Wireless Medium Access Control and CDMA, 3G and 4G Communication

Lesson 10

3G– IMT2000, UMTS and CDMA2000

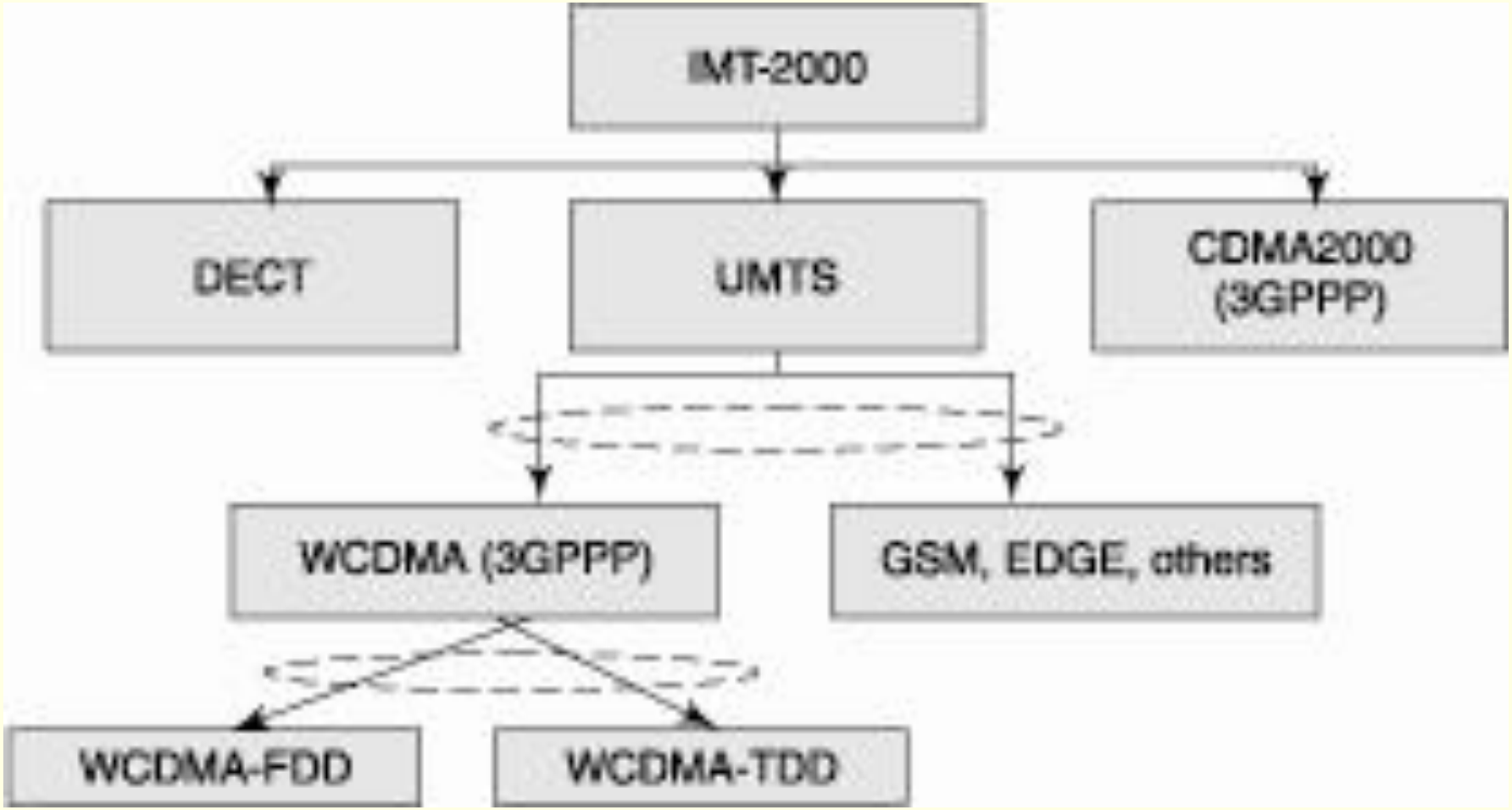
International mobile telecommunications-2000 (IMT-2000)

- Below 3G— Data rates lower than 153.6 kbps
- 3G wireless communications standard Defined by recommendations of International Telecommunication Union (ITU)

International mobile telecommunications-2000 (IMT-2000)

- 3G technologies — High quality of service and high data rate support for multimedia (audio, pictures, text, and video) transfer

3G technologies covered in IMT-2000 global standards



CDMA2000

- 400 MHz, 800 MHz, 900 MHz, 1700 MHz, 1800 MHz, 1900 MHz, and 2100 MHz
- A set of 3G communication CDMA2000 standards
- Compatibility with the cdmaOne standard

CDMA2000 standards

- CDMA2000 1x, CDMA2000 1xEV-DV (evolution for high speed integrated data and voice), and CDMA2000 1xEV-DO (evolution for data optimized)— approved IMT-2000 standards

CDMA2000 standards

- CDMA2000 1xEV-DV transmission rates are up to 614 kbps
- CDMA2000 1xEV-DO rates up to 2.05 Mbps

CDMA2000

- CDMA2000 1xEV-DO and CDMA2000 1xEV-DV enhancements of CDMA2000 1x— accepted as standards in 2004
- CDMA2000 3x — three 1.2288 Mbps channels
- Channel bandwidths for CDMA channels are 1.25, 5, 10, 15, and 20 MHz

External synchronization mechanism

- Base stations (BTSs) use an external synchronization mechanism– satellite based GPS
- A period of time is required for synchronization among the adjacent base stations in asynchronous stations in WCDMA, not in case of CDMA2000

External synchronization mechanism

- Adjacent cells can use the same frequency but must use distinct phase angles

Dedicated and Common Channels

- Reverse access and reverse pilot channels are the only common control channels present during the access setup phase

Dedicated and Common Channels

- The frame structure is 172 user data bits, 12 CRC bits, and 8 tail bits as 0s for a 4.8 kbps access channel
- A preamble before a message

Access channels

- Access is random
- Uses the slotted Aloha protocol

User data through dedicated channels

- Rate sets RS1 or RS2
- On putting the user channel data in the 20 ms time-slots, the rate becomes 307.2 kbps
- A four chip Walsh code (spread factor = 4)
- Chipping rate becomes 1.2288 Mchip/s

Data rate

- Low data rate employ one fundamental mode
- High data rate services and multimedia services employ a greater number of dedicated channels

Dedicated pilot

- A pilot signal is a reference signal
- The MS uses the continuously transmitting, code-divided, dedicated pilot for uplink
- The BTS uses the code-divided common pilot and dedicated or common auxiliary pilots for downlink

Code-divided dedicated pilot

- Helps in coherent detection of the reference signal
- The BTS pilot channel multiplexes the power control and a control bit called erasure indicator bit

Short and Long Data Packets

- Frame length modulation QPSK for downlink
- BPSK for uplink
- Frame length modulation gives frames of 5, 10, 20, 40, and 80 ms duration as per the packet size

Short and Long Data Packets

- Short data bursts use the slotted Aloha protocol
- Transmitted at variable power
- Power level enhanced after an unsuccessful access

Different types of physical channels

- CDMA2000 supports several different types of physical channels
- Chip rates are $n \times 1.2288$ Mchip/s, where n is a positive integer
- $n > 1$ facilitates multi-rate or single rate data transmission at higher rates, which are n times 1.2288 Mbps

Supplementary channels

- For reverse link (uplink) use turbo codes
- Other physical channels use ¼ convolution coding

Supplementary channels

- The signals are scrambled with long code sequences before chipping with orthogonal codes
- Followed by short code spreading of the carrier channels

Multi-rate transmission of signals

- Low data rate signals for voice and messages and High data rate signals for pictures, videos, and large packets
- An RS2 signal can be punctured to reduce data rates
- Low data rate signals of up to 19.2 kbps can be interleaved

Multi-rate transmission of signals

- A picture in CIF format resolution of 352 × 288 pixels and Transmitted at a data rate of 384 kbps
- Voice or other low data rate services and power control messages are transmitted at RS1 data rates of 9.6, 4.8, 2.4, or 1.2 kbps or at RS2 data rates of 14.4, 7.2, 3.6, or 1.8 kbps

High data rate signals

- Rate Reduction at 307.2 kbps for 384 kbps data
- Up to 307.2 kbps, variable length Walsh codes support both orthogonality as well as variable data rate for a physical channel

Multi-rate transmission of signals

- IS_95 spread factor is constant at 64
- Spread factor can vary from 4 to 256 depending upon the data rates in CDMA2000

Coding

- Downlink uses Walsh codes or quasi-orthogonal codes and uplink uses Walsh codes
- Quasi-orthogonal means not strongly orthogonal
- Orthogonal coding for channelization asymmetrical in uplink and downlink

Multi-rate data encoding in Traffic Channels

- Rate Set RS1 transmits at 9.6, 4.8, 2.4 or 1.2 kbps
- An optional rate set RS2 transmits at 14.4, 7.2, 3.6 or 1.8 kbps
- Requires different type of convolution encoding and error encoding depending on considerations of service quality
- Service quality low or high– high or low bit error rates, respectively

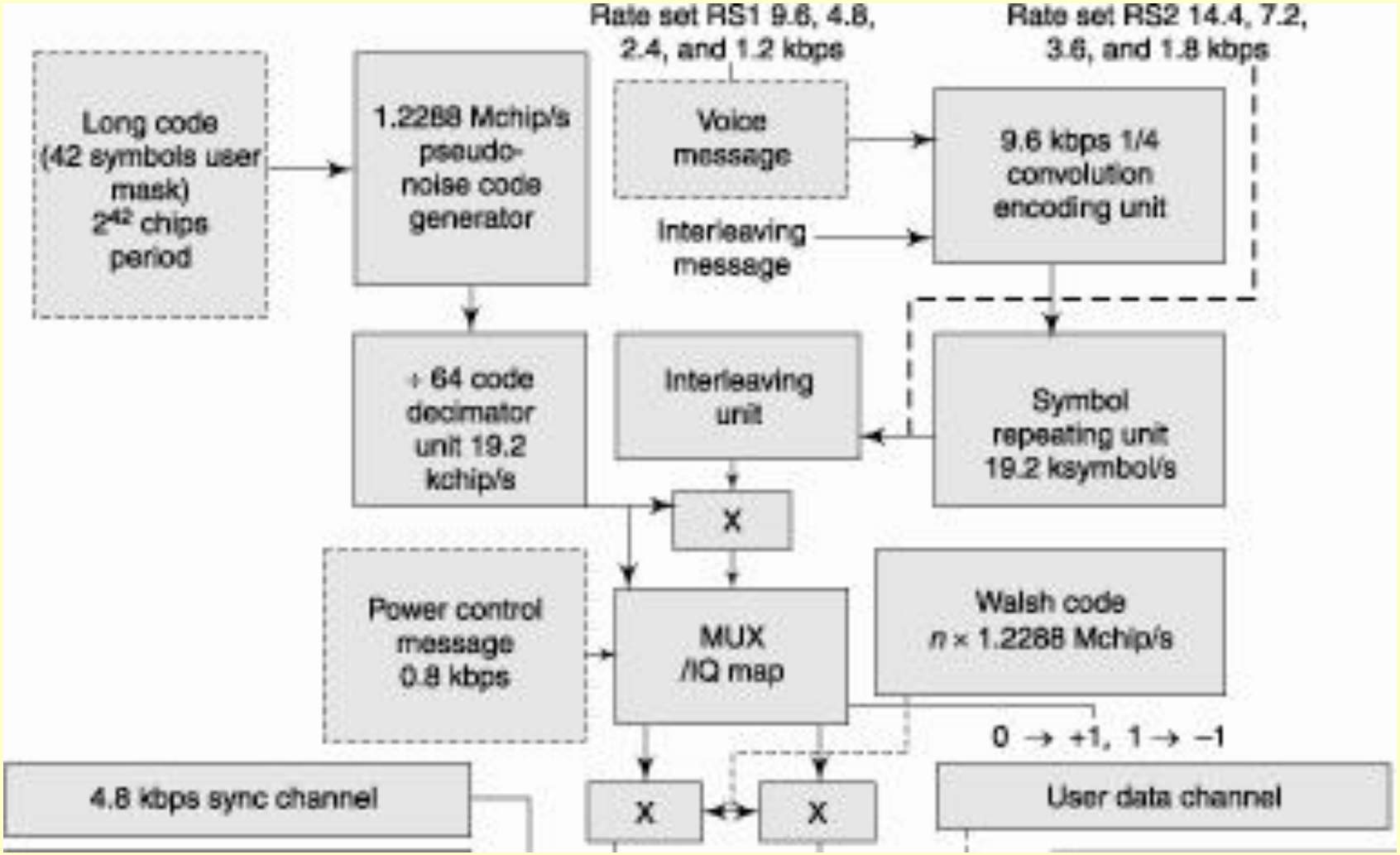
Multi-rate data encoding in Traffic Channels

- Multi-encoded rate signals are systems that transmit at variable data rates after convolution coding
- In IS-95, RS1 and RS2 data rate symbols are matched, repeated, and interleaved so that before chipping, the symbol transmission rate is constant at 19.2 ksymbol/s

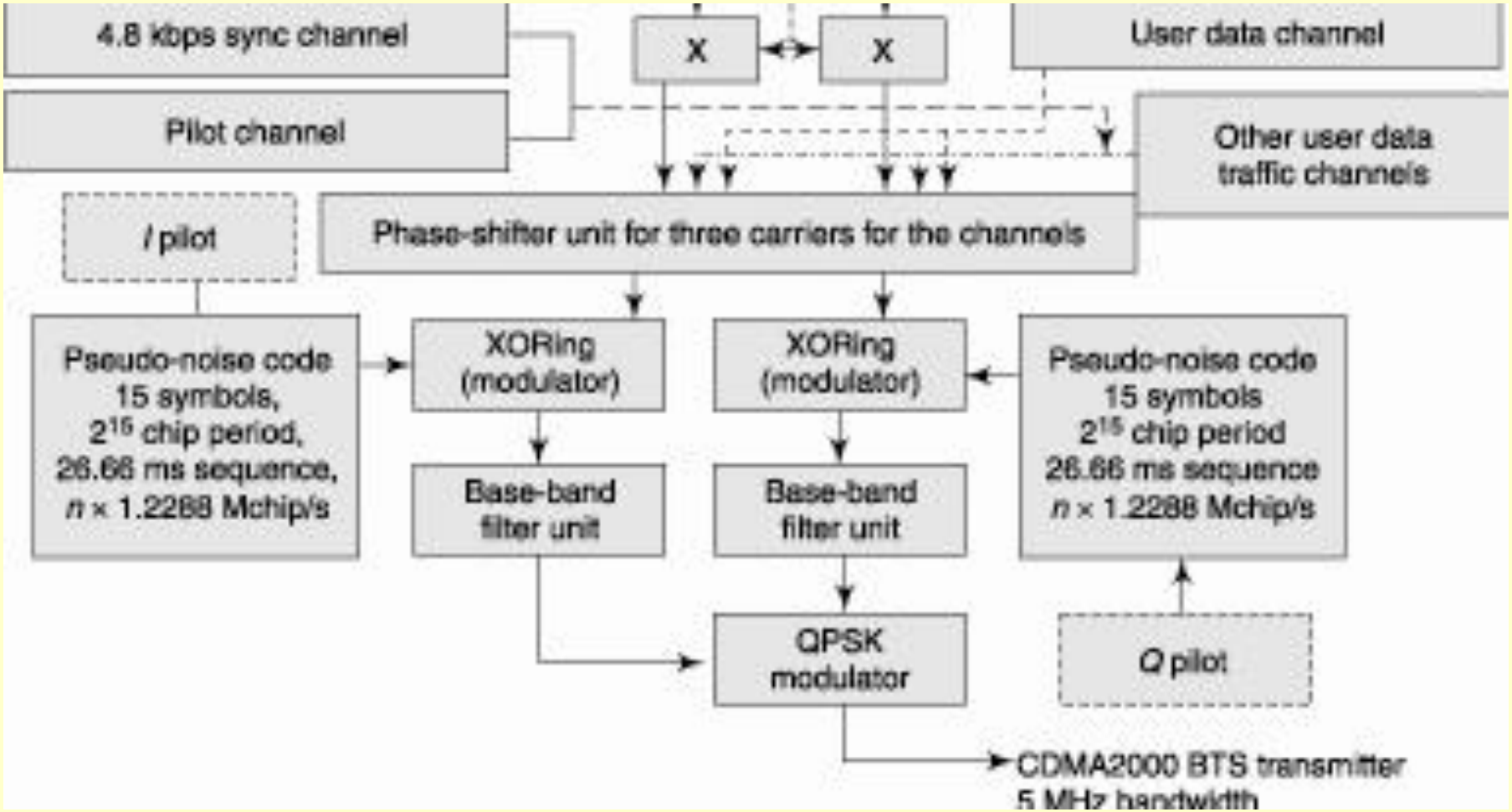
Pilots

- Downlink and uplink Modulations of Spreading Signals (Pilots)
- Spreading signal (pilots) modulation is balanced QPSK modulation for downlink and dual channel QPSK modulation for uplink
- The modulation of radio carrier frequency is asymmetrical for uplink and downlink

Processing units for power control messages and channels for data, sync, pilot, and traffic



Processing units for power control messages and channels for data, sync, pilot, and traffic



Processing units

- Use of a MUX/IQ unit
- Long code and mask
- PN_Q and PN_I, and Walsh codes

Long codes

- Use the same length M-sequences
- Used for channels data divided in two different phases (I and Q) for each channel before scrambling

Processing units

- In IS-95 the data channel divided into the *I* (in-phase) and *Q* (quadrature) components after chipping with Walsh codes
- In CDMA2000 it is divided before scrambling

Processing units

- The main difference with respect to the IS-95 processing unit is that in CDMA2000, the MUX/IQ (multiplexer and signal mapping unit) first divides the signal into the I and Q components
- Followed by chipping of the signal using Walsh codes and then encoding using short code PN sequences

MUX/IQ

- An MUX/IQ unit performs signal mapping
- Each 0 is mapped to + 1 and each 1 is mapped to –—1as per 3GPP specifications

MUX UNIT

- Multiplexes (i) the user data after decimation (dividing by a factor) by a decimator, and (ii) the power control bits. *I* and *Q* components are then coded with Walsh codes

Walsh coded components I and Q

- From the units and Walsh coded components *I* and *Q* from other user traffic, user data, pilot, and synchronization channels multiplexed
- Pass through PN-short-code spreaders
- Base-band filters

MUX UNIT

- Three sets of chips after multiplexing when the chipping rate is 3×1.2288 Mchip/s
- Each chip has two components, *I* and *Q*

Modulation

- After the PN short code encoding with *I* and *Q* pilots and base-band filtering of *I* and *Q* components, a balance QPSK modulator modulates the signal for downlink
- A dual channel QPSK modulator modulates it for uplink

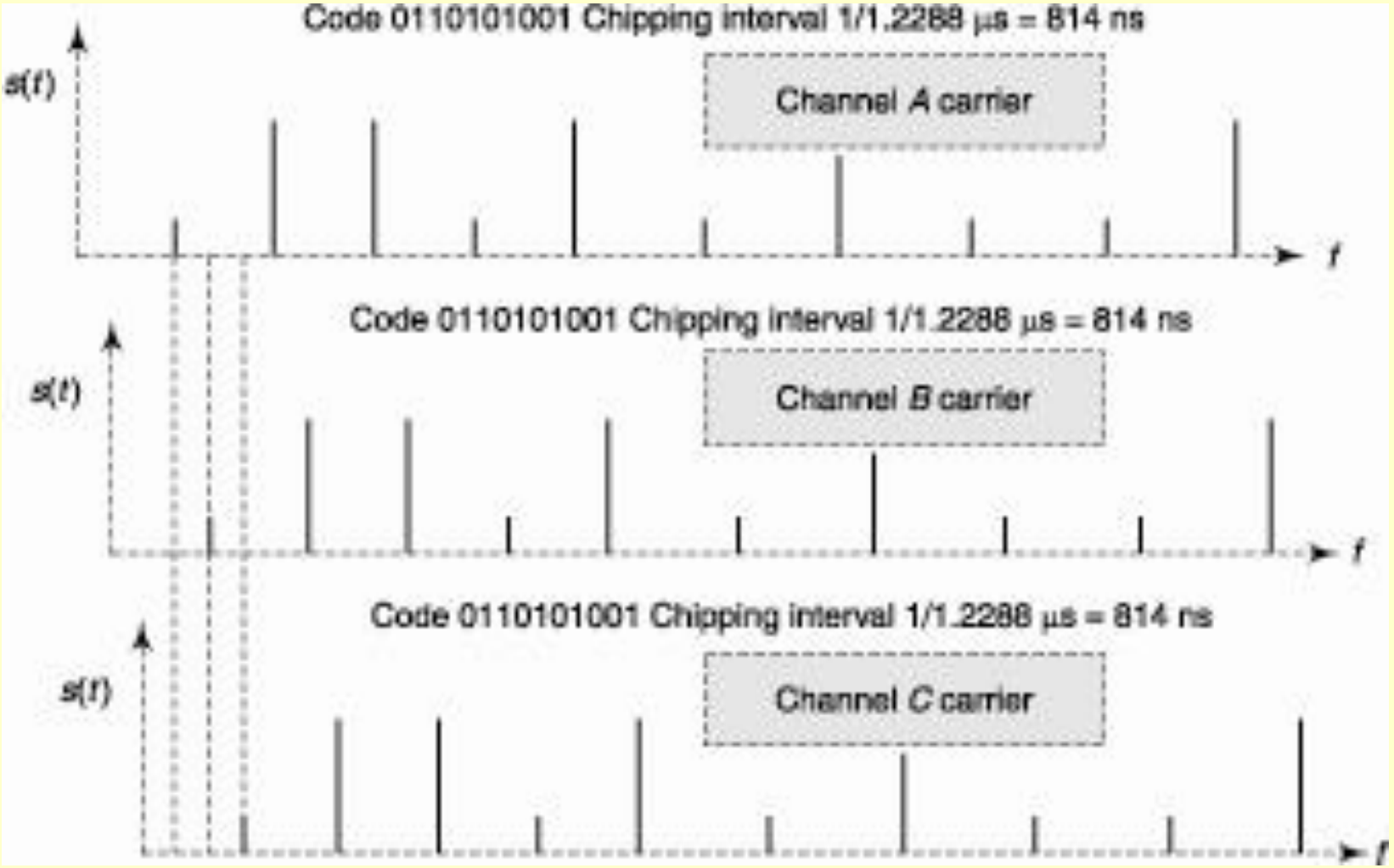
Multi-Carrier Rate support for transmission of signals

- Chipping rates of $n \times 1.2288$ Mchip/s (n = 1, 3, 6, 9, or 12) can be used
- Bandwidth for CDMA2000 3x = 5 MHz.
- While uplink uses DS-CDMA, downlink can use either multi-chip rate CDMA $n \times 1.2288$ Mchip/s, where n is the number of carriers)
- DS-CDMA (Assuming that there is no mapping of 1s and 0s)

Three carriers

- 3 carriers of 1.25 MHz each for $n = 3$ and all carriers have a separate code for each channel

3 carrier signal frequencies with three chipping codes of 10 symbol (code 1101010001) example



Multi-carrier transmission

- Uses multiplexing in time-space
- All channel carriers chipped using the same orthogonal code and scrambled using the same PN long codes, but the chipping instants of each carrier channel are shifted by $(1/n) \times 814$ ns (phase angle change of $360°/n$) in CDMA2000

Multi-carrier rates

- Can be adopted in CDMA2000
- When *n* channel data is to be transmitted, then each carrier uses 1.2288 Mchip/s for transmission
- When single channel data or time division multiplexed data of different channels is to be transmitted at high data rates, then a single carrier uses $n \times 1.2288$ Mchip/s for chipping

Summary

- CDMA2000 3G technology
- Synchronous base stations
- Interleaving of signals of low data rates (between 0.8 kbps to 4.8 kbps)
- Multi-rate transmission by variable spread factor (between 4 and 256) for data rates of 307.2 kbps to 4.8 kbps

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...Summary

- Use of a MUX/IQ unit
- Long code and mask
- PN_Q and PN_I, and Walsh codes
- Data channel divided into the *I* (in-phase) and *Q* (quadrature) components before chipping with Walsh codes
- Divided before scrambling

...Summary

- Multi-carrier (MC) FDD mode-2 transmission by using chipping rate = $n \times 1.2288$ Mchip/s (where n = 1, 3, 6, 9, or 12; All *n* carriers have unified power control)
- Distinct uplink and downlink multiple access, modulation, spreading, and channelization codes

End of Lesson 10

3G– IMT2000, UMTS and CDMA2000