a failure, no reply
Success or failure	In either case, no reply

Class number	Definition
1	Synchronous: Report success (result) or failure (error)
2	Asynchronous: Report success (result) or failure (error)
3	Asynchronous: Report failure (error) only
4	Asynchronous: Report success (result) only
5	Asynchronous: Report nothing

Interworking of IS-41 and AMPS



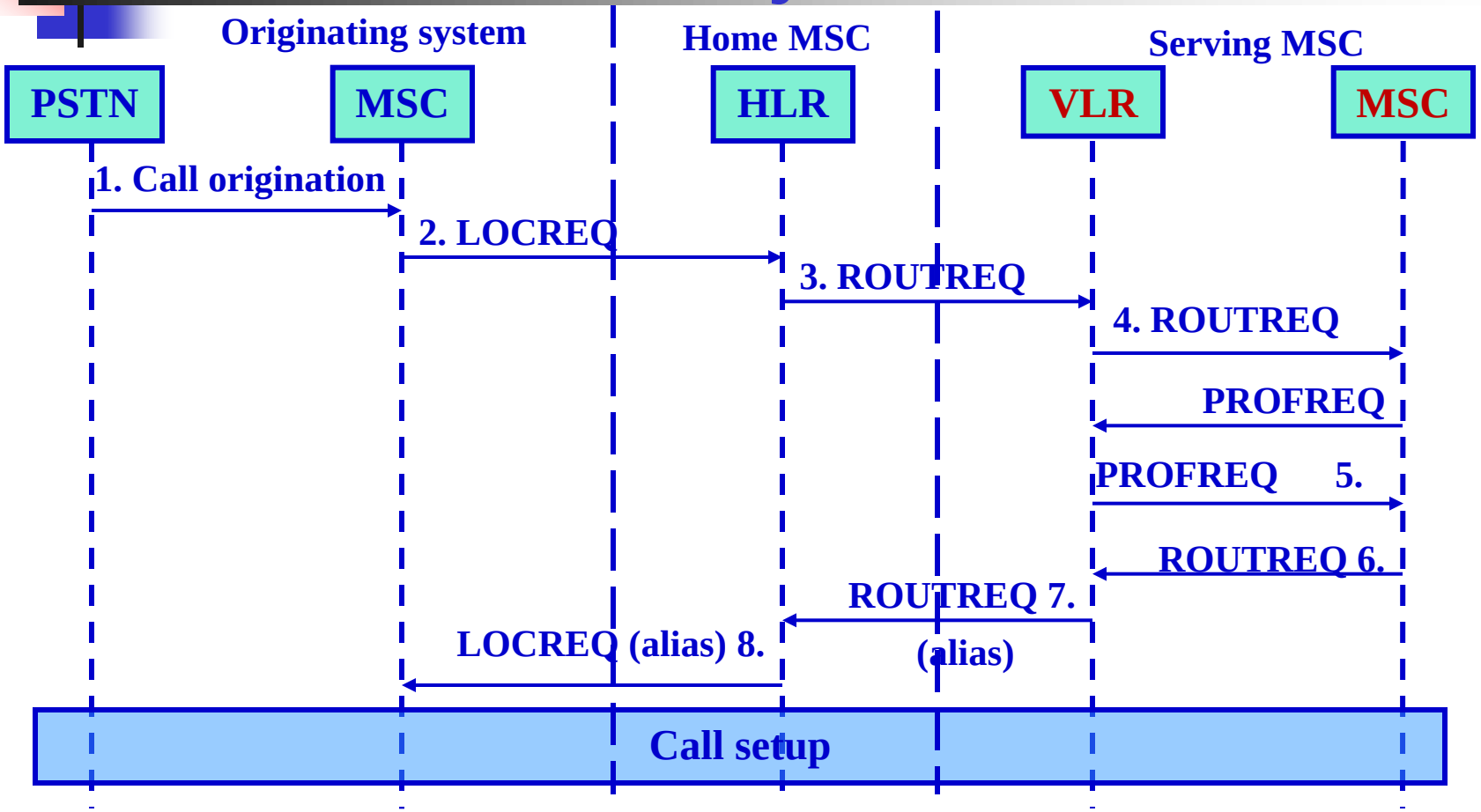
Registration with a New MSC



REGNOT – Registration notification messages:
QUALREQ – Qualification request message:
REGCANC – Registration cancellation message
PROFREQ – Service profile request message

Upper case represents ROSE INVOKE message
Lower case represents ROSE RETURN RESULTS message

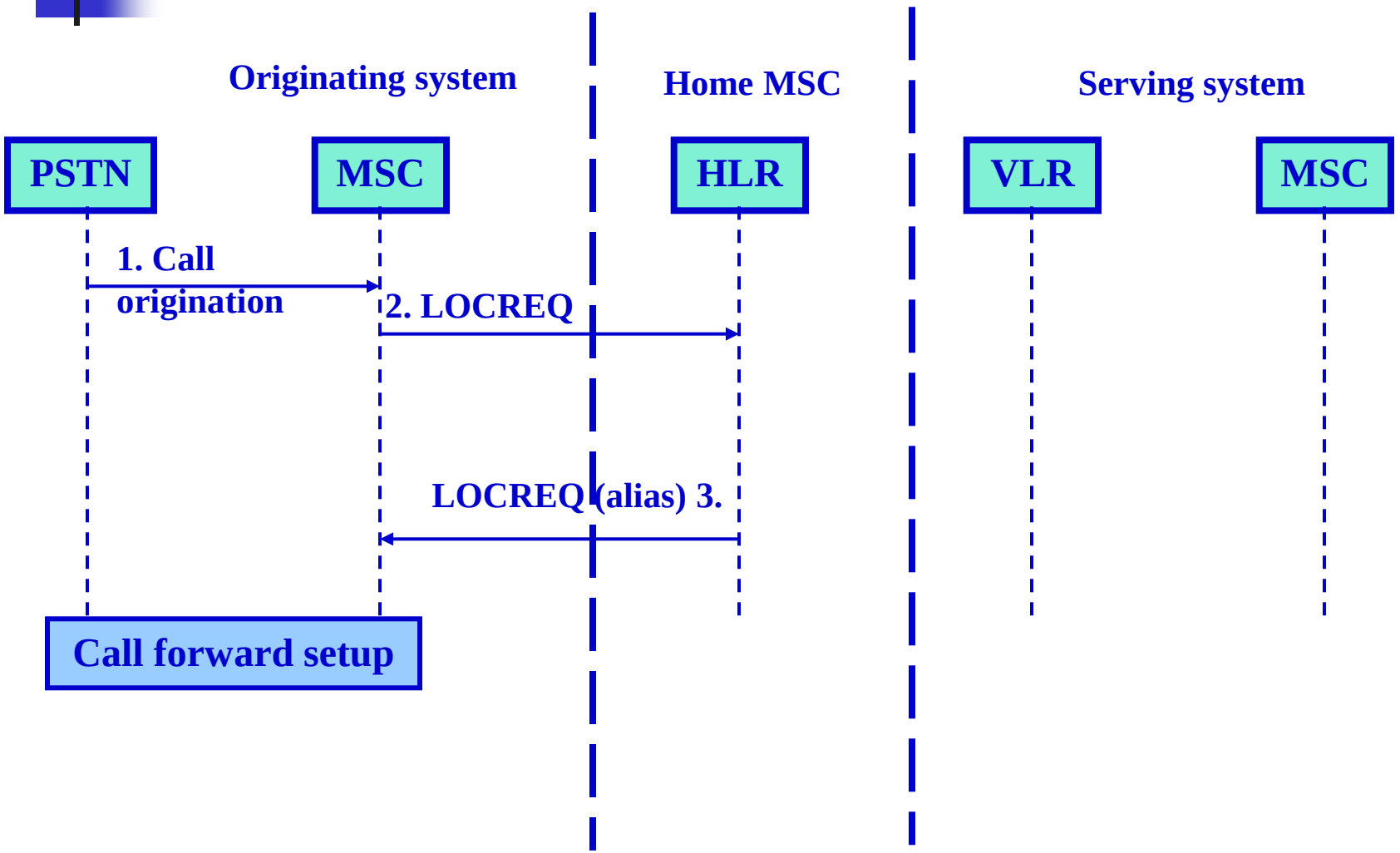
Calling an Idle MS in a new System



LOCREQ – Location request messages: **ROUTREQ – Routing request message**
PROFREQ – Service profile request message

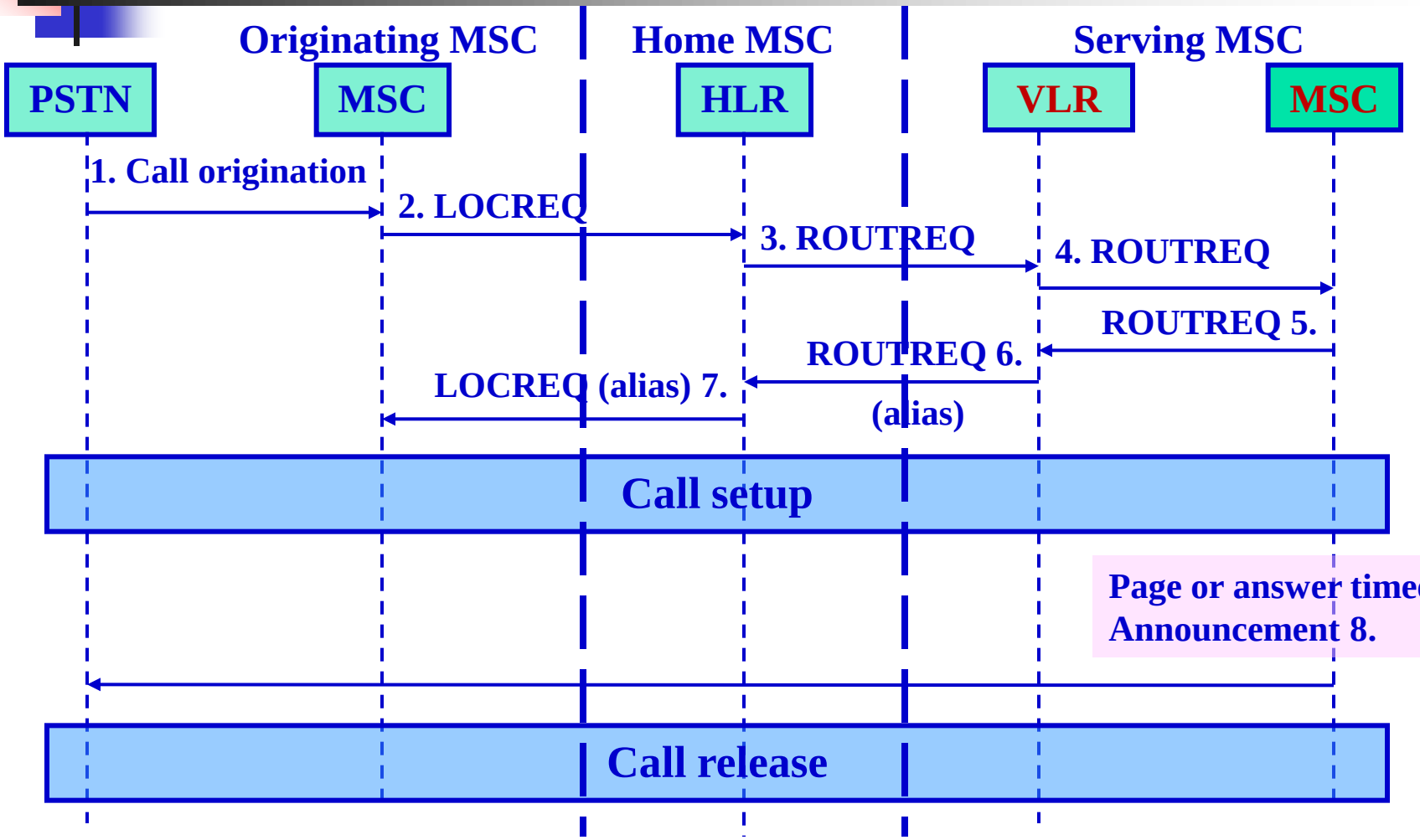
Upper case represents ROSE INVOKE message
Lower case represents ROSE RETURN RESULTS message

Call with unconditional Call Forwarding



LOCREQ – Location request messages

Call with no Answer



LOCREQ – Location request messages: **ROUTREQ – Routing request message**

Upper case represents ROSE INVOKE message
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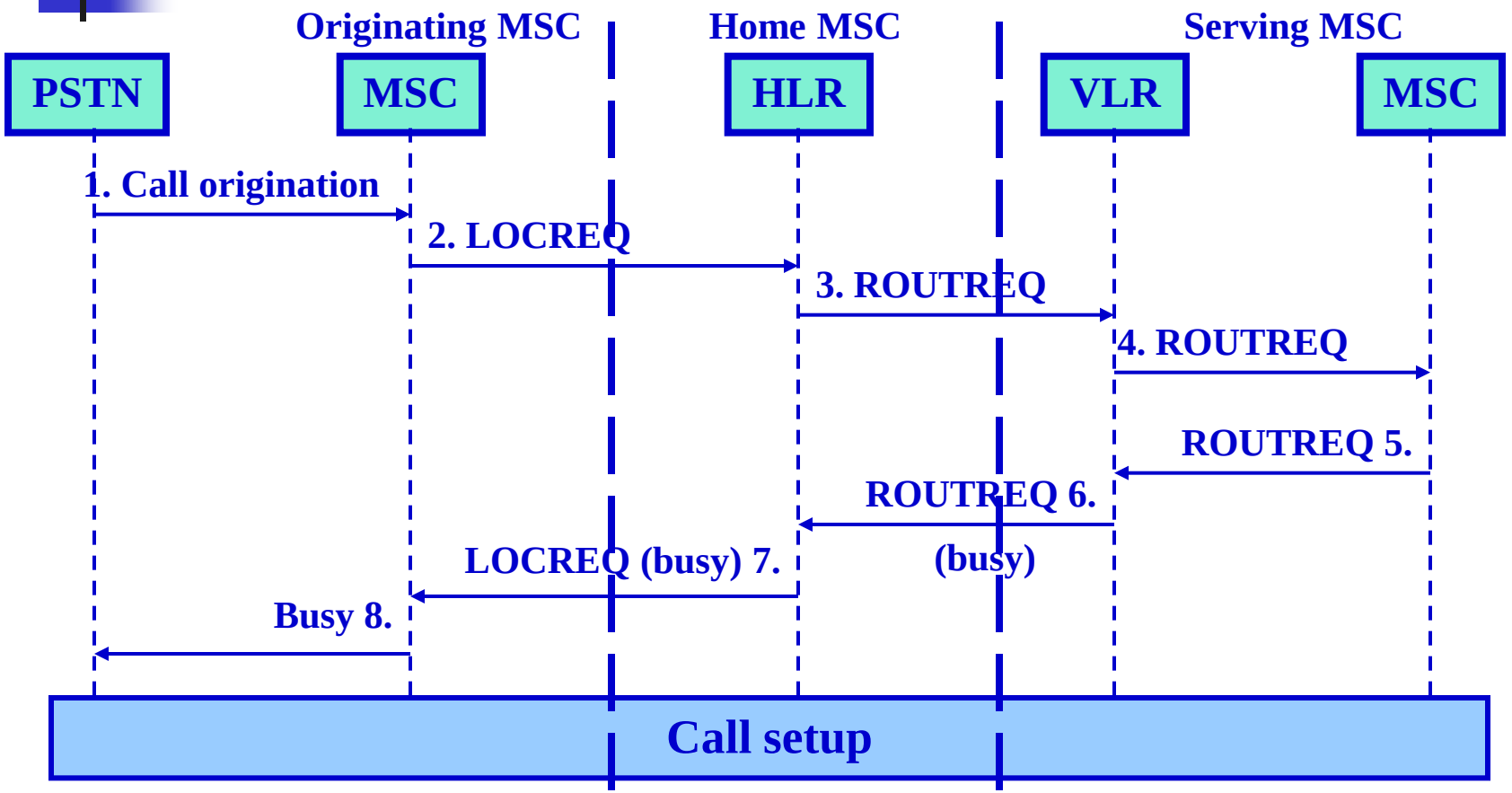
Calling a Busy MS

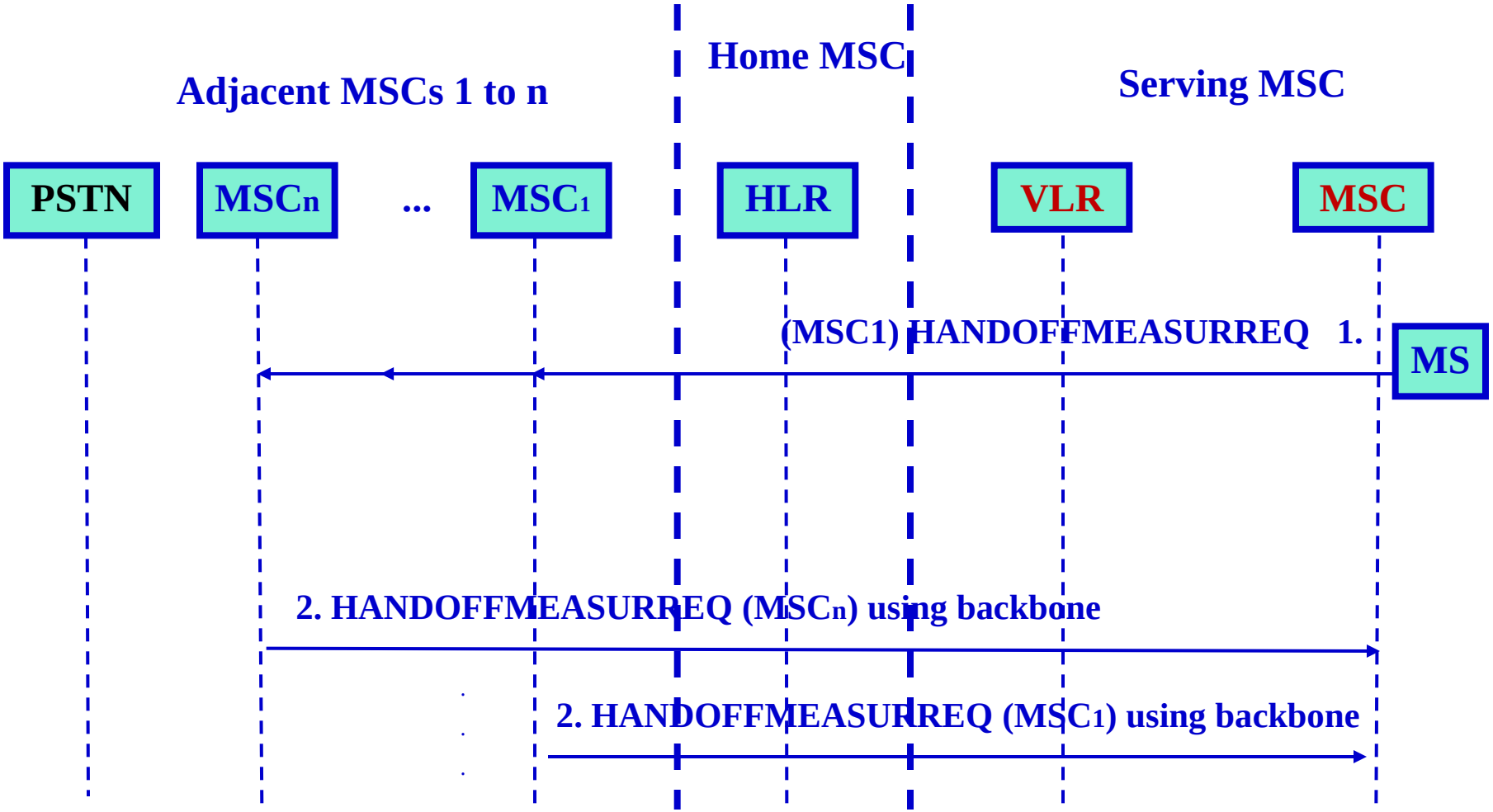


LOCREQ – Location request messages:

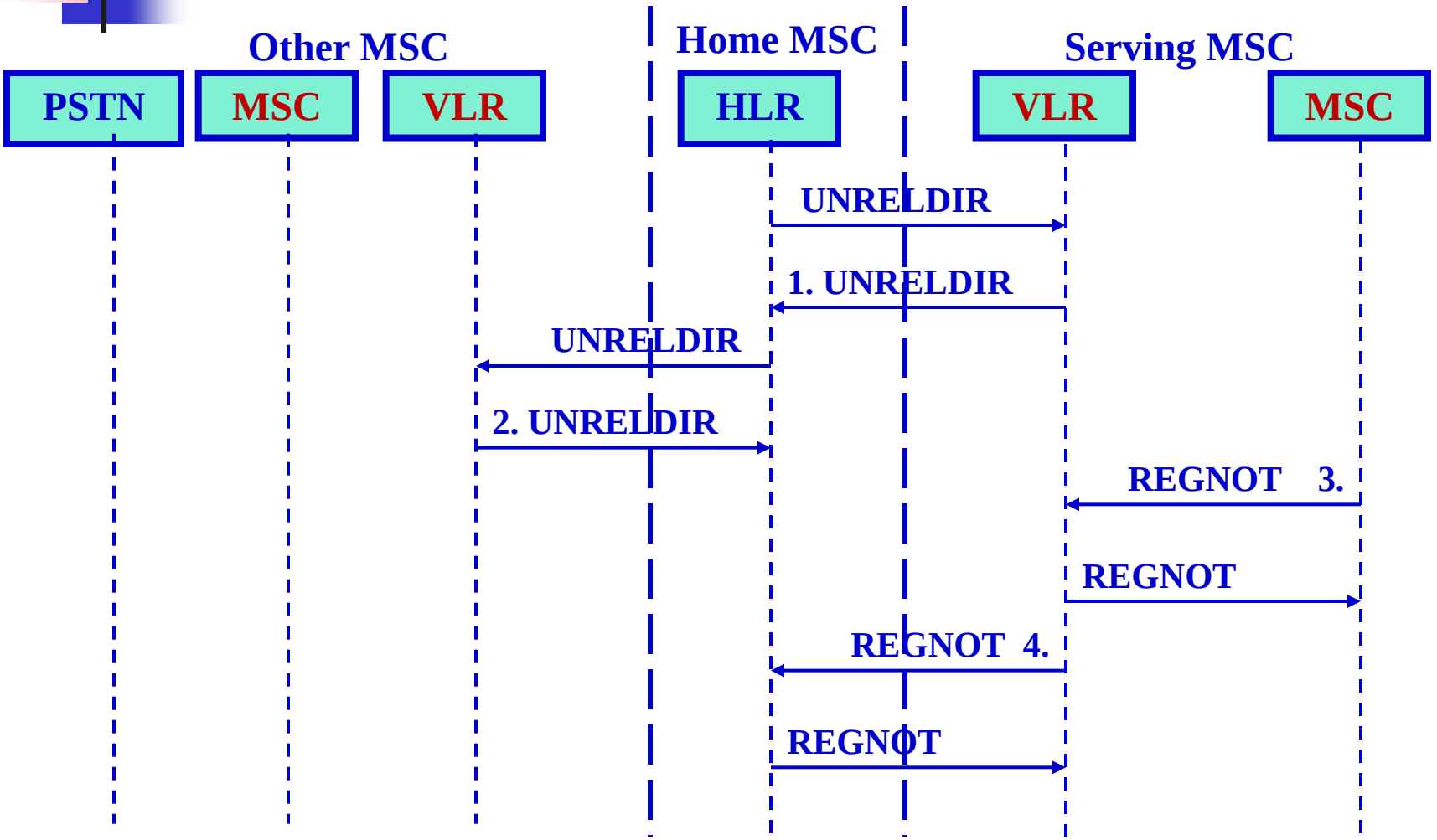
ROUTREQ – Routing request message

Upper case represents ROSE INVOKE message
Lower case represents ROSE RETURN RESULTS message

Handoff Measurement Request

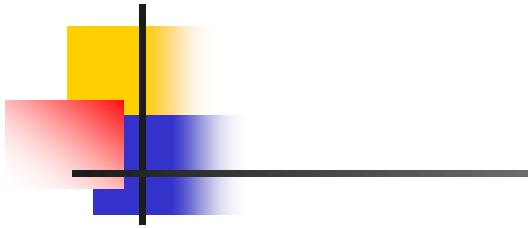


Recovery from Failure at the HLR



UNRELDIR – Unreliable roamer data directive

REGNOT – Registration notification messages:



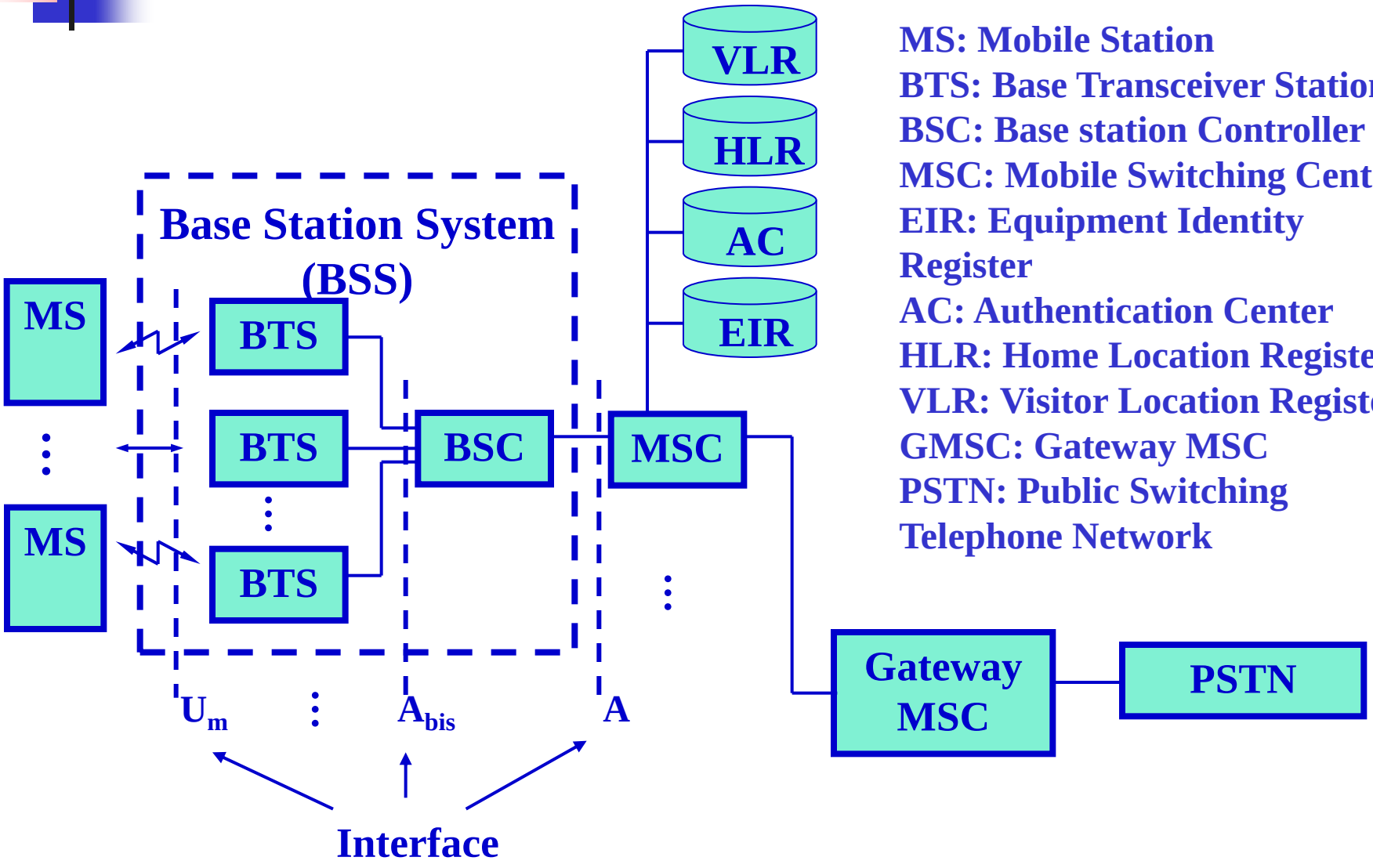
Global System for Mobile Communications

(GSM)

Group Special Mobile OR Global System for Mobile Communications:Europe

- GSM infrastructure (TDMA)
- Frequency Bands and Channels
- Frames in GSM
- Identity numbers used by a GSM System
- Layers, planes and Interfaces of GSM

GSM Infrastructure



MS: Mobile Station
BTS: Base Transceiver Station
BSC: Base station Controller
MSC: Mobile Switching Center
EIR: Equipment Identity Register
AC: Authentication Center
HLR: Home Location Register
VLR: Visitor Location Register
GMSC: Gateway MSC
PSTN: Public Switching Telephone Network

Constituents Functionalities of GSM

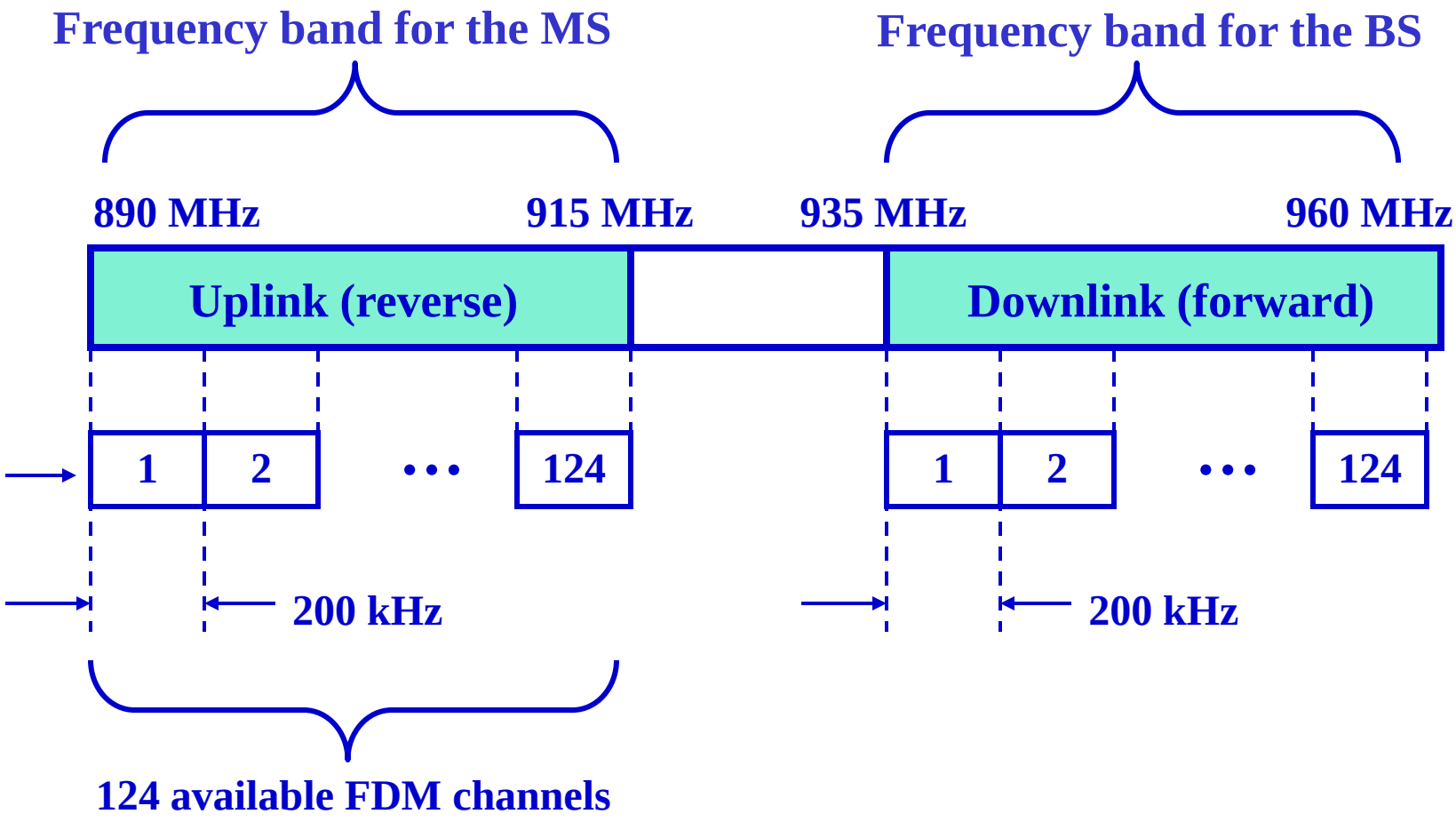
Base Station Controller (BSC): looks over a certain number of BTS to ensure proper operation, takes care of Handoff between BTSs

Mobile Switching Center (MSC): Mainly performs the switching by controlling calls to and from other telephone/data systems. Also, performs functions such as network interfacing, common channel signaling, etc.

Authentication Center (AC): AC unit provides authentication and encryption parameters that verify the user's identity and ensure the confidentiality of each call

Equipment Identity Register (EIR): EIR is a database that contains information about the identity of mobile equipment that prevents calls from stolen, unauthorized, or defective MSs

Frequency Band Used by GSM



Channels in GSM

Group		Channel	Direction
Control Channel	BCCH (Broadcast control channel)	BCCH (Broadcast control channel)	BS → MS
		FCCH (Frequency correction channel)	BS → MS
		SCH (Synchronization channel)	BS → MS
	CCCH (Common control channel)	PCH (Paging channel)	BS → MS
		RACH (Random access channel)	MS → BS
		AGCH (Access grant channel)	BS → MS
	DCCH (Dedicated control channel)	SDCCH (Stand-alone dedicated control channel)	BS ←→ MS
		SACCH (Slow associated control channel)	BS ←→ MS
		FACCH (Fast associated control channel)	BS ←→ MS
Traffic Channel	TCH (Traffic Channel)	TCH/f (Full-rate traffic channel)	BS ←→ MS
		TCH/s (Half-rate traffic channel)	BS ←→ MS

Control Channels of GSM

Control Channels used to Broadcast Information to all MSs.

- **Broadcast Control Channel (BCCH): Used to transmit the system parameters like the frequency of operation in the cell, operator identifiers, etc.**
- **Frequency Correction Channel (FCCH): Used for transmission of frequency references and frequency correction bursts**
- **Synchronization Channel (SCH): Used to provide the synchronization training sequences burst of 64 bits length to the MSs**

Control Channels used to establish link between MS and BS

- **Random Access Channel (RACH): Used by the MS to transmit information regarding the requested dedicated channel from GSM**
- **Paging Channel: Used by the BS to communicate with individual MS in the cell**
- **Access Grant Channel: Used by the BS to send information about timing and synchronization**

Control Channels of GSM

Dedicated Control Channels used to serve for any control information transmission during the actual communication

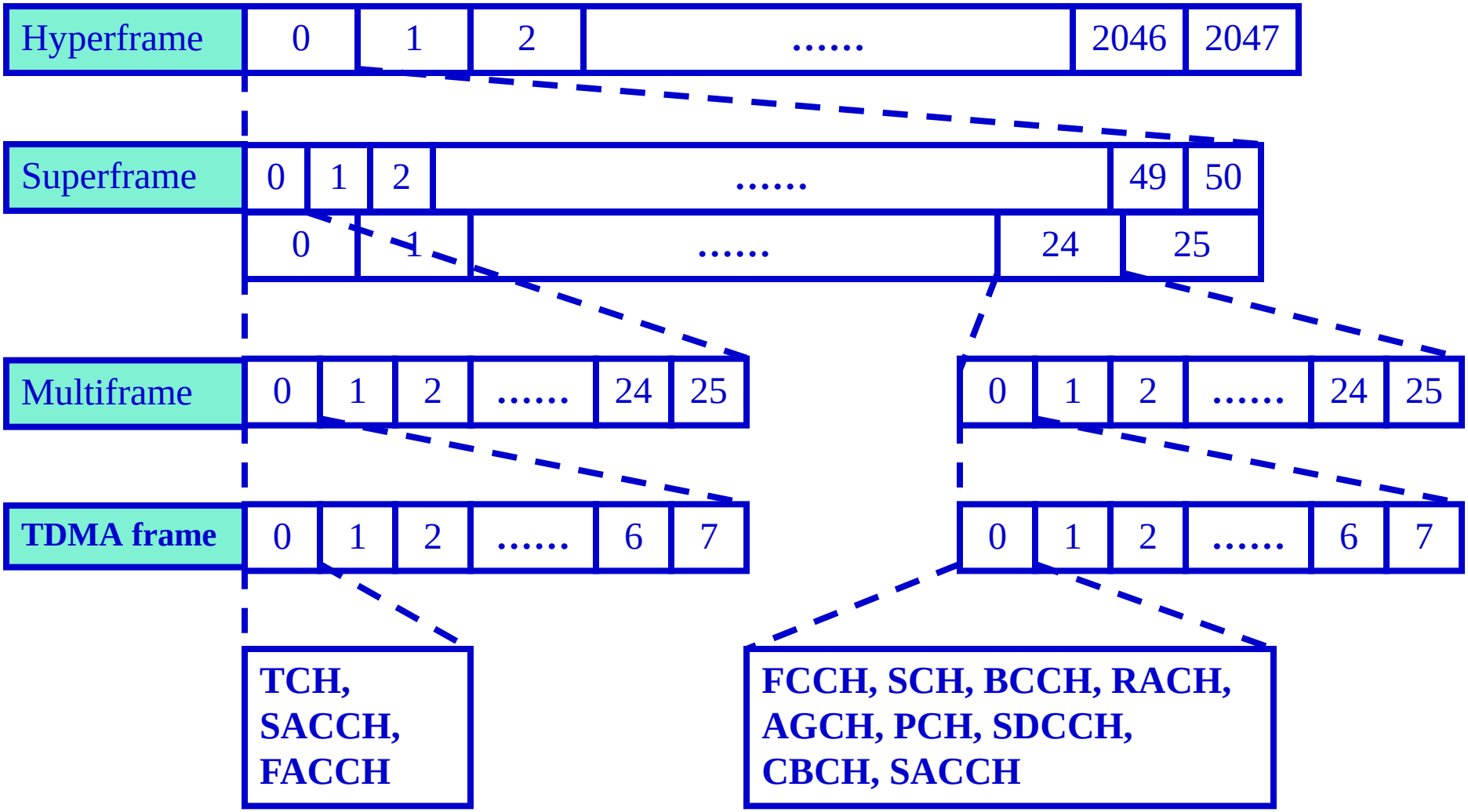
- **Slow Associated Control Channel (SACCH): Allocated along with a user channel, for transmission of control information during the actual transmission**

- **Stand-alone dedicated Control Channel: Allocated with SACCH, used for transfer of signaling information between the BS and the MS**

- **Fast Associated Control Channel (FACCH): Not a dedicated channel but carries the same information as SDCCH. But, it is a part of Traffic channel while SDCCH is a part of control channel**

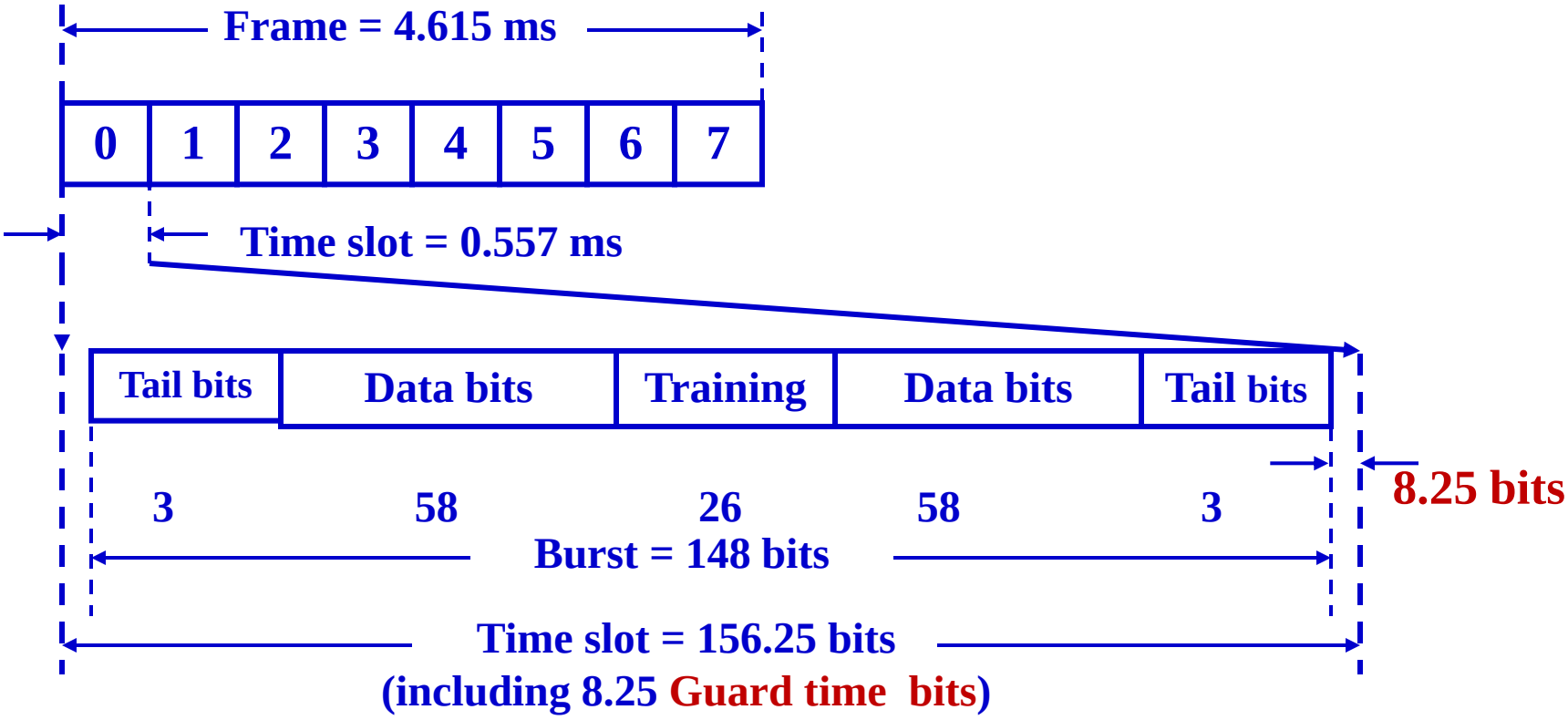
Frames in GSM

1 hyperframe = 2048 superframes = 2715684 TDMA frames (3 hr, 28 min, 53 s, 750 ms)



Structure of a TDMA Frame

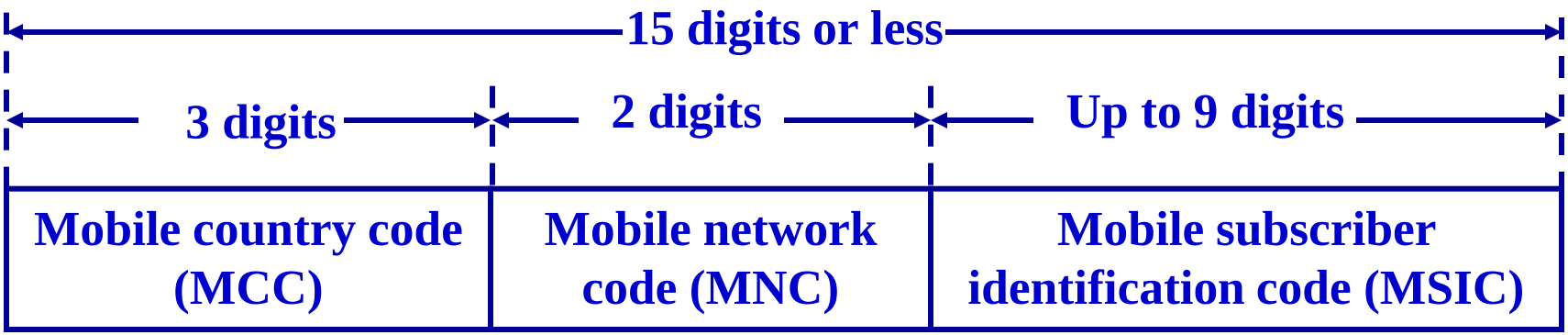
- A carrier frequency is divided into eight physical TDM channels (i.e., 8 time slots)



International Mobile Subscriber Identity (IMSI)

- Each mobile unit is identified uniquely with a set of values. These values are used to identify the country in which the mobile system resides, the mobile network, and the mobile subscriber
- The remainder of the IMSI is made up of the mobile subscriber identification code (MSIC), which is the customer identification number
- The IMSI is also used for an MSC/VLR to find out the subscriber's home PLMN (Public land mobile network)
- The IMSI is stored on the subscriber identity module (SIM), which is located in the subscriber's mobile unit

Format of IMSI



Example:

MCC = 05 → Australia; **MCC = 234 → UK**

MNC = 01 → Telecom Australia; **MNC = 234 → UK Vodafone**

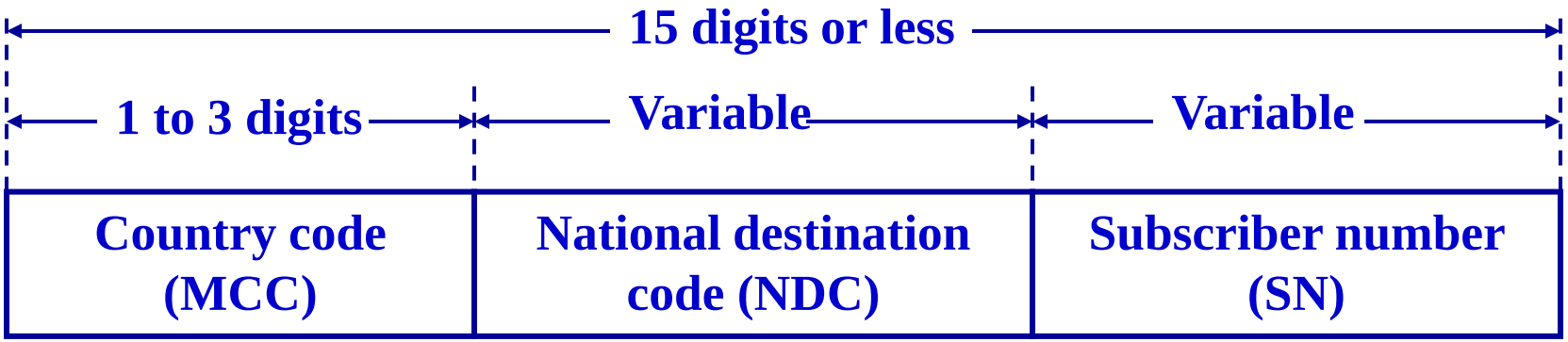
Airtel02=4040211; Vodaf01=4040111; Vodaf05=4040511;
Vodaf46=4044611 → **India**

Mobile=4600202; Unicom=4600158 → **China**

Subscriber Identity Module (SIM)

- SIM contains subscriber-specific information such as:
  - Phone numbers
  - Personal identification number (PIN)
  - Security/Authentication parameters
- SIM can also be used to store short message
- SIM can be a small plug-in module that is placed (somewhat permanently) in the mobile unit, or it can be a card (like a credit card)
- A modular portable SIM allows a user to use different terminal sets
- SIM supports roaming

Mobile System ISDN (MSISDN)

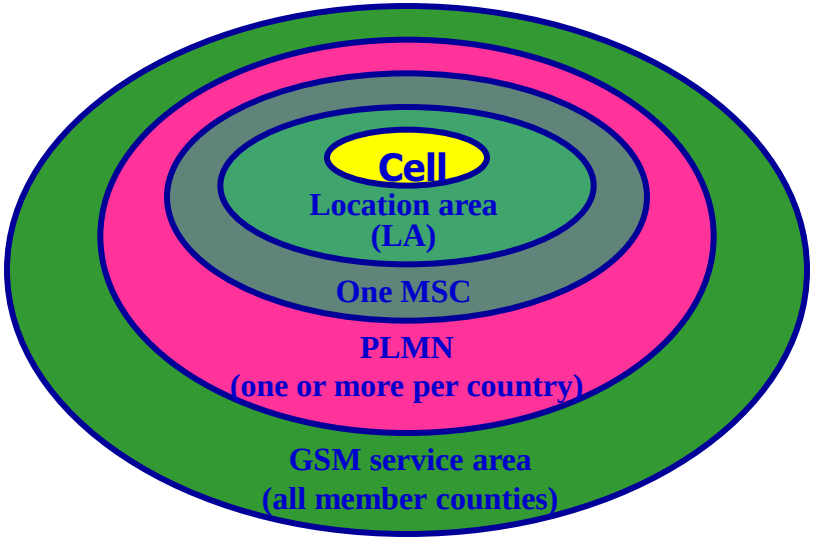


The format of MSISDN

- MSISDN is the number that the calling party dials in order to reach the subscriber
- It is used by the land network to route calls toward an appropriate MSC

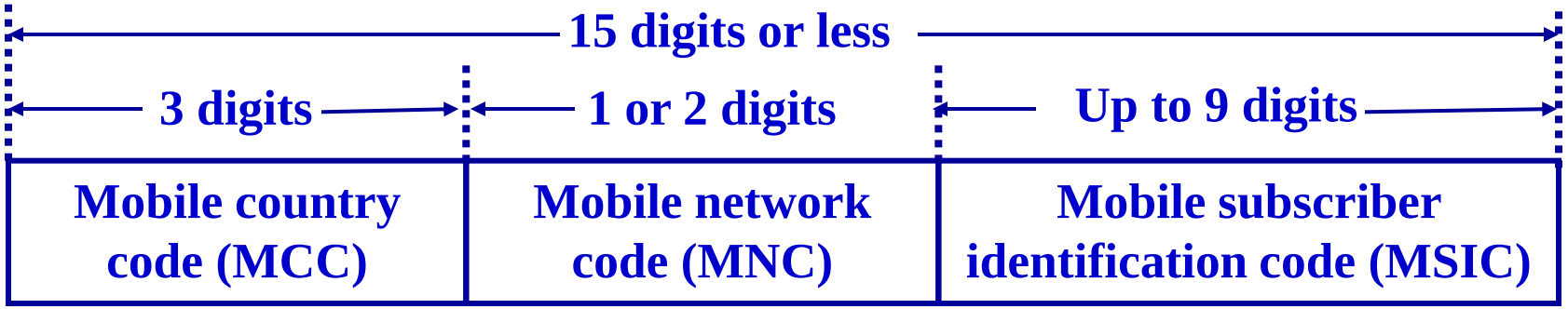
Location Area Identity (LAI)

- LAI identifies a cell or a group of cells.
- Relation between areas in GSM:



PLMN: Public Land Mobile Network

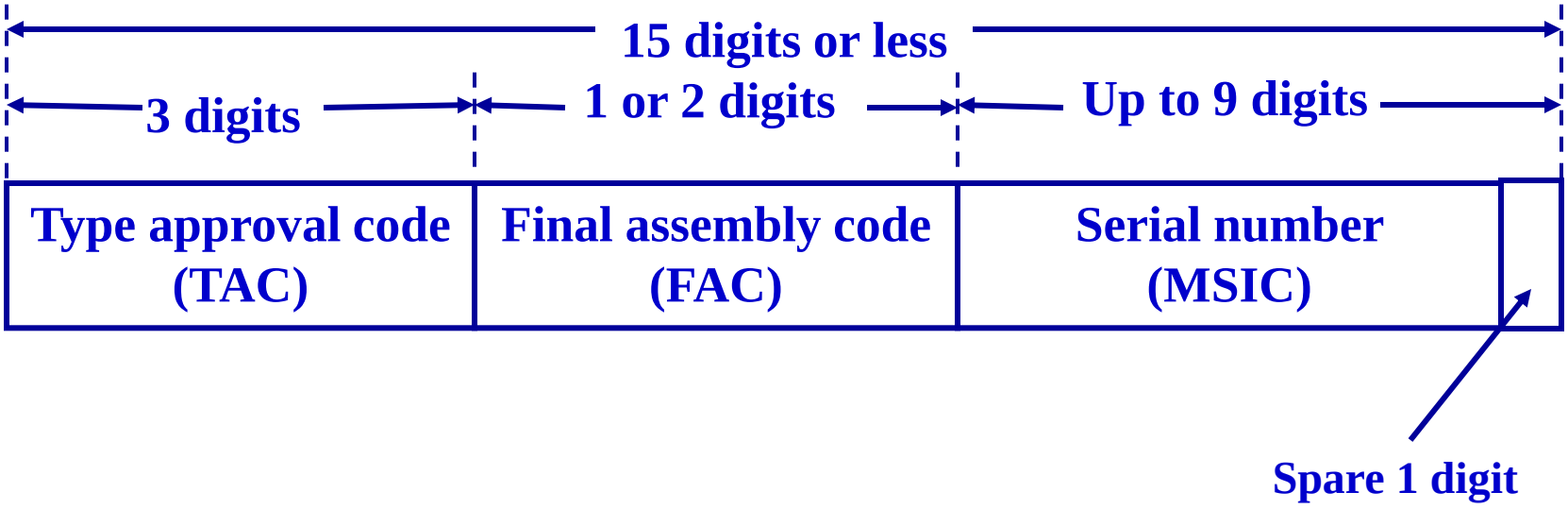
The format of LAI



International MS Equipment Identity (IMSEI)

- IMSEI is assigned to each GSM unit at the factory

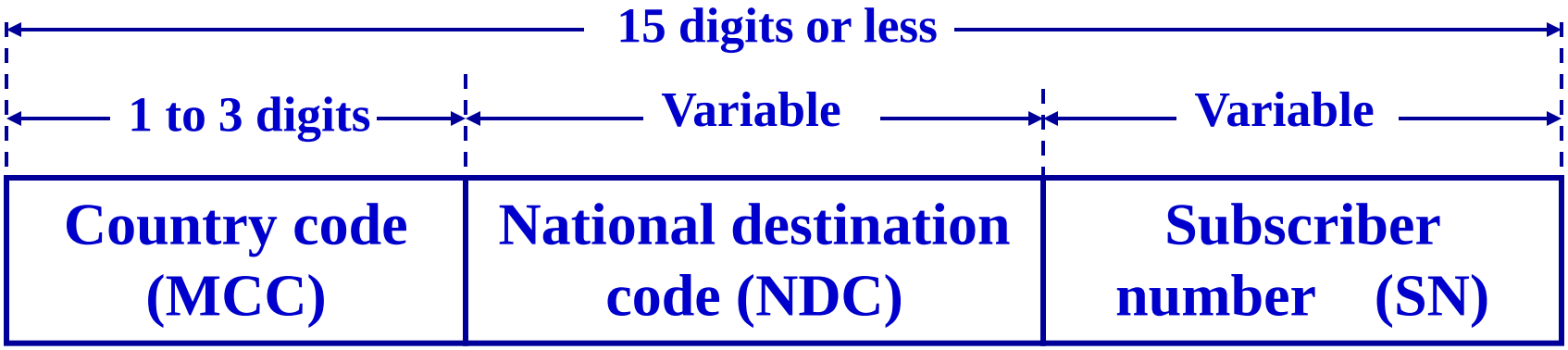
The format of IMSEI



Mobile Station Roaming Number (MSRN)

- MSRN is allocated on a temporary basis when the MS roams into another numbering area
- MSRN is used by the HLR for rerouting call to the MS

The format of MSRN



IMSI and TMSI

International Mobile Subscriber Identity (IMSI)

- IMSI is the primary function of subscriber within the mobile network and is permanently assigned to him

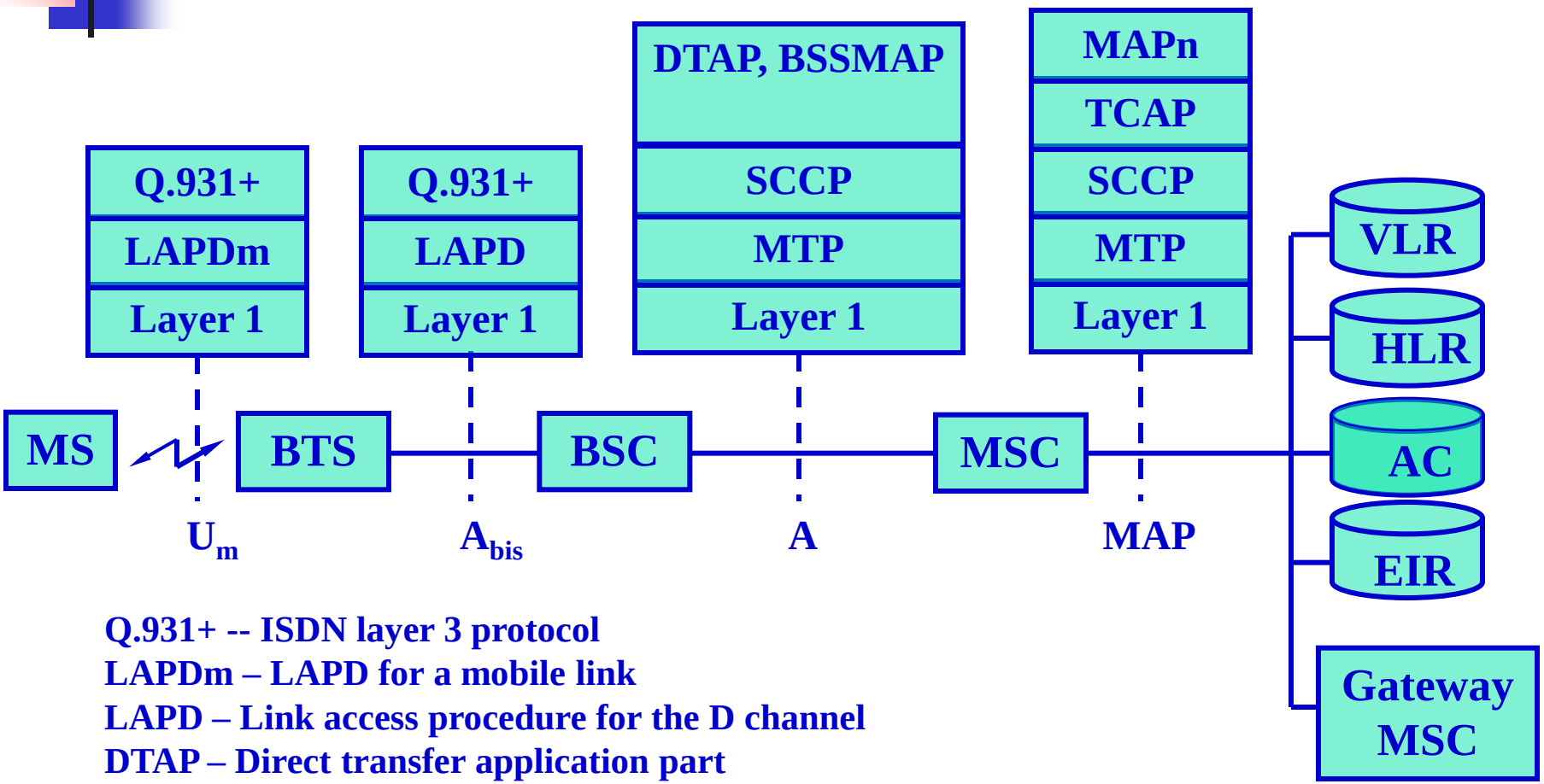
Temporary Mobile Subscriber Identity (TMSI)

- TMSI is an alias, used in place of the IMSI. This value is sent over the air interface in place of the IMSI for purposes of security

Interfaces of GSM

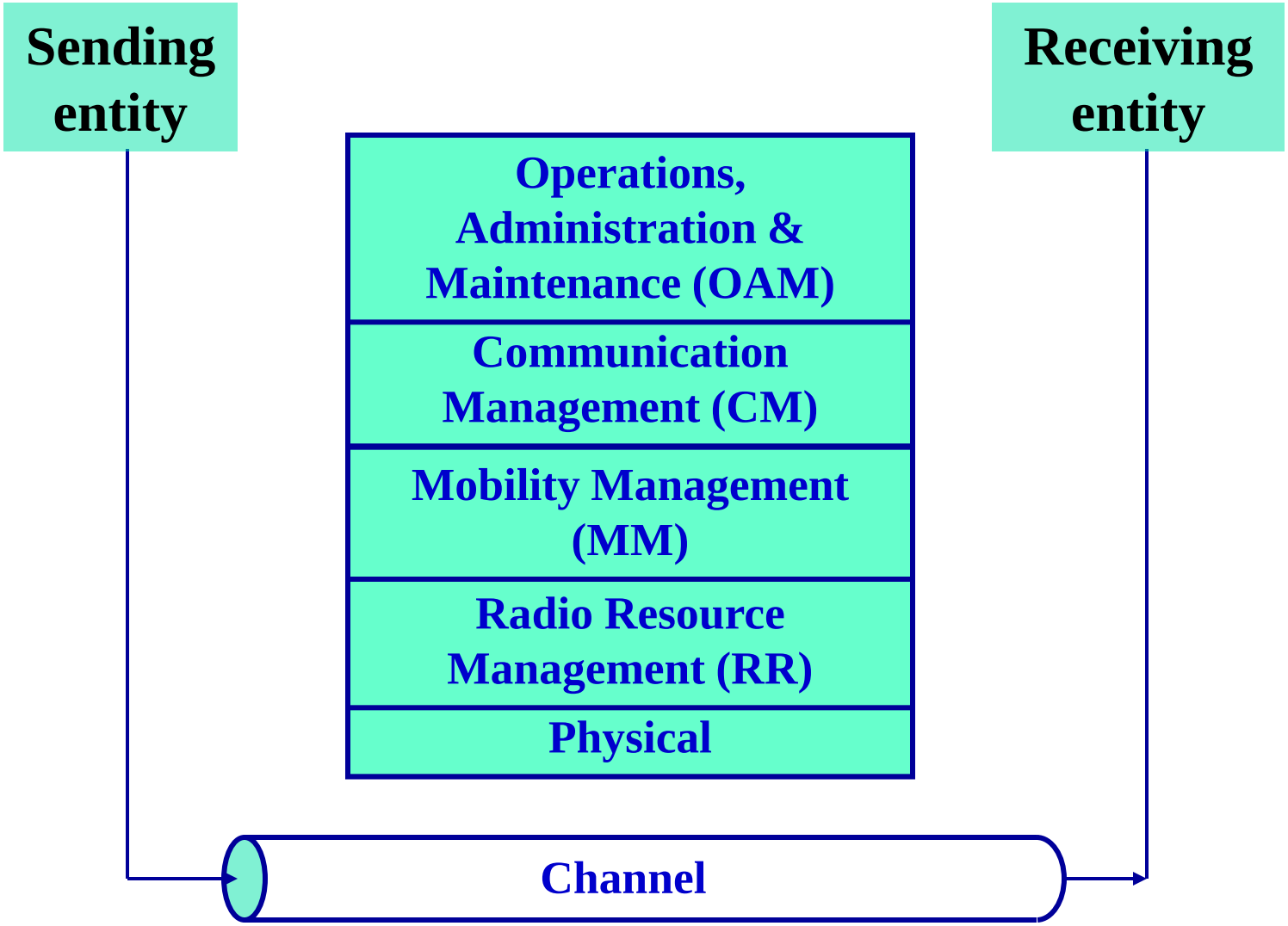
Interface Designation		Between
U_m		MSC – VLR
A_{bis}		MSC – HLR
A		HLR – VLR
MAPn	B	MSC – VLR
	C	MSC – HLR
	D	HLR – VLR
	E	MSC – MSC
	F	MSC – EIR
	G	VLR – VLR

Layers, Planes and Interfaces of GSM

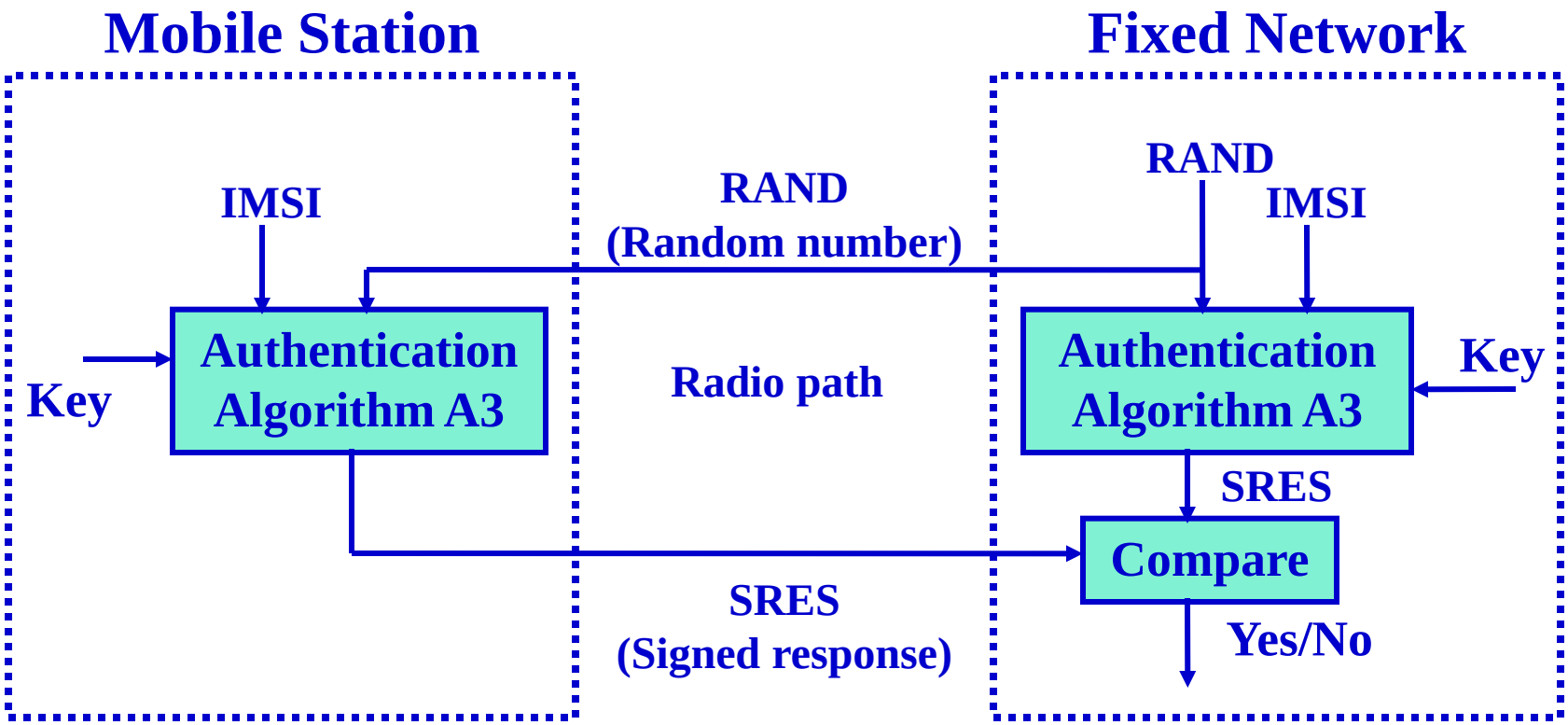


Q.931+ -- ISDN layer 3 protocol
LAPDm – LAPD for a mobile link
LAPD – Link access procedure for the D channel
DTAP – Direct transfer application part
BSSMAP – BSS management part
MTP – Message transfer part SCCP
– Signaling connection control part
TCAP – Transaction capabilities application part

GSM Functional Planes



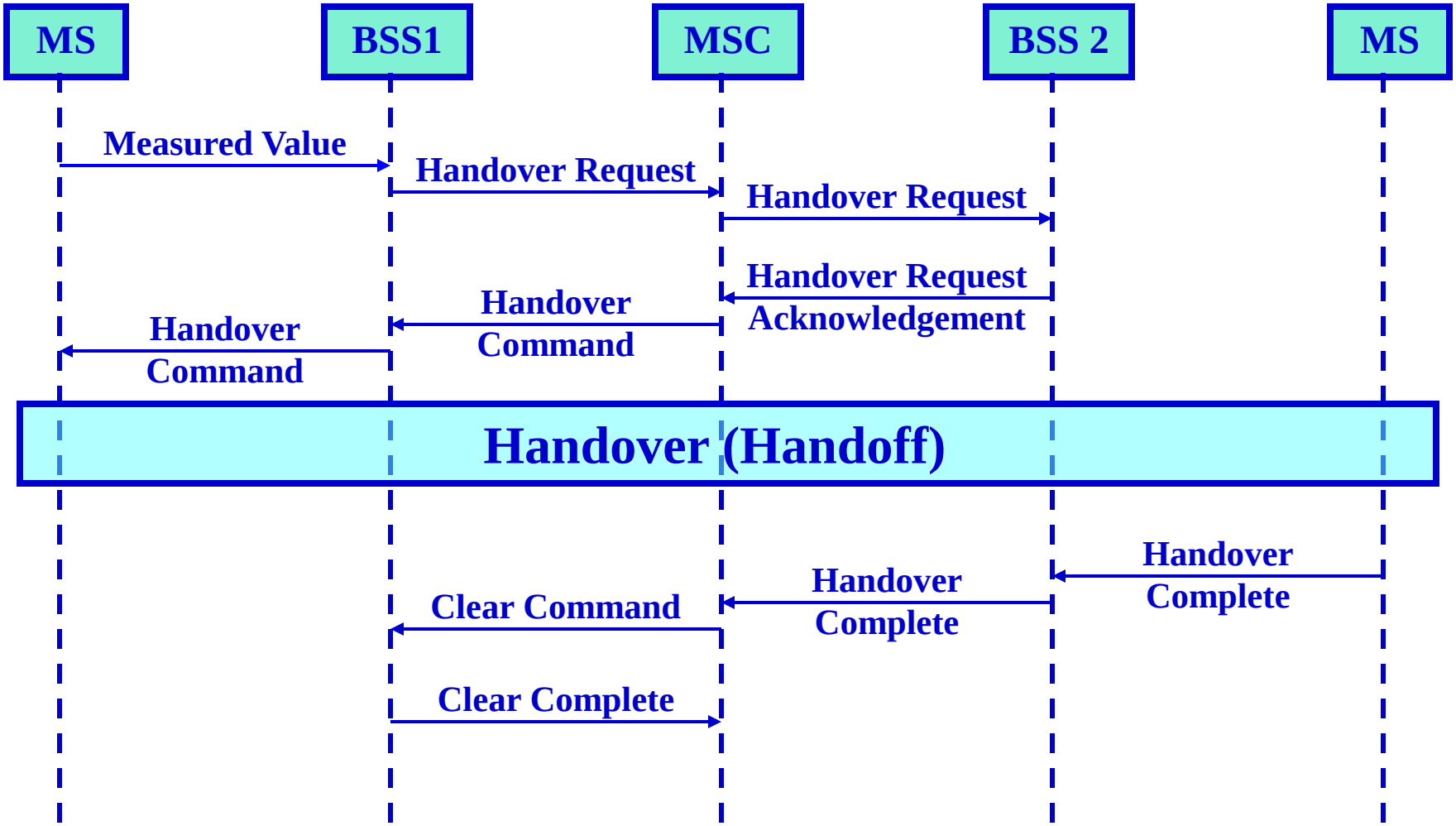
Authentication Process



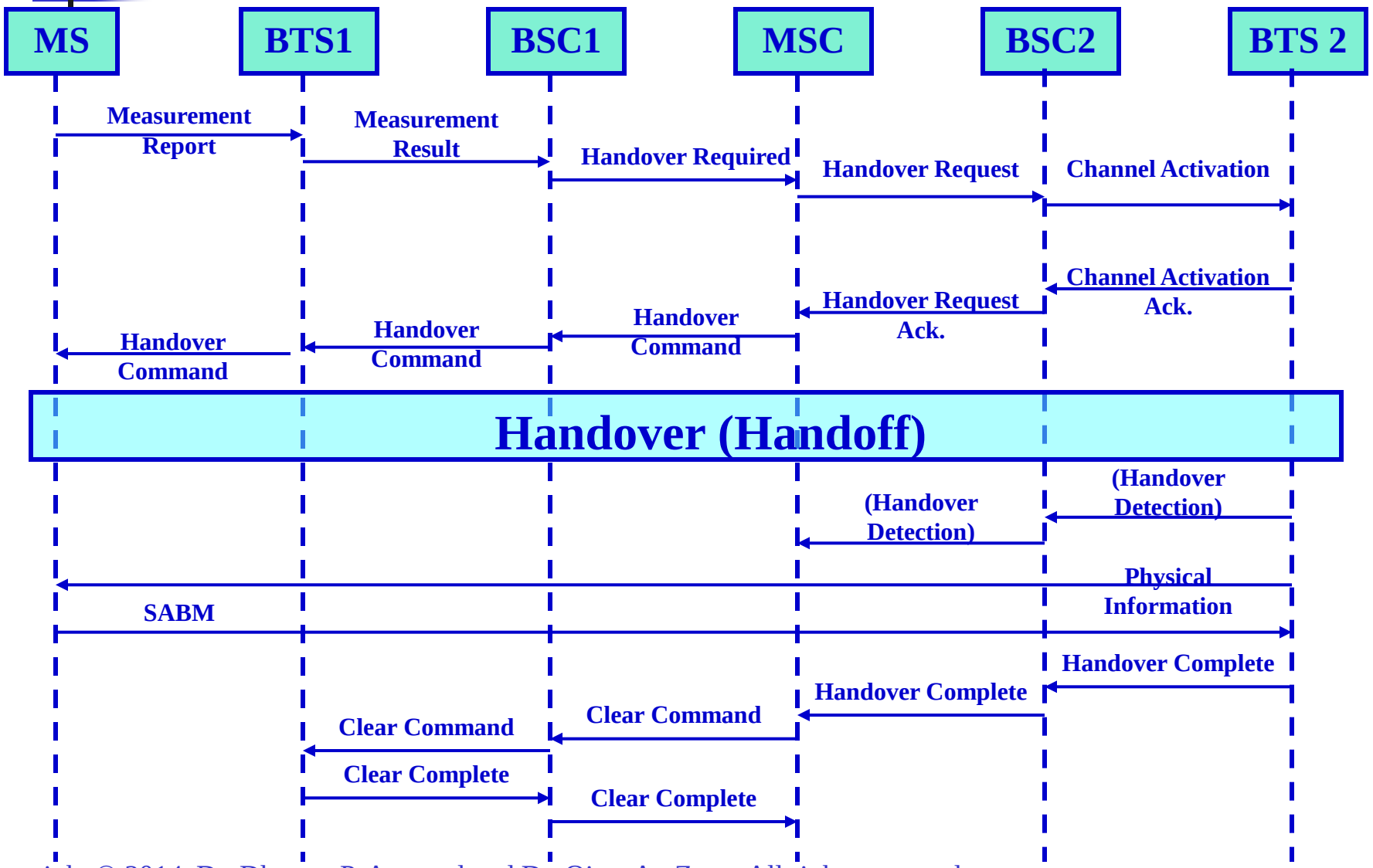
Handover (Handoff)

Handover	Description
Intra-cell / Intra-BTS	The channel for the connection is changed within the cell, e.g., if the channel has a high level of interference. The change can apply to another frequency of the same cell or to another time slot of the same frequency
Inter-cell / Intra-BSC	In this case there is a change in radio channel between two cells that are served by the same BSC
Inter-BSC / Intra-MSC	A connection is changed between two cells that are served by different BSCs but operate in the area of the same MSC
Inter-MSC	A connection is changed between two cells that are in different MSC areas

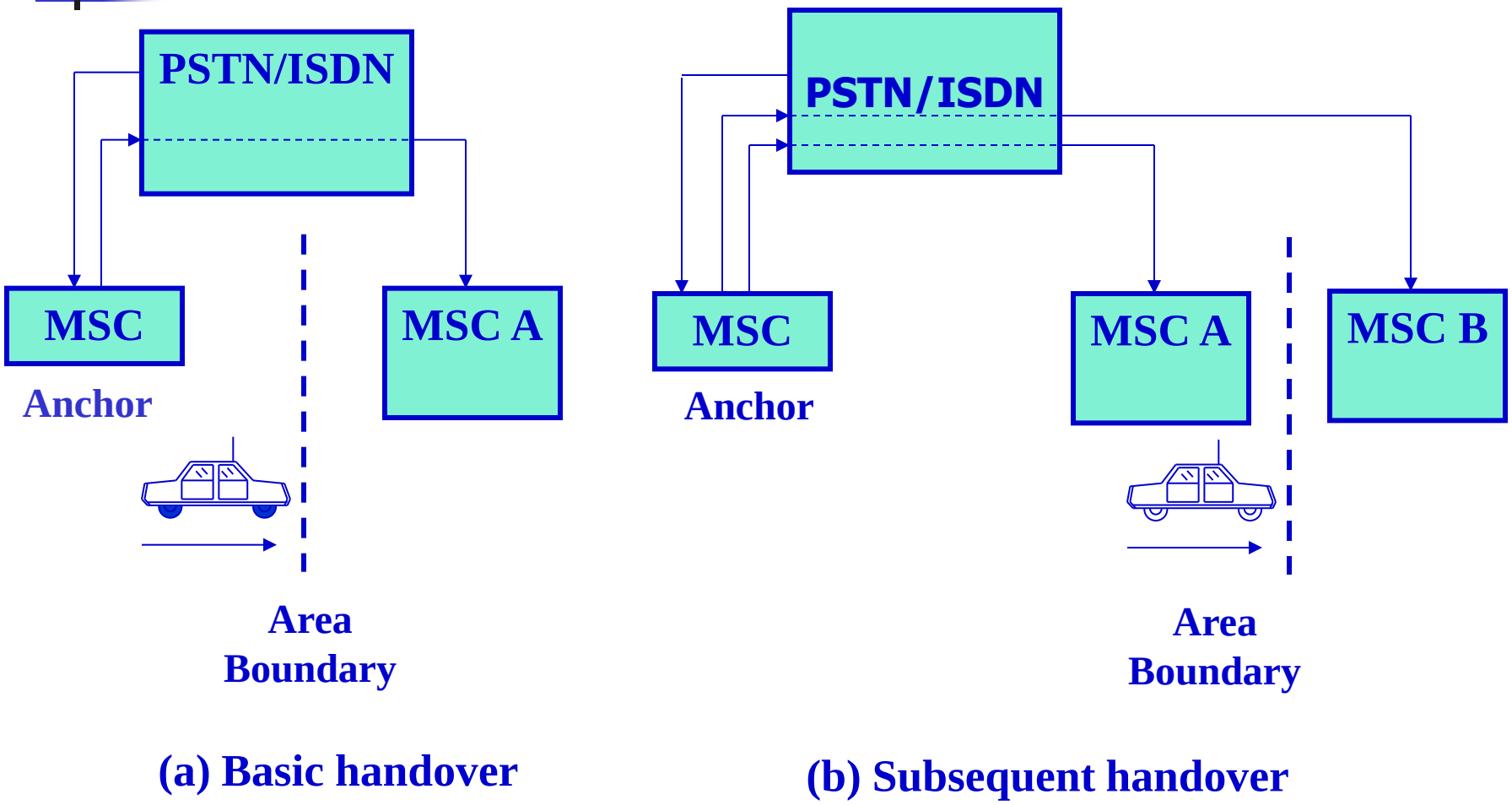
Handover (BSS 1 → BSS 2) Executed with an MSC



Intra-MSC Handover



Inter-MSC Handover



The Six Personal Communications Service (PCS) Standards

High tier	Low tier
IS-54 based	PACS
IS-95 based	W-CDMA
DCS based	DECT based

PACS – Personal Access Communications Systems

DCS – Digital Communications Service

DECT – Digital European Cordless Telephone

The PCS High-Tier Standards

	IS-54 based	IS-95 based	DCS based
MAC	TDMA	CDMA	TDMA
Duplexing	FDD	FDD	FDD
Carrier BW	30 KHZ	1.25 MHz	200 KHz
Cannels/carrier	3	20	8
x AMPS	3	10	8
Modulation	$\pi/4$ DQPSK	QPSK	GMSK
Frequency reuse	7	1	4
Power	100 mw	200 mw	125 mw
Frame length	40 ms	20 ms	4.165 ms
Equalizer	Yes	Rake filters	Yes
Vocoder	8/4 kbps	8/4/2/1 kbps	13/6.5 kbps

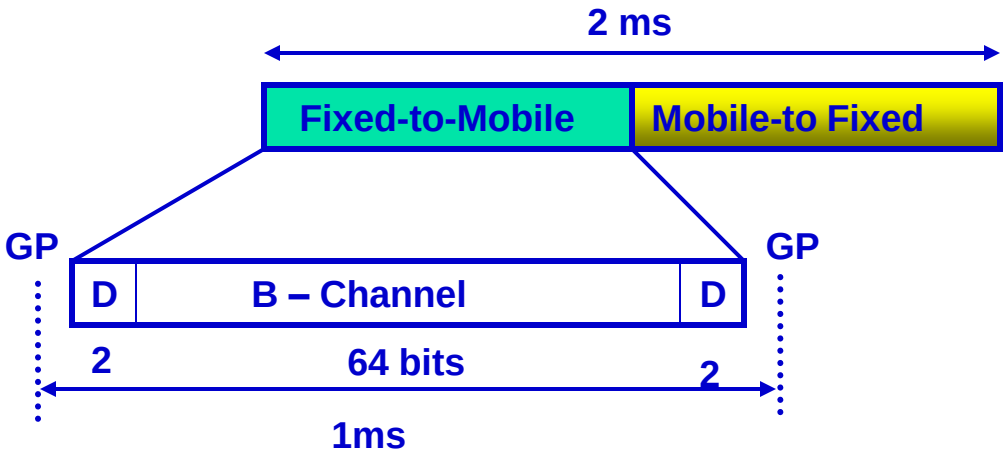
The PCS Low-Tier Standards

	PACS	W-CDMA	DECT based
MAC	TDMA	W-CDMA	TDMA
Duplexing	FDD	FDD	TDD
Carrier BW	300 KHZ	>5 MHz	1728 KHz
Cannels/carrier	8	128	12
x AMPS	0.8	16	0.2
Modulation	$\pi/4$ DQPSK	QPSK	GFSK
Frequency reuse	7	1	9
Power	100 mw	500 mw	20.8 mw
Frame length	40 ms		10 ms
Equalizer	Yes	No	No
Vocoder	32 kbps	>32 kbps	32 kbps

In discussion

CT2 TDD Slots (First-generation)

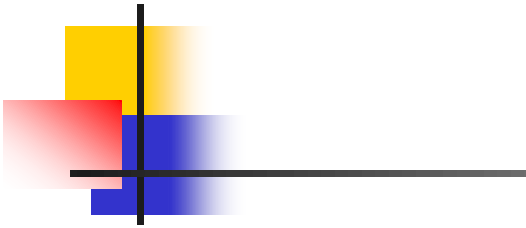
CT2 – Cordless telephone or cordless communications systems)



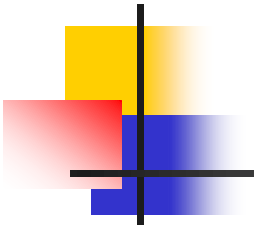
B channel – Information channel

D channel – Control channel

GP – Guard period



IS-95 CDMA



IS-95 CDMA

- CDMA concept
- IS-95 CDMA
- Logical channels
- Forward channel
- Reverse channel
- Power control
- Soft handoff
- Diversity
- Use of the Rake concept in IS-95

IS-95 CDMA

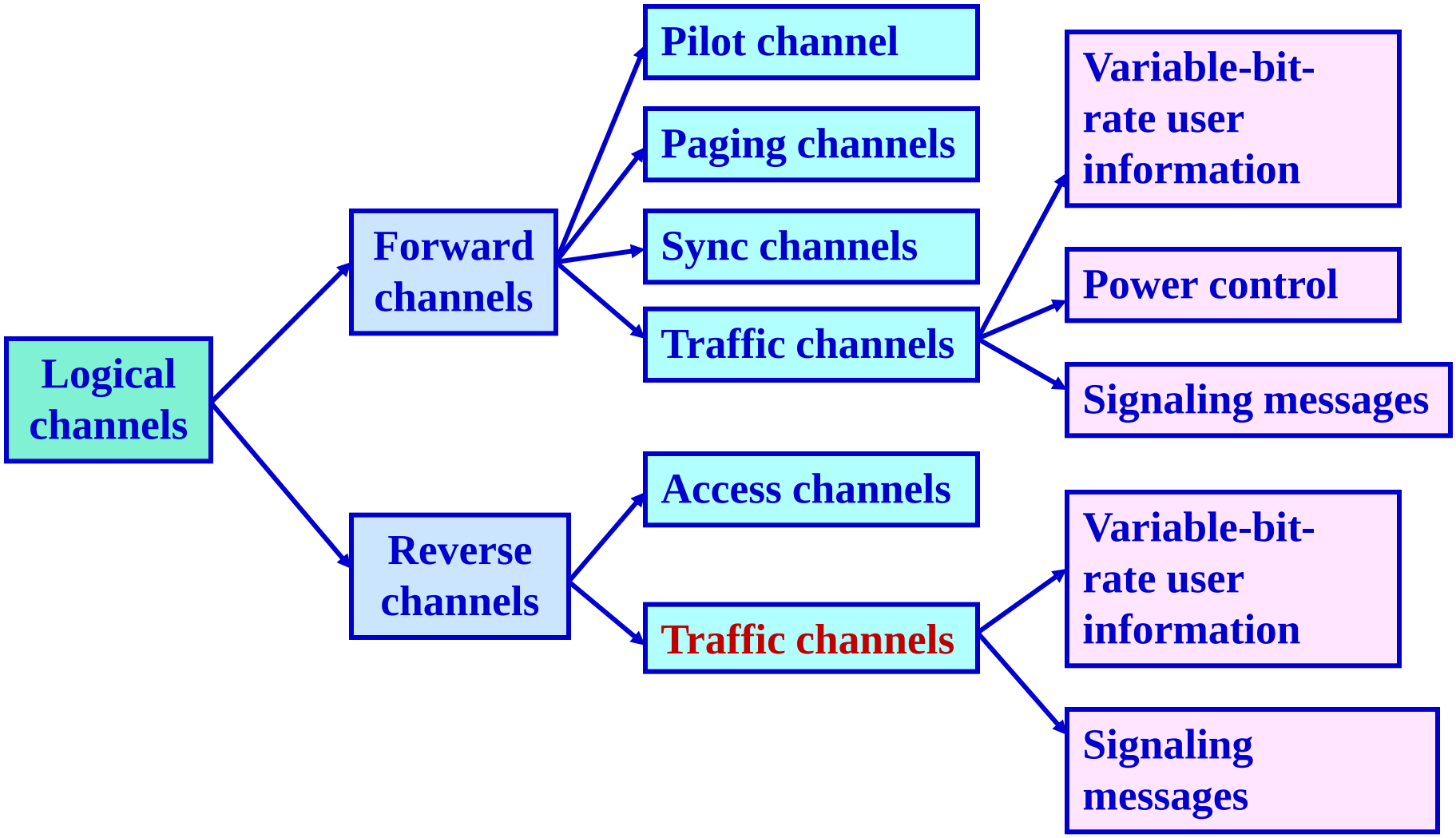
- The existing 12.5 MHz cellular bands are used to derive 10 different CDMA bands (1.25 MHz per band)
- The frequency reuse factor in CDMA is 1
- The channel rate is 1.2288 Mbps (actually chips not bits)
- Multipath fading is exploited in CDMA. It provides for space (path) diversity
- RAKE receivers are used to combine the output of several received signals

Coding and Modulation Process

- 64 bit Walsh codes (proving 64 bit orthogonal codes) are used to provide 64 channels within each frequency band
- Besides the Walsh codes, two other codes are used in IS-95:
  - Long PN (Pseudo Noise) code: generated from a 42 bit shift register having $2^{42}-1=4.398\text{x}10^{12}$ different codes. These codes are used for:
    - Data scrambling/encryption in the forward link
    - Data spreading and encryption in the reverse link
  - Short PN code: generated from a pair of 15 bit shift register having $2^{15}-1=32{,}767$ codes. These codes are used for
    - Synchronization in the forward and reverse links
    - cell identification in the forward link (Each cell uses one of 512 possible offsets. Adjacent cell must use different offsets)

    The chip rate is 1.2288 Mcps

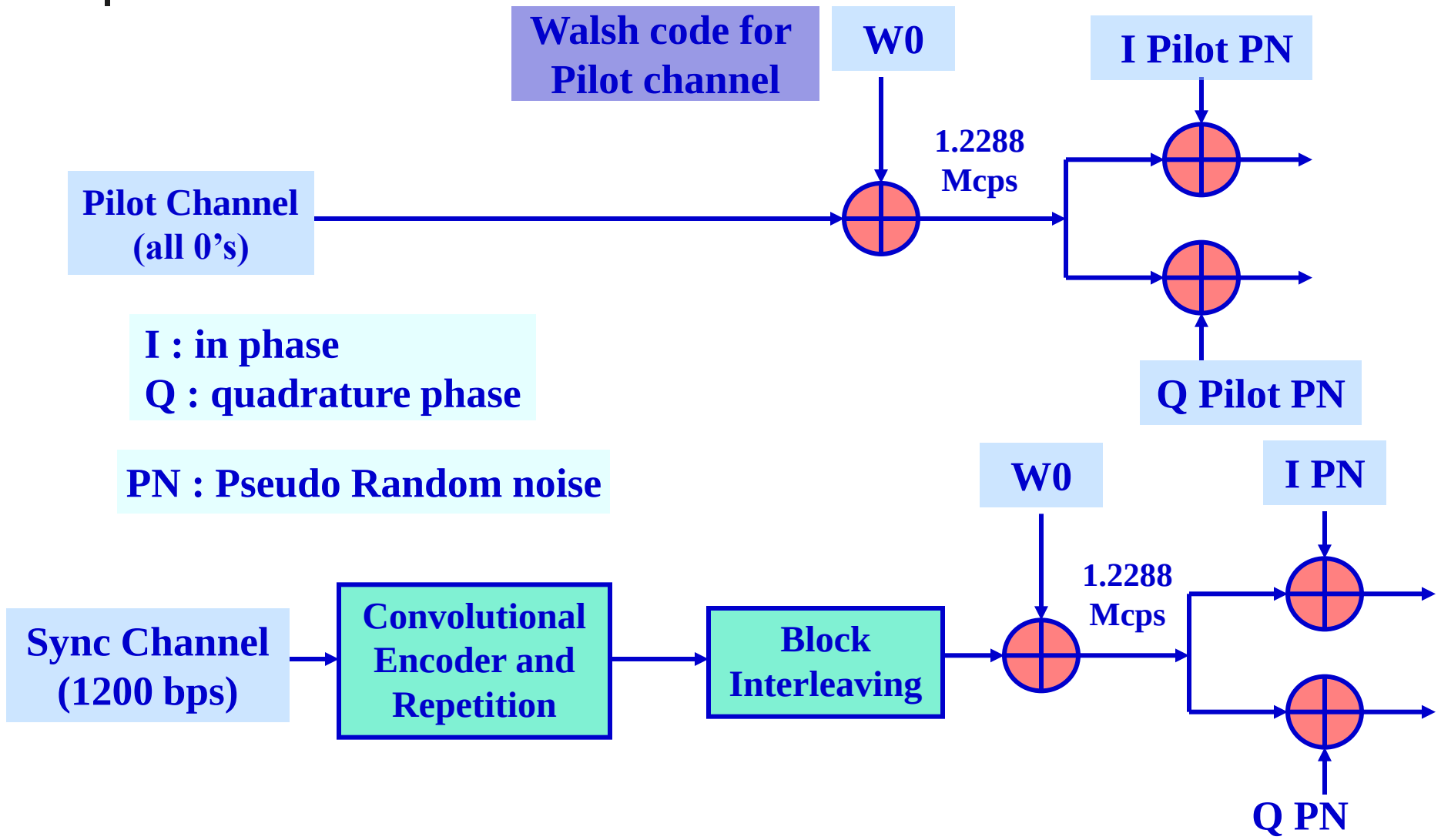
The Logical Channels



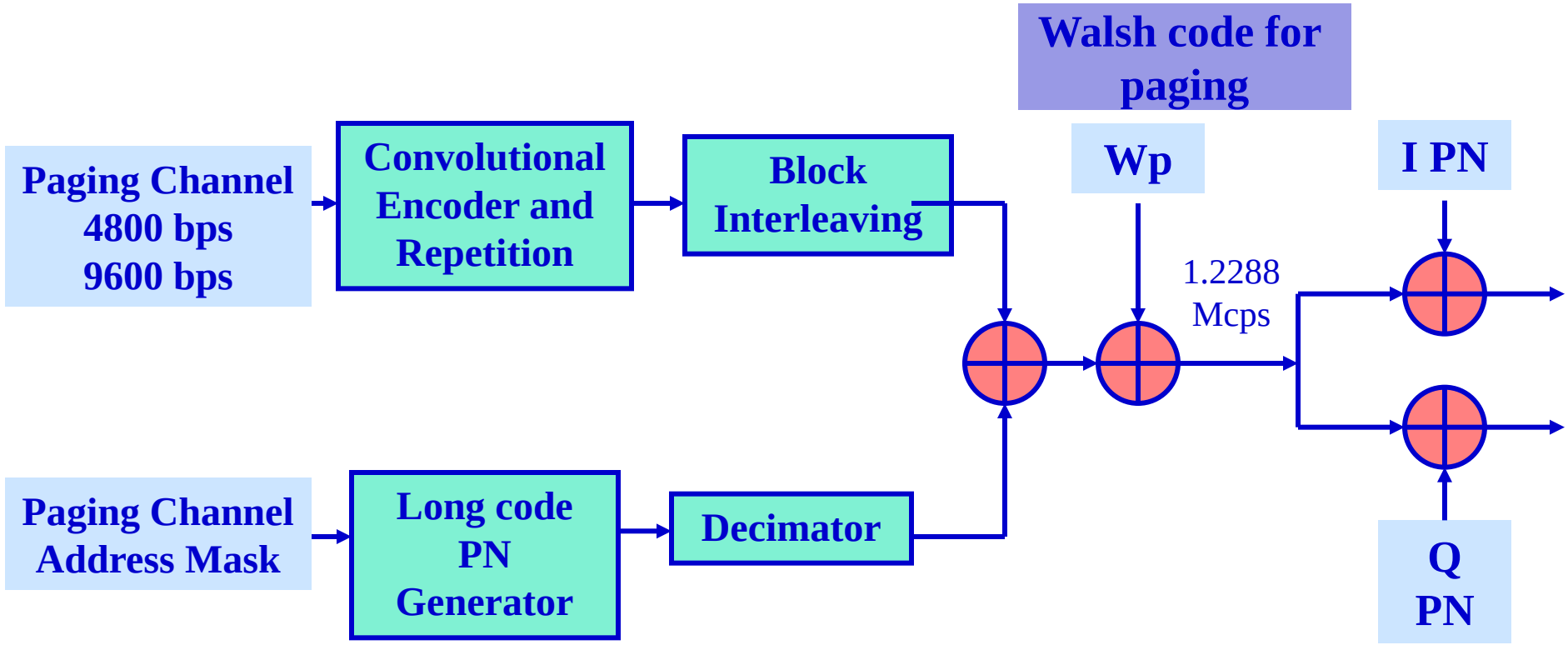
The Logical Channels (or Links)

- Forward and reverse links are separated by 45 MHz.
- The forward channel comprises the following logical channels:
  - Pilot channel (always uses Walsh code W0) (Beacon Signals)
  - Paging channel(s) (use Walsh codes W1-W7)
  - Sync channel (always uses Walsh code W32)
  - Traffic channels (use Walsh codes W8-W31 and W33-W63)
- The reverse channel comprises the following logical channels:
  - Access channel
  - Traffic channel

Pilot and Sync Channel Generation



Paging Channel Generation



The Channel Protocol

- The channel protocol can be summarized as follows:
  - MS acquires phase, timing, and signal strength via the pilot channel
  - MS synchronizes via the sync channel
  - MS gets system parameters via the paging channel
  - MS and BS communicate over the access and paging channels during system acquisition and paging

The Forward Traffic Channels

- **Pilot channel:**
  - **Transmitted at all times**
  - **Uses Walsh code W0**
  - **Provides phase and timing reference to MS**
  - **Provides signal strength to MS for channel acquisition**
  - **Reused in every cell and sector with different short PN code offset**
- **Sync channel can be received by an MS after it has been able to lock onto a pilot signal. Features of the sync channels:**
  - **Operates at 1200 bps**
  - **Has a frame length of 26.666ms**
  - **Uses Walsh code W32 and uses the same PN sequence and offset as pilot**
  - **Provides timing information to MS for synchronization**
  - **Provides pilot PN offset**
  - **Provides system time (needed for the short PN sequence generation)**
  - **Provides system and network Ids**
  - **Provides paging channel rates**
  - **Provides BS protocol revision level**
  - **channel number**

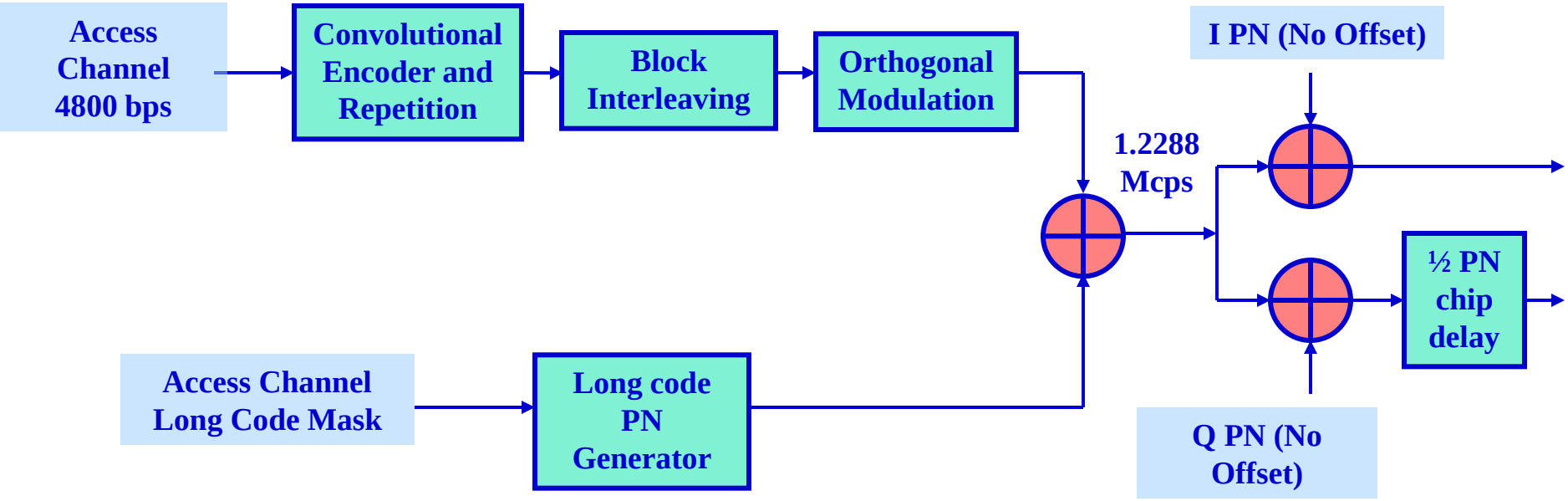
Forward Traffic Channels

- Paging channel is used to page MSs and transmit system information. A system can use 1-7 paging channels depending on traffic load. The paging channel can operate in slotted mode cycle where MS will only listen to a predefined set of slots in a cycle of slots. This allows the MS to power down and conserve power. The paging channel number and the predefined slots can be determined by an MS from its ESN and MIN
- The long PN code mask consists of the paging channel number and pilot PN offset. Features are:
  - Bit rate of 9600 or 4800 bps
  - Frame length 80ms – messages can occupy several slots (1-4)
  - Use Walsh codes W1-W7
  - Transmit the system parameter message: registration information, BS class, power control thresholds, etc.
  - Transmit the access parameter message: number of access channels, initial access power requirements, number of access attempts, authentication information, etc.
  - Carry pages for MSs
  - Carry the channel assignment for a traffic channel to an MS

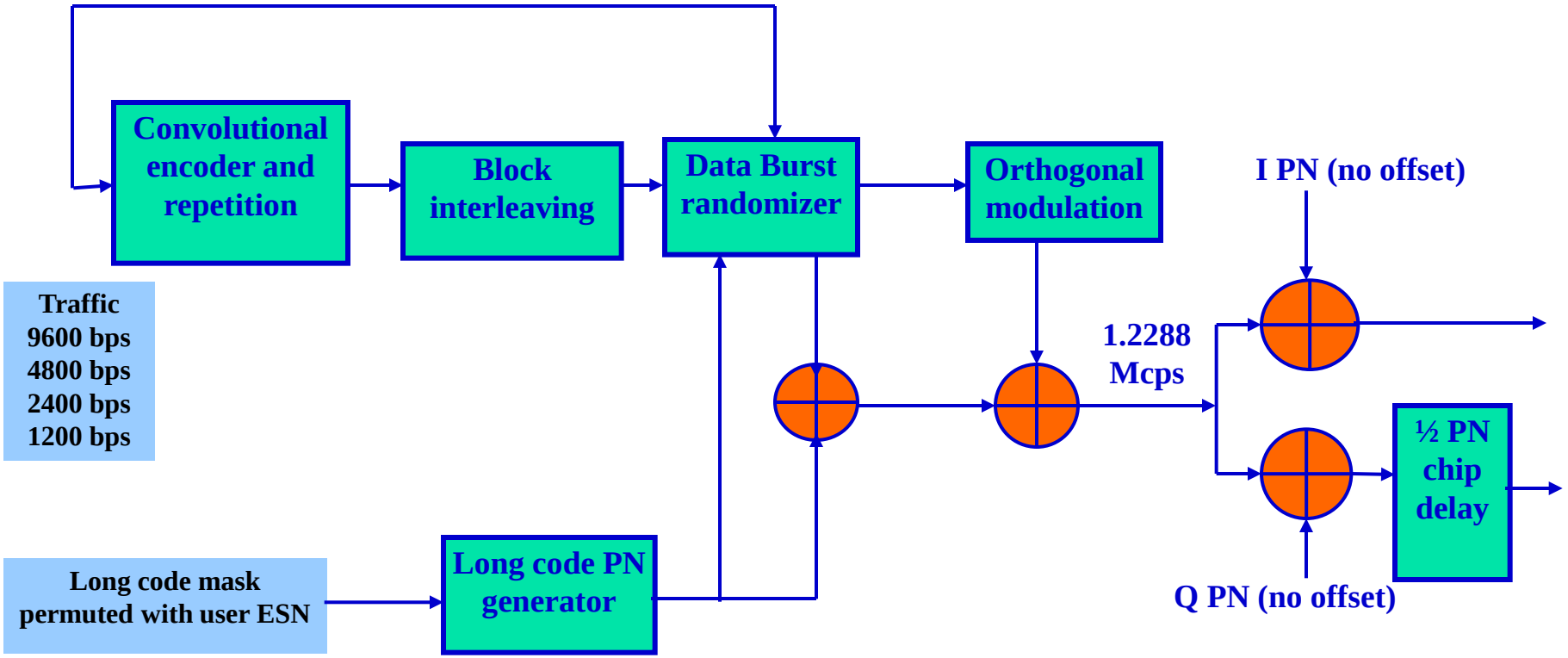
The Forward Traffic Channels

- **Forward traffic channels are used to carry user data and signaling data. Features are:**
  - **Bit rate up to 9600 bps (rate set 1) and up to 14.4 kbps (rate set 2)**
  - **Frame length of 20 ms (192 bits for rate set 1 and 288 bits for rate set 2)**
  - **Use Walsh codes W8-W31 and W33-W63**
  - **Can be used in two modes: blank and burst or dim and burst**
  - **Blank and burst is similar to NA-TDMA (North American TDMA), signaling data replace speech data**
  - **Dim and burst multiplexes signaling data or a secondary data stream with speech data (speech data sent at 4.8, 2.4, or 1.2 kbps for rate set 1 and 7.2, 3.6, or 1.8 kbps for rate set 2)**

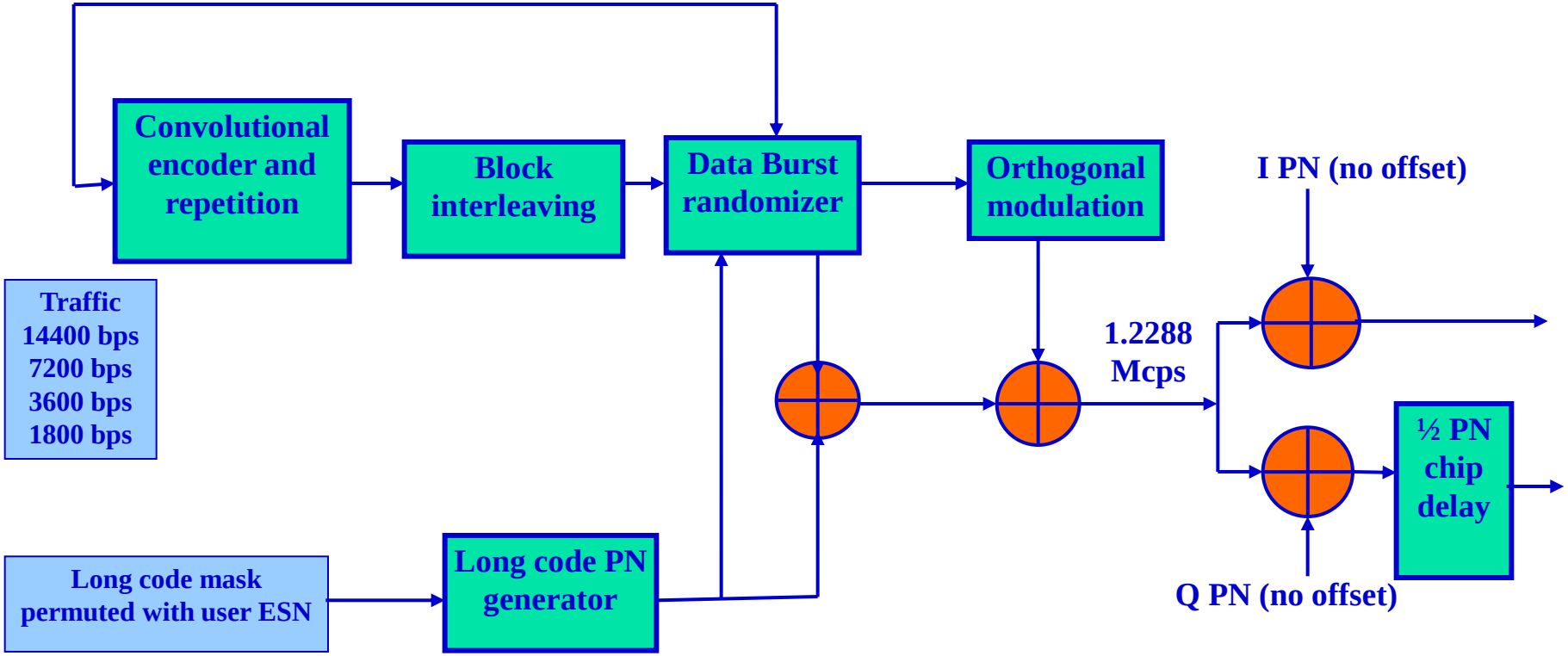
Access Channel Generation in IS-95



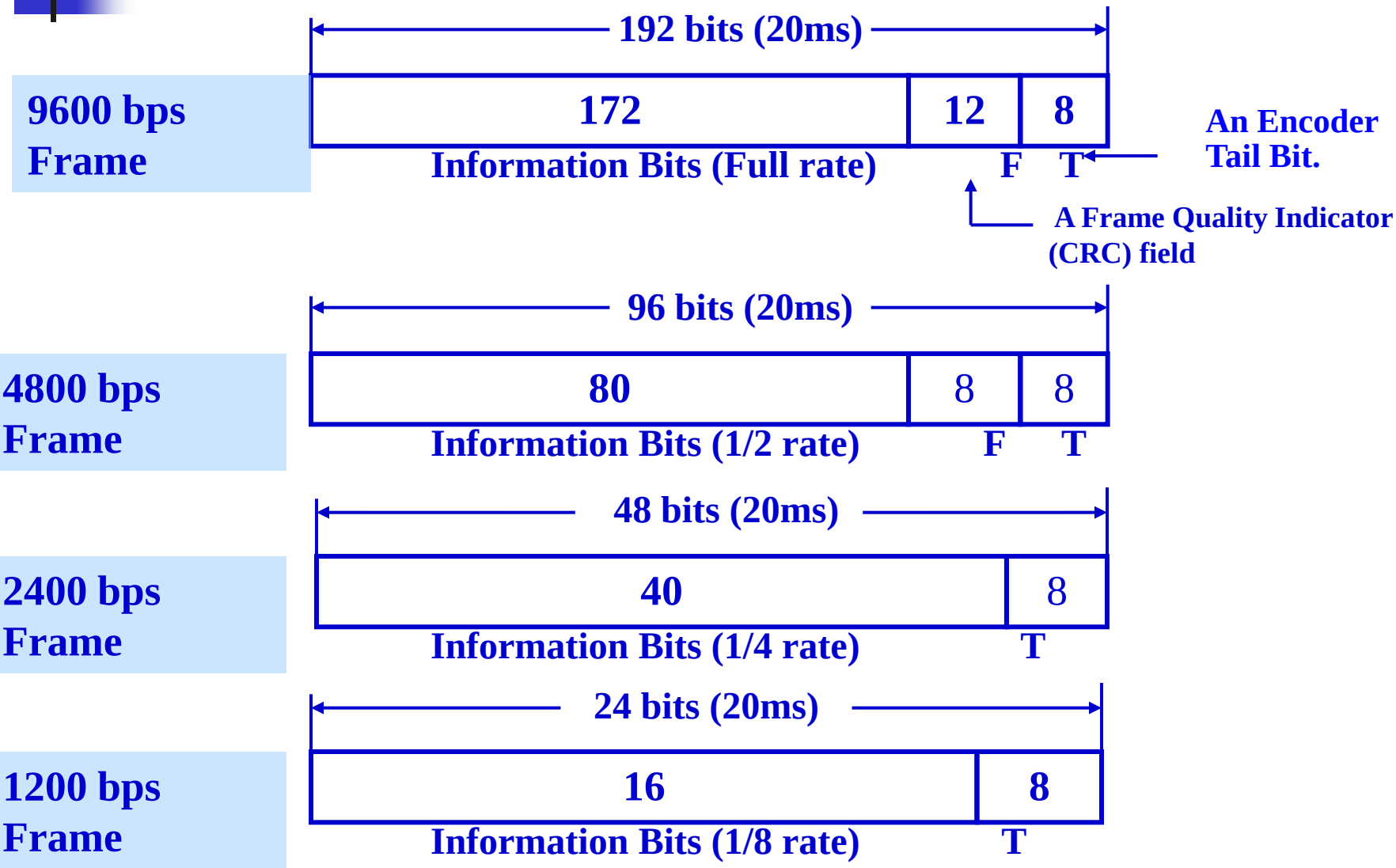
Rate Set 1 Forward Traffic Generation in IS-95



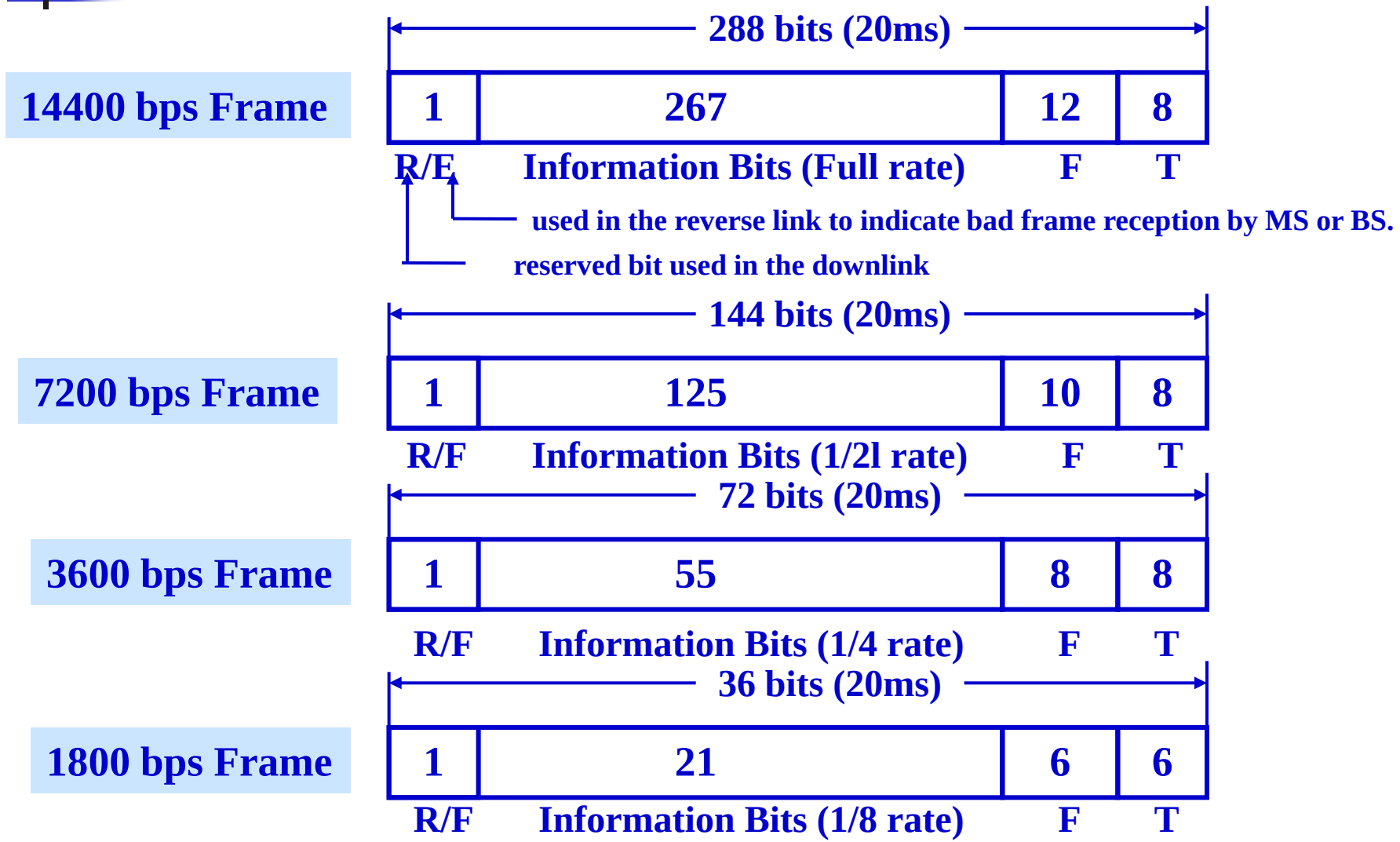
Rate Set 2 Forward Traffic Generation in IS-95



Forward/Reverse Traffic Channel Frame Structure for Rate Set 1



Forward/Reverse Traffic Channel Frame Structure for Rate Set 2



Different Spreading and Scrambling Processes for the Forward and Reverse Channels

- The forward channels are spread using one of 64 orthogonal Walsh codes. This provides perfect separation between the channels. Then, to reduce interference between MSs that use same Walsh code in the neighboring cells, all signals in a particular cell are scrambled using short PN sequence (cell identification) in the radio modulator. For the paging and traffic channels, the long PN sequence is used to scramble the signal before spreading
- The reverse channels are spread using the long PN sequence. All 64 orthogonal Walsh codes are used to provide orthogonal modulation. The stream is then scrambled using the short PN sequence for cell identification purposes

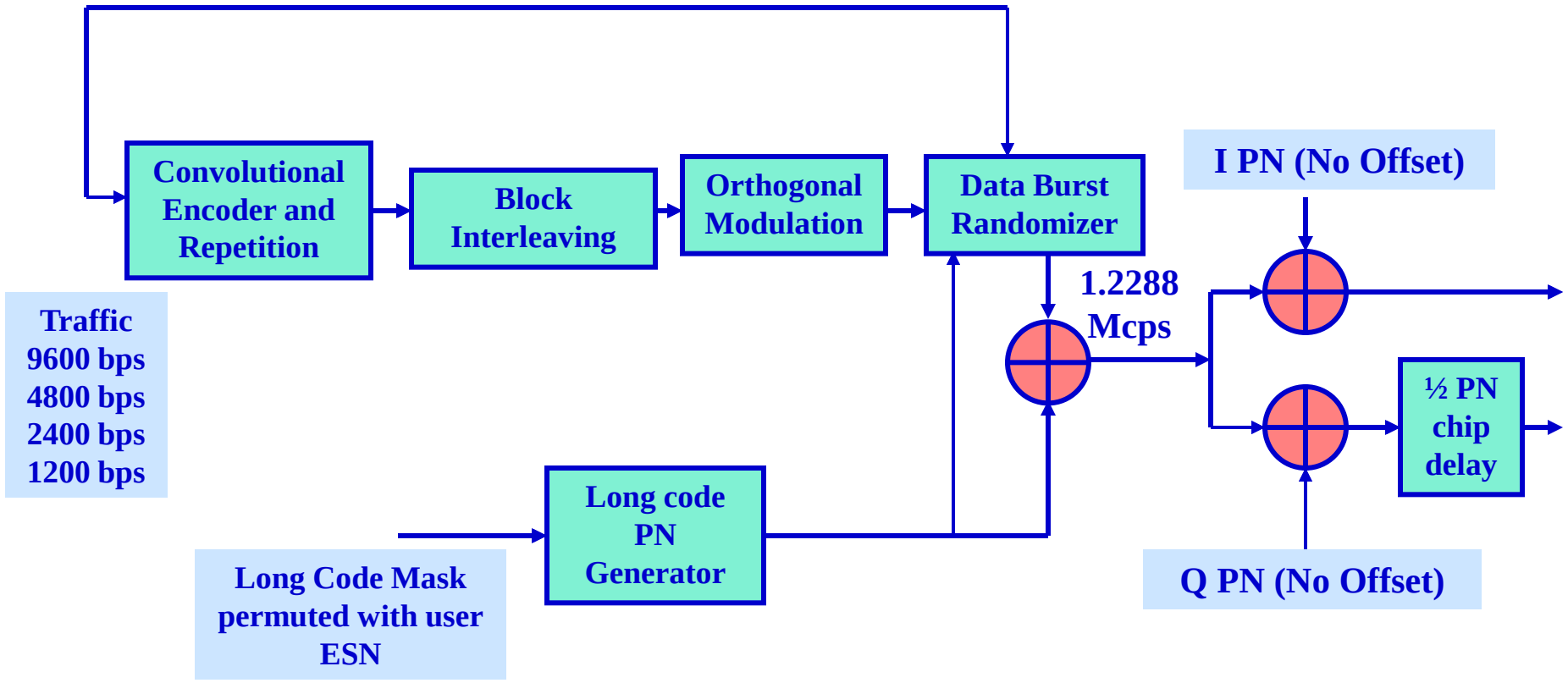
The Reverse traffic Channels

- **Access channel: It is a random access channel used by MSs to send information (not user data) to the BS. One or more access channels are paired with a paging channel (max. is 32 in total). MSs respond to paging messages on their corresponding access channels. Features of the access channel are:**
  - **The bit rate is 4800 bps**
  - **The long PN code mask consists of: access channel number, BS identifier, the corresponding paging channel number, and PN offset**
  - **MSs compete for access. An MS chooses an access channel at random from the set associated with the paging channel. If two MSs choose the same access channel, and PN time alignment (time shift for long code), their transmissions will interfere with each other and the BS will not be able to distinguish between them. No channel sensing for collision avoidance**
  - **If a terminal does not get an ACK back before the timer expires it makes another attempt (at a higher power level) after a random wait. It repeats this process for a max. number of times, if it does not succeed, it waits a random time and then restarts it all over again**

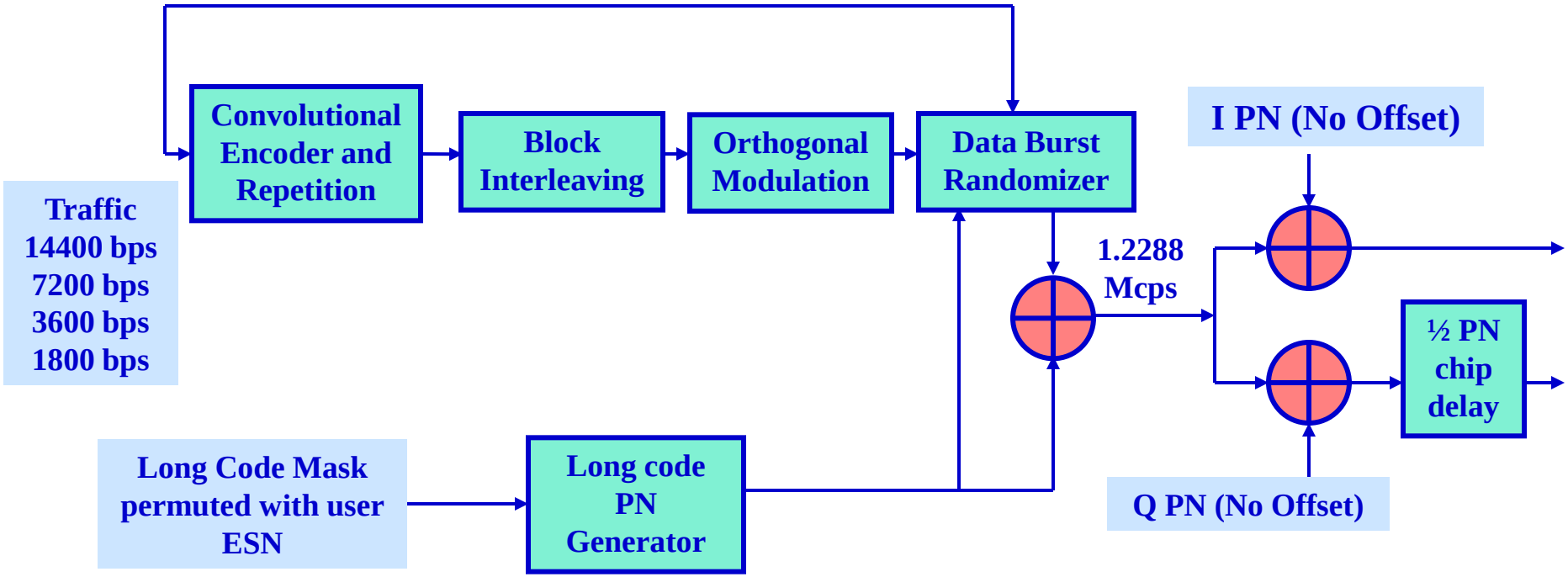
The Reverse traffic Channels

- **Reverse traffic channel: it is used to carry user data (primary and secondary) and signaling data. A BS will support up to 61 channels. Its main features are:**
  - **It supports data transfers at 4 different levels within a rate set**
  - **Signaling information is multiplexed with the user data, where possible (i.e., if variable data rates are supported). If not possible, then the signaling information takes over the channel briefly to transmit a message (blank and burst). Instead of signaling information, a secondary traffic stream can be multiplexed too (i.e., voice is primary and data is secondary)**
  - **A long PN mask is used to uniquely identify an MS. Can be of two types: The public one consists of the MS's ESN, the private one is derived from the encryption and authentication process**
  - **The orthogonal modulation consists of sending one of 64 possible Walsh functions for each group of six coded bits. The Walsh function number is selected as follows: $c_0+2c_1+4c_2+8c_3+16c_4+32c_5$, where the c's represent the coded bits. Output rate is 28.8x64/6=307.2 kbps**

Rate Set 1 Reverse Traffic Generation

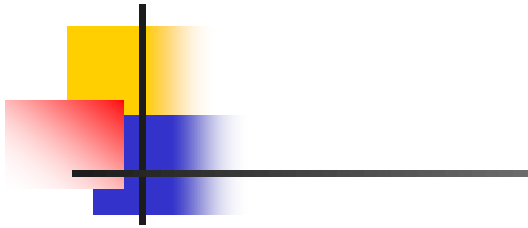


Rate Set 2 Reverse Traffic Generation



Power Control

- It is of paramount importance for a CDMA system. In order to have maximum efficiency, the power received at the BS from all the MSs must be nearly equal
- Terminal's power is too low → Bit error occur
- Terminal's power is too high → The interference will go up
- Closed loop power control at the terminals:
  - Power control information is sent to the MSs from the BS. This message either indicates a transition up or a transition down in power
- Open loop power control at the terminals:
  - The MS senses the strength of the pilot signal and can adjust its power based upon that. If signal is very strong, the assumption can be made that the MS is very close to BS and the power should be dropped
- Open loop power control at the BS:
  - The BS decreases its power level gradually and waits to hear from the MS what frame error rate (FER) is. If high then it increases its power level



IMT-2000
(International Mobile Telecommunications)

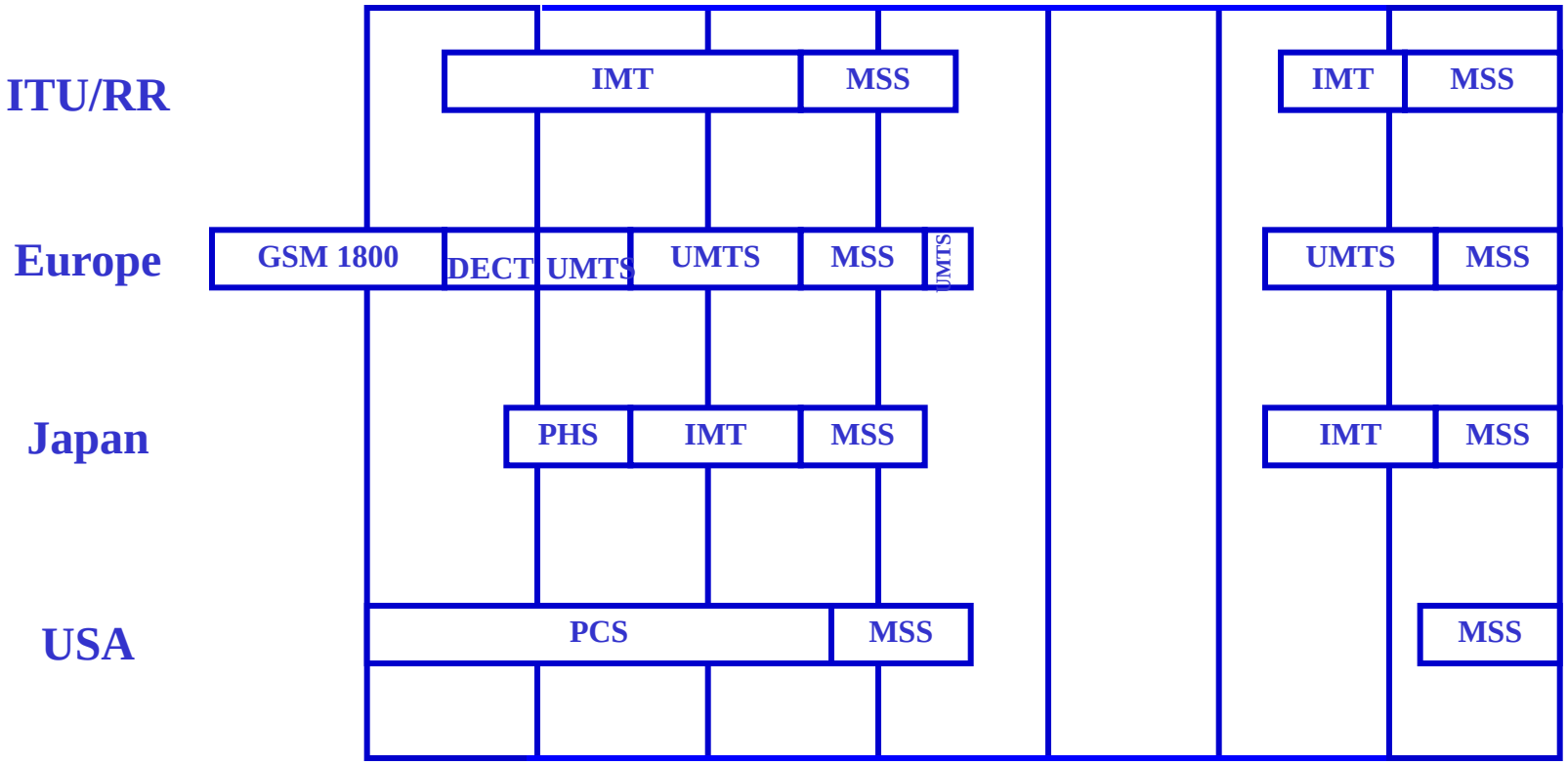
IMT–2000

- Key Features
- International Spectrum allocation
- Services Provided by Third-Generation Cellular Systems
- Harmonized 3G Systems
- Multimedia Service (MMS)
- UMTS
- UTRAN
- Channels in UTRAN

Key Features

- High degree of commonality of design worldwide
- Compatibility of services within IMT-2000 and with fixed networks
- High quality
- Small terminal for worldwide use, including pico, micro, macro and global satellite cells
- Worldwide roaming capability
- Capability for multimedia applications and a wide range of services and terminals

International Spectrum Allocation



ITU/RR – International Telecommunications Union / Radio Regulation

MSS – Mobile Satellite Service

PHS – Personal Handyphone System

Service Provided by Third-Generation Cellular Systems

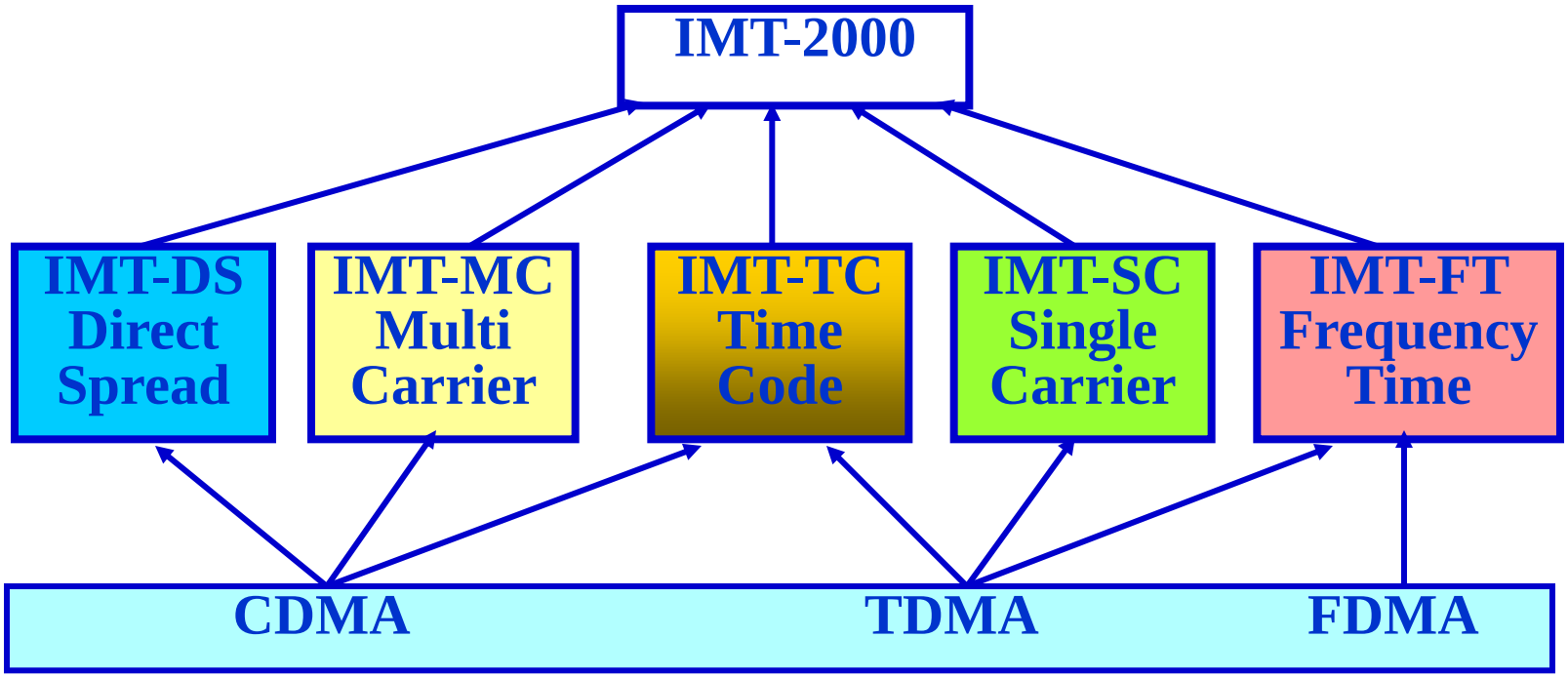
- High bearer rate capabilities including

Possible Application scnarios:

For indoor/outdoor and pedestrian environment

  - 144 kbps for vehicular environment
- Standardization work
  - Europe $\Rightarrow$ UMTS (W-CDMA)
  - USA $\Rightarrow$ W-CDMA
- Scheduled Service
  - Service started in October 2001 (Japan's W-CDMA)

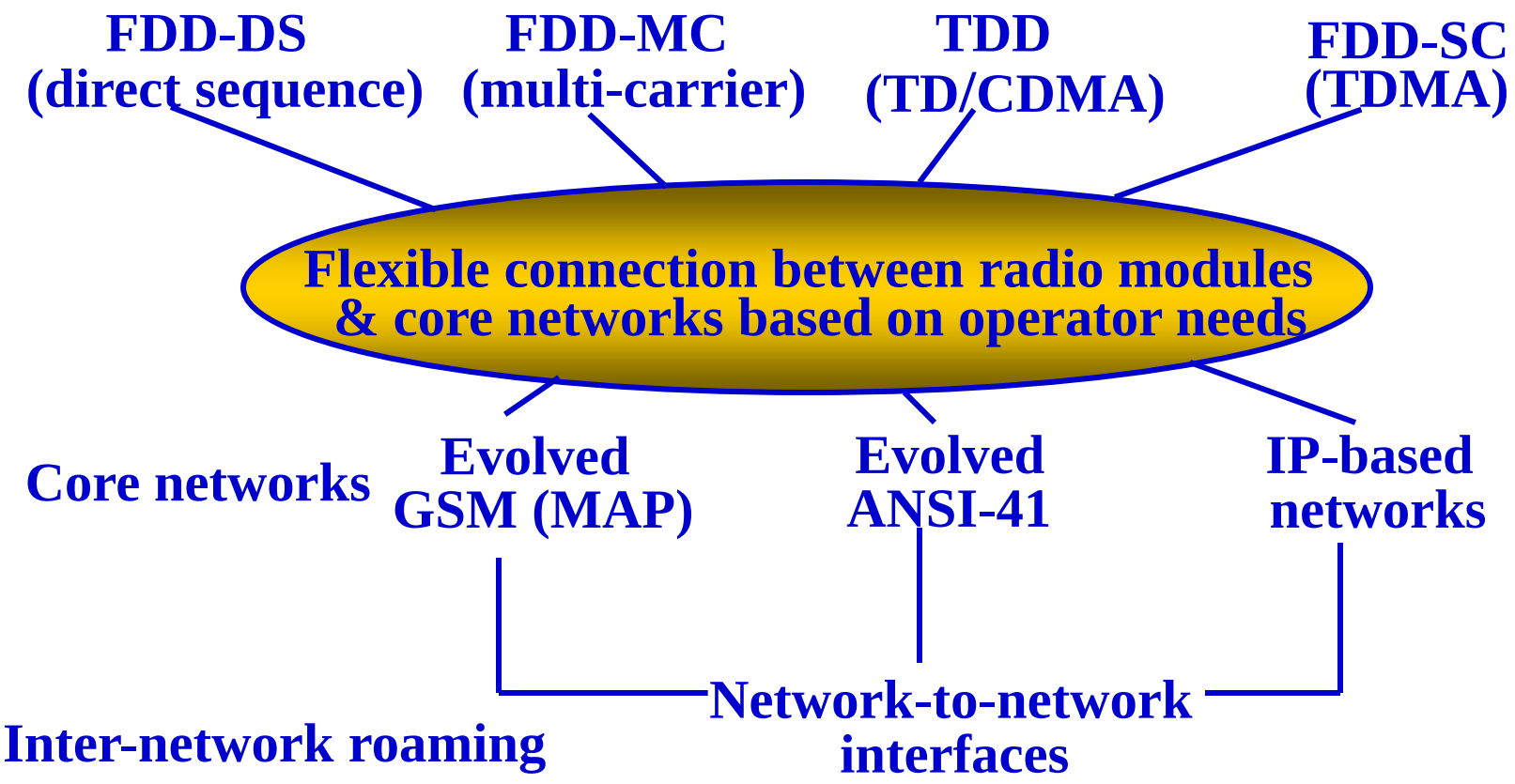
Radio Interfaces for IMT-2000



Harmonized 3G Systems

- High speed data services including Internet and intranet applications
- Voice and nonvoice applications
- Global roaming
- Evolution from the embedded base of 2G systems
- ANSI-41 and GSM-MAP core networks
- Regional spectrum needs
- Minimization of mobile equipment and infrastructure cost
- Minimization of the impact of IPRs
- The free flow of IPRs
- Customer requirements on time

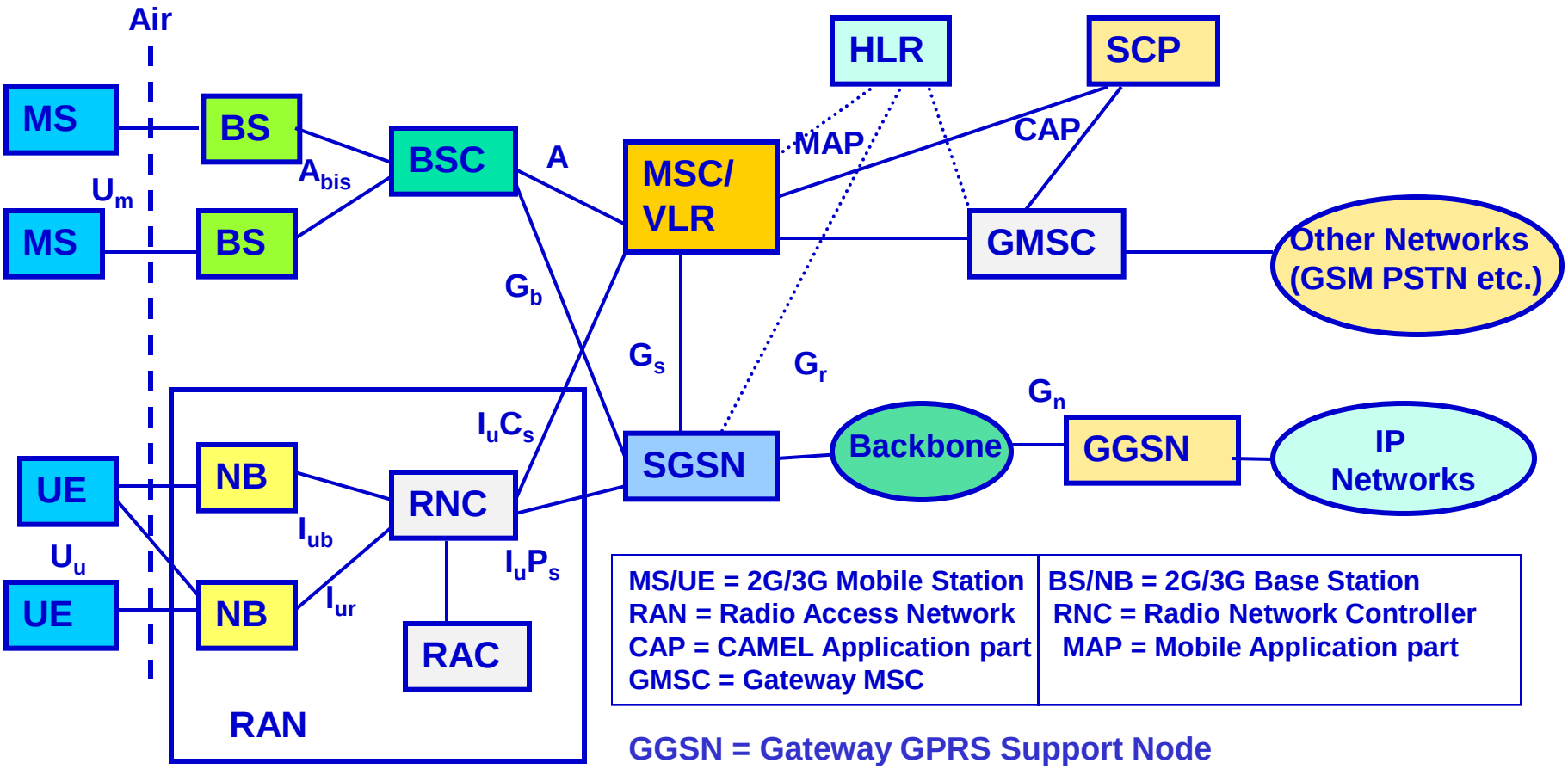
Modular IMT-2000 harmonization (Terrestrial Component)



Multimedia Messaging Service (MMS)

- Main components of MMS Architecture are:
  - Europe
  - MMS Relay
  - MMS Server
  - MMS User Agent
  - MMS User Database
- Possible Application scenarios:
  - Next Generation Voicemail
  - Immediate Messaging
  - Choosing how, when, and where to view the messages
  - Mobile FAX
  - Sending multimedia postcards

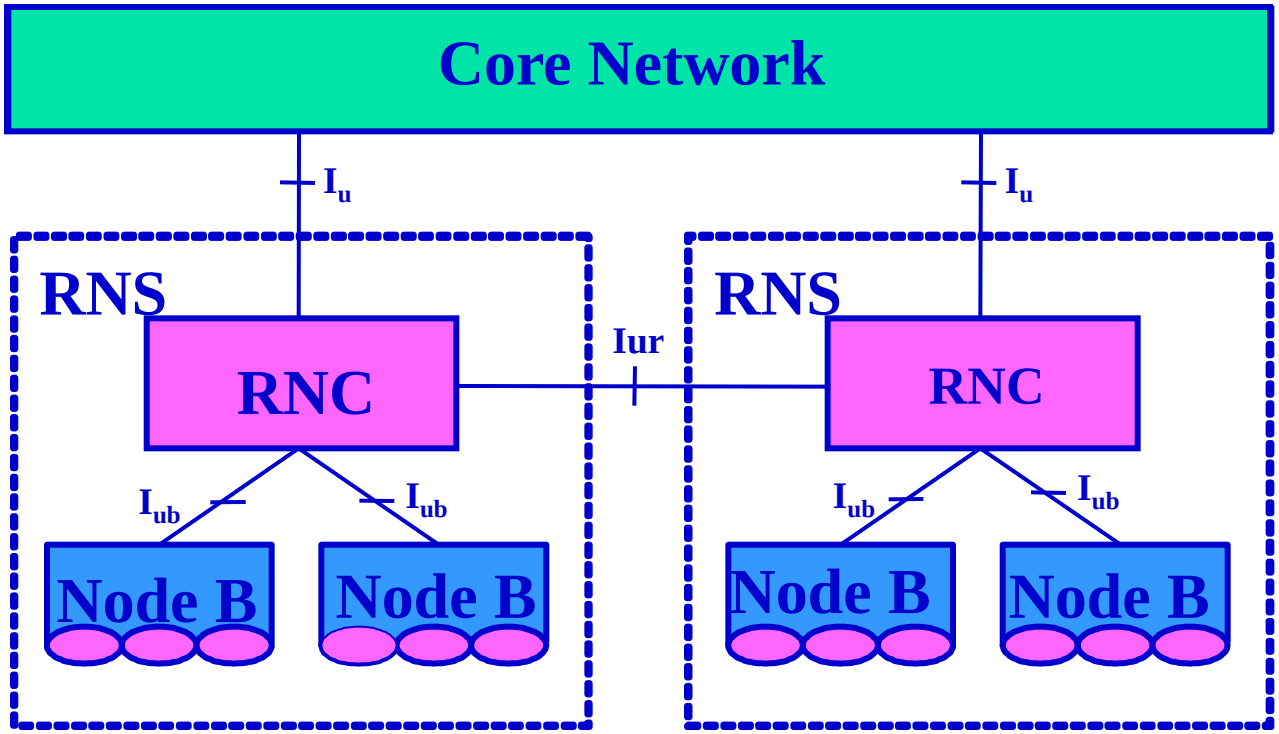
UMTS-Network Reference Architecture



UMTS Terrestrial Radio Access Network (UTRAN)

- The UTRAN consists of a set of radio network subsystems (RNSs)
- Two main elements:
  - Node B
  - Radio Network Controller (RNC)
- RNC Responsible for:
  - Intra UTRAN Hand off
  - Macro-diversity combining and splitting of the Iub datastreams
  - Frame Synchronization
  - Radio Resource Management
  - Outer loop power control
  - Serving RNS relocation
  - UMTS radio link control (RLC) sublayers function execution

UTRAN – Architecture



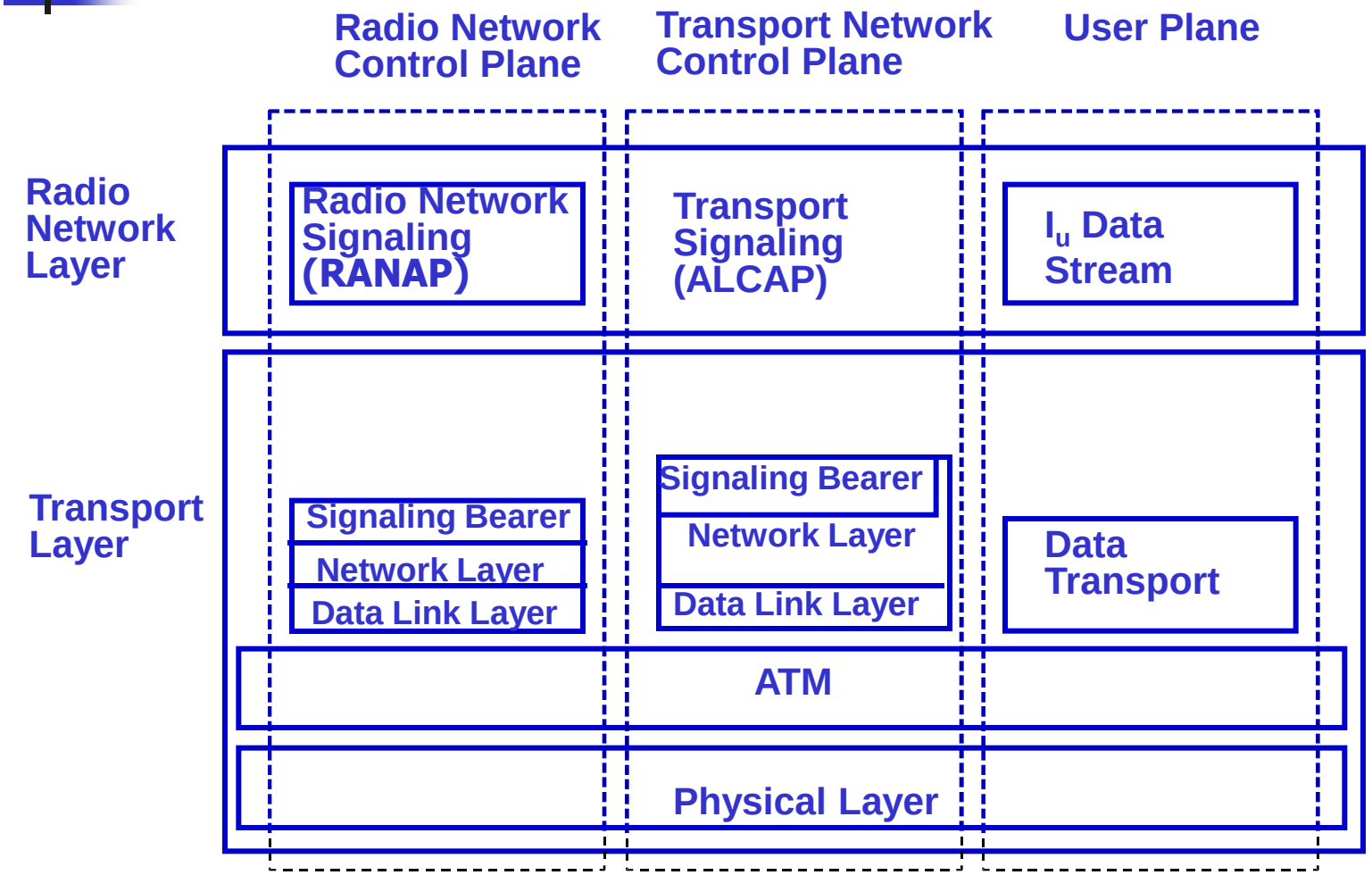
RNC includes:

-Intra-UTRAN handoff **-Microdiversity**

-Frame synchronization **-Radio resource management**

Outer loop power control

Protocol Structure for UTRAN Logical Interfaces



ALCAP – Access Link Control Application Part

Transport Channels in UTRAN

- Types of Transport Channels
  - Common Transport Channel Types
    - Random Access Channel (RACH)
    - ODMA (Opportunity Driven Multiple Access) Random Access Channel (ORACH)
    - Common Packet Channel (CPCH)
    - Forward Access Channel (FACH)
    - Downlink Shared Channel (DSCH)
    - Uplink Shared Channel (USCH)
    - Broadcast Channel (BCH)
    - Paging Channel (PCH)
  - Dedicated Transport Channel Types
    - Dedicated Channel (DCH)
    - Fast Uplink Signaling Channel (FAUSCH)
    - ODMA Dedicated Channel (ODCH)

Logical Channels in UTRAN