

Course 336

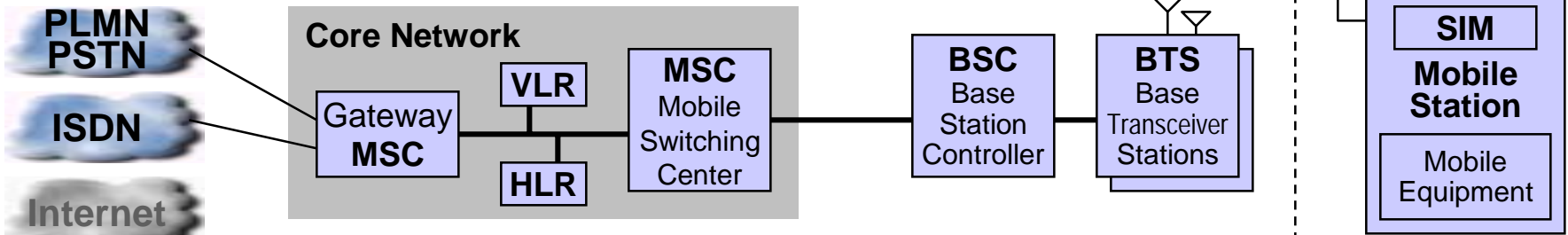
GSM 3G Migration: Introduction to UMTS, UTRA, Applications, Networks

Foreword: UMTS Perspective

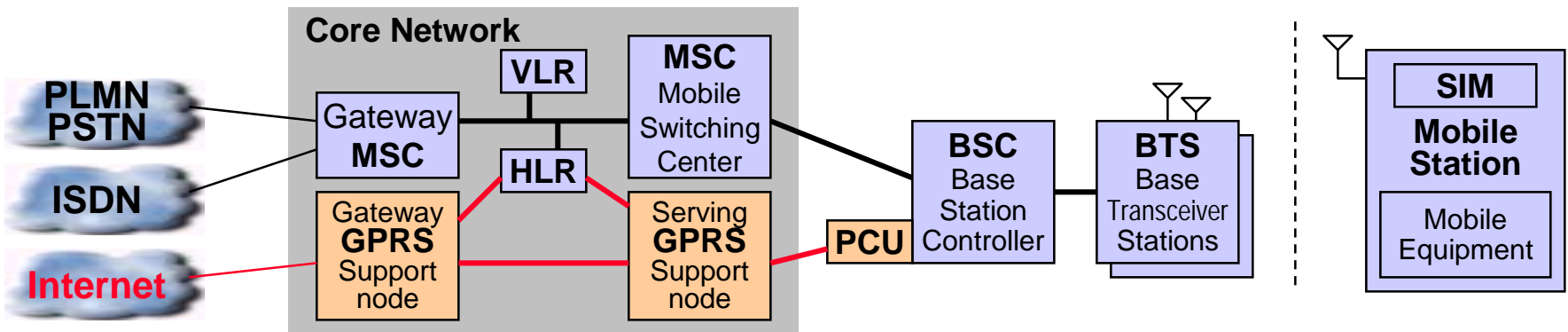
- Just a few years ago it was unthinkable nonsense that the GSM community would be joyfully planning a migration to a new-generation wireless service based on Wideband CDMA
- Yet in 2001, this is precisely the case!
 - Roughly U\$100 Billion already has changed hands in spectrum auctions looking toward new European W-CDMA networks
- Longtime CDMA detractor Ericsson has bought Qualcomm's network infrastructure business along with valuable IPR property for further CDMA developments
- Still, there are major differences between the "flavor" of CDMA in the US and the new W-CDMA which will supplement (and some say replace) GSM around the world
 - The chip rates differ significantly
 - W-CDMA does not normally use precise timing and PN offsets
- Nevertheless, this is a wireless milestone to be savored because of the cooperation within the wireless community that has made it possible, and the tremendous potential that this new technology offers for the benefit of humankind

3 Steps to 3G: GSM Transition to W-CDMA

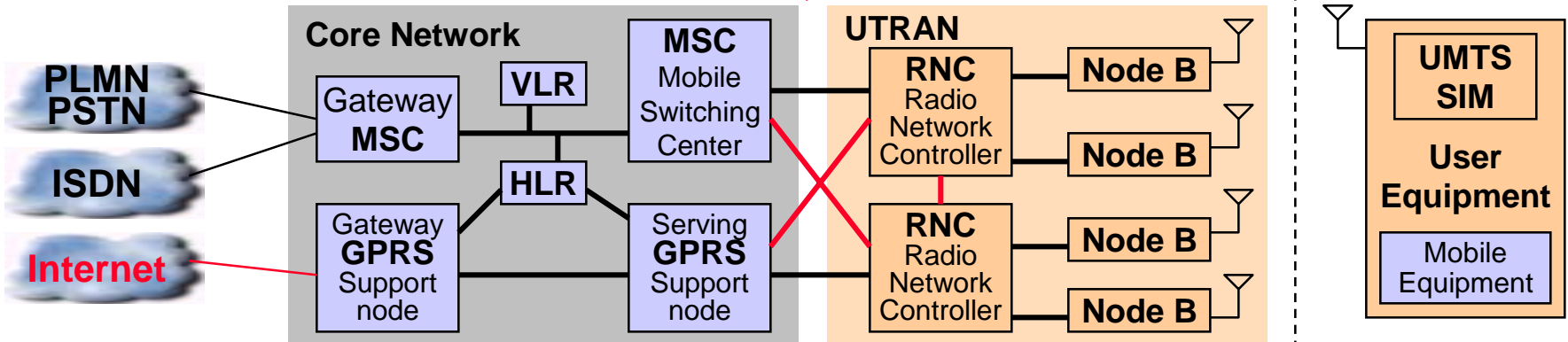
GSM TODAY



2.5G: GSM + GPRS



3G: UMTS, UTRA W-CDMA

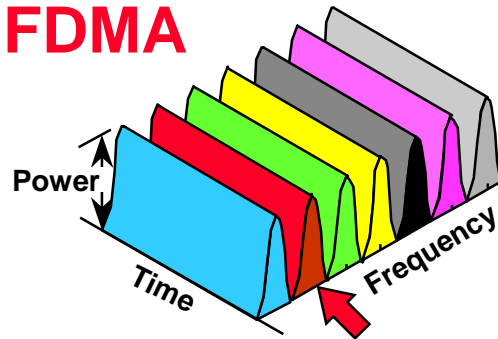


GSM - GPRS - UMTS WCDMA

GSM & CDMA: The Technologies

Wireless Multiple Access Methods

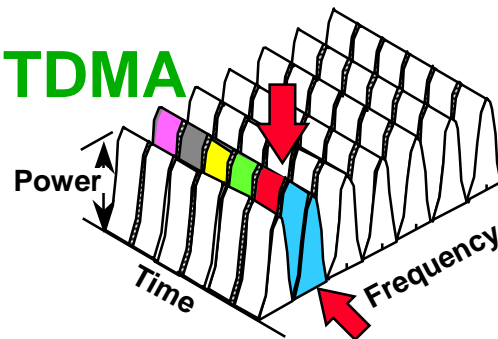
FDMA



Frequency Division Multiple Access

- A user's channel is a private frequency

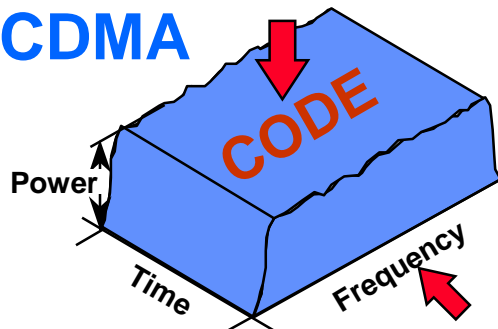
TDMA



Time Division Multiple Access

- A user's channel is a specific frequency, but it only belongs to the user during certain time slots in a repeating sequence

CDMA

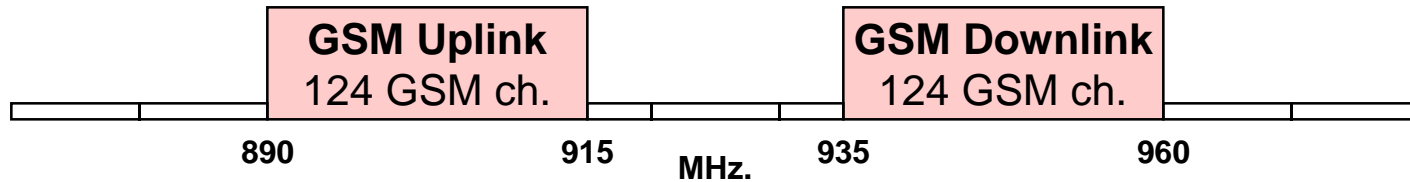


Code Division Multiple Access

- Each user's signal is a continuous unique code pattern buried within a shared signal, mingled with other users' code patterns. If a user's code pattern is known, the presence or absence of their signal can be detected, thus conveying information.

The Frequencies Used by GSM

900 MHz. Europe and International

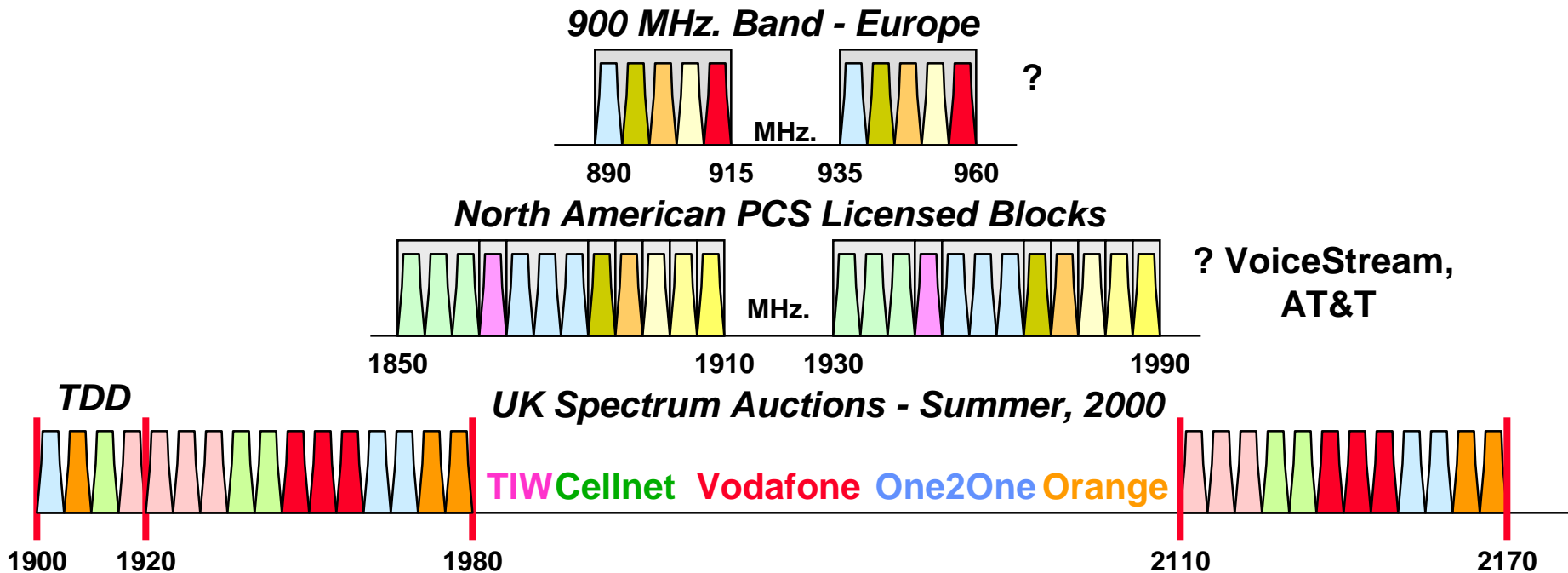


1900 MHz. North American PCS Licensed Blocks



- GSM operates in a variety of frequency bands worldwide
- GSM carrier frequencies are normally assigned in 200 KHz. Increments within the operator's licensed block of spectrum
- Spectrum is provided in "blocks"
 - Base stations transmit in the upper block
 - Mobiles transmit in the lower block
- Each cell uses a certain number of carriers, called its "allocation"

W-CDMA Potential Frequency Deployment



- Auctions just completed in the UK divided spectrum as shown and raised more than \$US34 Billion. UMTS W-CDMA is expected to deploy as shown for the five winner companies
- The US PCS 1900 MHz. Block is usable for W-CDMA and the hypothetical W-CDMA carriers are shown. Voicestream and AT&T Wireless are expected to deploy at least one carrier each
- Will there ever be W-CDMA over the ashes of the GSM 900 MHz. allocation?

W-CDMA vs cdma2000

Comparison of IS-2000 and W-CDMA

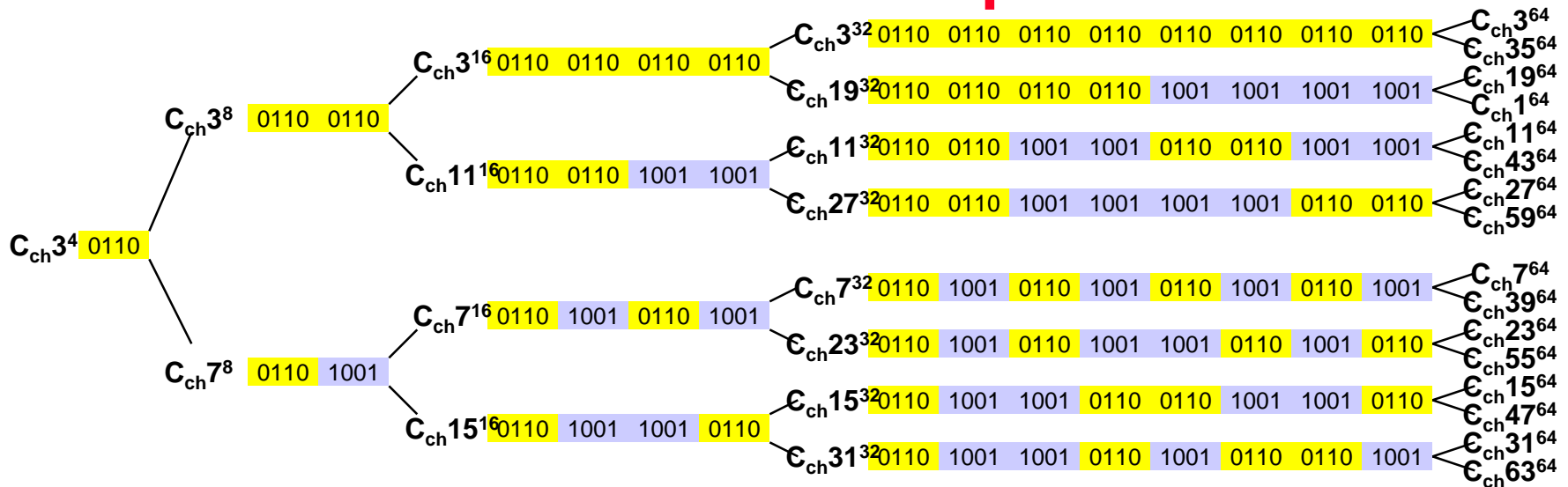
Parameters	3GPP2 (cdma2000)	3GPP (W-CDMA)
Multiple Access Technique and duplexing scheme	Multiple access: DS-CDMA (UL) MC-CDMA(DL) Duplexing: FDD	Multiple Access: DS-CDMA Duplexing: FDD
Chip Rate	$N \times 1.2288$ Mchip/s ($N = 1,3,6,9,12$)	3.84 Mchips/s
Pilot Structure	Code-divided continuous dedicated pilot (UL) Code-divided continuous common pilot (DL) Code-divided continuous common or dedicated auxiliary pilot (DL)	Dedicated pilots (UL) Common and/or dedicated pilots (DL)
Frame Length	5, 10, 20, 40, 80 ms	10 ms with 15 slots
Modulation and Detection	Data modulation: UL-BPSK DL-QPSK Spreading modulation: UL-HPSK DL-QPSK Detection: pilot-aided coherent detection	Data mod:UL-dual channel QPSK; DL-QPSK Spreading modulation: QPSK Detection: pilot-aided coherent detection
Channelization Code	Walsh Codes (UL) Walsh Codes or quasi-orthogonal codes(DL)	Orthogonal variable spreading factor codes
Scrambling Code	Long code (period $2^{42}-1$ chips for $N=1$) Short PN code (period $2^{15}-1$ chips for $N=1$) $N =$ spreading rate number	UL - short code (256 chips from family of $S(2)$ codes or long code (38,400 chips, Gold-code-based) DL: Gold-code-based
Access Scheme	RsMa - flexible random access scheme Allowing three modes of access: -Basic Access -Power controlled Access -Reserved access Designated access scheme - access scheme initiated by the base station message	Acquisition-indication-based random access mechanism with power ramping on preamble followed by message
Inter-base-station operation	Synchronous	Asynchronous Synchronous (optional)

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

The Codes of W-CDMA

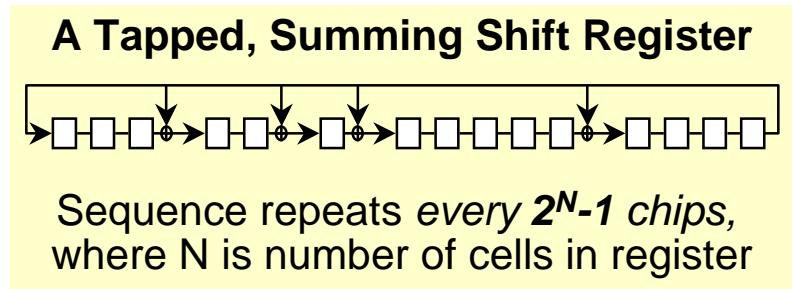
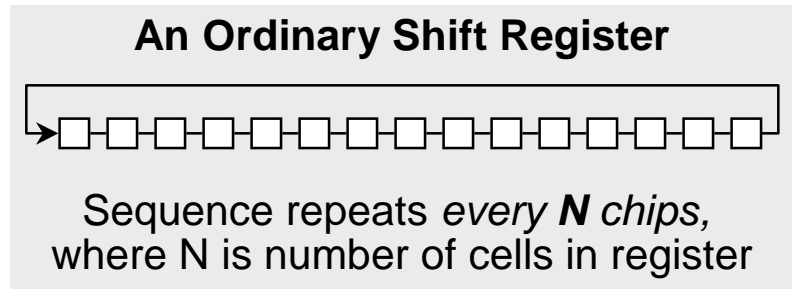
OVSF Trees and Interdependencies



- Entire OVSF matrices can be built by replicating and inverting -- Individual OVSF sequences can also be expanded in the same way.
- CDMA adds each symbol of information to one complete OVSF code
- Faster symbol rates therefore require shorter OVSF codes
- If a short OVSF is chosen to carry a fast data channel, that OVSF and all its replicative descendants are compromised and cannot be reused to carry other signals
- Therefore, the supply of available OVSF codes on a sector diminishes greatly while a fast data channel is being transmitted!

PN M-Sequences: Generation & Properties

- Maximal-length sequences used in W-CDMA are generated in linear shift registers
- Plain shift register: no fun, sequence = length of register
- Tapped shift register generates a wild, self-mutating sequence 2^N-1 chips long (N=register length)
 - Such sequences match if compared in step (no-brainer, any sequence matches itself)
 - Such sequences appear approximately orthogonal if compared with themselves not exactly matched in time
 - Cross-correlation typically <2%



A Special Characteristic of Sequences Generated in Tapped Shift Registers

Compared In-Step: Matches Itself

Sequence:

Self, in sync:

Sum: Complete Correlation: All 0's

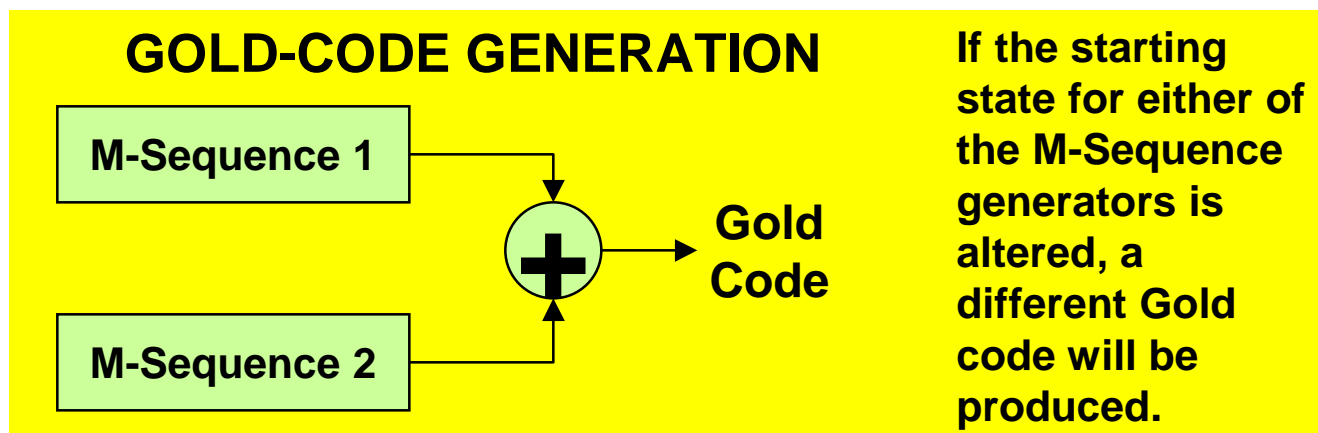
Compared Shifted: Little Correlation

Sequence:

Self, Shifted:

Sum: Practically Orthogonal: Half 1's, Half 0's

PN Sequences: Gold Codes



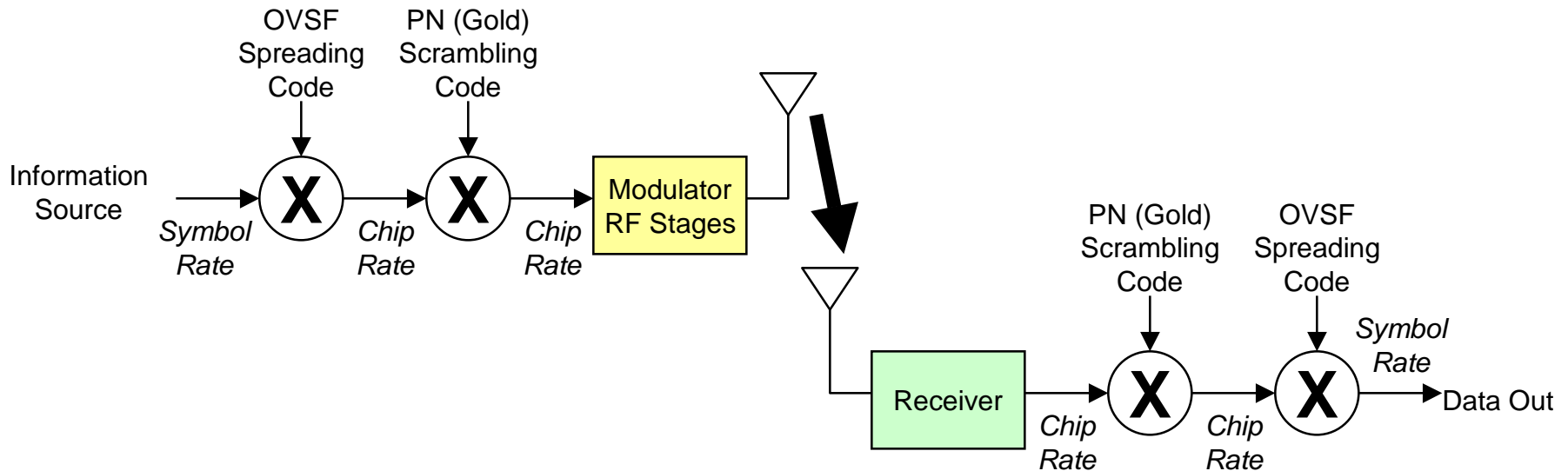
- Gold Codes were first described by R. Gold in 1967
 - Gold described a method for generating a PN sequence from a pair of primitive polynomials
- Gold Codes have defined and bounded cross-correlation
 - The cross-correlation can be much less than that achieved from M-sequences alone
- Gold Codes also provide a larger number of available codes than can be achieved using M-sequences alone

UMTS

Air Interface - Physical Layer

Spread Spectrum Basics

Spreading and Scrambling



- At the transmitter, the information source provides symbols
 - The symbols are applied to a spreading code
 - The resulting chip-rate spread signal is applied to a Scrambling Code
 - The resulting chip-rate spread/scrambled signal modulates the transmitter
- The Receiver recovers the signal and the same scrambling code descrambles it
 - Next the spreading code de-spreads the signal, yielding the original symbol-rate data

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)

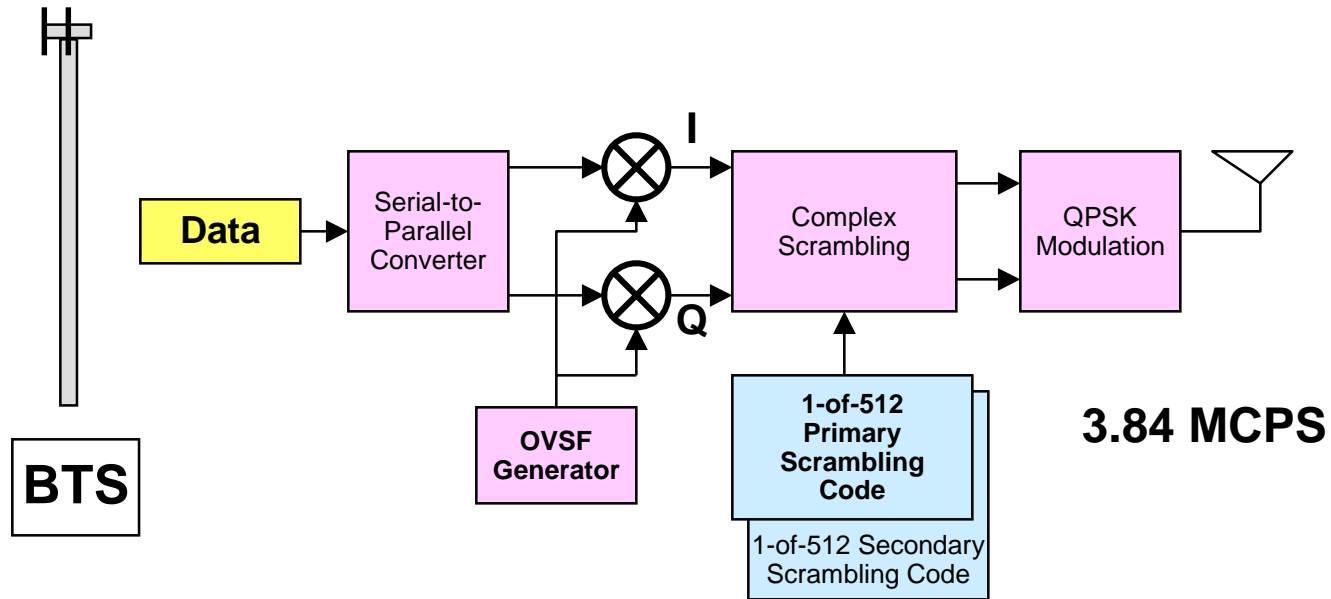
■ Uplink

- 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

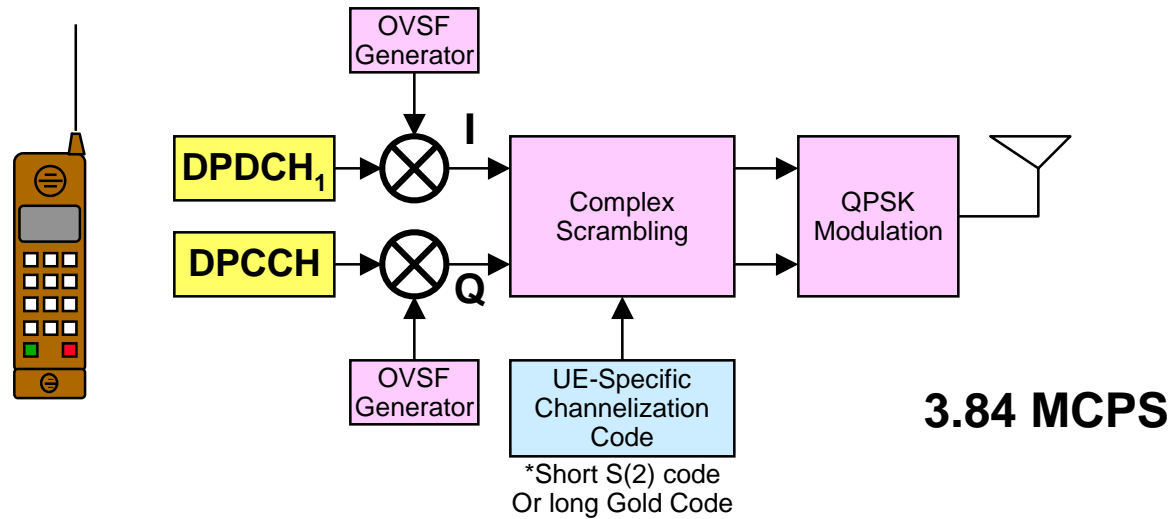
- Orthogonal OVSF codes are used for channelization
- OVSF codes are used from a tree structure
 - This ensures that only orthogonal codes are used

Downlink Spreading and Modulation



- Data modulation is QPSK
- Each pair of two bits are serial-parallel converted and mapped to the I and Q branches
 - I and Q are then spread to chip rate with an OVSF unique for the specific channel
- Complex spreading is performed with one of 512 primary scrambling codes; at least the primary CCPCH is scrambled this way
- Other downlink physical channels can be transmitted scrambled with the primary scrambling code or with a secondary scrambling code from the set of 511 associated with the particular 1-of-512 primary scrambling code

Uplink Spreading and Modulation



- Dual-channel QPSK is used
- DPCCH channel mapped to Q, first DPDCH mapped to I
 - Subsequently-mapped DPDCHs can be mapped to I or Q
- I and Q are then spread to chip rate with two different OVSF codes
- In an ordinary BTS, a 38.4K-long Gold Code is used for complex scrambling
 - In BTS with advanced receiver, a 256 code from the S(2) family is used instead

UMTS

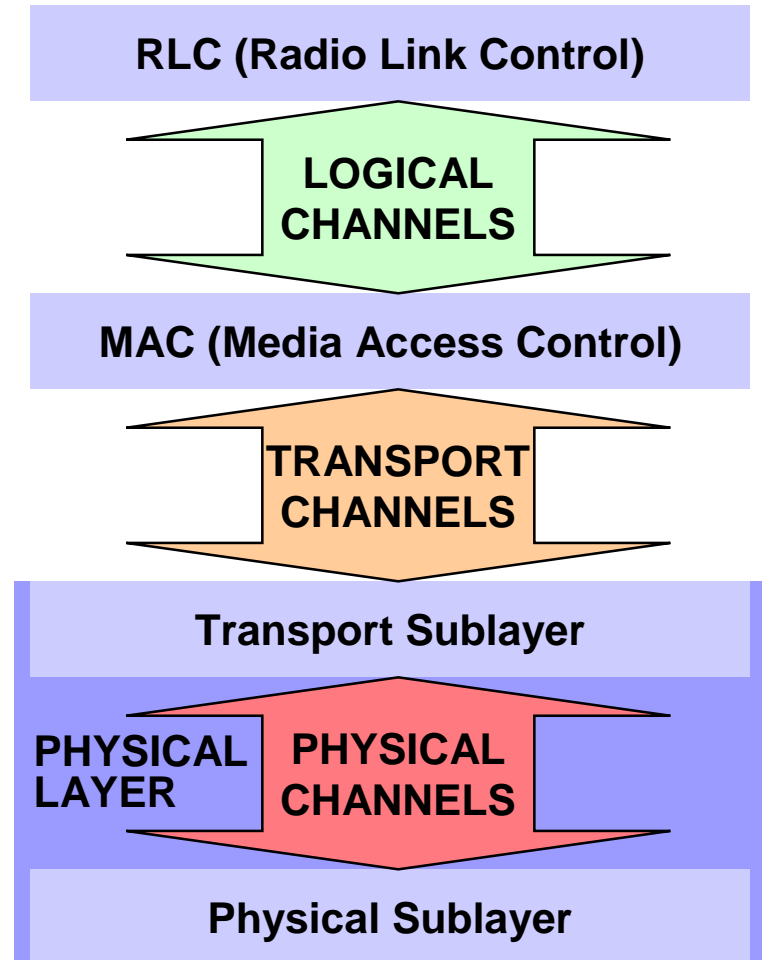
The Channels of UMTS

The Channels of UMTS

- In UMTS, information and traffic flow through three types of channels:
- Logical Channels - analogous to airline companies
 - Logical channels are functional, conceptual groupings of information and/or traffic
 - At this level, it is easy to understand the purposes and objectives of the channels, the types of activities being carried out on each channel, and the call processing steps involved
- Transport Channels - analogous to scheduled flights
 - Transport channels are the intermediate, individual flows of information which carry subcomponents of the logical channels and which are represented by bits on the physical channels
- Physical Channels - analogous to individual aircraft
 - These are the real over-the-air channels made up of bits
 - At this level, the channels are just patterns of bits - multiframe, frames, timeslots, and the various fields of bits which are defined to occupy them

Channels and the Protocol Stack

- The mapping between Logical and Transport channels is performed by the LAC layer
- The mapping between Transport and Physical channels is performed by the Physical layer



W-CDMA Logical Channels

DOWNLINK

UPLINK



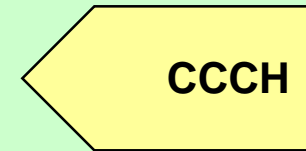
BROADCAST CONTROL CHANNEL
System Control Information for all users
Configuration and Parameters



DEDICATED CONTROL CHANNEL
A private channel carrying control information
between one user and the network



COMMON CONTROL CHANNEL
A shared channel carrying control information
Between many users and the network



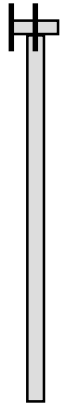
PAGING CONTROL CHANNEL
A shared channel carrying paging information
Between the network and many users



DEDICATED TRAFFIC CHANNEL
A private bi-directional channel carrying
traffic between one user and the network



COMMON TRAFFIC CHANNEL
A shared channel carrying traffic from the
network to many users or to groups of users



BTS



W-CDMA Logical Channels (1)

- The following logical channels are defined for W-CDMA
- **BCH** Broadcast Channel
 - Carries system and cell-specific information; always transmitted over the entire cell with a low fixed bit rate
- **FACH** Forward Access Channel
 - Carries control information from base station to mobile in one cell when the system knows the location cell of the mobile
 - May also carry short user packets
 - May be transmitted over whole cell or over a portion using lobe-forming antennas
- **PCH** Paging Channel
 - For messages to the mobiles in the paging area
- **RACH** Random Access Channel
 - Uplink channel used to carry control information from the UE
 - May also carry short user packets
 - Always received from the entire cell

W-CDMA Logical Channels (2)

■ CPCH Common Packet Channel

- Carries small and medium-sized packets
- A contention-based, random access channel used for transmission of bursty data traffic
- Associated with a dedicated channel on the downlink, which provides power control for the uplink CPCH

■ DCH Dedicated Channel

- A downlink or uplink channel used to carry user or control information between the network and the UE
- Corresponds to three channels:
 - DTCH Dedicated Traffic Channel
 - SDCCH Stand-Alone Dedicated Control Channel
 - ACCH Associated Control Channel
- Transmitted over the whole cell or only a part using lobe-forming antennas
- May have fast rate changes (even every 10 ms), and fast power control

W-CDMA Transport Channels

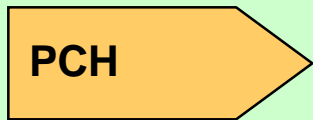
DOWNLINK

UPLINK



BROADCAST CHANNEL
 Low fixed bit rate, transmitted over the
 Entire sector coverage area

*Configuration
 information*



PAGING CHANNEL
 Uses efficient sleep/slotted-mode procedures
 Transmitted over entire sector coverage area

*Pages,
 Notifications*

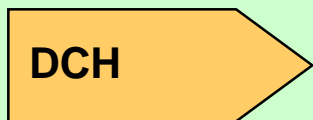
*Contention-based,
 Access, SMS*

RANDOM ACCESS CHANNEL
 Limited data fields, risk of collisions,
 Power control is open loop



FORWARD ACCESS CHANNEL
 Data rate can change each frame (10 ms)
 No fast power control; can use beam-forming

*Common downlink
 For small bursts*

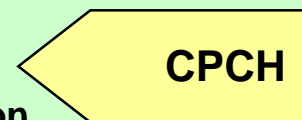


DEDICATED CHANNEL
 Data rate can change each frame (10 ms)
 Fast power control; can use beam-forming



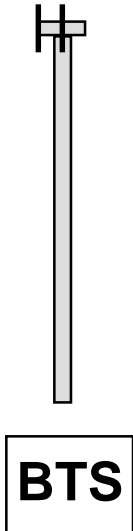
*Contention-based,
 Bursty traffic*

COMMON PACKET CHANNEL
 Change data rates fast; Open-loop ramp-up
 Fast power control; beam-forming, collision detection

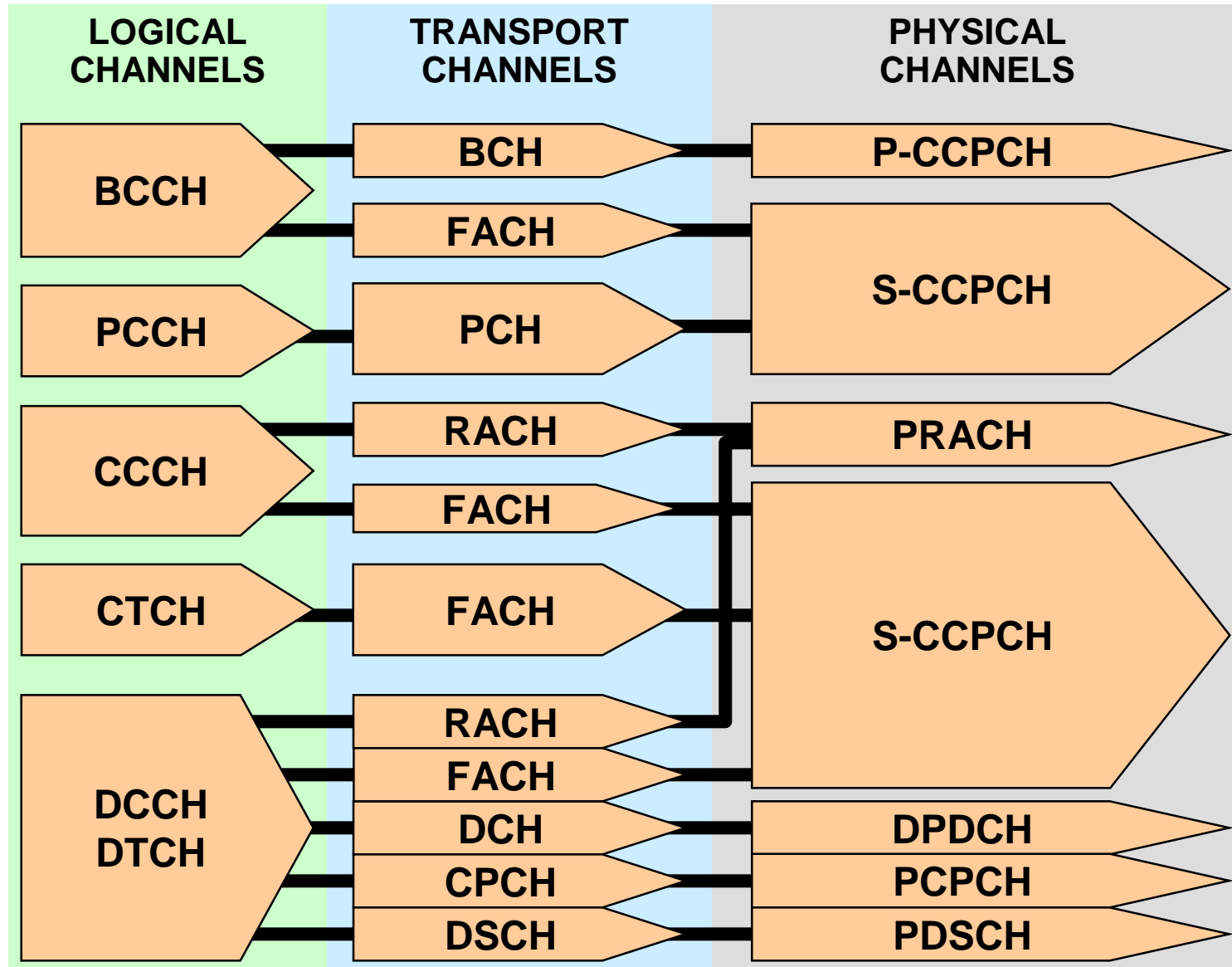


DOWNLINK SHARED CHANNEL
 Fast power control; can use beam-forming
 Belongs to just one DCH

*Shared control or
 Bursty traffic*



Logical, Transport, Physical Channel Mapping



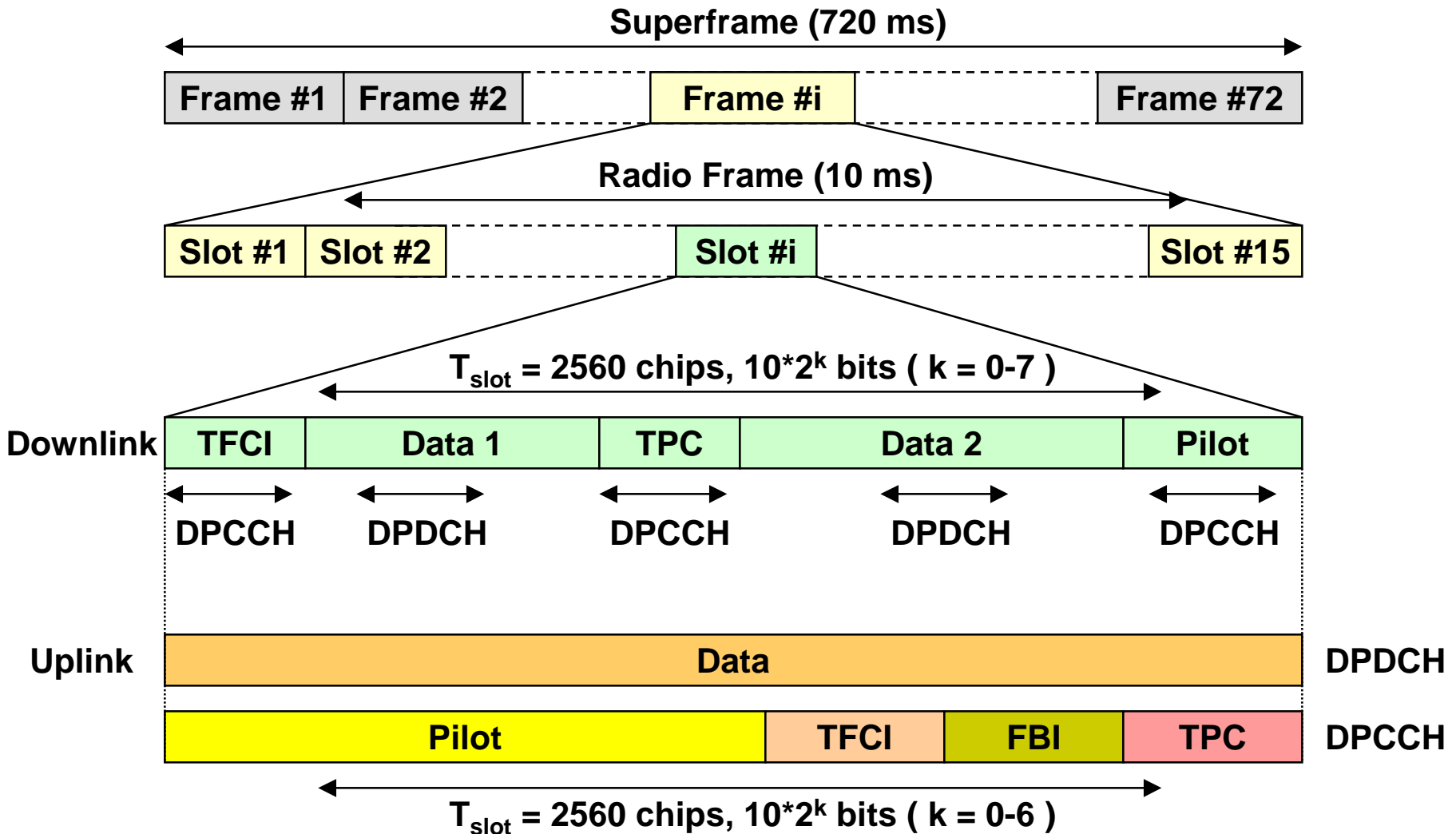
UMTS

Physical Channel Details

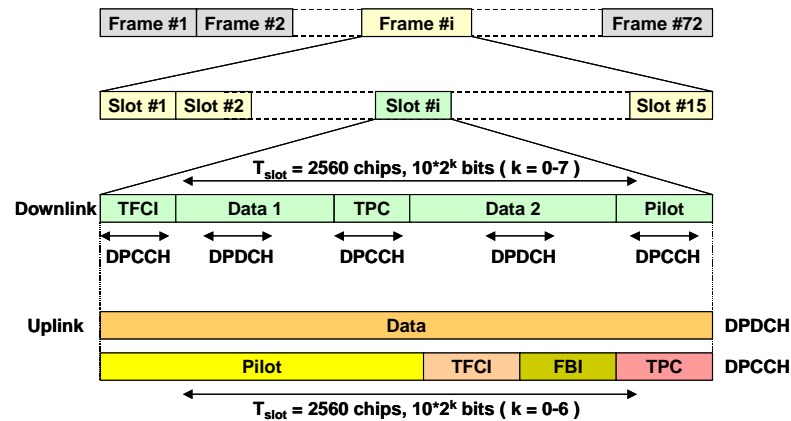
Physical Channel Details

- W-CDMA physical channels typically consist of a three-layer structure of superframes, radio frames, and time slots
 - Depending on the symbol rate of the physical channel, the configuration of the radio frames or time slots varies
- A Superframe has a duration of 720 ms and consists of 72 radio frames
- A Radio Frame is a processing unit with 15 time slots
- A time slot is a unit containing information symbols
 - The number of symbols per time slot depends on the physical channel
- A physical channel corresponds to a specific
 - Carrier frequency
 - Code
 - On the uplink: Relative phase (0 or $\pi/2$)

Dedicated Physical Channel Frame Structure

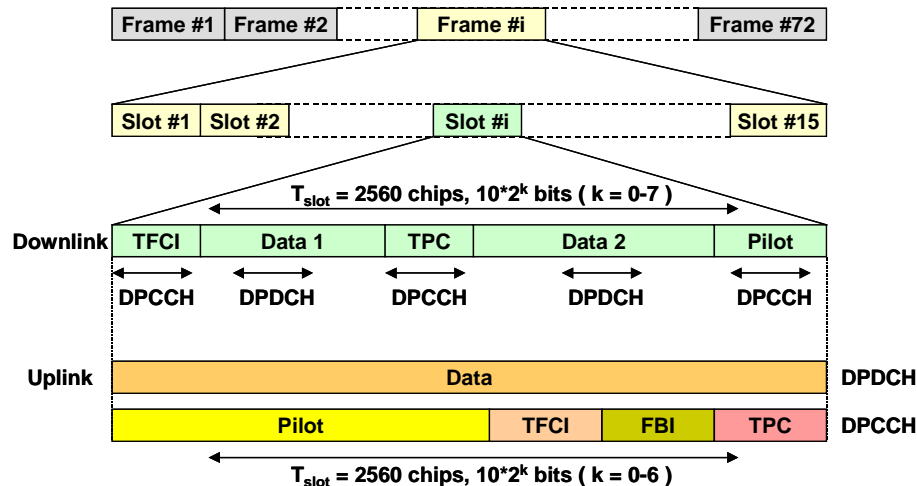


Physical Frame Structure



- Each radio frame of 10 ms is split into 15 slots
- Uplink Physical Channels DPDCH and DPCCH are I/Q multiplexed
- Downlink Physical Channels are time-multiplexed within each slot
 - DPCH, the channel on which user data is transmitted, is always associated with a DPCCH containing layer 1 information
 - The Transport Format Combination Indicator field is used to indicate the demultiplexing scheme of the data stream
 - The TFCI field does not exist for static (fixed bit rate allocations) or where blind transport format detection is used
 - The Feedback Information (FBI) field is used for transmit and site diversity functions
 - The Transmit Power Control bits are used for power control
 - On the downlink, a number of dedicated pilot bits may be included

Physical Channel Bit Rates



Uplink

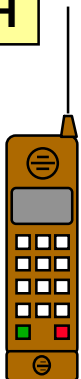
- Maximum physical channel bit rate is 960 kb/s using a spreading factor of 4
- A user may use several physical channels to obtain higher bit rates
- The channel bit rate of the DPCCH is fixed at 15 kb/s
- The maximum uplink spreading factor is 256

Downlink

- Maximum channel bit rate is 1920 kb/s with a spreading factor of 4
- The maximum downlink spreading factor is 512

Uplink Physical Channels

- There are two dedicated channels and one common channel on the uplink
- DPDCH Dedicated Physical-Data Channel
 - Carries user data
- DPCCH Dedicated Physical Control Channel
 - Carries control information
- PRACH Physical Random Access Channel
 - A common-access channel
- In most cases, only one DPDCH is allocated per connection
 - Services are jointly interleaved using the same DPDCH
 - However, multiple DPDCHs can be allocated
 - For example, to avoid a too-low spreading factor at high data rates



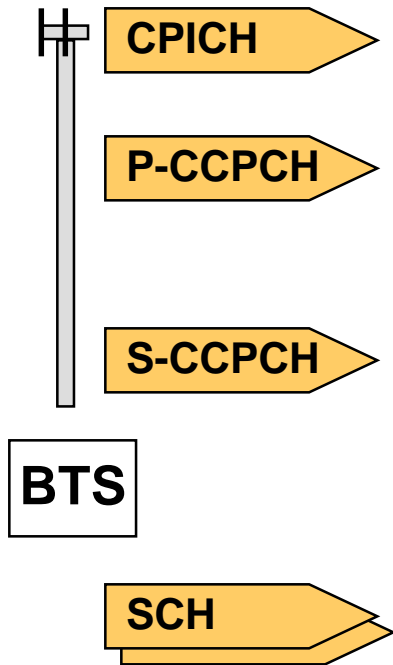
DPCCH Dedicated Physical Control Channel

- The DPCCH is needed to transmit pilot symbols
 - For coherent reception
 - Power control signaling bits
 - Rate information for rate detection
- The physical control and data channels can be
 - Time-multiplexed
 - Resulting gating of transmission may cause electromagnetic interference to hearing aids, etc
 - Code-multiplexed
 - Preferred method; dual-channel QPSK carries I and Q channels

W-CDMA Random Access

- W-CDMA random access is based on slotted-Aloha technique with fast acquisition indication
- The Mobile can start the transmission at any of many well-defined time offsets
 - All relative to the frame boundary of every second frame of the received BCH of the current cell
 - These time offsets are called “access slots”
 - There are 15 access slots per two frames, spaced 5120 chips apart
 - The BCH tells what access slots are available on the current cell
- Before transmitting a random access request, the mobile
 - Achieves chip, slot, and frame synchronization on target BTS
 - Gets downlink scrambling code from SCH
 - Gets random access code(s) used in the sector from the BCCH
 - Estimates downlink path loss to calculate open loop transmit power
- There are also special provisions for including packet data in a burst if desired

Downlink Physical Channels



- On the downlink, there are four common physical channels
- CPICH Common Pilot Channel
 - Facilitates coherent detection
- P-CCPCH Primary Common Control Physical Channel
 - Fixed data rate, Used to carry the BCH
 - Same OVSF in every cell, easy for UE to find
- S-CCPCH Secondary Common Control Physical Channel
 - Carries PCH and FACH time-multiplexed
 - May be different rates in different cells due to activity
 - OVSF of S-CCPCH is given on P-CCPCH
- SCH Synchronization Channel: subchannels Primary and Secondary
 - short code masking speeds long code acquisition
 - Unmodulated P-SCH gives timing for S-SCH
 - Modulated S-SCH gives long code group for this BTS
 - This greatly speeds long code acquisition

SCH Coding

- The Primary SCH consists of an unmodulated code 256 chips long
 - Transmitted once every slot
 - The same code is used for every base station in the system
 - Transmitted time-aligned with the slot boundary
- The Secondary SCH consists of one modulated code 256 chips long, transmitted in parallel with the Primary SCH
 - The code is one of 8, determined by the code group set to which the base station's downlink scrambling code belongs
 - S-SCH is modulated by a binary sequence 16 bits long, repeated each frame
 - The same sequence is used for each BTS and has good cyclic autocorrelation
- The SCH is transmitted intermittently (one codeword per slot)
 - Multiplexed with DPDCH/DPCCH and CCPCH after long code scrambling
 - So SCH is non-orthogonal to the other downlink physical channels

Downlink Dedicated Physical Channel

DPCH

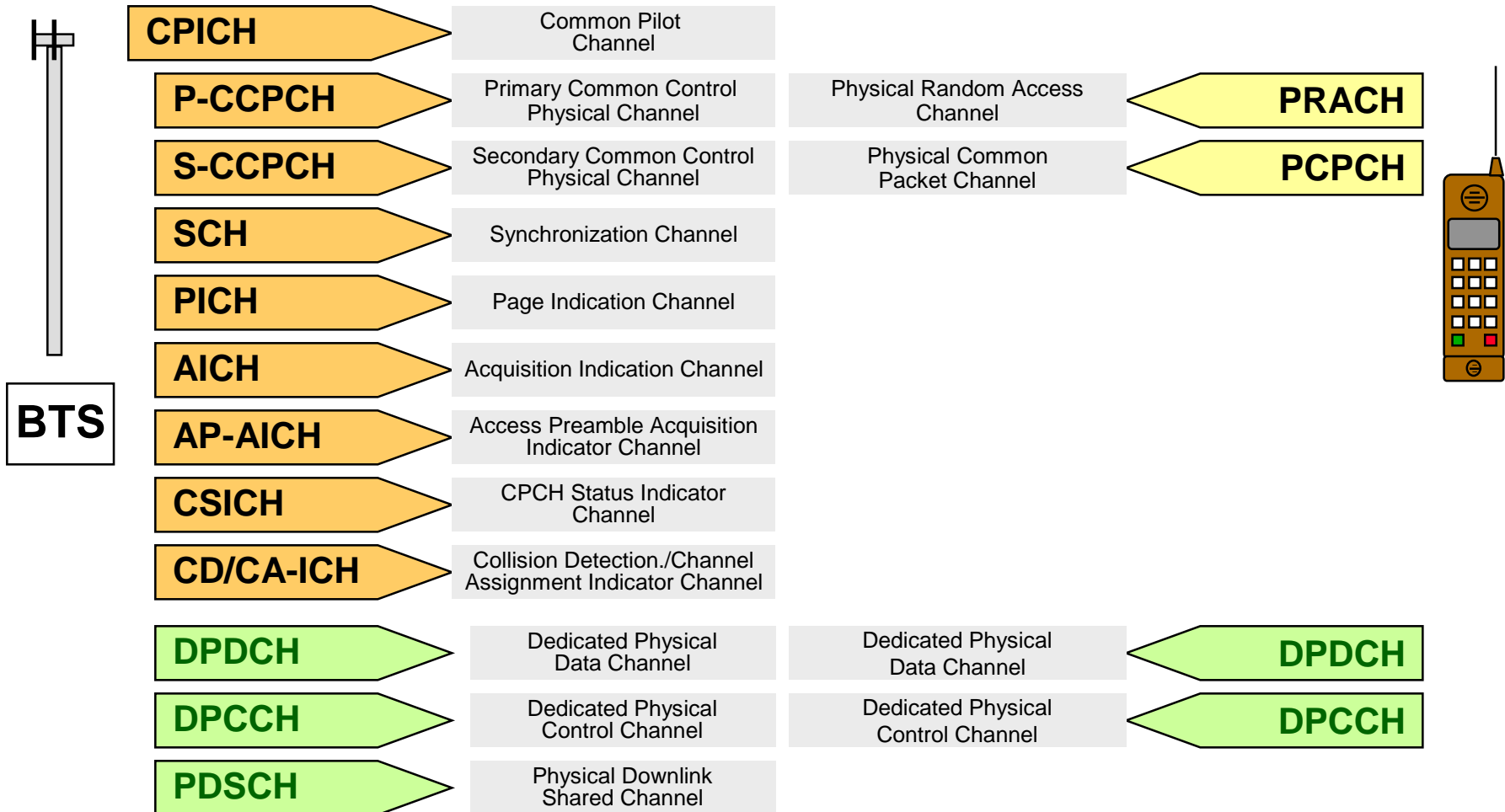
■ DPCH Dedicated Physical Channel

- This is the only dedicated channel on the downlink
- Data in one DPCH is time-multiplexed with control information from Layer 1
 - Known pilot bits, TPC commands, optional Transport Format Combination Indicator (TFCI)

W-CDMA Physical Channels

DOWNLINK CHANNELS

UPLINK CHANNELS



Physical Channel Details (1)

■ DPCH - Dedicated Physical Channel

- A downlink or uplink dedicated physical channel used to carry user or control information to User Equipment (UE) over an entire or cell or part of the cell that uses beamforming antennas

■ PRACH - Physical Random Access Channel

- A common uplink physical channel used to carry control information or short user packets from the UE

■ PCPCH - Physical Common Packet Channel

- A common uplink physical channel used to carry short and medium-sized user packets. It's always associated with a downlink channel for power control

■ CPICH - Common Pilot Channel

- A fixed-rate downlink physical channel that carries a predefined bit/symbol sequence

Physical Channel Details (2)

■ P-CCPCH Primary Common Control Physical Channel

- A fixed-rate downlink channel used to broadcast system and cell-specific information
- The P-CCPCH is not transmitted during the first 256 chips of each slot (i.e., it maintains a 90% duty cycle)

■ S-CCPCH Secondary Common Control Physical Channel

- A downlink physical channel used to carry the FACH and PCH transport channel

■ SCH Synchronization Channel

- A downlink signal used for cell search. The SCH consists of two subchannels, the primary and secondary SCH, which are transmitted during the P-CCPCH idle period

■ PDSCH

- A downlink channel used to carry the DSCH transport channel

Physical Channel Details (3)

■ AICH Acquisition Indicator Channel

- A fixed-rate downlink physical channel used to carry access preamble acquisition indicators for the random access procedure

■ AP-AICH Access Preamble Acquisition Indicator Channel

- A fixed-rate downlink physical channel used to carry access preamble acquisition indicators of CPCH

■ PICH Paging Indicator Channel

- A fixed-rate downlink physical channel used to carry the paging indicators which disclose the presence of a page message on the PCH

■ CSICH - CPCH Status Indicator Channel

- A fixed-rate downlink channel used to carry CPCH status information
- A CSICH is always associated with a physical channel used for transmission of CPCH AP-AICH, and uses the same channelization and scrambling codes

Physical Channel Details (4)

- CD/CA-ICH Collision-detection/Channel-Assignment Indicator Channel
 - A fixed-rate common downlink physical channel used to carry CD indicator only if the CA is not active, or a CD/CA indicator at the same time if the CA is active
- CDM Continuous Code Division Multiplex Pilot Channel
 - Similar to the cdma2000 pilot
 - Two types of pilot channels are defined:
 - Primary CPICH (P-CPICH)
 - Transmitted over the entire cell
 - Used as phase reference for SCH, P-CCPCH, AICH, PICH, and default reference for all other downlink physical channels
 - Secondary CPICH (S-CPICH)
 - Can be transmitted over part of the cell, not entire cell. May be used as reference for the S-CCPCH and downlink DPCH, or in beamforming antenna schemes

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Special Topics

Multirate

- Multiple services of the same connection are multiplexed on one DPDCH
 - After service multiplexing and channel coding, the multiservice data stream is mapped to one DPDCH
 - If the total rate exceeds the upper limit for single code transmission, several DPDCHs are allocated
- A second alternative for service multiplexing is to map parallel services to different DPDCHs in a multicode fashion with separate channel coding and interleaving
 - This allows independent control of the power and quality of each service
 - For BER 10^{-3} services, convolutional coding of 1/3 is used
 - For high bit rates, a code rate of 1/2 can be used
 - For higher quality service classes, parallel concatenated convolutional code is used
- Retransmission can be used to guarantee service quality

Rate Matching

- After channel coding and service multiplexing, the total bit rate can appear quite arbitrary!
 - The rate matching adapts this rate to the limited set of possible bit rates of a DPDCH
 - Repetition or puncturing is used to match the coded bit stream to the channel gross rate
- For Uplink, rate matching to the closest uplink DPDCH rate is always based on unequal repetition or code puncturing
 - Puncturing is chosen for bit rates less than 20% above
 - In all other cases, unequal repetition is performed
- For Downlink, rate matching to the closest DPDCH rate, using unequal repetition or code puncturing, is only made for the highest rate of a variable rate connection

Packet Data

- W-CDMA has two types of Packet Data transmission modes
- Common Channel Packet Transmission
 - Short Data Packets can be appended directly to a random access burst
 - Used for short infrequent packets, where link maintenance to set up a dedicated channel would cause unacceptable overhead
- Dedicated Channel Packet Transmission
 - Larger or more frequent packets are transmitted on a dedicated channel
 - A large single packet is transmitted using a scheme where the channel is released immediately after the packet has been transmitted
 - In a multipacket scheme, the dedicated channel is maintained by transmitting power control and synchronization information between subsequent packets

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UMTS Handovers

Soft Handover

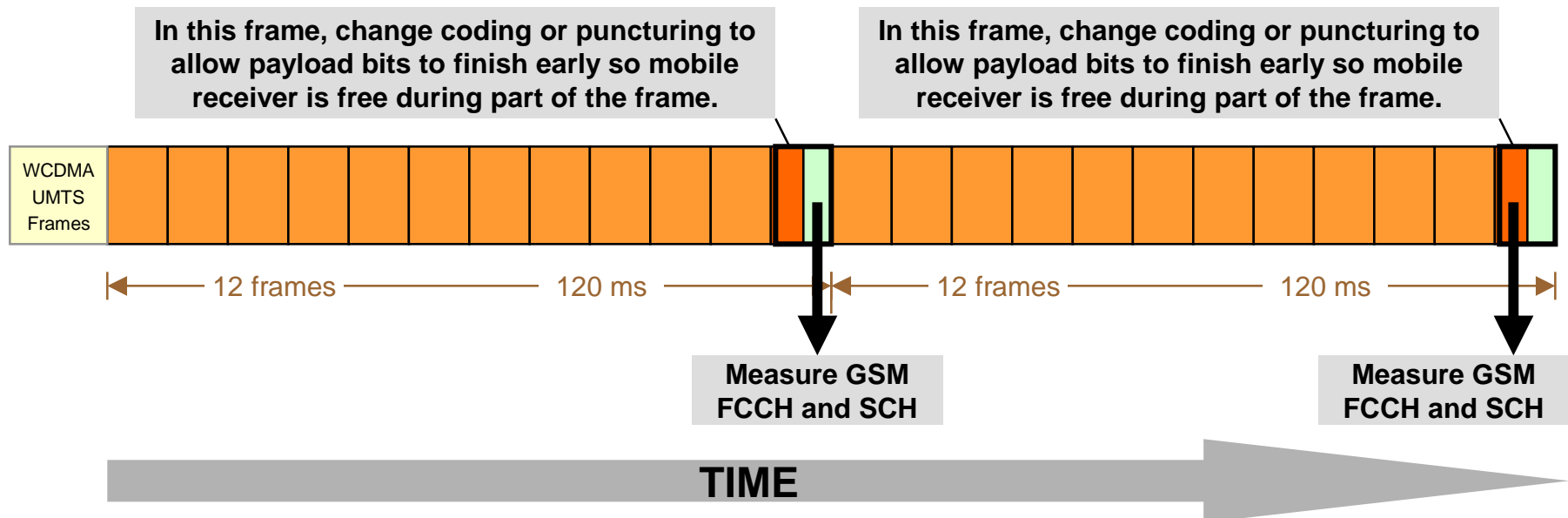
- Before entering soft handover, the mobile
 - Measures the observed timing differences of the downlink SCHs from the two (!!!!!) base stations
 - Reports the timing differences back to the serving base station
- The timing of the new downlink soft handover connection is adjusted with a resolution of one symbol
 - This enables the rake receiver in the mobile to collect the macrodiversity energy from the two base stations
 - Timing adjustments of dedicated downlink channels is carried out with a resolution of one symbol without losing orthogonality of the downlink codes

Interfrequency Handovers

- Interfrequency handovers arise during utilization of hierarchical cell structures (macro, micro, indoor cells)
 - Several carriers and interfrequency handovers may also be used for taking care of high capacity needs in hot spots
 - Interfrequency handovers are also needed to second-generation systems such as GSM or IS-95
 - An efficient method is needed for making measurements on other frequencies while still having the connection running on the current frequency
- Two methods are available to do interfrequency measurements in WCDMA: Dual Receiver and Slotted Mode
 - Dual receiver is considered feasible especially if the mobile uses antenna diversity
 - One receiver branch can be switched to the other frequency
 - Slotted Mode is necessary if the receiver has no diversity
 - The information transmitted during a 10 ms frame is compressed by puncturing or changing the FEC rate and the mobile is free to make a quick measurement on the other frequency

WCDMA-GSM Handovers Measurement Process

- Since GSM use is so widespread, W-CDMA--GSM handovers are quite important
 - The GSM compatible multiframe structure allows similar timing for intersystem measurements as in the GSM system itself
 - The needed measurement interval is not as frequent as for GSM terminals operating in a GSM system



Modes and States - RRC Modes

