

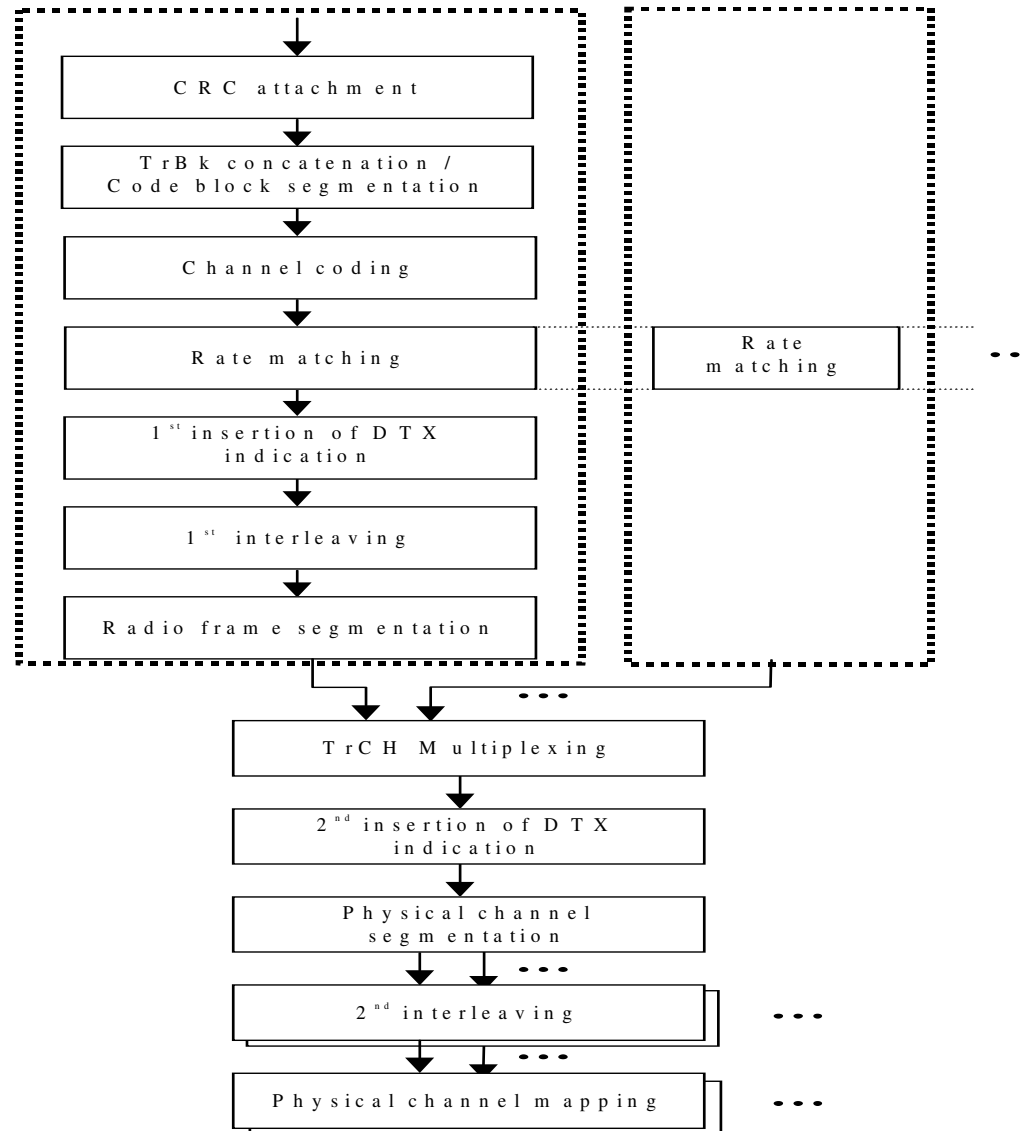
WCDMA Physical Layer

NOKIA

Outline

- Physical Layer Functions
- 3GPP WCDMA Parameters
- Modulation
- Channelization
- Scrambling
- Initial Synchronization

Downlink Channel Transmission



Physical Layer Functions

- Encoding/decoding of transport channels
- Error detection on transport channels and indication to higher layers
- Rate matching/Rate de-matching
- Interleaving
- Multiplexing/De-multiplexing of coded composite transport channels
- Mapping of coded composite transport channels onto physical channels

Physical Layer Functions

- Modulation and spreading / De-spreading and Demodulation of physical channels
- Synchronization
- Soft handover execution
- Power control
- RF Processing, Radio characteristics measurements

3GPP WCDMA Parameters

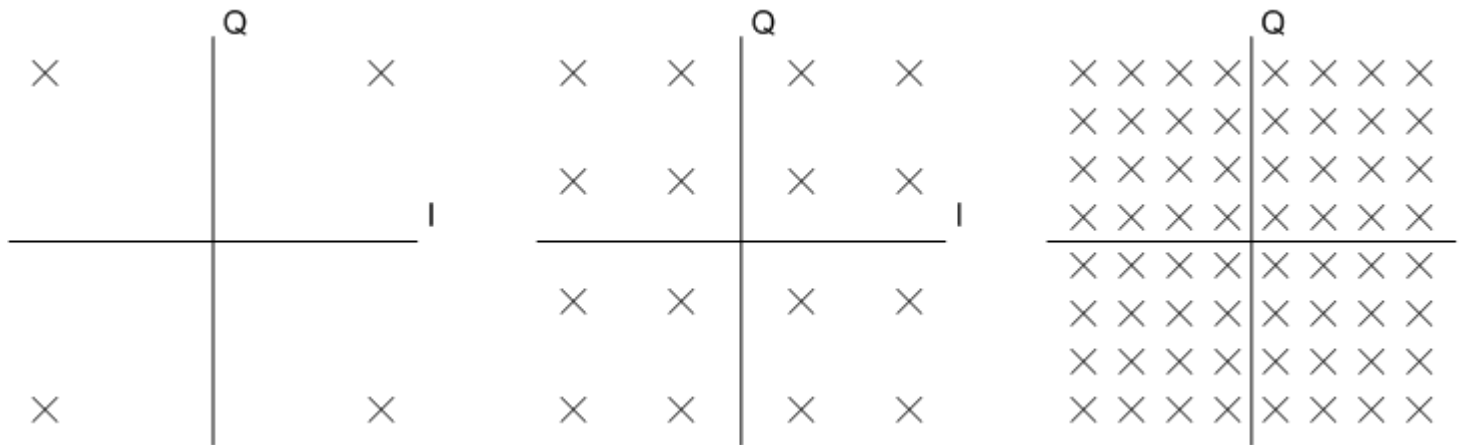
- Carrier spacing = 5MHz
- Chip rate = 3.84Mcps
- Frame Length = 10ms, 15 slots/frame, 2560 chips/slot
- Uplink SF = 4 to 256
- Downlink SF = 4 to 512
- Uplink Modulation – QPSK, 16QAM
- Downlink Modulation – QPSK, 16QAM, 64QAM
- Channelization codes are OVSF codes, Scrambling codes are complex PRN
- Soft handover with up to 6 base-stations is permitted.
- Fast power control commands: 1500Hz.

FDD Operating Bands

• Band	Uplink	Downlink
• I	1920 – 1980 MHz	2110 –2170 MHz
• II	1850 –1910 MHz	1930 –1990 MHz
• III	1710-1785 MHz	1805-1880 MHz
• IV	1710-1755 MHz	2110-2155 MHz
• V	824 – 849 MHz	869-894 MHz
• VI	830-840 MHz	875-885 MHz
• VII	2500-2570 MHz	2620-2690 MHz
• VIII	880 – 915 MHz	925 – 960 MHz
• IX	1749.9-1784.9 MHz	1844.9-1879.9 MHz
• X	1710-1770MHz	2110-2170 MHz

Modulation

- QPSK, 16QAM, 64QAM modulations are supported.
- Based on modulation type used bits are grouped into 2(QPSK), 4(16QAM), 6 (64QAM) to form a symbol
- For each symbol I,Q values to be transmitted are mapped as per 3GPP specs

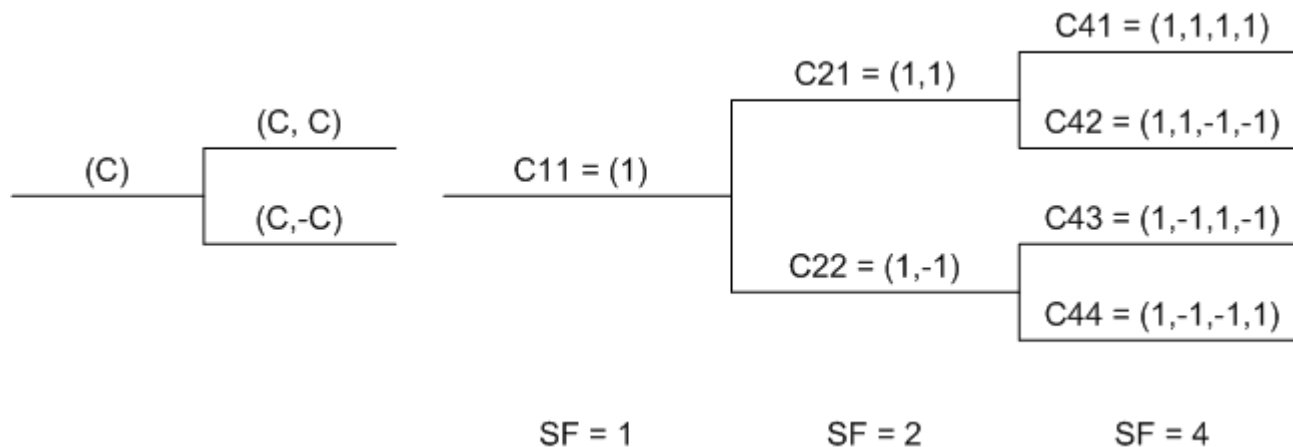


Channelization

- Channelization codes are used to separate different transmissions or channels from the same device
- Each physical channel from a UE or cell uses different channelization code
- Channelization codes do spreading, i.e. increase the signal BW from bit rate to chip rate
- Different UE can use same channelization codes for UL transmission

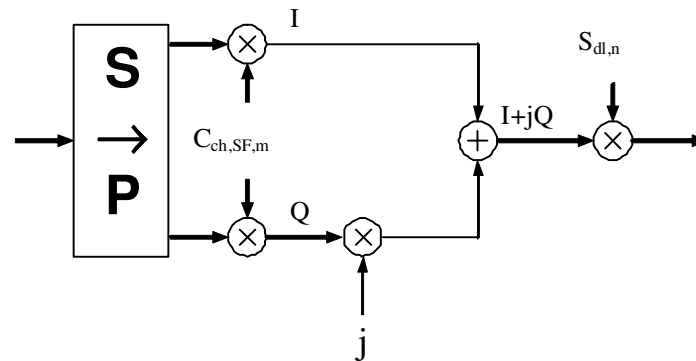
Channelization

- Orthogonal codes, based on OVVSF (orthogonal variable spreading factor) technique are used
- Channelization codes are picked from a code tree
- Once a code is picked, no other codes from its sub-tree can be picked

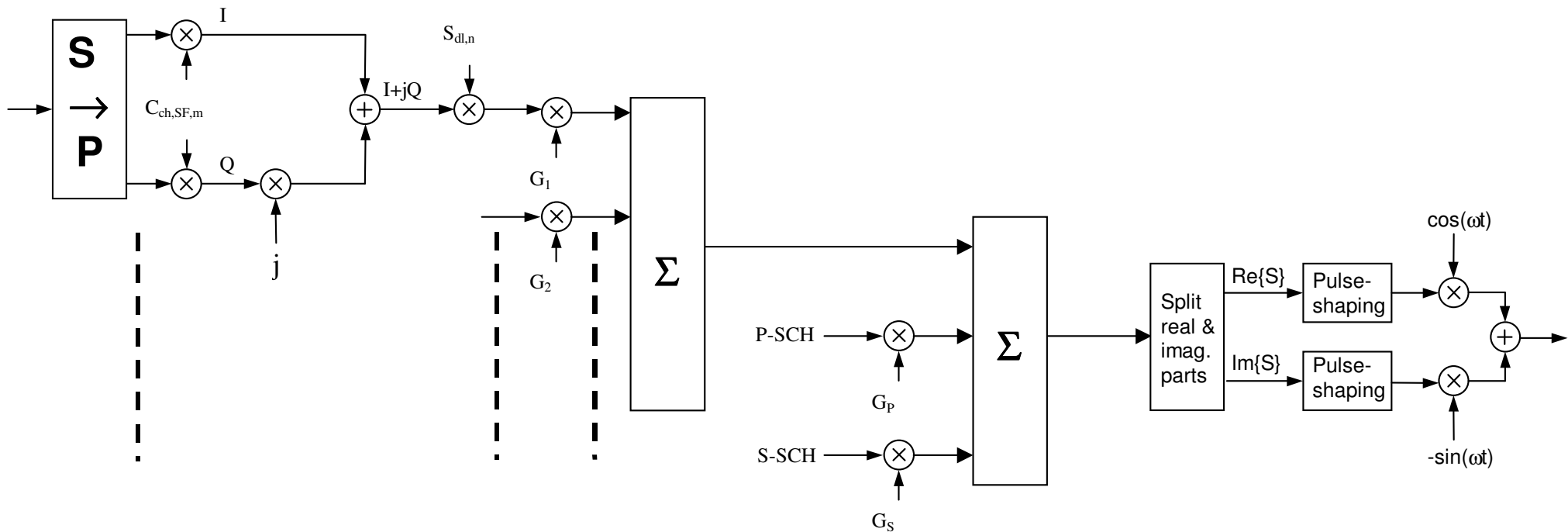


Scrambling

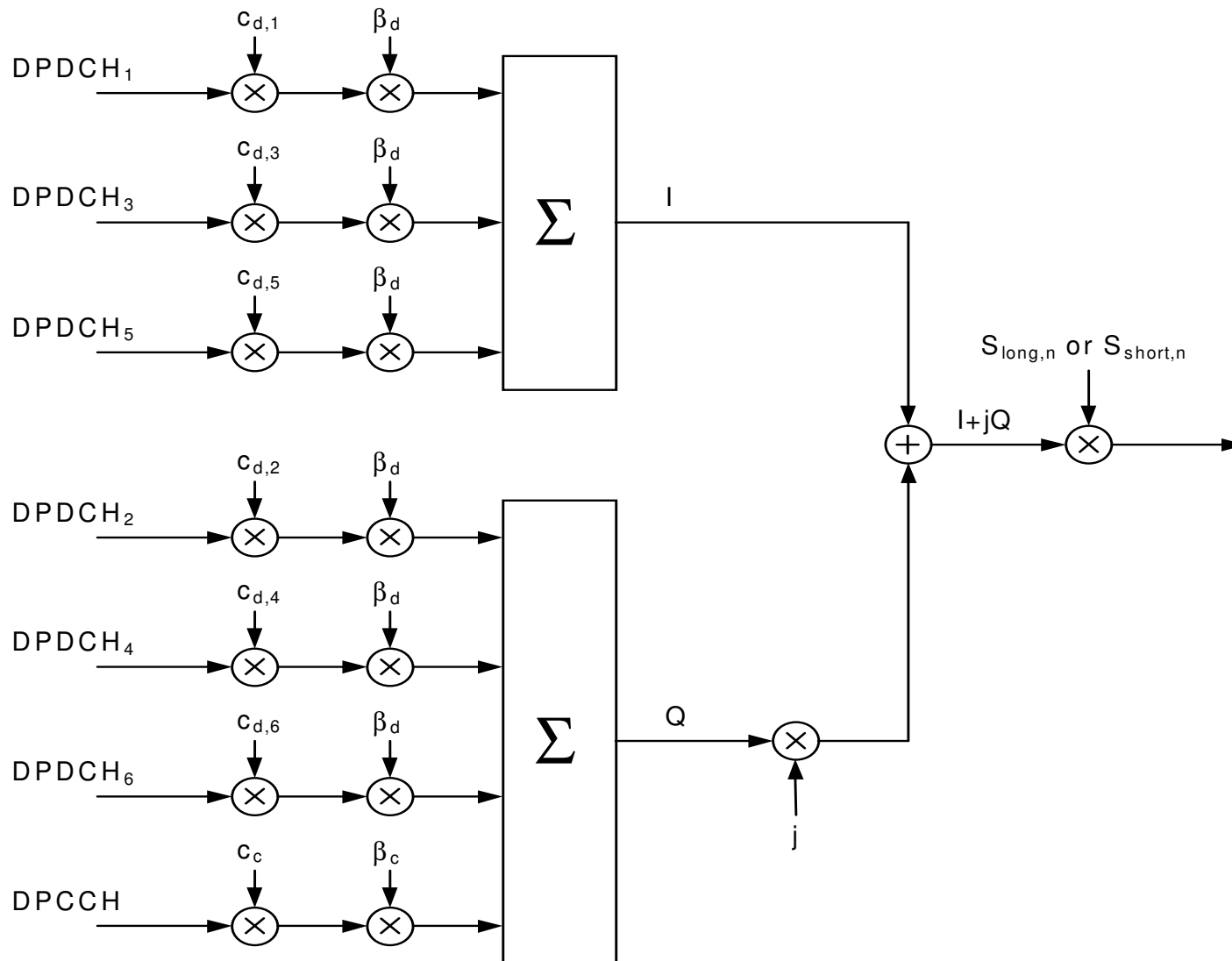
- Scrambling codes are used to separate different transmitting devices
- Each UE, Cell uses a unique scrambling code
- Scrambling codes do not spread the signal, BW remains unchanged @ chip rate
- Scrambling codes are complex pseudo random number sequence



Downlink Channelization, Scrambling and Modulation



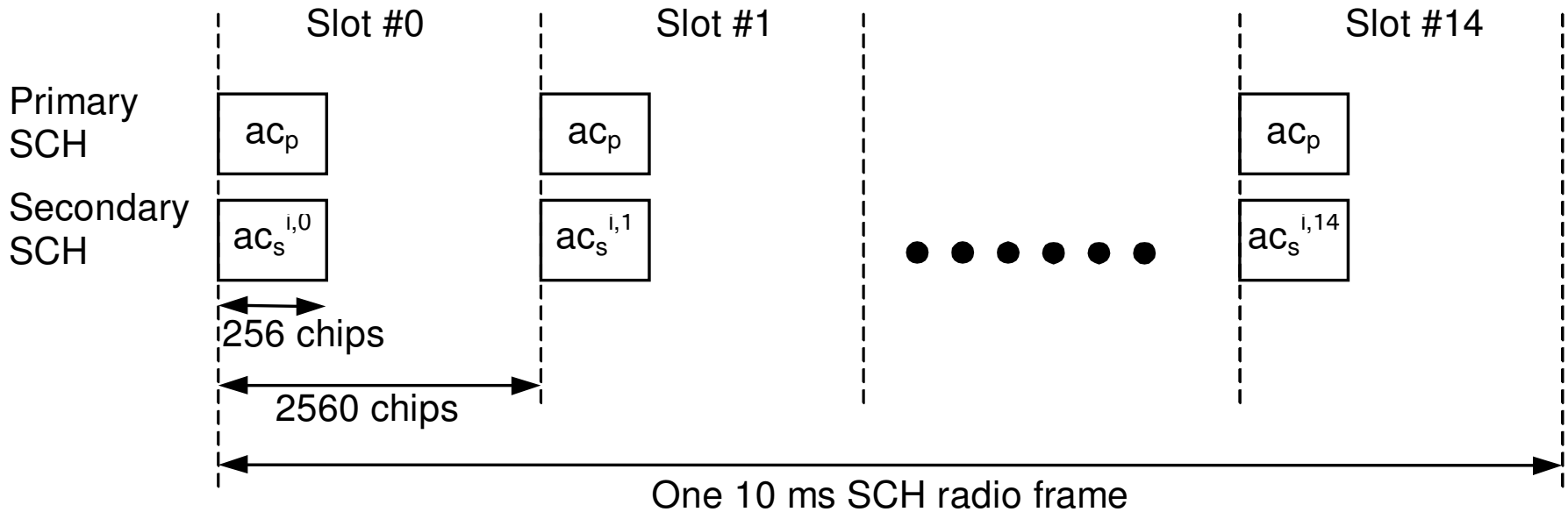
Uplink Channelization, Scrambling and Modulation



Initial Synchronization

- Three step process to identify
 - Slot timing of the cell
 - Frame timing of the cell
 - Scrambling code of the cell
- UE is capable of receiving DL transmission once the above 3 are available
- SCH (primary and secondary) and CPICH channels are used for this purpose

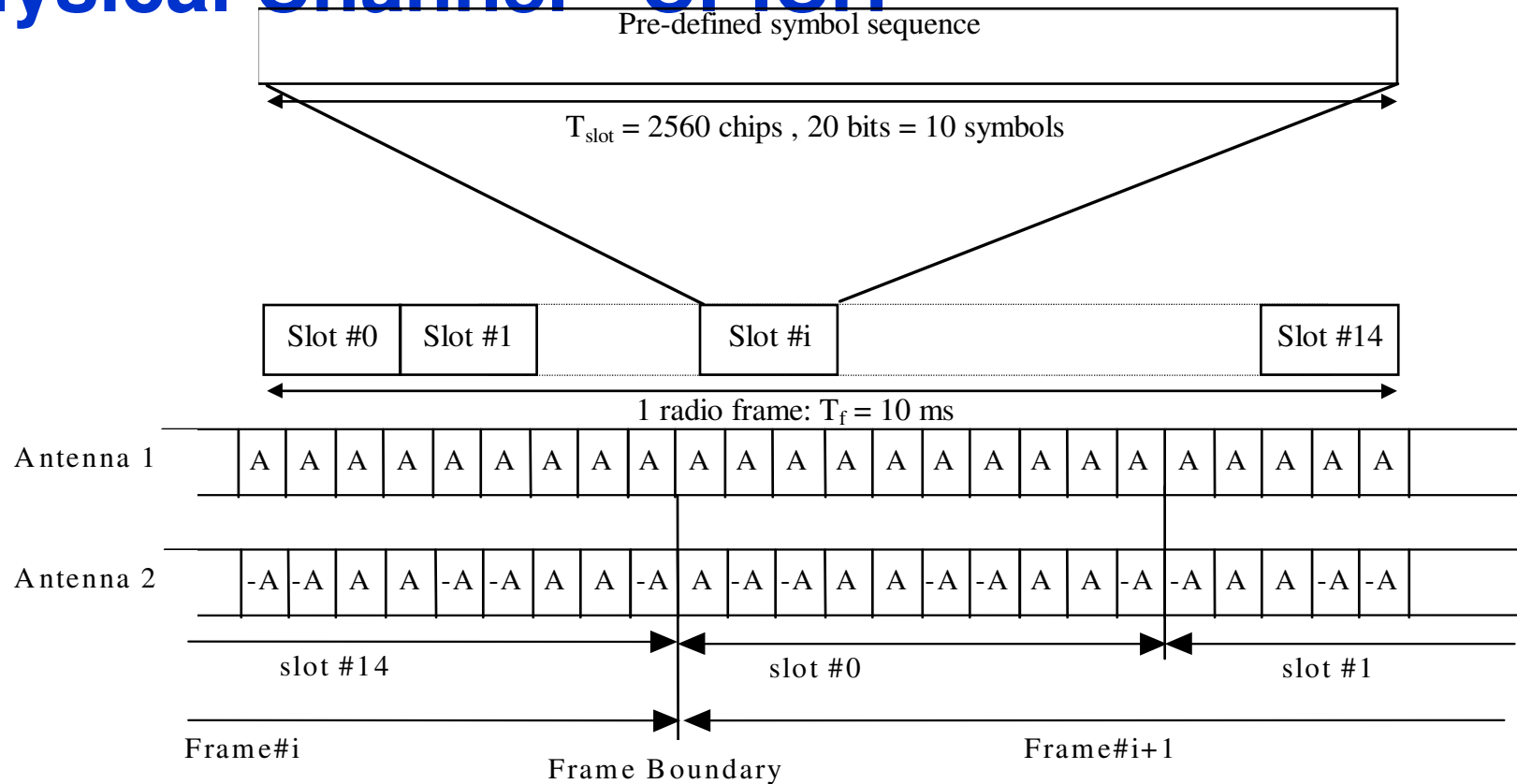
Physical Channel - SCH



- primary - SCH, same for every cell, no channelization/scrambling used
- Number of scrambling codes for DL = 512, divided into 64 code groups
- Secondary - SCH, indicates which of the 64 code groups scrambling code of that cell belongs to, no channelization/scrambling used

15 Broadcast over entire cell

Physical Channel - CPICH



- Uses Fixed channelization code and the scrambling code of the cell
- Broadcast over entire cell
- Used for channel estimation and initial synchronization

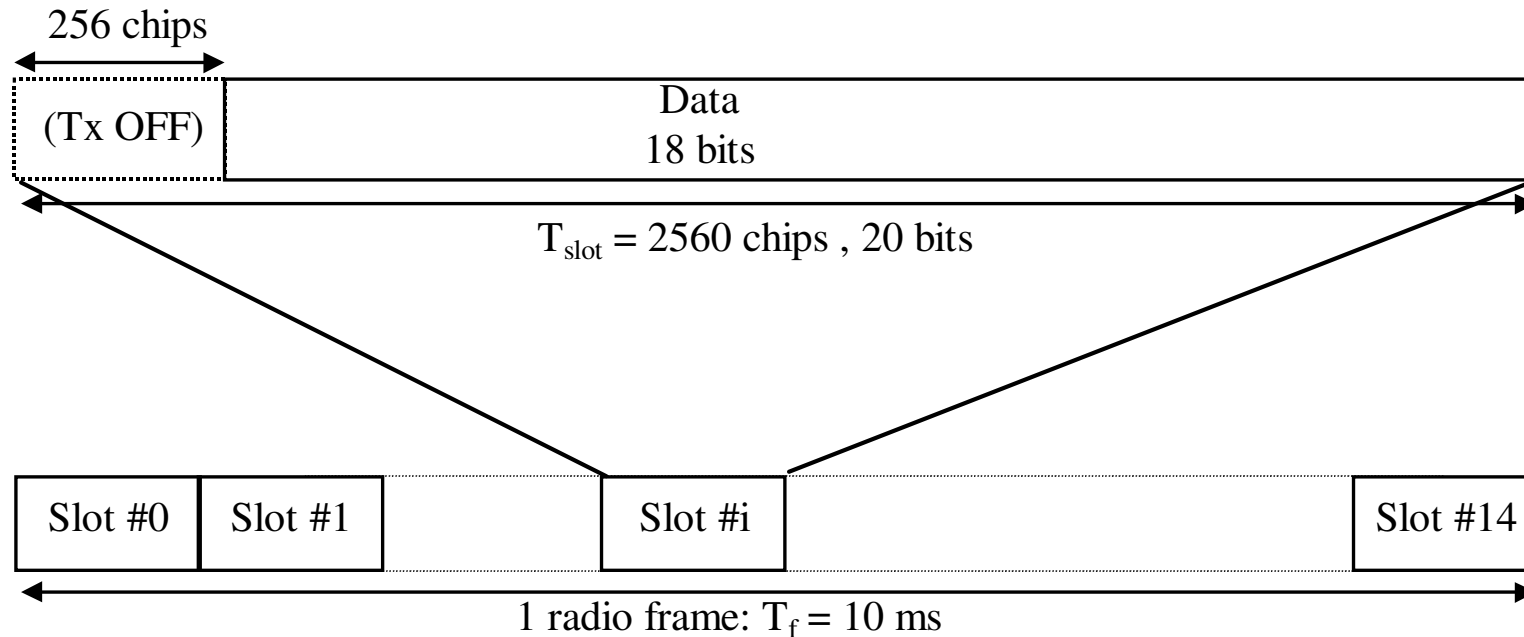
Initial Synchronization

- Slot Timing
 - Correlate the incoming chips with PSC word over a slot
 - Correlation peak indicates the location of PSC word and hence the start of the slot
- Scrambling code group
 - 16 SSC words are defined by 3GPP
 - 64 code words (each containing 15 SSC words from above) are defined by 3GPP
 - Receive the SSC words being transmitted at start of slot for 15 consecutive slots (1 frame)
 - Identify which of the 64 code words is being transmitted to find scrambling code group

Initial Synchronization

- Frame timing
 - Identify the phase of the code word to find frame start timing of the cell
- Scrambling code
 - Receive known sequence of pilots using all 8 scrambling codes from the scrambling code group
 - The scrambling code that gives best results is the scrambling code of the cell

Physical Channel - PCCPCH



- Broadcast over entire cell, with OVSF code #1
- The 'Tx-off' space is taken up by the SCH channel
- Contains the BCH transport data - System information
- Fixed spreading factor (=256)
- This is the only channel with fixed channel coding scheme.

FDD Physical Channels

- Common Pilot Channel (P-CPICH)
- Synchronization Channel (SCH)
- P-CCPCH
- S-CCPCH
- Paging Indication Channel (PICH)
- Physical Random Access Channel (PRACH)
- Acknowledge Indication Channel (AICH)
- Dedicated Channel (DPCH): contains DPCCH (L1 ctrl) and DPDCH(data) fields.
- HSDPA channels – HS-SCCH, HS-DSCH and HS-DPCCH (rel5)
- E-DCH channels – E-DPCCH, E-DPDCH, E-AGCH, E-RGCH and E-HICH (rel6)
- F-DCH (rel6)

Transport Channels

- BCH - carries system wide information
- FACH - downlink common signaling channel
- RACH - uplink common signaling channel
- PCH - paging channel
- DCH - dedicated channel
- E-DCH – HSUPA dedicated channel
- HS-DSCH – HSDPA dedicated channel
- MTCH, MCCH – MBMS transport channels

Transport to Physical Channel Mapping

Transport Channels	Physical Channels
DCH	<ul style="list-style-type: none"> ————— Dedicated Physical Data Channel (DPDCH) ————— Dedicated Physical Control Channel (DPCCH) ————— Fractional Dedicated Physical Channel (F-DPCH)
E-DCH	<ul style="list-style-type: none"> ————— E-DCH Dedicated Physical Data Channel (E-DPDCH) ————— E-DCH Dedicated Physical Control Channel (E-DPCCH) ————— E-DCH Absolute Grant Channel (E-AGCH) ————— E-DCH Relative Grant Channel (E-RGCH) ————— E-DCH Hybrid ARQ Indicator Channel (E-HICH)
RACH	<ul style="list-style-type: none"> ————— Physical Random Access Channel (PRACH)
BCH	<ul style="list-style-type: none"> ————— Common Pilot Channel (CPICH) ————— Primary Common Control Physical Channel (P-CCPCH)
FACH	<ul style="list-style-type: none"> ————— Secondary Common Control Physical Channel (S-CCPCH)
PCH	<ul style="list-style-type: none"> ————— Synchronisation Channel (SCH) ————— Acquisition Indicator Channel (AICH) ————— Paging Indicator Channel (PICH) ————— MBMS Notification Indicator Channel (MICH)
HS-DSCH	<ul style="list-style-type: none"> ————— High Speed Physical Downlink Shared Channel (HS-PDSCH) ————— HS-DSCH-related Shared Control Channel (HS-SCCH) ————— Dedicated Physical Control Channel (uplink) for HS-DSCH (HS-DPCCH)

THANKS 😊

Q & A ?

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BACKUP

HSDPA

- Circuit switched Vs Packet switched calls
- Uses 3 physical channels (2 on the DL, 1 on the UL)
- HS-PDSCH
 - Shared data channel, SF = 16.
 - HS-PDSCH can use multiple codes
 - Higher order modulation 16-QAM, 64QAM
 - To achieve greater peak data rate
 - Shared channel allows dynamic allocation of resources among users (e.g. guided by channel quality indicator from UE)

HSDPA

- HS-SCCH
 - Channelization-code-set information
 - Modulation scheme information
 - Transport-block size information
 - Hybrid-ARQ process information
 - Redundancy and constellation version
 - New data indicator
 - UE identity
- HS-DPCCH - UL
 - ACK/NACK
 - CQI
- No soft handover, UTRAN can command serving cell change
- New concept of hybrid ARQ (HARQ)

HARQ – Hybrid Automatic Repeat Request

- Channel coding (forward error correction) relies on transmitting redundant bits so that the receiver can perform error correction
- Idea with hybrid ARQ is that if the UE does not receive a block correctly (i.e. CRC pass), it still contains useful information
- Some additional information can be transmitted and added to what has been received until the message is decoded successfully
- Chase combining (CC): The **SAME** bits are transmitted again and soft combined with the bits that the UE has already received
- Incremental redundancy: Some **NEW** parity bits are transmitted which can be concatenated with the already received bits to help decode the message
- Constellation remapping : The **SAME** bits are transmitted but mapped onto the IQ constellation in a different way (16 QAM only)
- Redundancy version bits on the HS-SCCH indicate which of these possibilities is being performed

HARQ – Hybrid Automatic Repeat Request

- New data indicator on the HS-SCCH indicates that this is a new transmission, rather than a retransmission -> indicates that all received data is flushed and start decoding from scratch
- Up to 8 multiple HARQ processes run in parallel
- With HARQ retransmission is desirable because it means that just the right amount of resources (power etc) has been used to get the message through to the UE