WCDMA Overview

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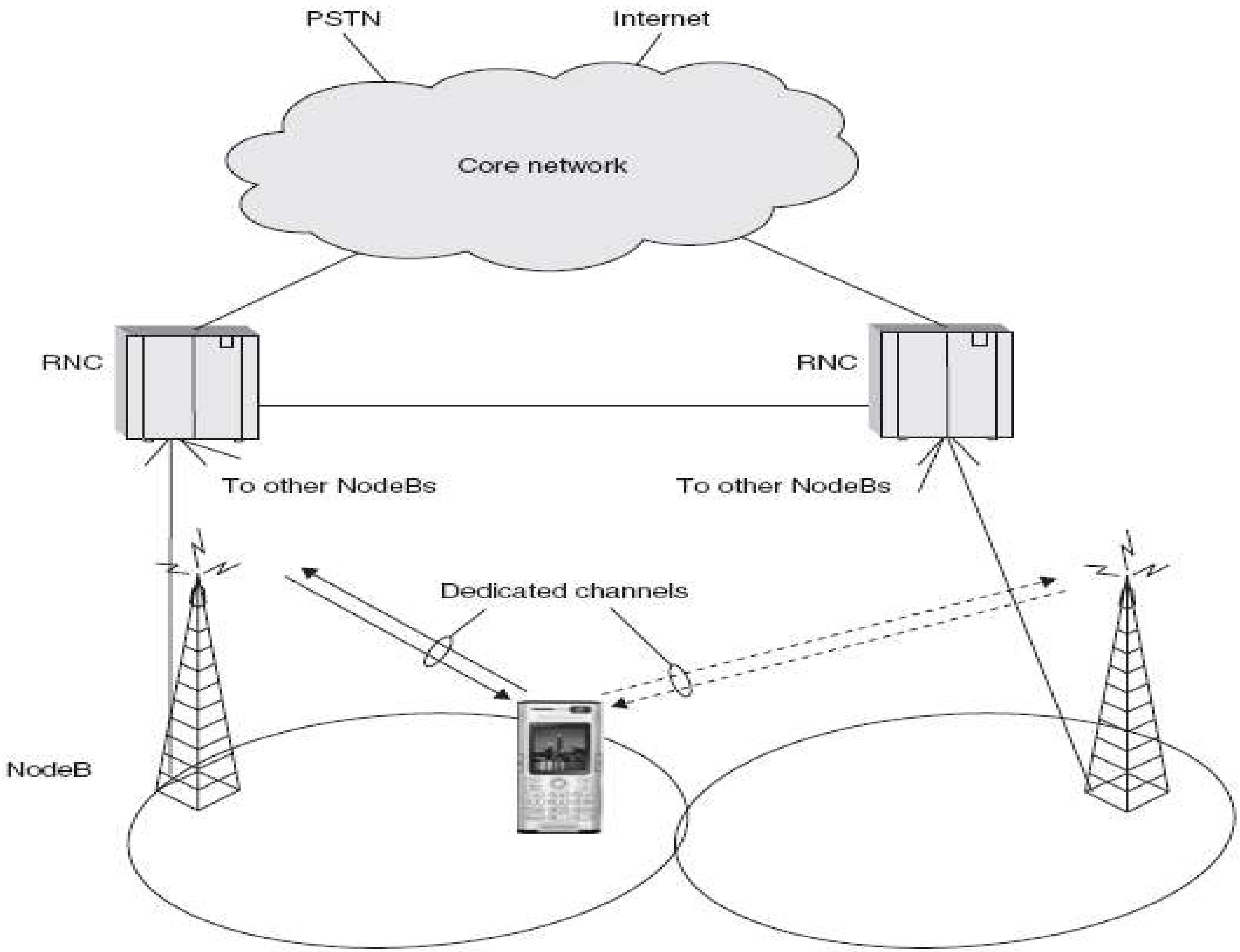
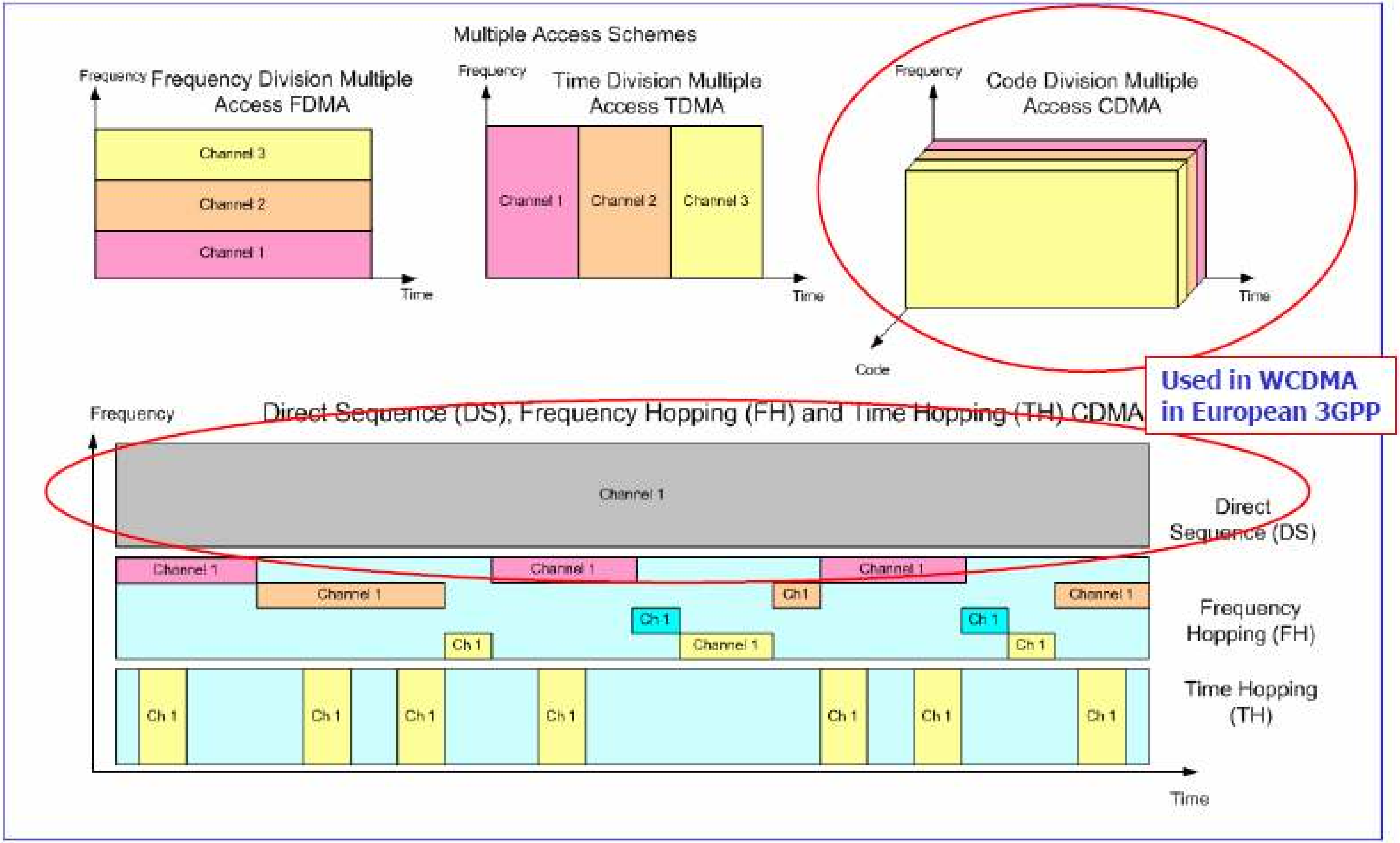
WCDMA RAN Architecture



WCDMA Radio Access Network

- WCDMA network is deployed in UMTS
- A User Equipment (UE) or terminal communicates with several NodeBs.
- NodeB is a base station responsible for physical layer processing such as error correcting coding, modulation, spreading, conversion from baseband to RF signal transmitted from antenna. A NodeB can handle transmission/reception from one to several cells.
- One Radio Network Controller (RNC) controls Multiple (up to hundreds) NodeBs. RNC in charge of call setup, QoS handling, radio resource management in cells. The ARQ protocol and most of the intelligence in radio access network resides in RNC.
- RNC is connected to the internet and PSTN through the core network

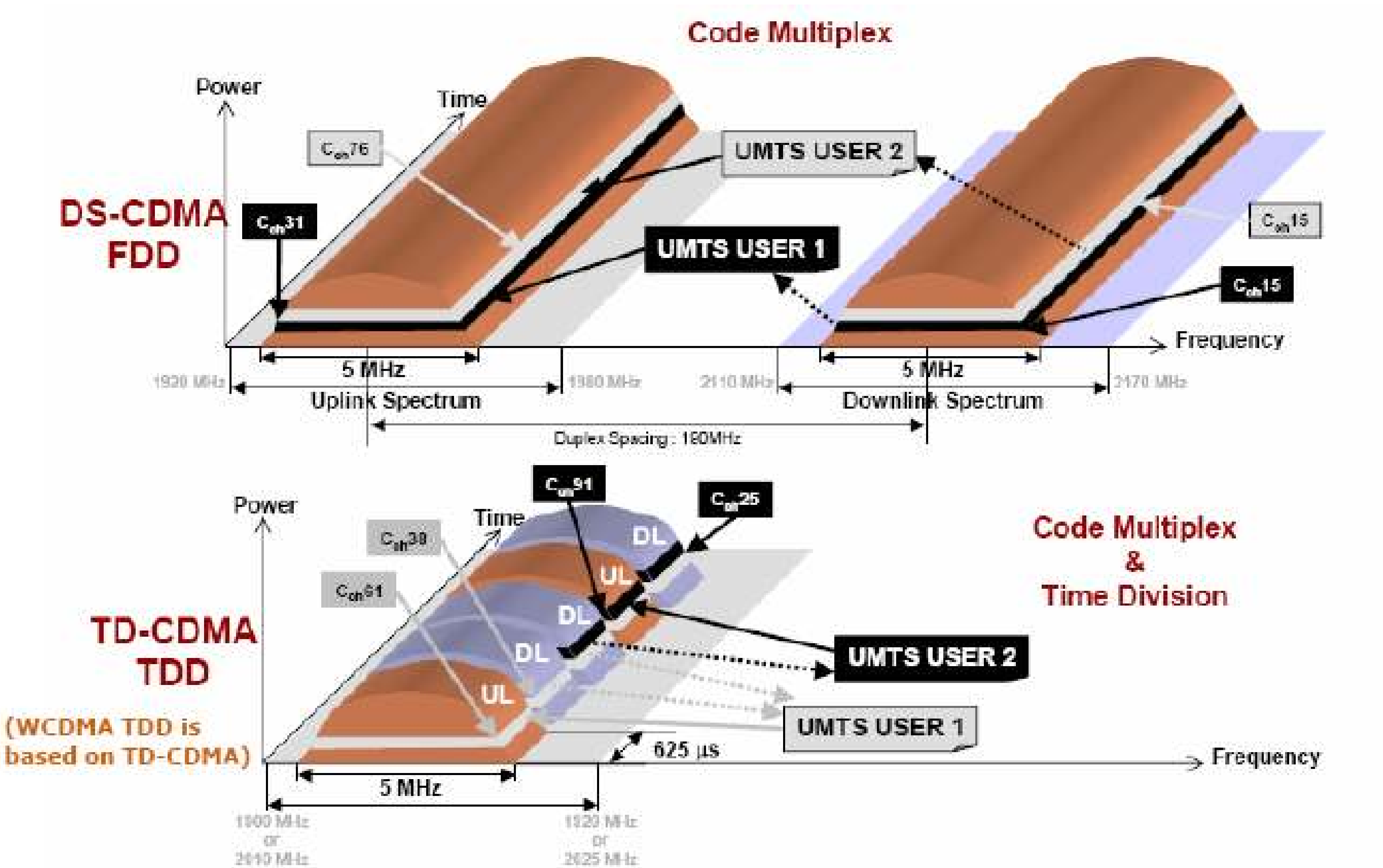
Multiple Access and CDMA Classification



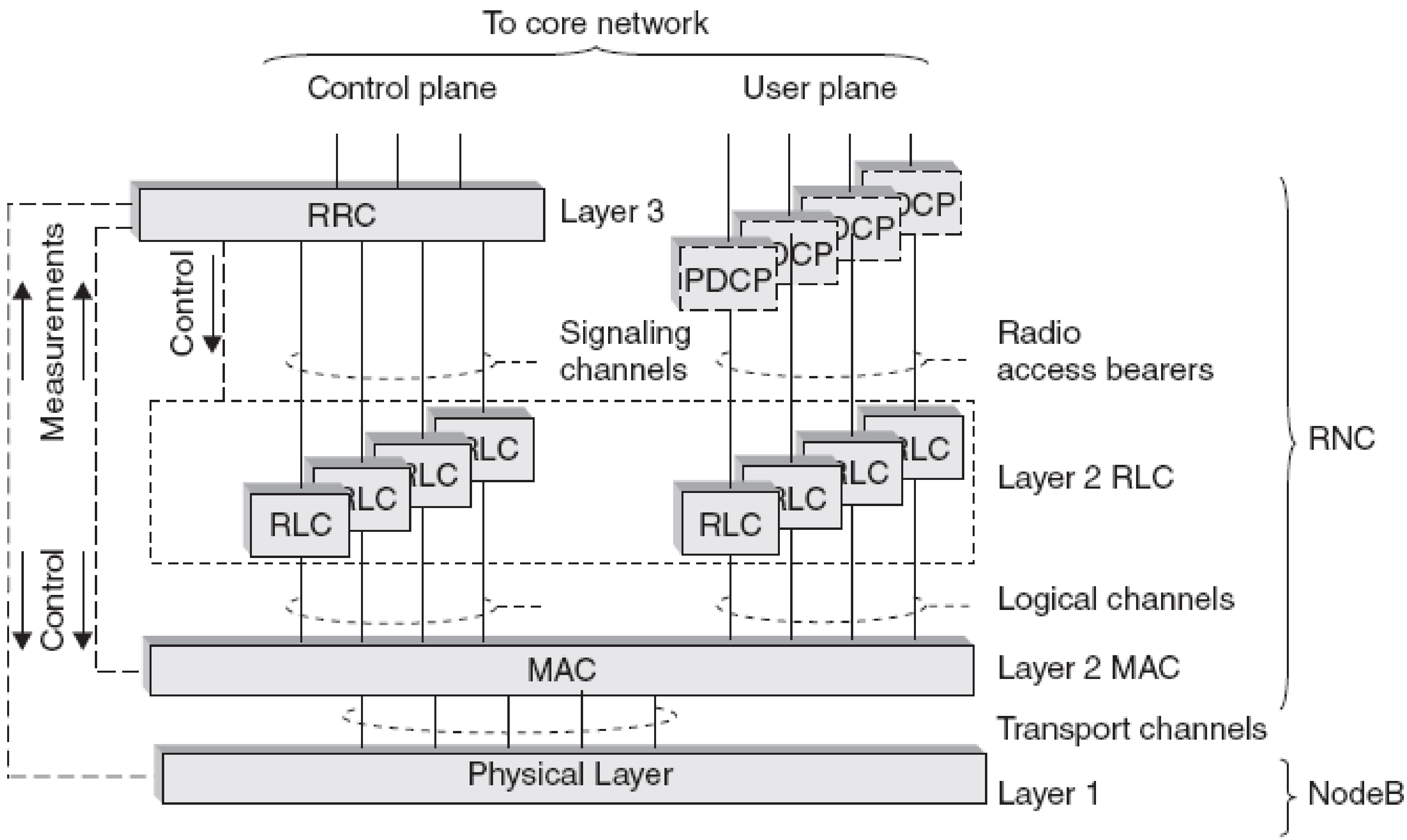
WCDMA Characteristics

- Channel Bandwidth: 5 MHz
- Support two basic modes: FDD and TDD
- High chip rate (3.84 Mcps) and data rates (up to 2Mbps)
- Frame length: 10 ms
- Employ coherent detection on uplink and downlink based on use of pilot symbols
- Inter-cell Asynchronous operation
- Fast adaptive power control in downlink based on SIR
- Provision of multirate services using variable spreading and multicode
- Packet data
- Seamless inter-frequency handover
- Intersystems handovers, e.g. between GSM and WCDMA
- Support advanced technologies like multiuser detection (MUD) and smart adaptive antennas

WCDMA Radio Access Modes



WCDMA protocol Architecture



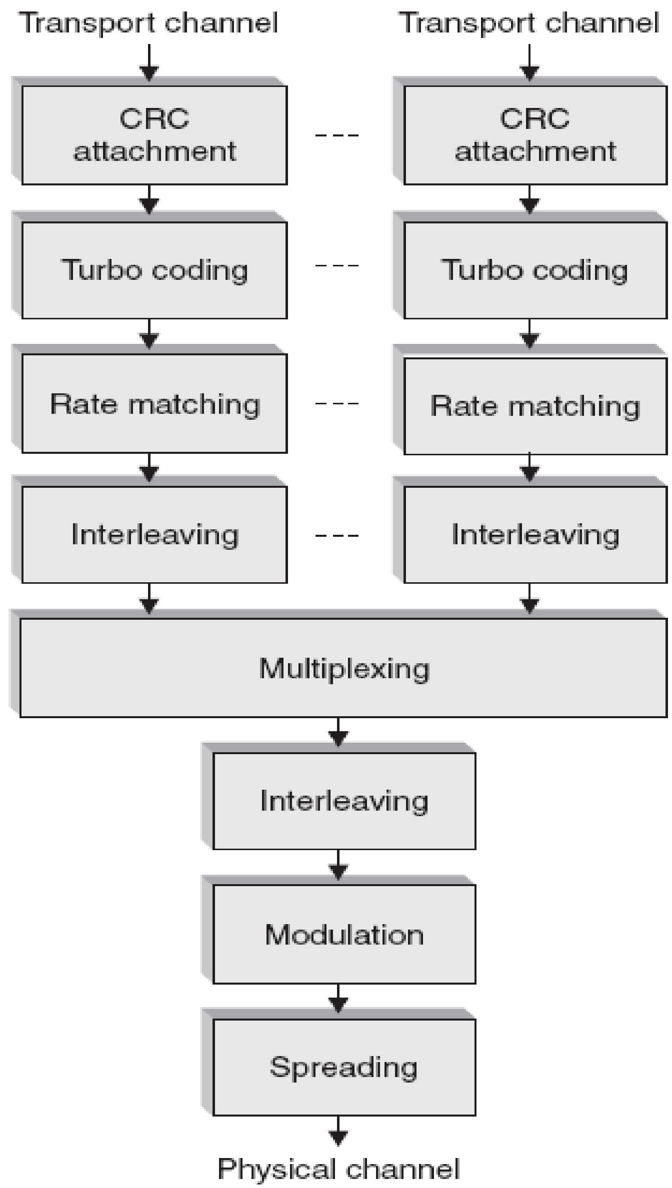
WCDMA Protocol Layers

- Packet Data Convergence Protocol (PDCP) performs IP packet header compression on user data from core network
- Radio Link Protocol (RLC) responsible for segmentation/reassembly of IP packet into/from RLC Protocol Data Unit (RLC PDU). RLC also handle ARQ protocol – for each incorrectly received PDU, RLC requested a retransmission
- Medium Access Control (MAC) layer offer services to RLC using logical channels. MAC layer can multiplex data from multiple logical channels and determine the instantaneous data rate send to the physical layer. The interface between MAC layer and Physical layer is specified through transport channels over which data in form of transport blocks are transferred.
- Radio Resource Control (RRC) Protocol configures PDCP, RLC, MAC and Physical Layer. RRC performs admission control, handover decisions and provides the necessary QoS requested by the Core network.

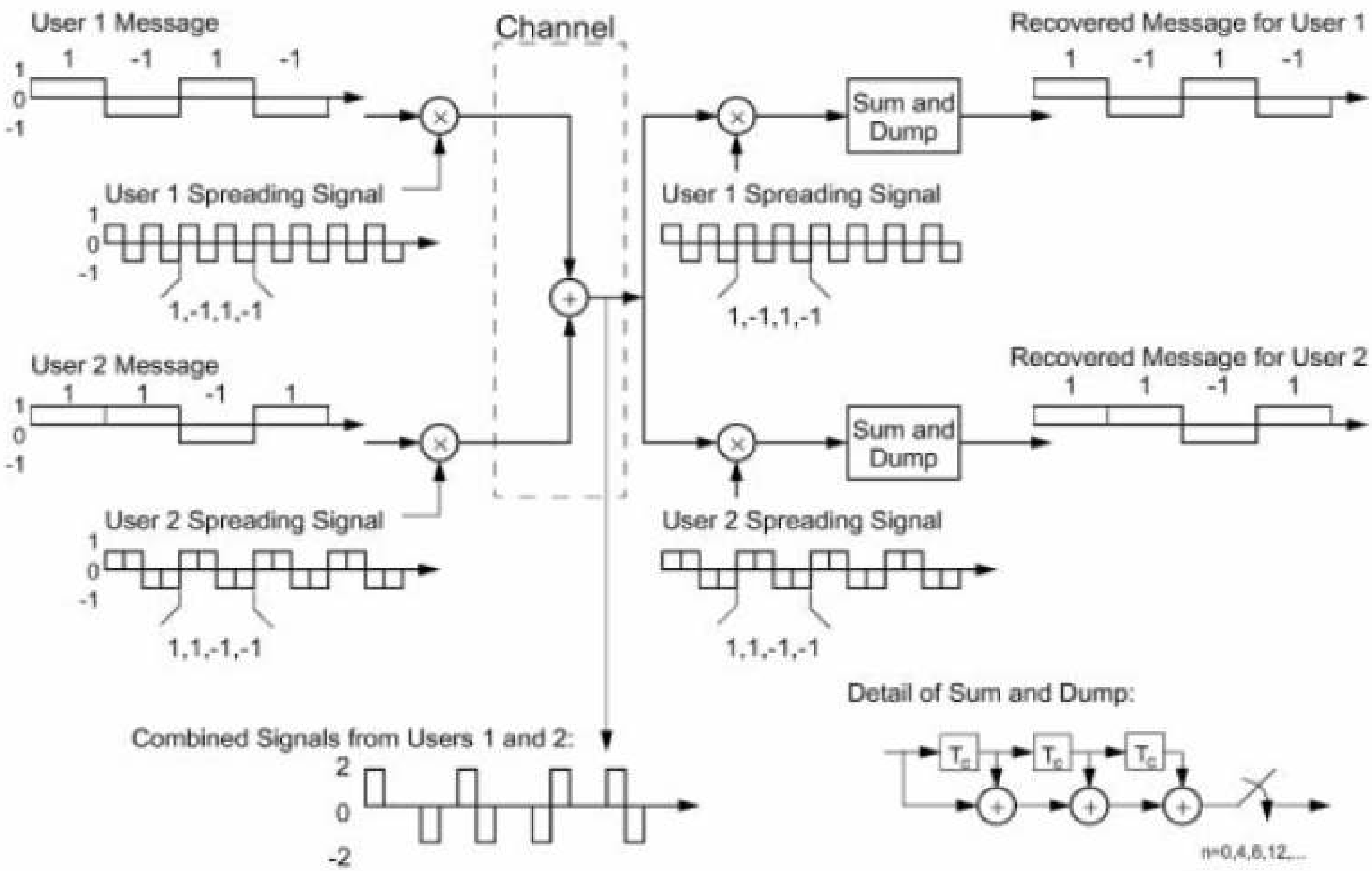
Logical Channels

- MAC layer provides data transfer services on logical channels, control and traffic channels:
  - Control channel to transfer control plane information
  - Traffic channels to transfer user plane information
- Control channels
  - Broadcast control channels (BCCH) - downlink broadcast control
  - Paging control channel (PCCH) - downlink paging information
  - Dedicated control channel (DCCH) - dedicated between mobile & network
  - Common control channel (CCCH) - common between mobile & network
  - Shared channel control information (SHCCH) - for UL & DL (TDD only)
- Data channels
  - Dedicated traffic channel (DTCH) - P2P ch. dedicated to one mobile (UL & DL)
  - Common traffic channel (CTCH) - P2MP ch. for unidirectional data

WCDMA Physical Layer Processing



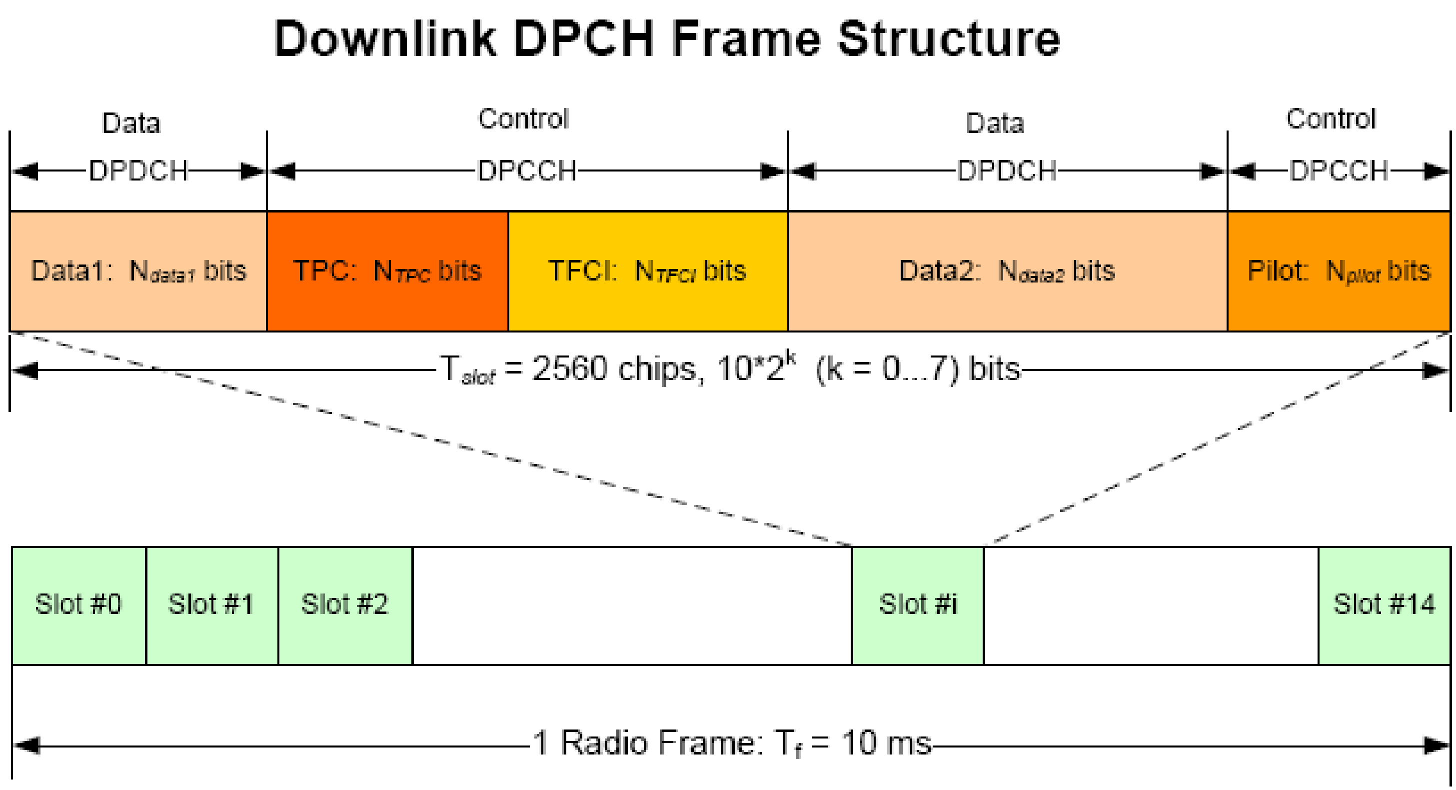
Spreading and De-spreading



WCDMA Physical Layer

- The basis of WCDMA physical layer is the spreading of transmitted data to the chip rate (3.84 Mchip/s).
- The transmitter physical layer add Cyclic Redundant Check (CRC) to each transport block for error detection and use 1/3 turbo code or Convolution code to encode the data.
- For downlink, QPSK modulation is used, while the uplink uses BPSK. The modulated symbols are mapped into a physical channel corresponds to a unique spreading code used to separate transmission to/from different users.
- Spreading operation consist of two steps: spreading to chip rate using orthogonal channelization code followed by scrambling using non-orthogonal scrambling sequences with a length of 10 ms radio frame.
- Channelization codes are Orthogonal Variable Spreading Factor (OVSF) codes. The key property of OVSF codes is mutual orthogonality between data streams of different rate spread with different OVSF codes.
- Spread Factor SF = Chip Rate Rc (chip/s) / Information Rate Rb (Symb/s)

Frame Structure for Downlink Dedicated Physical Channel (DPCH)

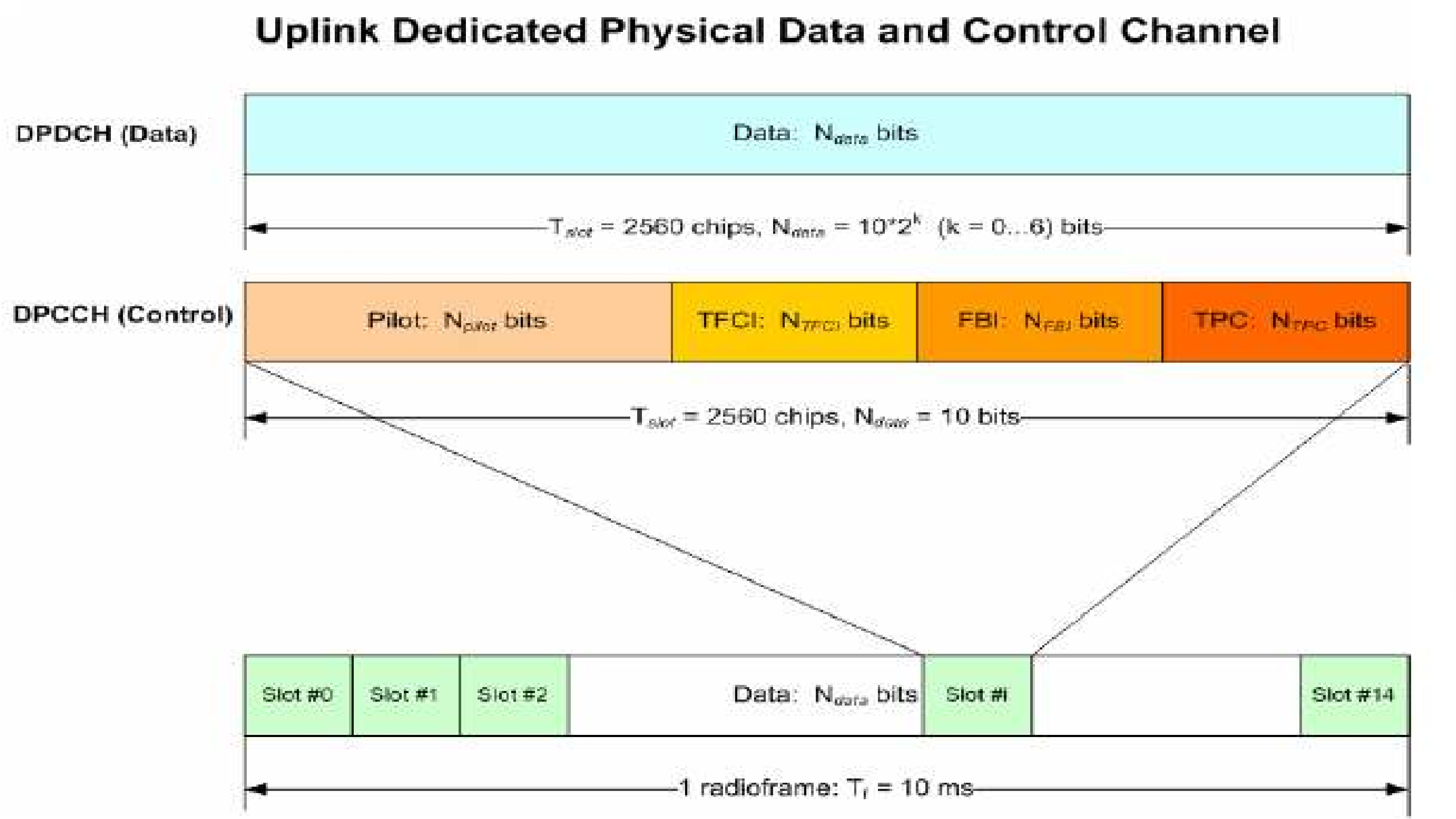


- The dedicated transport channel is sent time multiplexed with control information generated at layer 1 (pilot bits, power-control commands, optional transport format combination indicator)

WCDMA Downlink Physical Channels

- In the downlink, data to certain user, include control information is carried in one Dedicated Physical Channel (DPCH) corresponding to one OVSF code. Multiple physical channel can be used for a single user for highest data rate.
- One OVSF code is reserved for reference signal transmission – Common Pilot Channel (CPICH) which contains known data used as a reference for downlink channel estimation for all UEs in the cell. There is also a pre-allocated control channel carrying cell specific control information.
- Downlink physical channels are separated by OVSF codes, transmission on different physical channels are orthogonal and will not interfere with each other.
- WCDMA support asynchronous operation in which transmission from different cells are not time synchronized. To separate different cells, the scrambling is cell specific for the downlink.
- Since scrambling sequence is non-orthogonal, transmission receives from one cell will be interferes by transmission from neighboring cell. This interference is suppressed by receiver with a factor proportional to processing gain.

Frame Structure for Uplink Dedicated Data and Control Channel



TPC = Transmit Power Control
FBI = Feedback Information
TFCI = Transport-Format Combination Indicator

WCDMA Uplink Physical Channel

- Uplink data is carried on the Dedicated Physical Data Channel (DPDCH) and different data rate is realized using different spreading factor.
- Due to Coherent modulation, each user's uplink requires an individual channel estimation. This and the data transport format is carried on the Dedicated Physical Control Channel (DPCCH).
- User specific scrambling are use in uplink and OVSF codes are used to separate different channels from the same terminals. Uplink are not synchronized and non-orthogonal as multiple UEs can use the same set of OVSF code. Different UE's transmission will interfere with each other.
- Uplink use fast closed loop power control to reduce interference between users. NodeB measured the signal to interference ratio (SIR) on the DPCCH from each terminal and 1500 times per second commands the terminals to adjust its transmission power to achieve the appropriate SIR level for each user. Required SIR depends on data rate & varies with user.
- NodeB commands UE to increase transmission power if SIR is too low for proper demodulation and lower transmission if SIR is too high which causes transmission from some users non-decodable. This is refer as the near – far problem.
- Downlink also use fast closed loop power control to combat fast fading by varying transmission power according to channel conditions. Less power for favorable channel conditions and vice versa.

WCDMA Soft Handover

- Soft handover, or macro diversity, implies terminals close to cell border is communicating with multiple cells or NodeB simultaneously to improve performance. RNC determine which active set of cells UE is communicating with based on measurements from the UE.
- Downlink soft handoff implies data to a UE is transmitted simultaneously from multiple cells, this provide diversity against fast fading.
- Uplink soft handover implies transmission from the UE is received in multiple cells or NodeBs to provide diversity against fast fading.
- If cells receiving the uplink transmission are located in the same NodeB, a Rake receiver can be used to combine the received signal. If the cells belongs to different NodeBs, each NodeB will decode the received signal and forward the correctly received data units to RNC. Transmission is successful as long as one NodeB receives the data correctly.
- Uplink soft handover implies power control from multiple cells. UE lowers its transmission power if at least one of the cell command it to do so. Only if all the cells request the UE to increase transmission power is the power increased. This ensures the average transmission to be kept as low as possible. This reduces average interference and translates into an increased capacity.