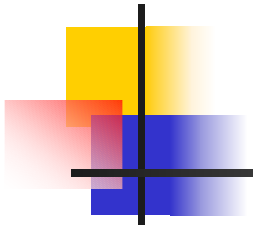
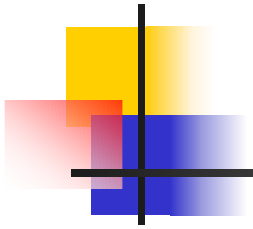


Chapter 10 (PART-2)

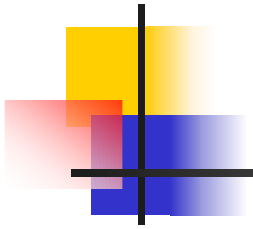
Existing Wireless Systems



Outline

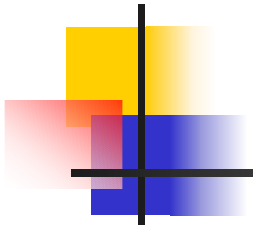
- IS-95 CDMA
- IMT 2000 3G systems

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

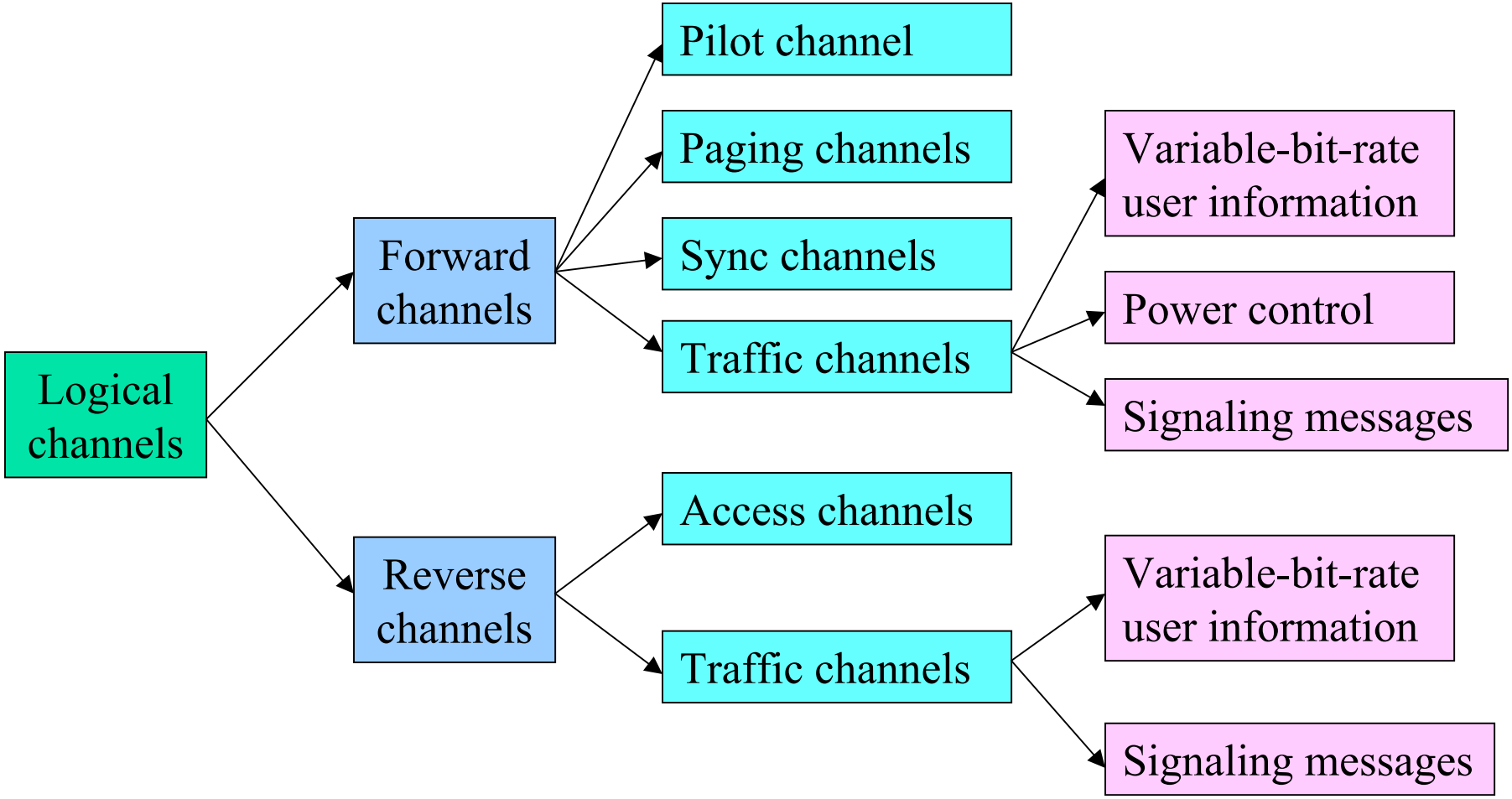
- The existing 12.5 MHz cellular bands are used to derive 10 different CDMA bands (1.25 MHz per band).
- The frequency reuse factor in CDMA is 1.
- The channel rate is 1.2288 Mbps (actually chips not bits).
- Multipath fading is exploited in CDMA. It provides for space (path) diversity.
- RAKE receivers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

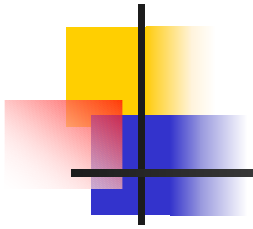
The Coding and Modulation Process

- 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

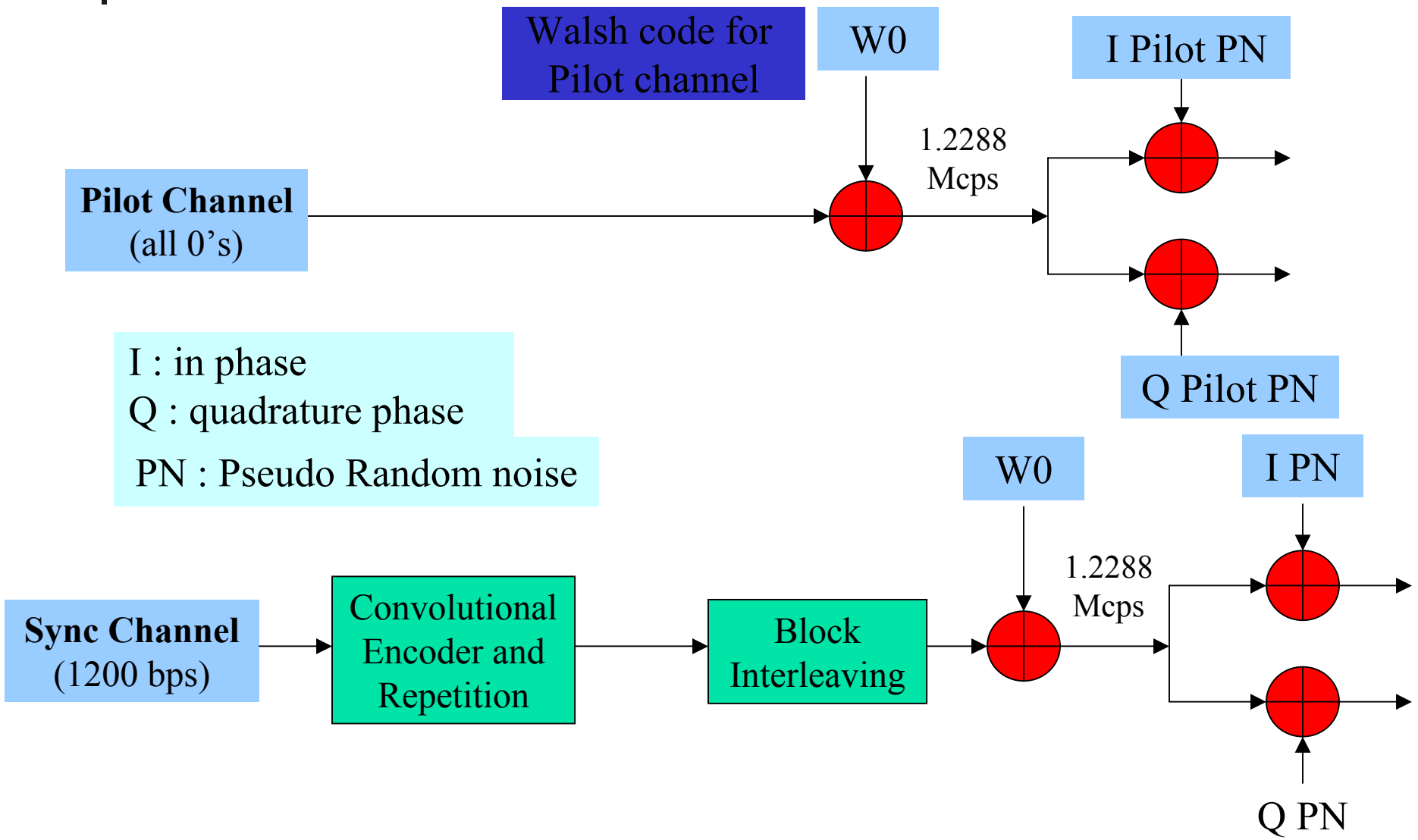




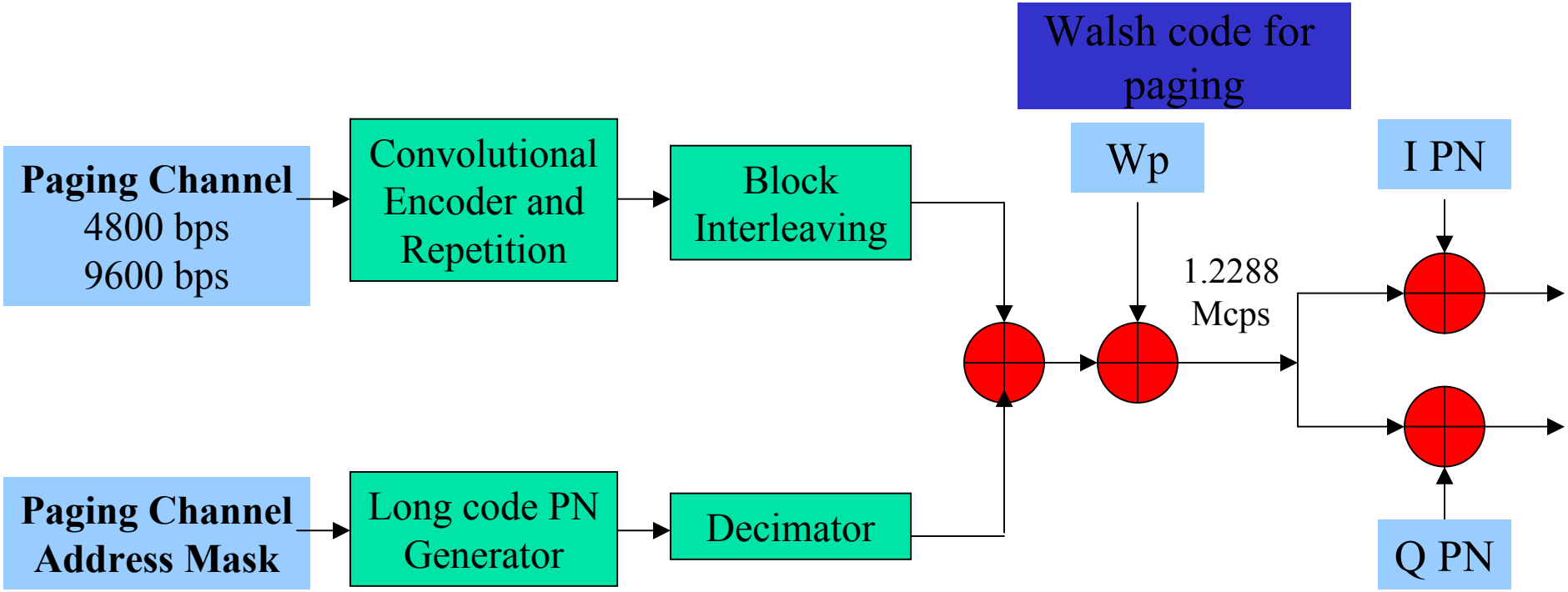
The Logical Channels (or Links)

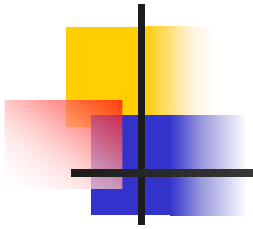
- The forward and reverse links are separated by 45 MHz.
- The forward channel comprises the following logical channels:
  - Pilot channel (always uses Walsh code W0) (Beacon Signals)
  - Paging channel(s) (use Walsh codes W1-W7)
  - Sync channel (always uses Walsh code W32)
  - Traffic channels (use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

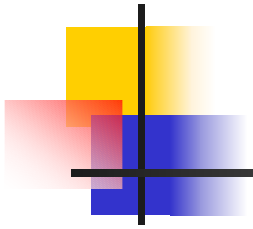
- The channel protocol can be summarized as follows:
  - MS acquires phase, timing, and signal strength via the pilot channel.
  - MS synchronizes via the sync channel.
  - MS gets system parameters via the paging channel.
  - MS and BS communicate over the access and paging channels during system acquisition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

The Forward Logical 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

The Forward Logical Channels (Cont'd)

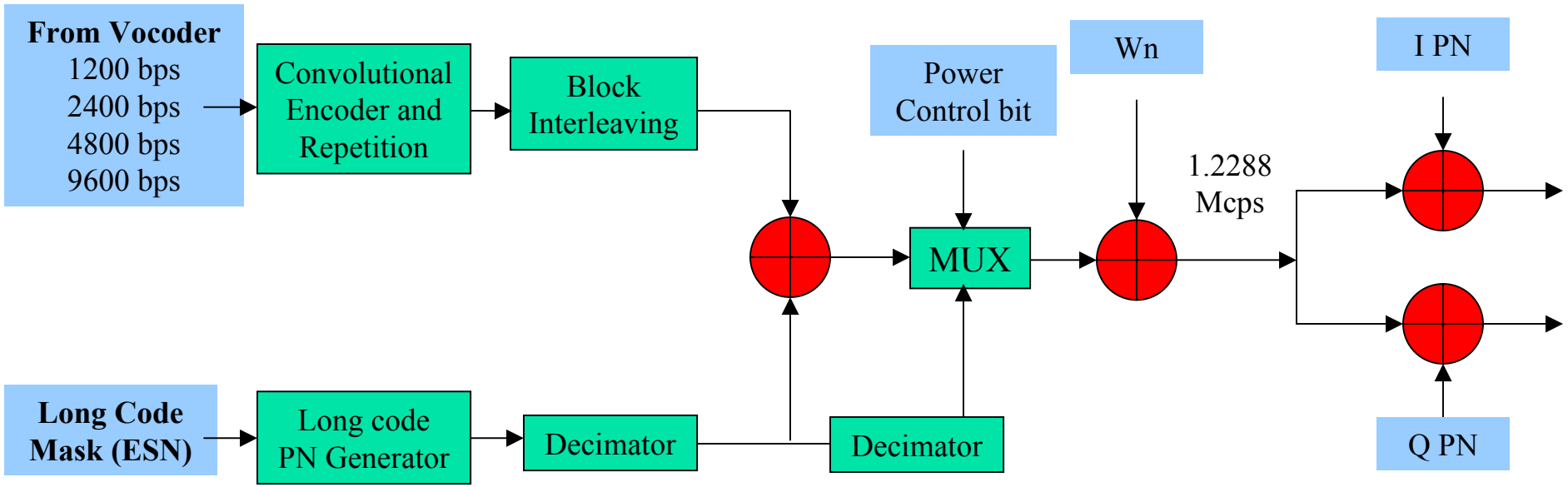
- Paging channel is used to page MSs and transmit system information. A system can use 1-7 paging channels depending on traffic load. The paging channel can operate in slotted mode cycle where MS will only listen to a predefined set of slots in a cycle of slots. This allows the MS to power down and conserve 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



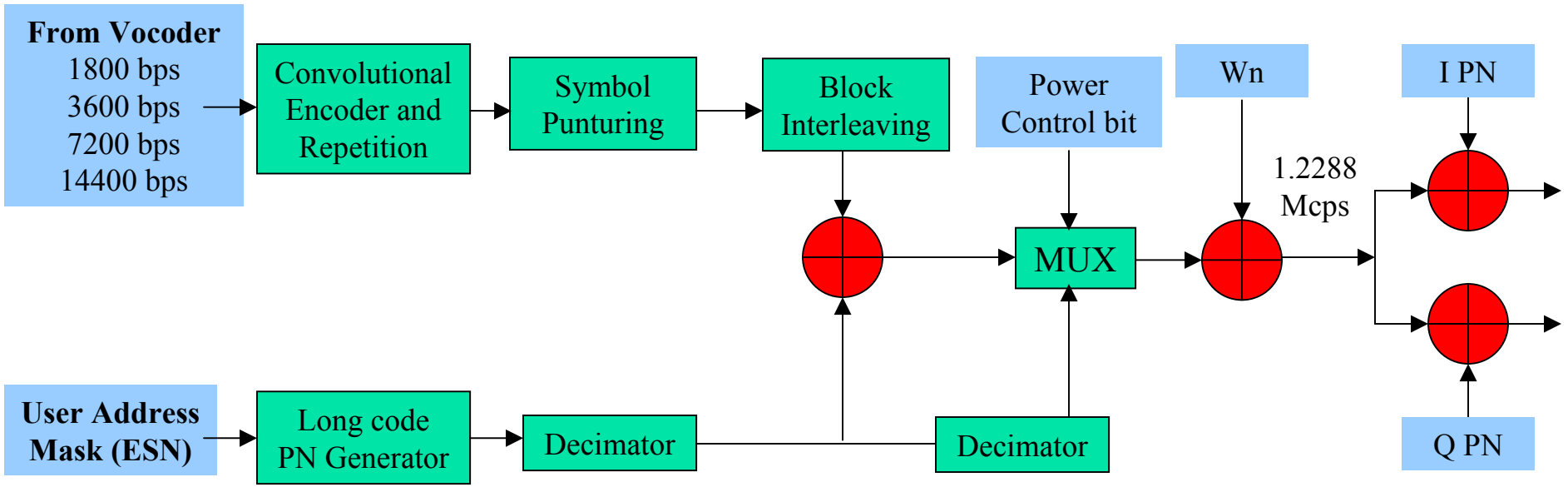
The Forward Logical Channels (Cont'd)

- 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, 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)

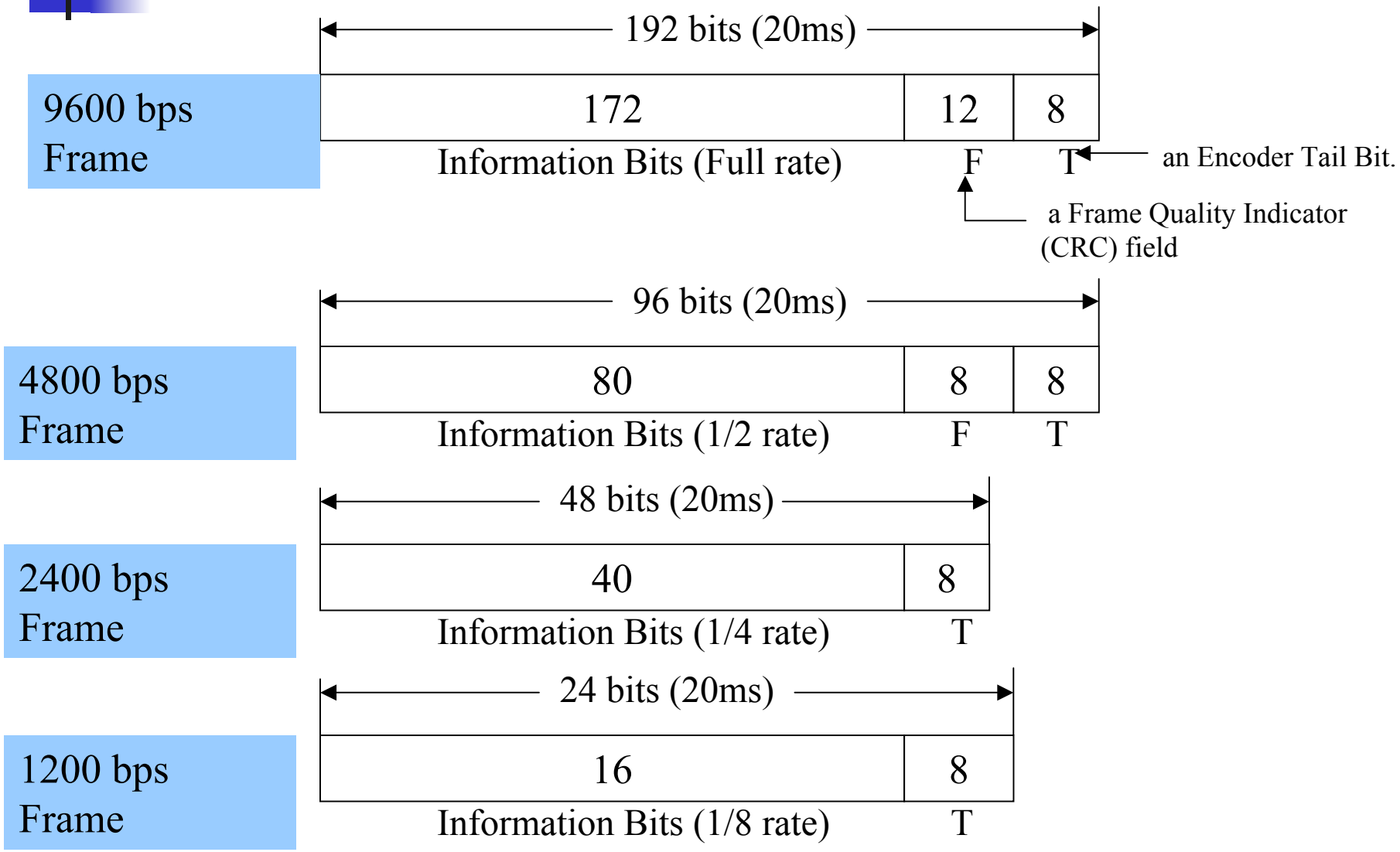
Rate Set 1 Downlink Traffic Channel Generation



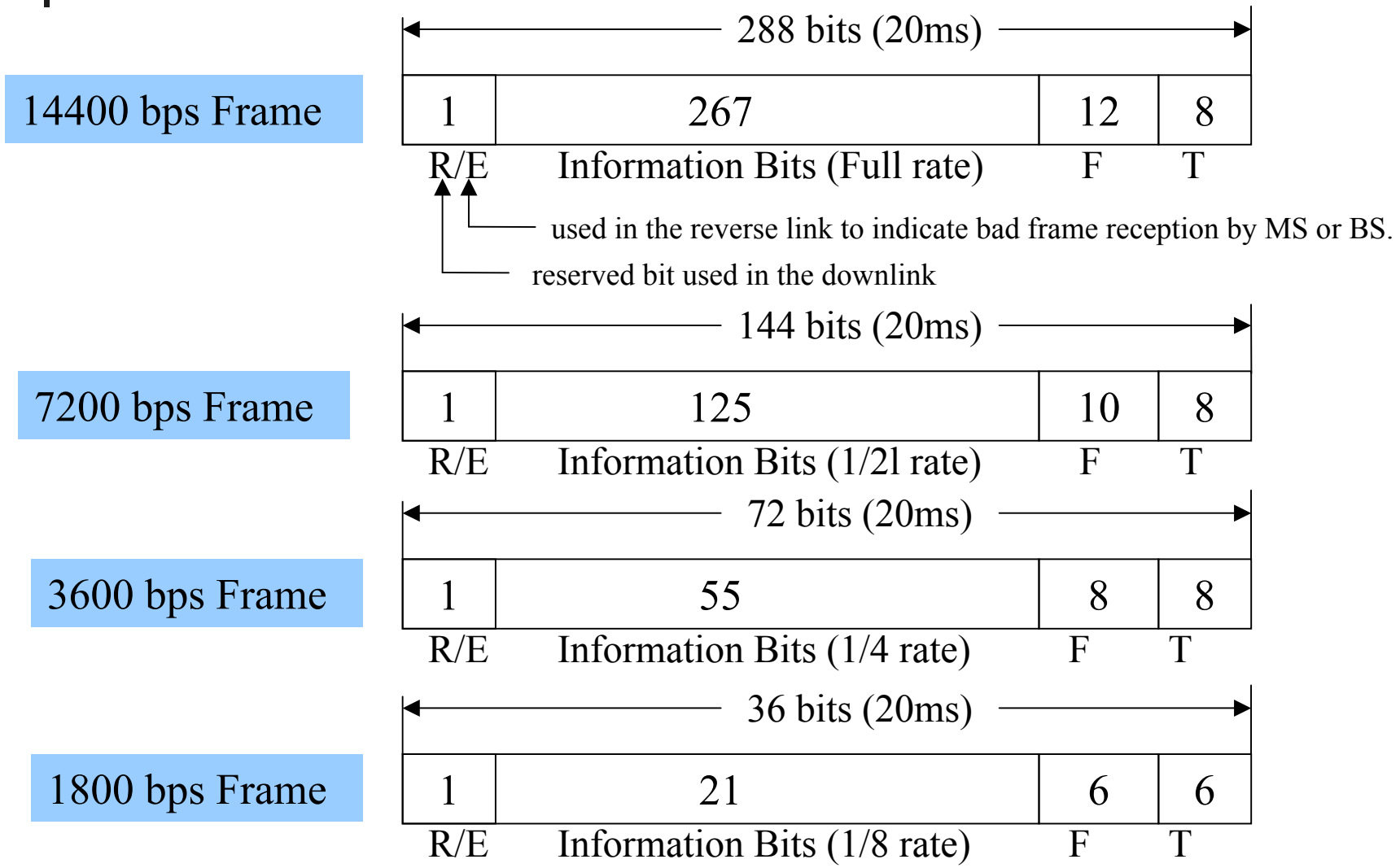
Rate Set 2 Downlink Traffic Channel Generation



Downlink/Uplink Traffic Channel Frame Structure for Rate Set 1



Downlink/Uplink 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.

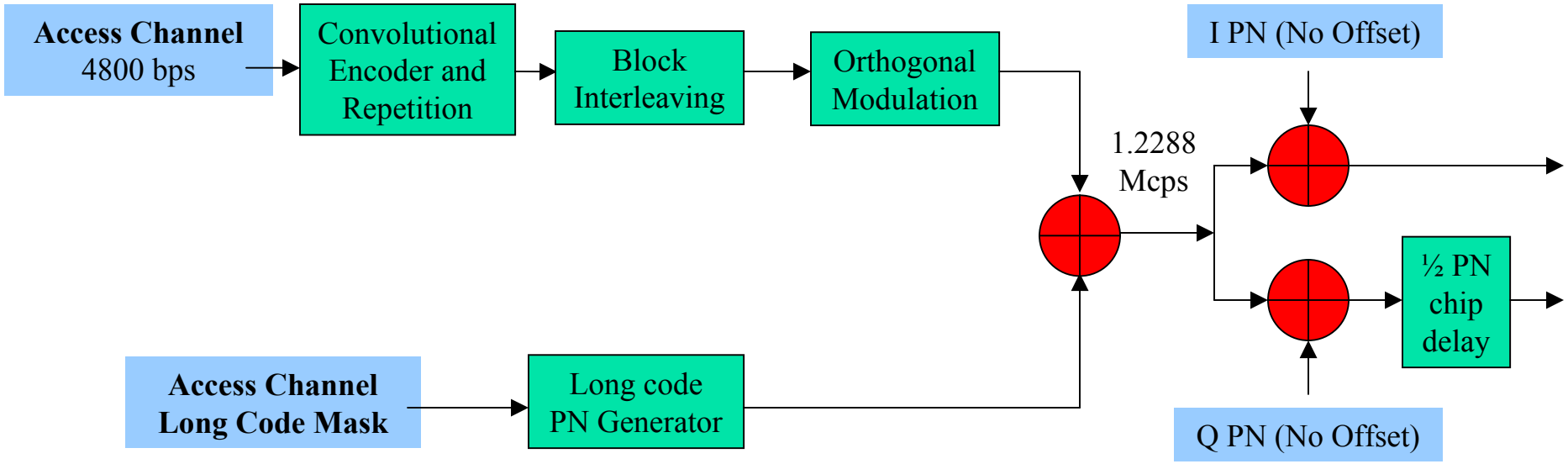
The Reverse Logical Channels

- 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.

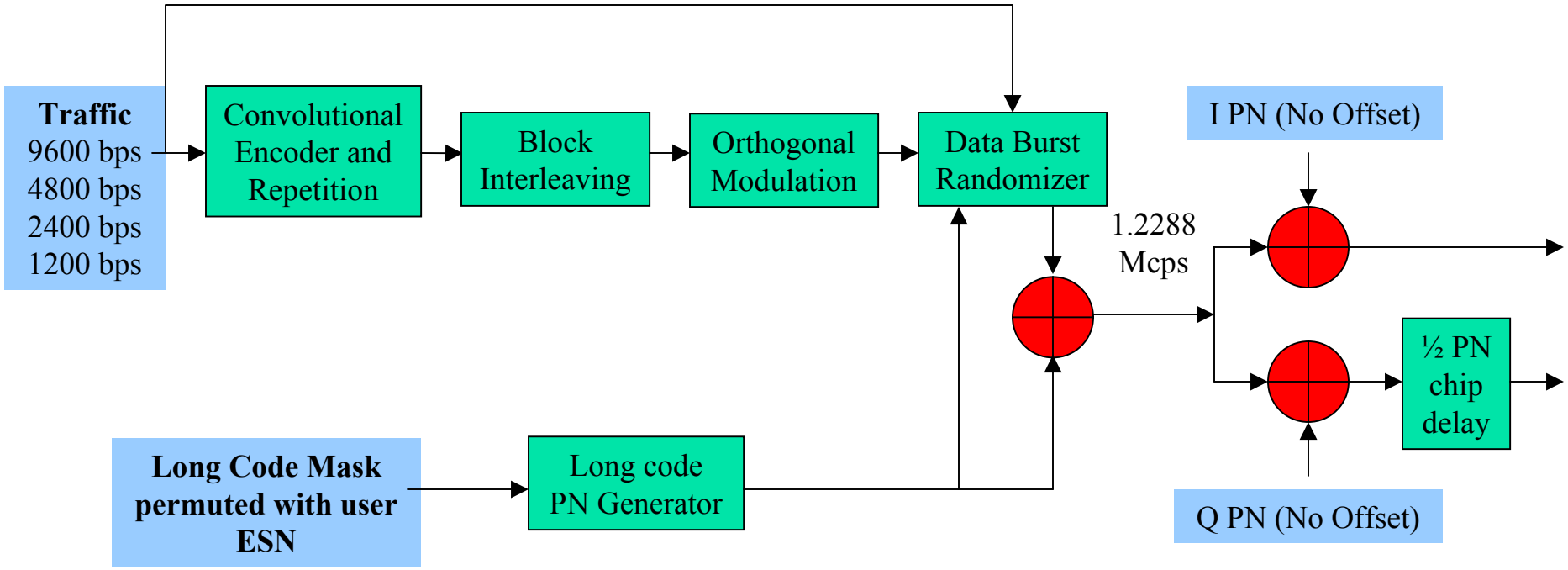
The Reverse Logical Channels (Cont'd)

- 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.

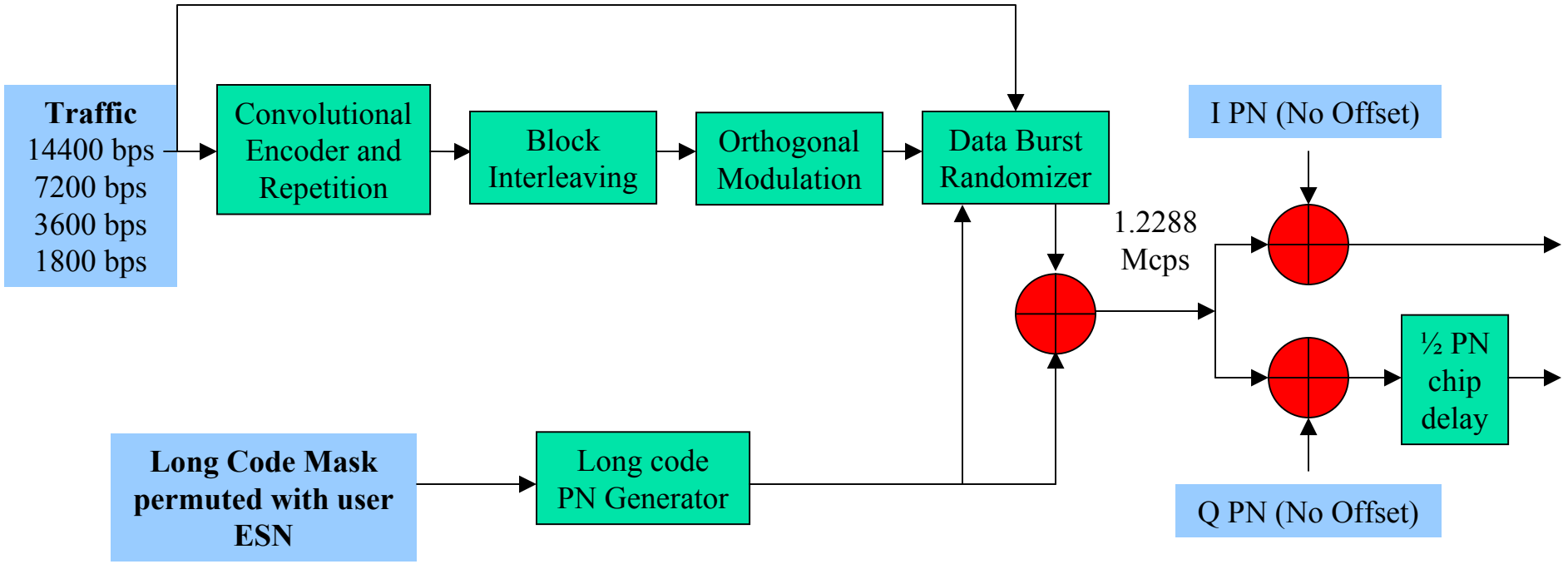
Access Channel Generation

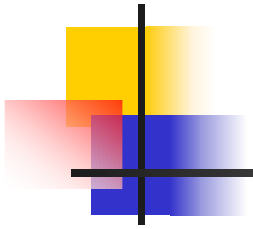


Rate Set 1 Uplink Traffic Channel Generation



Rate Set 2 Uplink Traffic Channel Generation

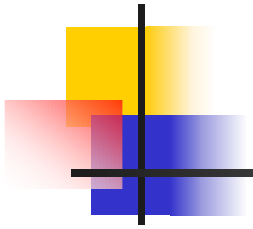




Power Control

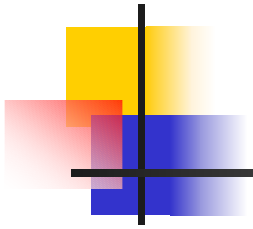
- It is of paramount importance for a CDMA system. In order to have maximum efficiency, the power received at the BS from all the MSs must be nearly equal.
- Terminal's power is too low → bit error occur.
- Terminal's power is too high → the interference will go up.
- Closed loop power control at the 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



IMT–2000

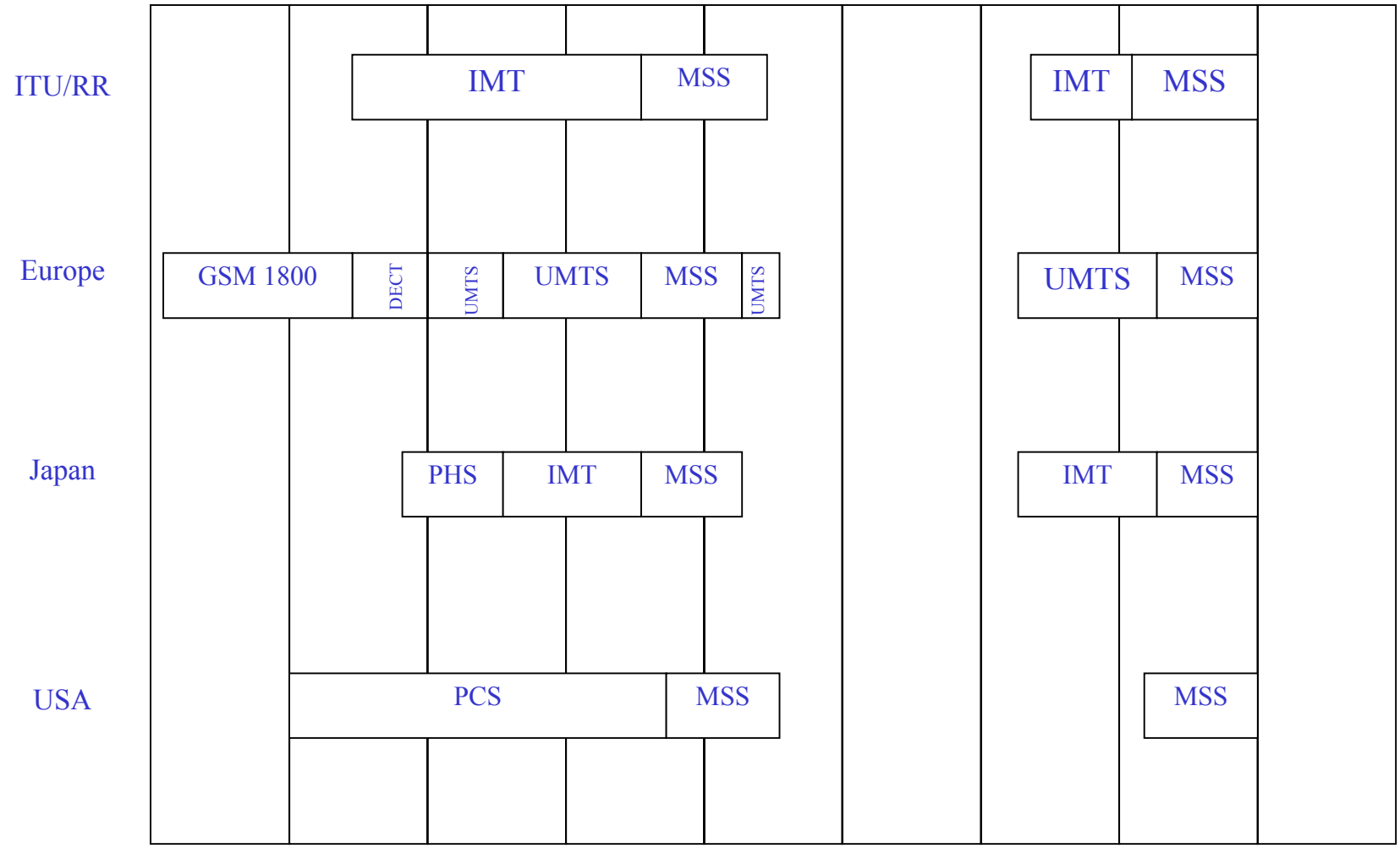
- Key Features
- International Spectrum allocation
- Radio Interfaces
- Harmonized 3G Systems
- UMTS
- UTRAN
- Channels in UTRAN



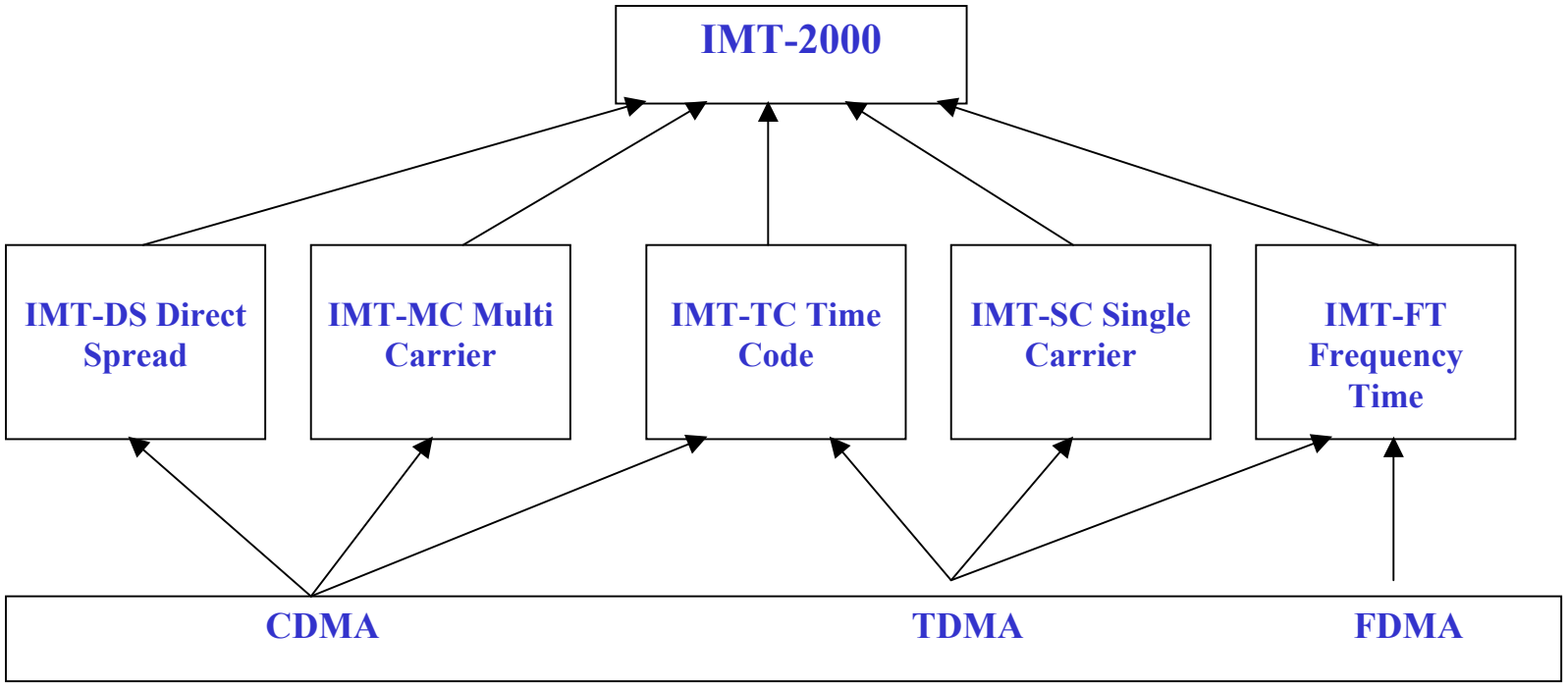
Key Features

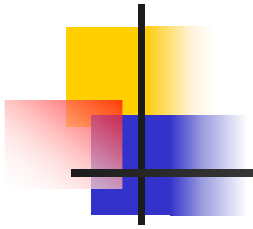
- High degree of commonality of design worldwide.
- Compatibility of services within IMT-2000 and with fixed networks.
- High quality.
- Small terminal for worldwide use, including pico, micro, macro and global satellite cells.
- Worldwide roaming capability.
- Capability for multimedia applications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

International Spectrum Allocation



Radio Interfaces

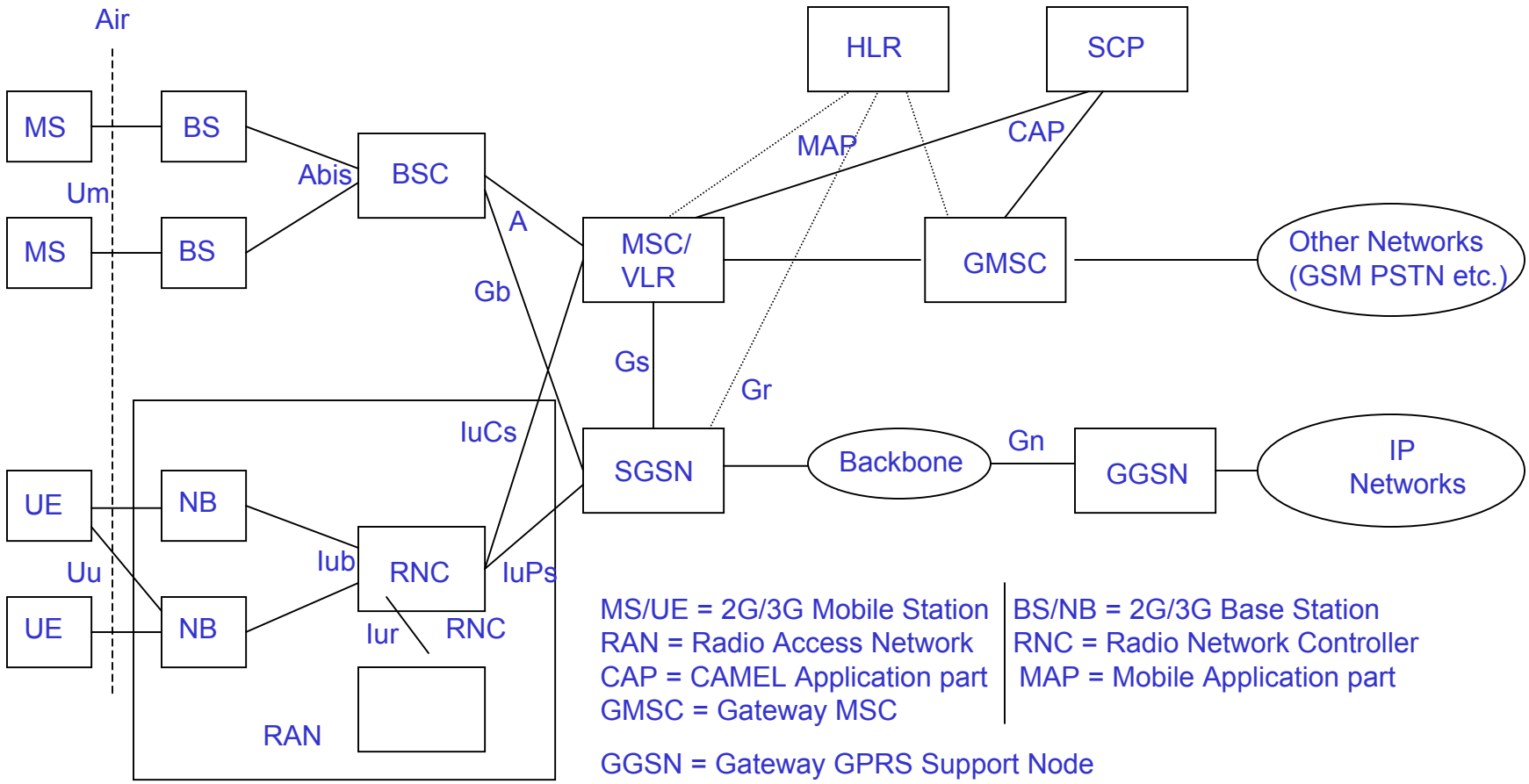




Harmonized 3G Systems

- 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.

UMTS-Network Reference Architecture



UMTS Terrestrial Radio Access Network (UTRAN)

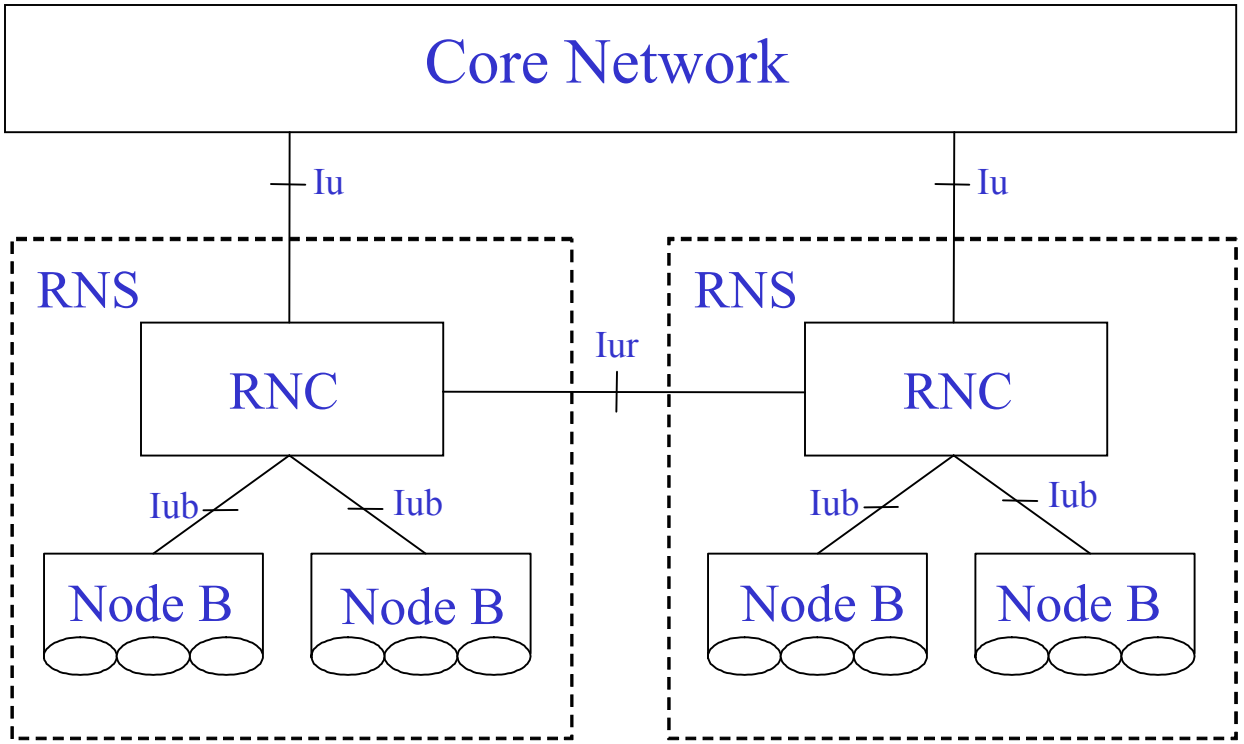
The UTRAN consists of a set of radio network subsystems (RNSs).

Two main elements:

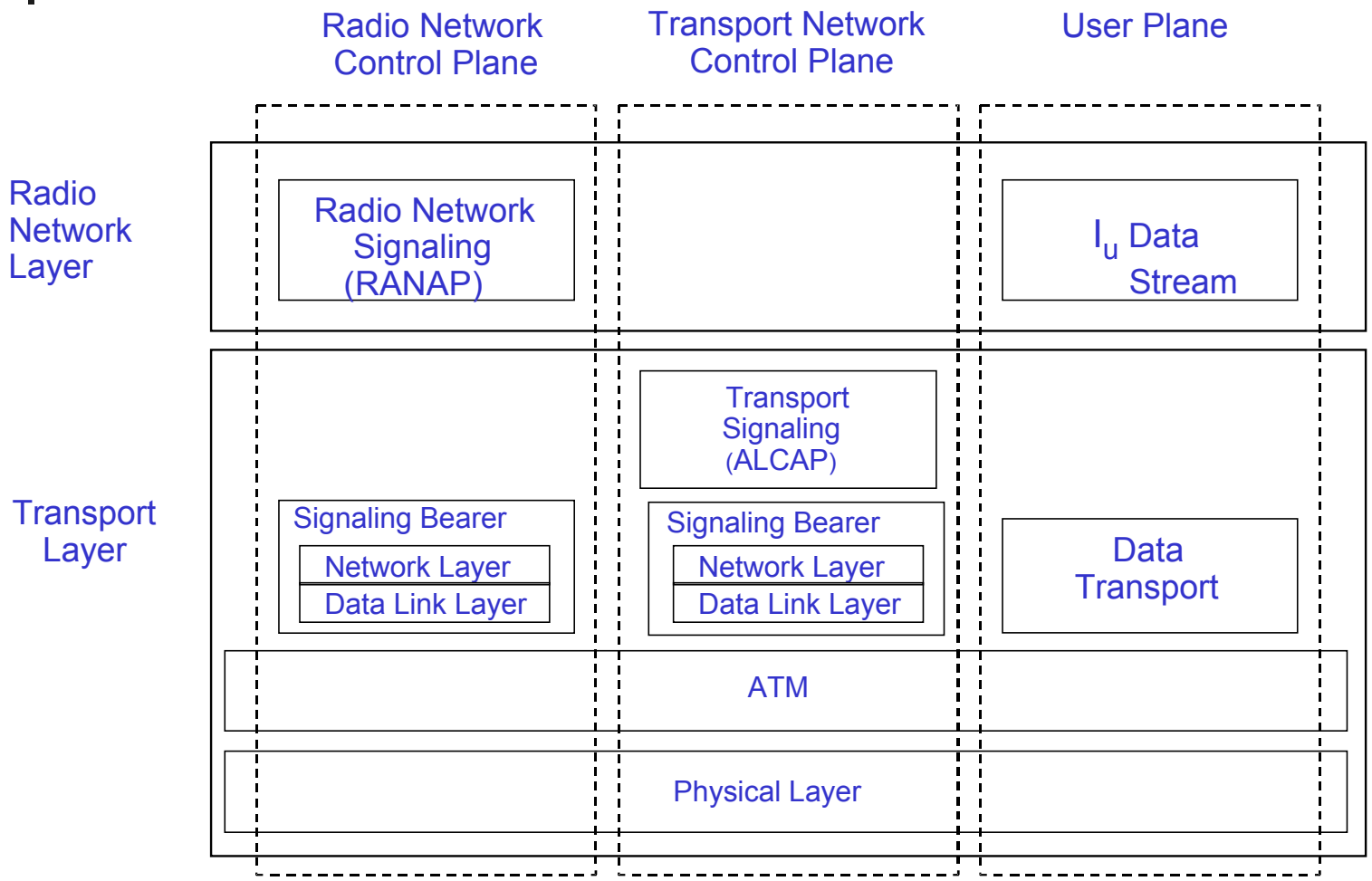
- Node B
- Radio Network Controller (RNC)

- 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

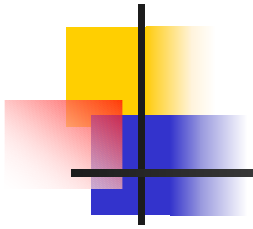
UTRAN – Architecture



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