Thesis Presentation

Study and Simulation of UMTS Physical layer

(Rel '99 for Downlink)

- Study and Research
  - Physical layer standards
    - Physical Channel Mapping
      - TS 25.211 v3.6.0
    - Coding and Multiplexing
      - TS 25.212 v3.6.0
    - Spreading and Modulation
      - TS 25.213 v3.6.0
    - Physical layer Procedures
      - TS 25.214 v3.6.0
  - Simulation
    - Mathworks' Simulink
    - Model design according to above mention standards
    - Shall simulate in Matlab

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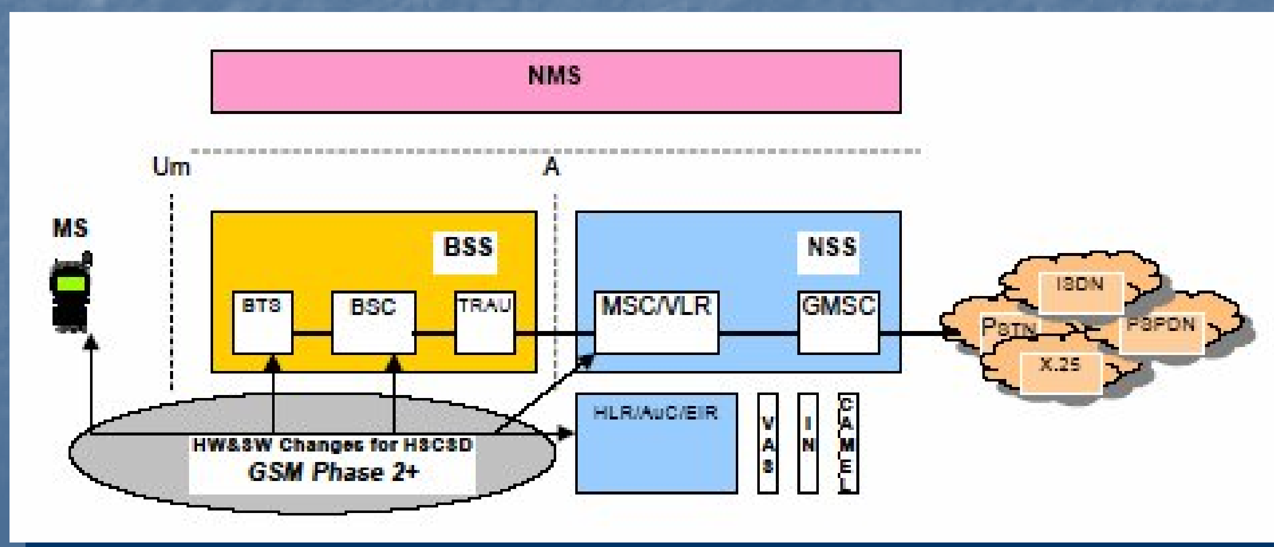
Standardization of WCDMA / UMTS

The 3rd Generation Partnership Project (3GPP)

Role: Create 3G Specifications and Reports

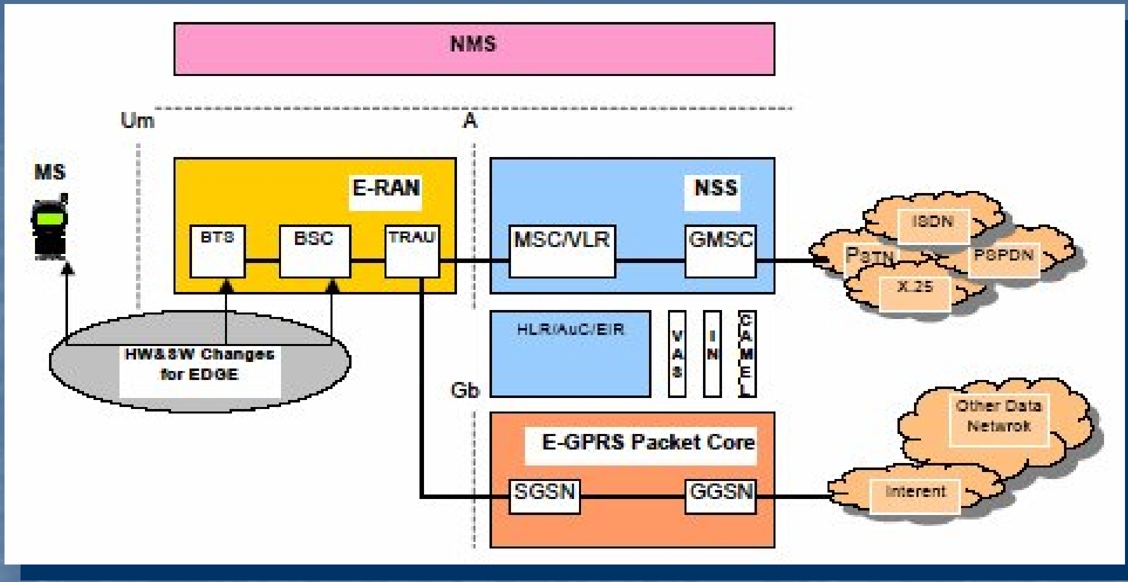
3G is standardized based on the evolved GSM core networks and the supporting Radio Access Technology

GSM

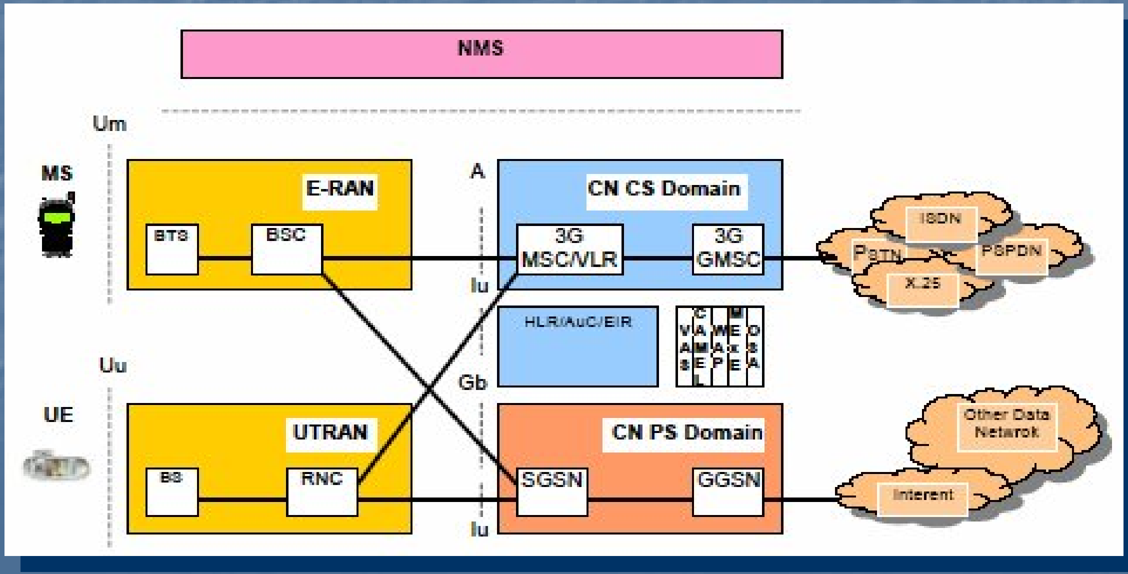


Introduction of

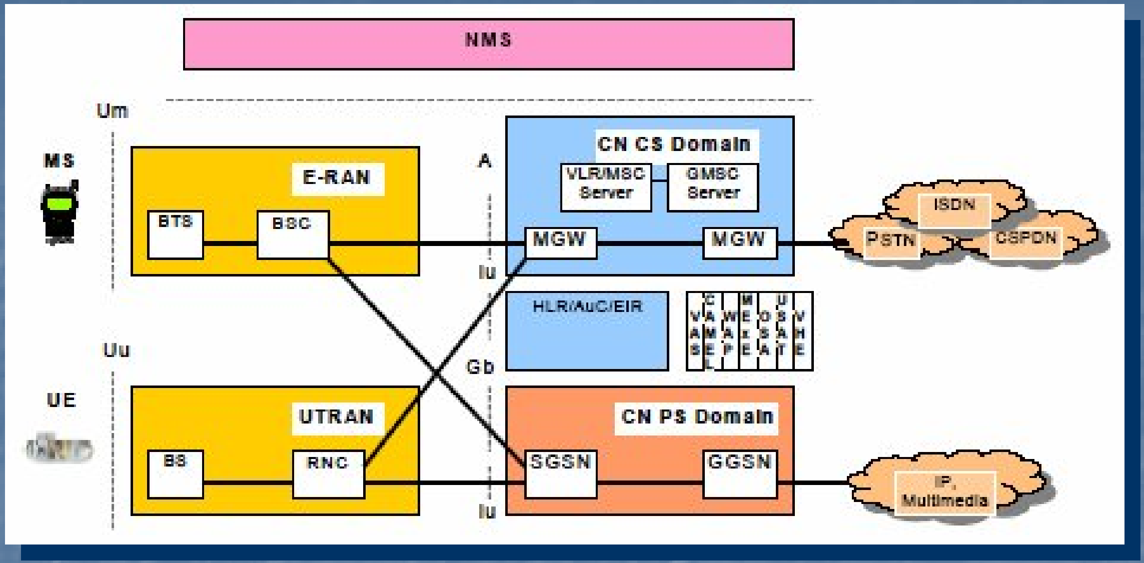
GPRS / E-GPRS



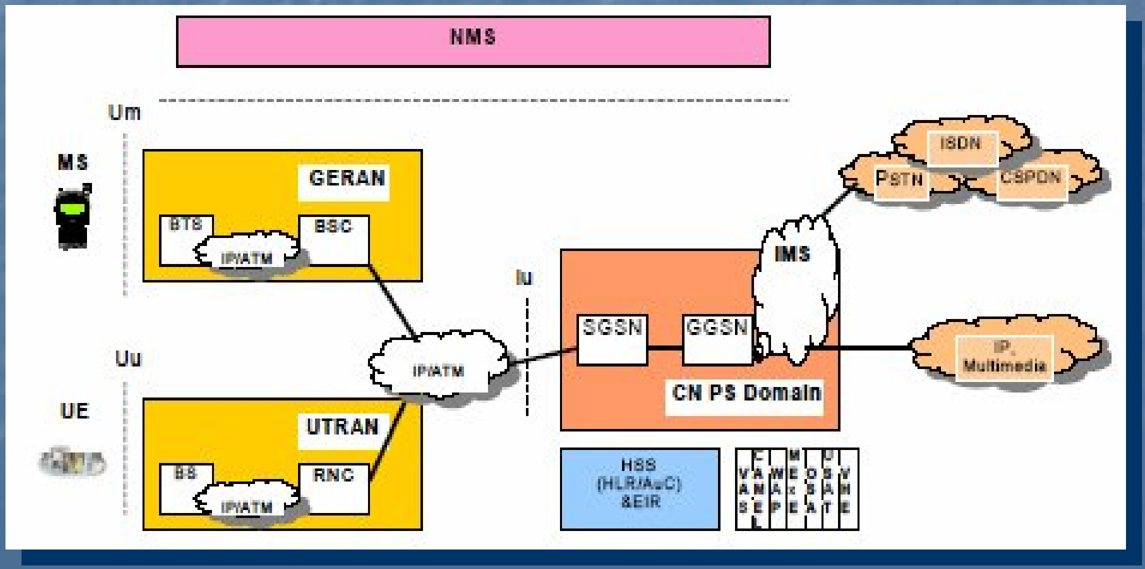
3GPP Release '99



3GPP Release 4



3GPP Release 5-6
All IP Vision



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Introduction to UMTS Physical layer

- Universal Mobile Telecommunication System
- Based on Wideband Code Division Multiple Access
- It is one of the five interfaces adopted by the ITU under the name "IMT-2000 Direct Spread"
- WCDMA can support multiple and simultaneous communications such as voice, images, data, and video
  - Very high and variable bit rates:
    - 144 kbps: vehicle speed, rural environ.
    - 384 kbps: walking speed, urban outdoor.
    - 2048 kbps: fixed, indoor.
  - Different QoS for different connections.
  - High spectrum efficient.
  - Coexistence with current systems

Functions of the Physical layer

- Physical layer provides data transport support to higher layers via Transport Channels
  - Error detection.
  - FEC encoding/decoding.
  - Rate Matching/Dematching.
  - Multiplexing/Demultiplexing different Transport Channels into/from a Coded Composite Transport Channel (CCTrCH).
  - Mapping/Demapping of CCTrCH into/from Physical Channels.
  - Modulation and Spreading/Demodulation and Despreading.
  - Power Weighting and combining of physical channels.
  - RF Processing.
  - ...

Features of UMTS

- Frequency Bands
  - 1920 to 1980 MHz (Uplink)
  - 2110 to 2170 MHz (Downlink)
- RF Carrier Spacing
  - 5 MHz
- RF Channel Raster
  - 200 KHz
- Two modes of operations
  - Time Division Duplex (TDD)
    - Implemented in form in China as TD-SCDMA
  - Frequency Division Duplex (FDD)
    - Implemented worldwide as HSDPA

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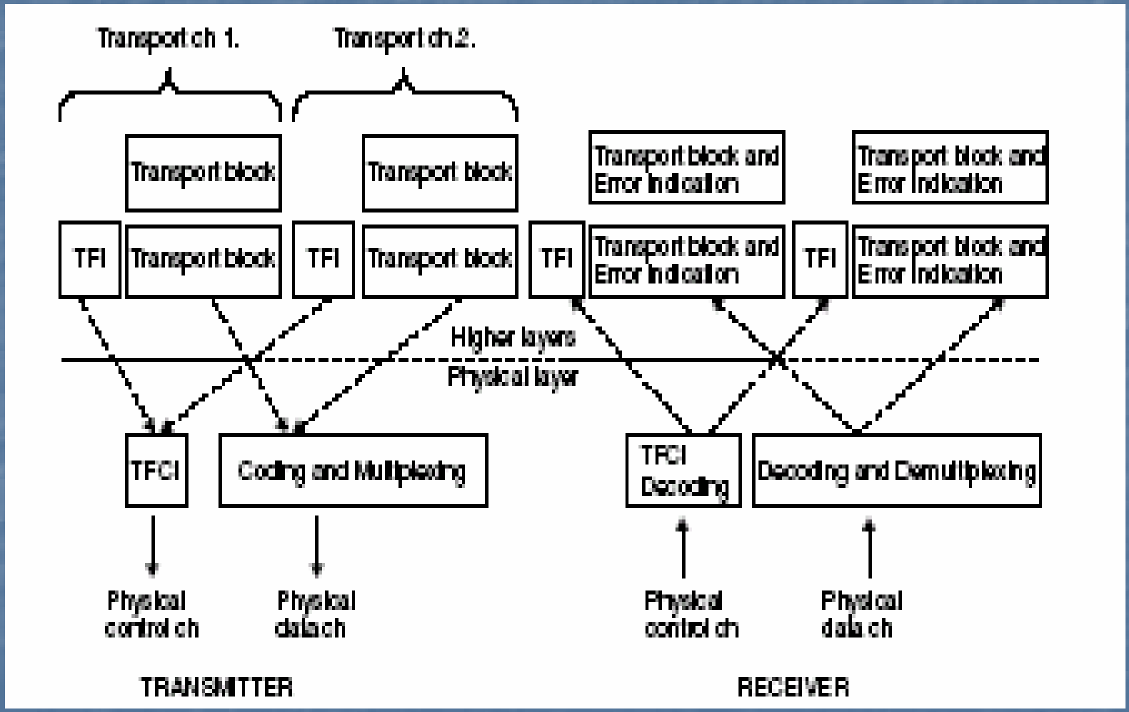
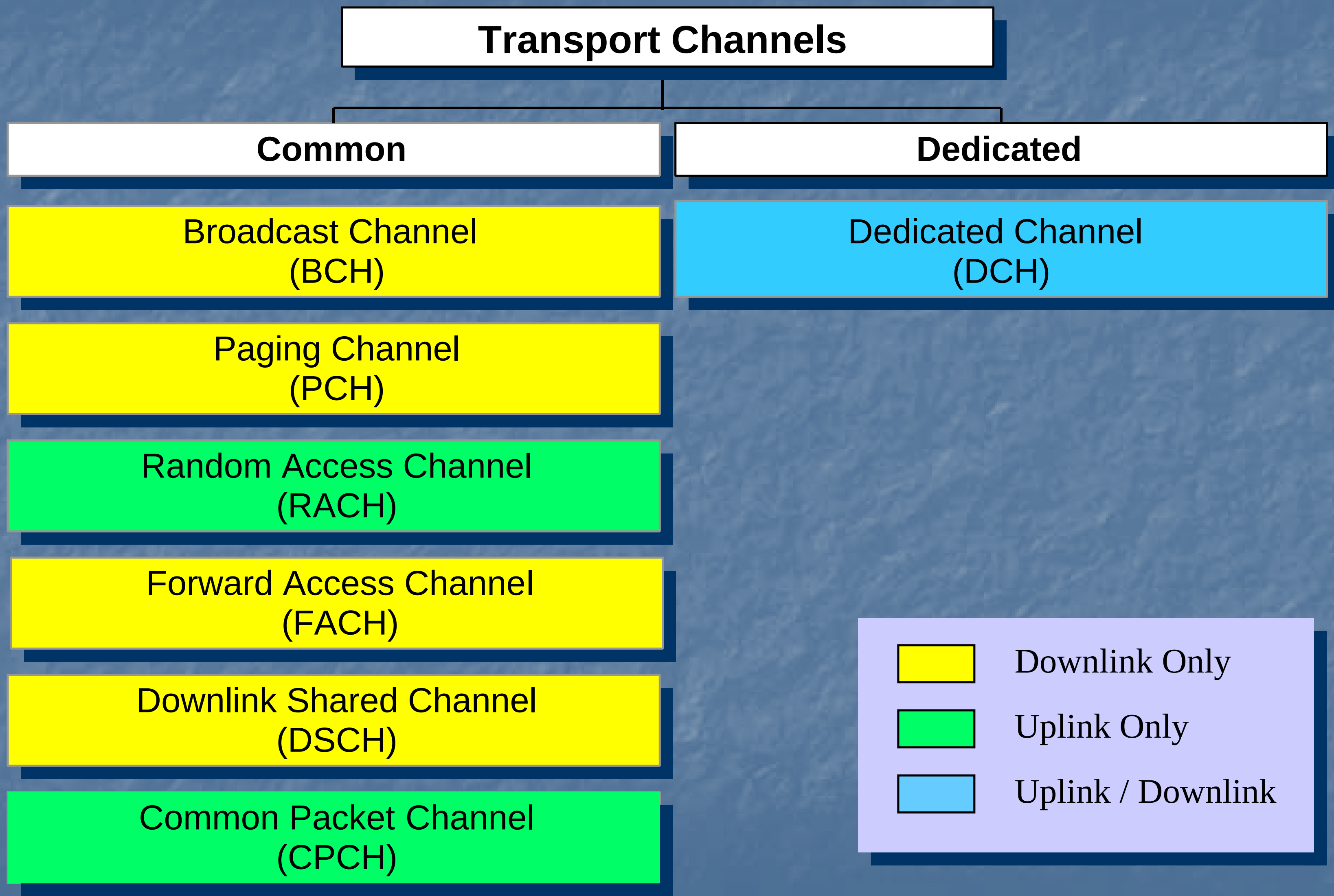
Physical Channel Mapping

3GPP TS 25.211 v3.6.0

What are transport channels?

Transport Channels are those which Carry data and signalling information from higher layer upto the physical layer. This means that they are not sent on the air interface. These channels are mapped to physical Channels which are sent on the air interface.

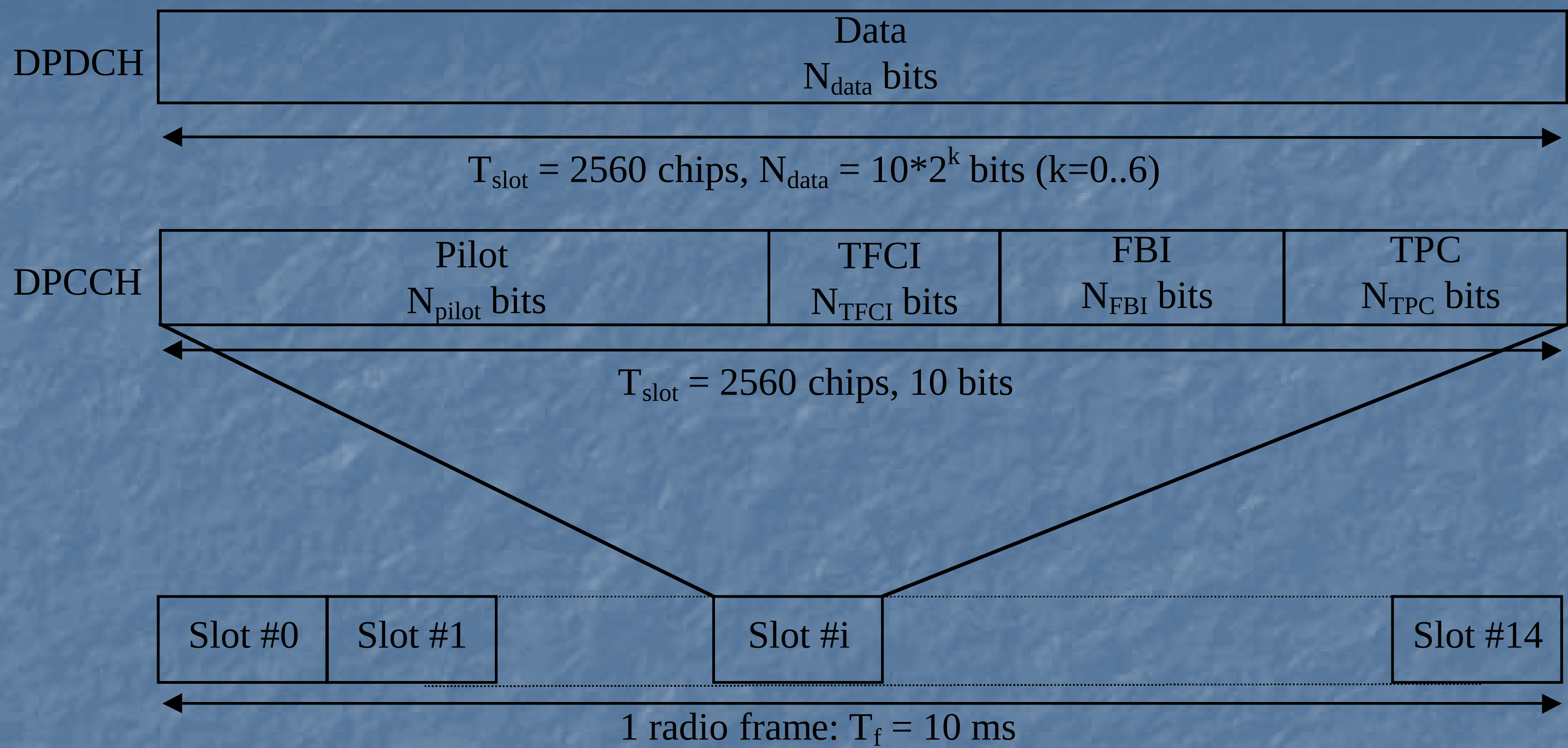



Transport Channels
Common
Dedicated
Broadcast Channel (BCH)
Paging Channel (PCH)
Random Access Channel (RACH)
Forward Access Channel (FACH)
Downlink Shared Channel (DSCH)
Common Packet Channel (CPCH)
Dedicated Channel (DCH)
Downlink Only
Uplink Only
Uplink / Downlink

Channel Mapping

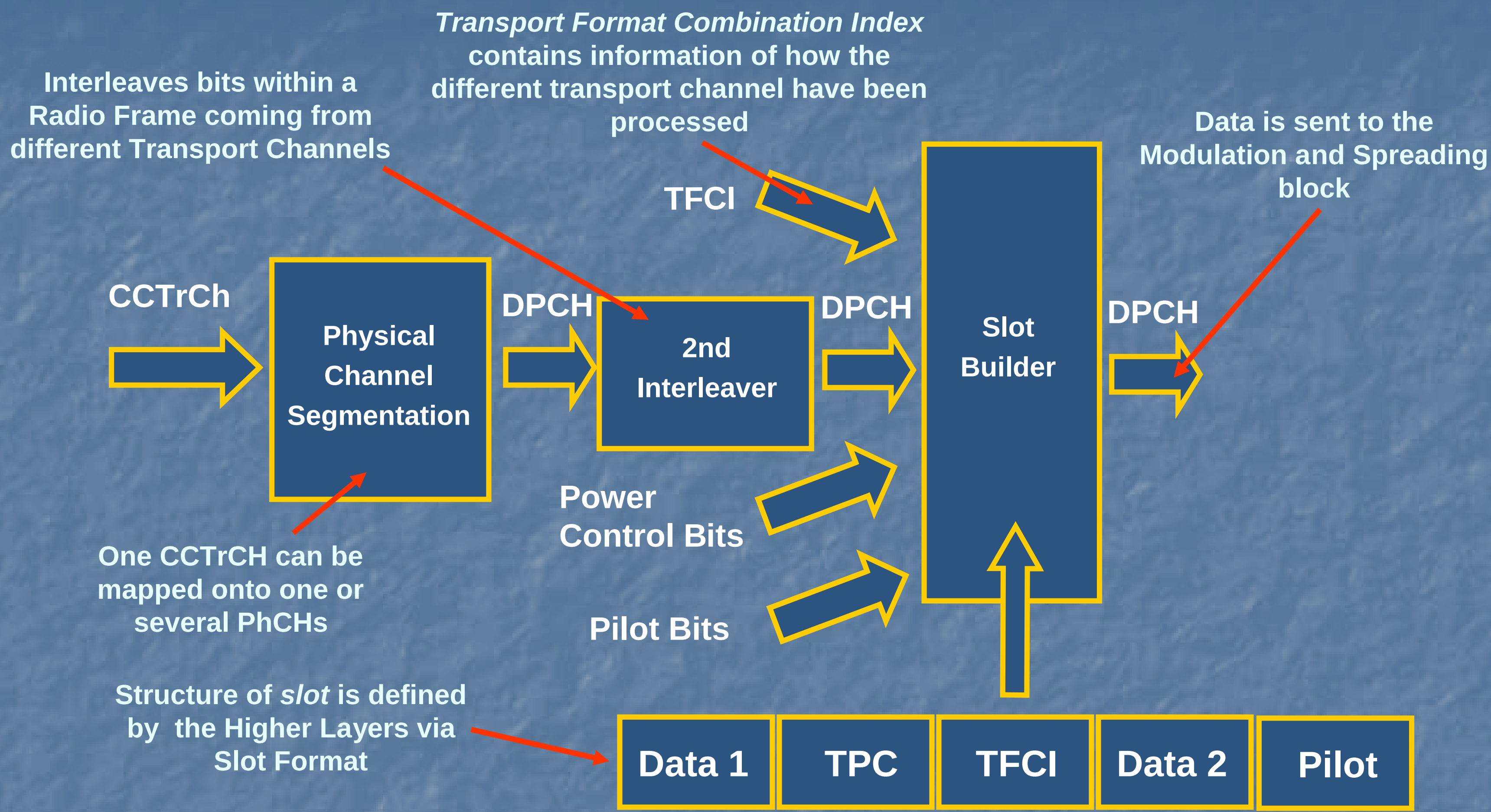
Transport Channels	Physical Channels
BCH	Primary Common Control Physical Channel (PCCPCH)
FACH	Secondary Common Control Physical Channel (SCCPCH)
PCH	
RACH	Physical Random Access Channel (PRACH)
DCH	Dedicated Physical Data Channel (DPDCH)
	Dedicated Physical Control Channel (DPCCH)
DSCH	Physical Downlink Shared Channel (PDSCH)
CPCH	Physical Common Packet Channel (PCPCH)
	Synchronization Channel (SCH)
	Common Pilot Channel (CPICH)

Frame structure for uplink dedicated data and control channel



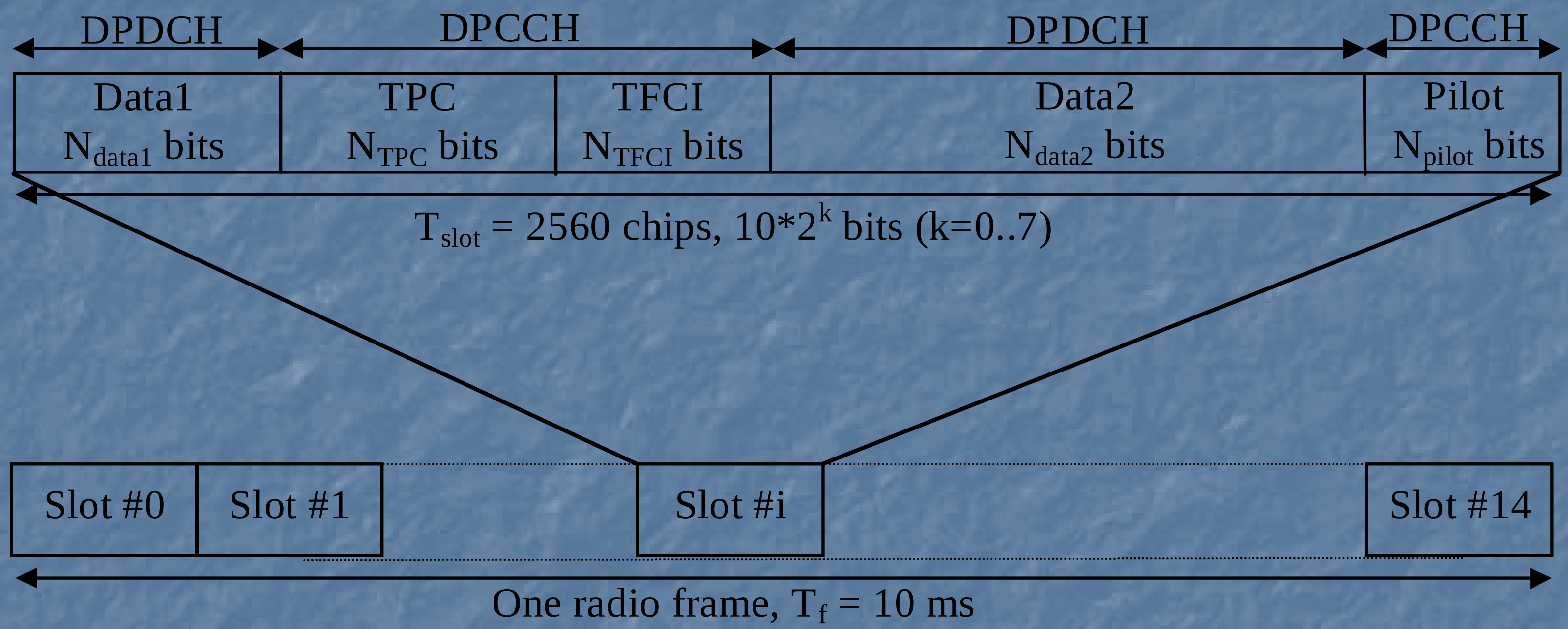
- Pilot bits provide the phase of the signal to coherently demodulate the channel.
- Transport Format Combination Indicator(TFCI) which transport channel is active for the current frame, however for fixed rate services TFCI is not included.
- Feedback Information (FBI) contains the feedback from mobile to Utran network to tell which transmit diversity scheme is used.

Downlink Dedicated Channel Generation



There are a total of 16 slot formats available for downlink dedicated channel each having different data rate.

Frame structure for downlink dedicated data and control channel



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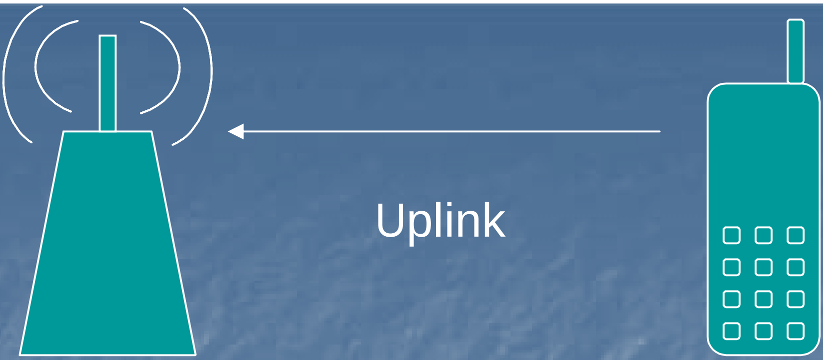
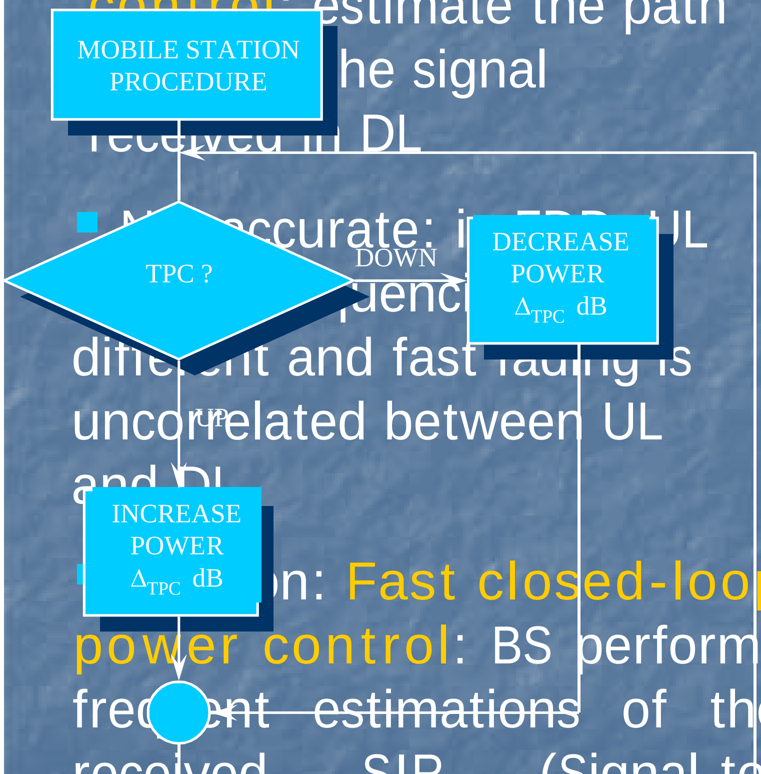
Physical layer Procedures

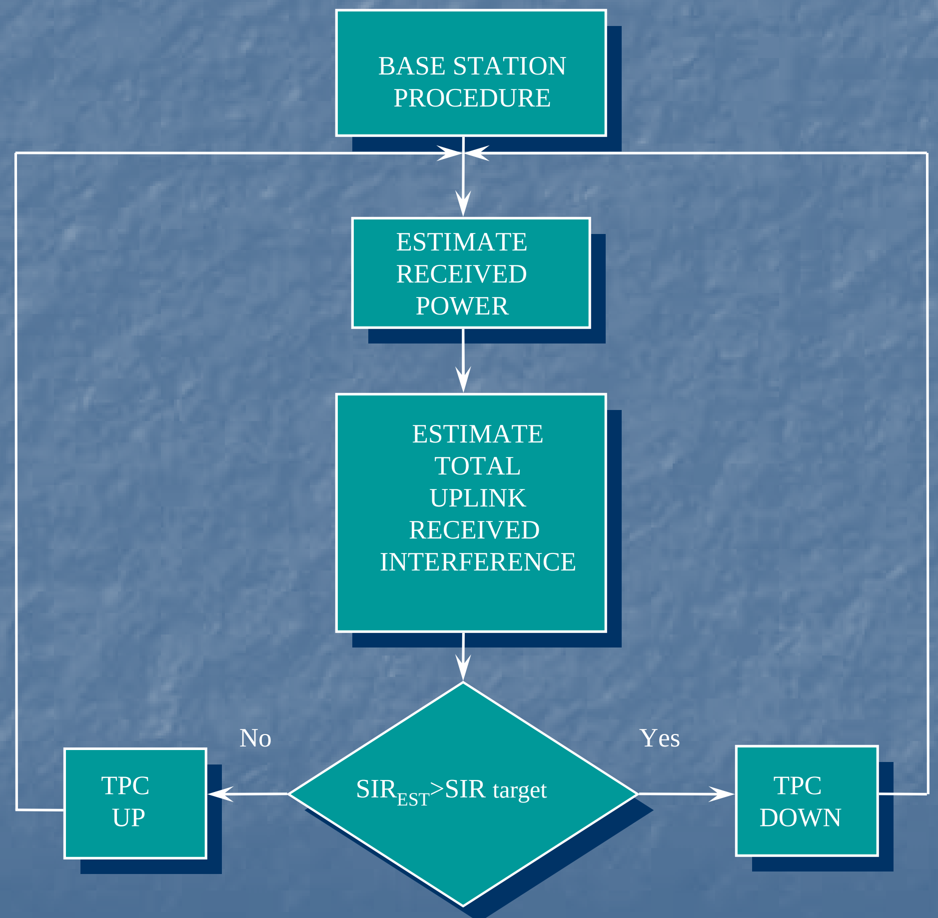
3GPP TS 25.214 v3.6.0

Power Control

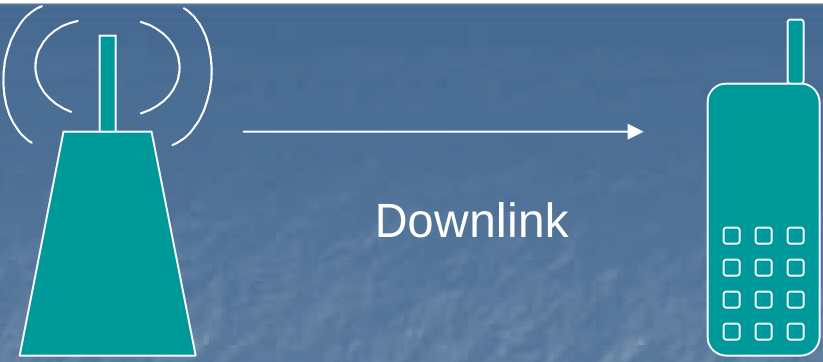


- Open loop power control: estimate the path loss from the signal received in DL
- Not accurate: in FDD, UL and DL frequencies different and fast fading is uncorrelated between UL and DL
- Solution: Fast closed-loop power control: BS performs frequent estimations of the received SIR (Signal-to-Interference Ratio) and compares to a target SIR

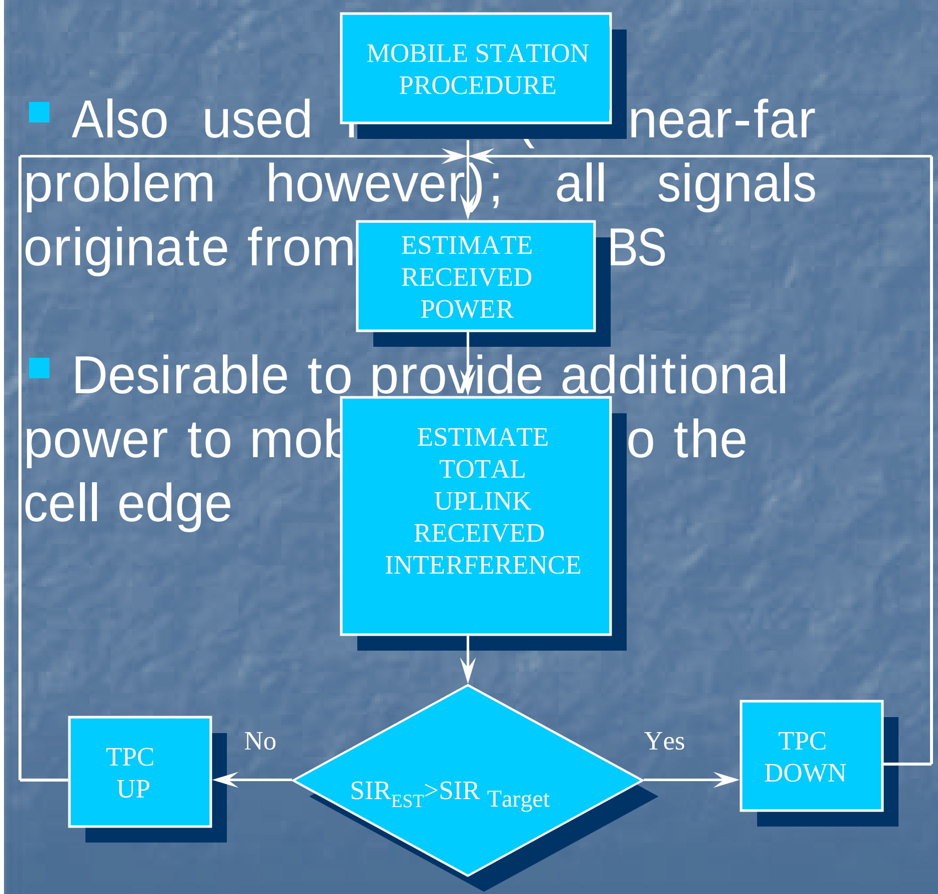


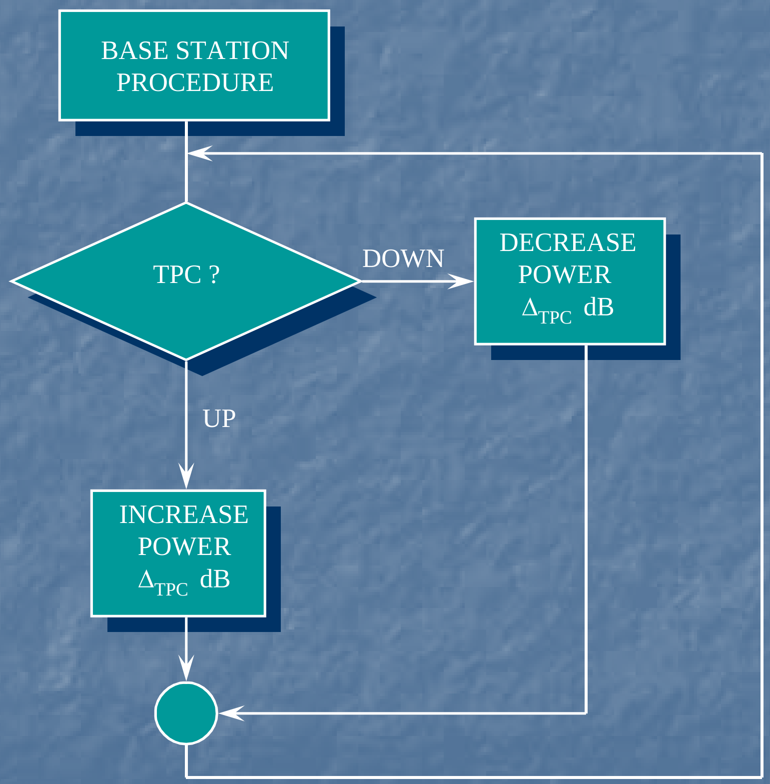


Power Control



- Also used f... (... near-far problem however); all signals originate from ... BS
- Desirable to provide additional power to mob... o the cell edge





Cell Search Procedure

STEP 1

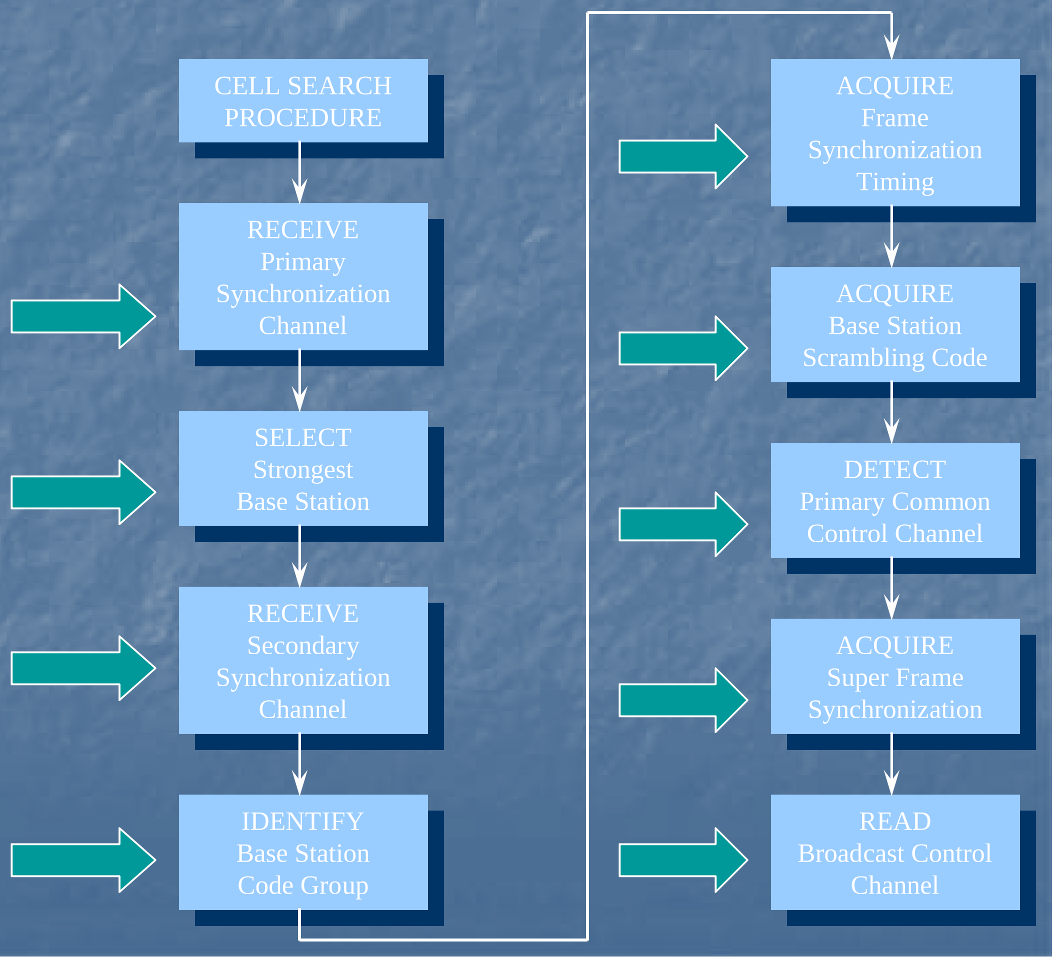
- Uses Primary synchronization code.
- Acquires slot synchronization using single matched filter.
- Obtain slot timing by detecting peaks in matched filter output.

STEP 2

- Uses secondary synchronization code.
- Correlates the received signal with all possible secondary synchronization code sequences.
- identify maximum correlation value.

STEP 3

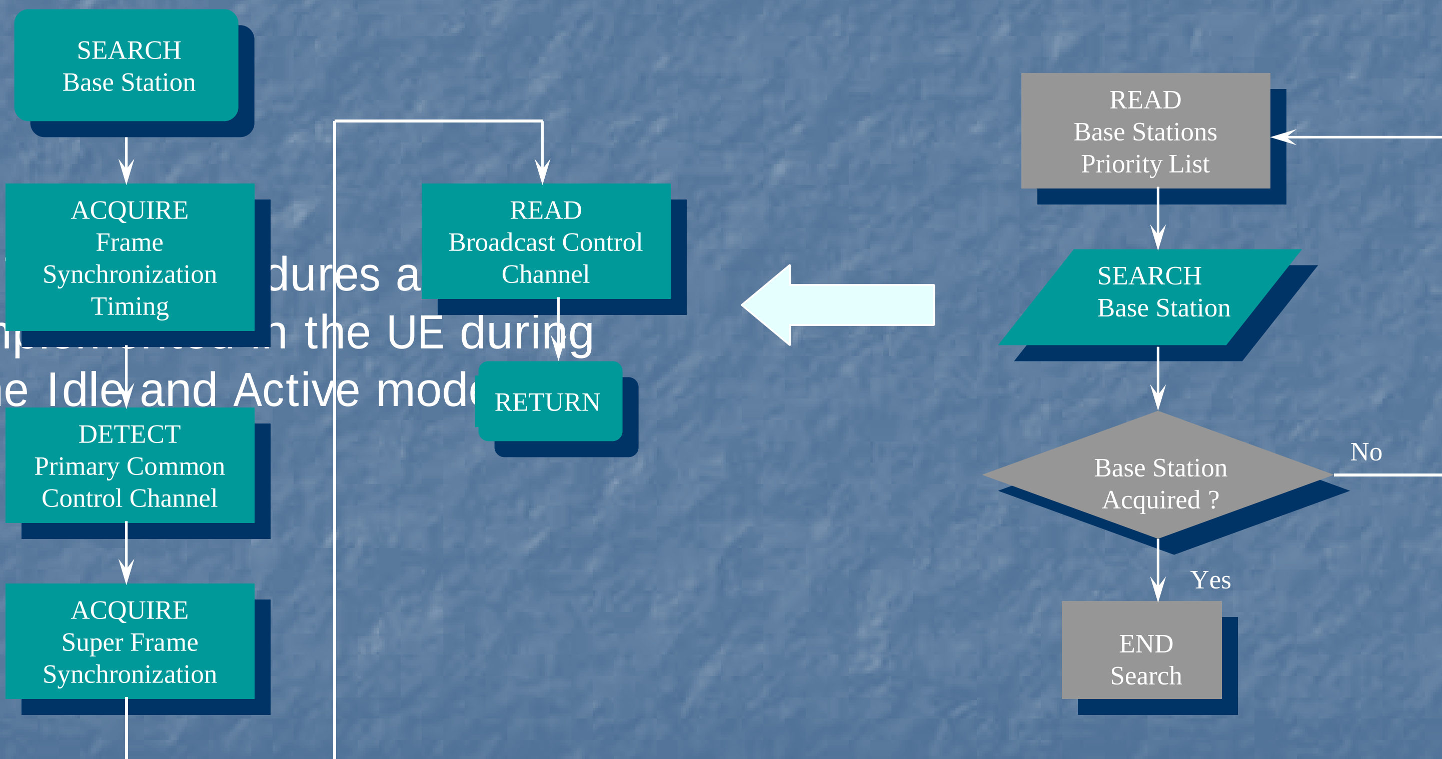
- UE determines the exact primary scrambling code.
- Primary CCPCH is detected and specific BCH information can be read.



Cell Search Procedure

Idle and Active Modes

- … dures a
im… n the UE during
the Idle and Active mod…



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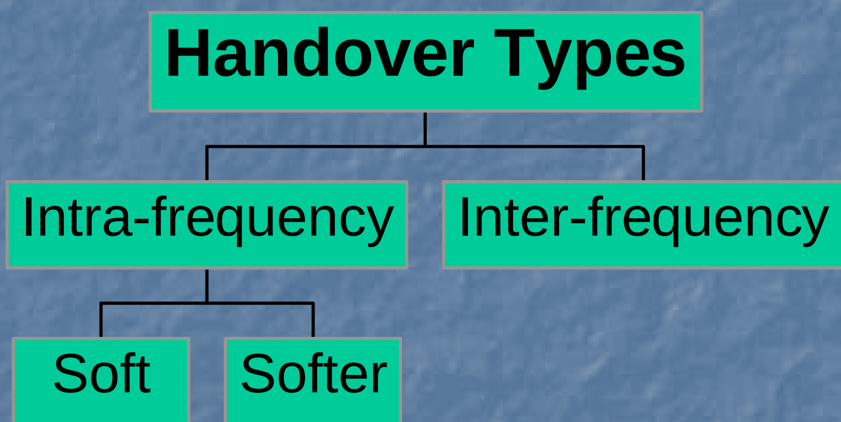
Handover in UMTS

The main relevance of the handover to the physical layer is what to measure for handover criteria and how to obtain measurements

Handover Procedures



- **UTRA supports two types of handoff:**
- **Between Base Stations operating at the same radio frequency (Intra-frequency Handoff).**
- **Between Base Stations operating in different radio frequencies (Inter-frequency Handoff)**
- **Intra-frequency Handoff is also known as *Soft or Softer Handoff*.**

Soft & Softer Handoff

- **During Soft Handoff, two or more Base Stations are used to simultaneously communicate with the same Mobile Station.**

- **During a soft handoff between two nodes, a mobile device maintains communication with he first node until after it has begun communication with second node. The mobile device only relinguishes the signal of the first node after conforming the signal of the second node. This known as" make before break"**

- **Softer handoff works in the same way between cell sectors.**

- **Soft ad Softer Handoff enable a mobile device to maintain the continuity and quality of the wireless connection while moving across cell boundries.**

Measurements for HANDOVER

- The UTRA-FDD intra frequency handover relies on the Ec/No measurement performed from the common pilot channel (CPICH). Quantities defined can be measured by the Terminal from the CPICH are as follows:
- Received Signal Code power (RSCP): which is the received power on one code after despreading, defined on the pilot symbols.
- Received Signal Strength Indicator (RSSI): which is the wideband received power within the channel bandwidth
- Ec/No, representing the received signal code power divided by the total received power in the channel bandwidth, which is defined as RSCP/RSSI
- Other parameters are SIR, Timing information in Asynchronous Network.

Inter-Frequency Handover

- For UTRA-GSM handover, Basically similar requirements are valid as for Gsm-Gsm handover. Normally the terminal receives he Gsm synchronization channel (Gsm Sch) during compressed frames in UTRA FDD to allow measurements from other Frequencies.

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Coding and Multiplexing

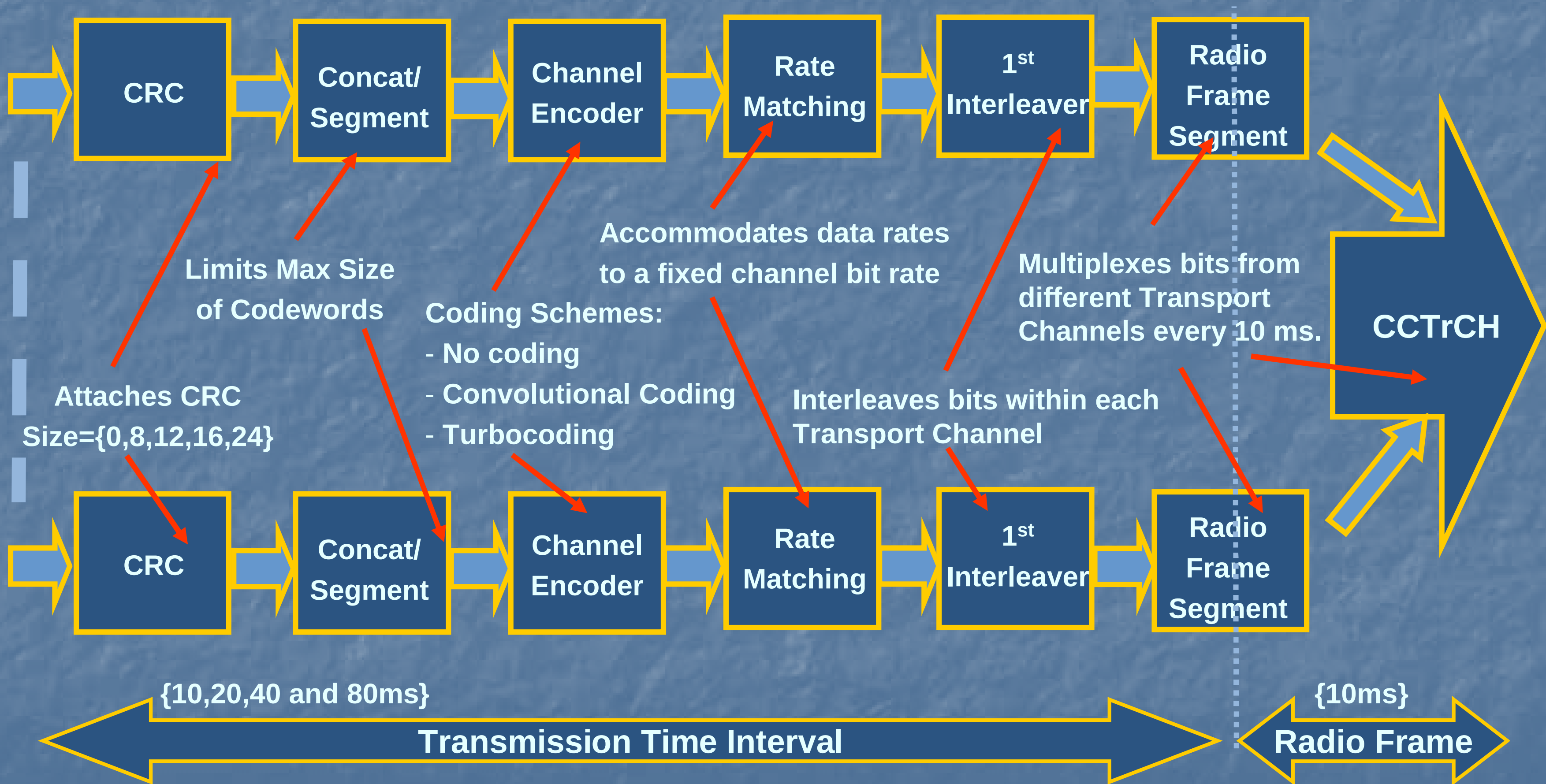
3GPP TS 25.212 v3.6.0

Coding and Multiplexing Specifications

- Data is transported from the MAC layer to the physical layer in the form of transport blocks
- The inter-arrival time is the Transmission Time Interval (TTI)
- More transport blocks in a TTI, higher the data rate
- Higher layers offer a 'Transport Format' to the physical layer for the delivery of a TrBlk to the radio interface

- Transport Formats
  - Dynamic part
    - Transport Block Size
    - Transport Block Set Size
  - Semi static part
    - Type of Error protection
      - Turbo coding
      - Convolutional coding
      - No channel coding
    - Coding rate
    - Static Rate Matching Attribute
    - Size of CRC
      - 24, 16, 12, 8 or 0 bits

Coding and Multiplexing Overview



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Spreading and Modulation

3GPP TS 25.213 v3.6.0

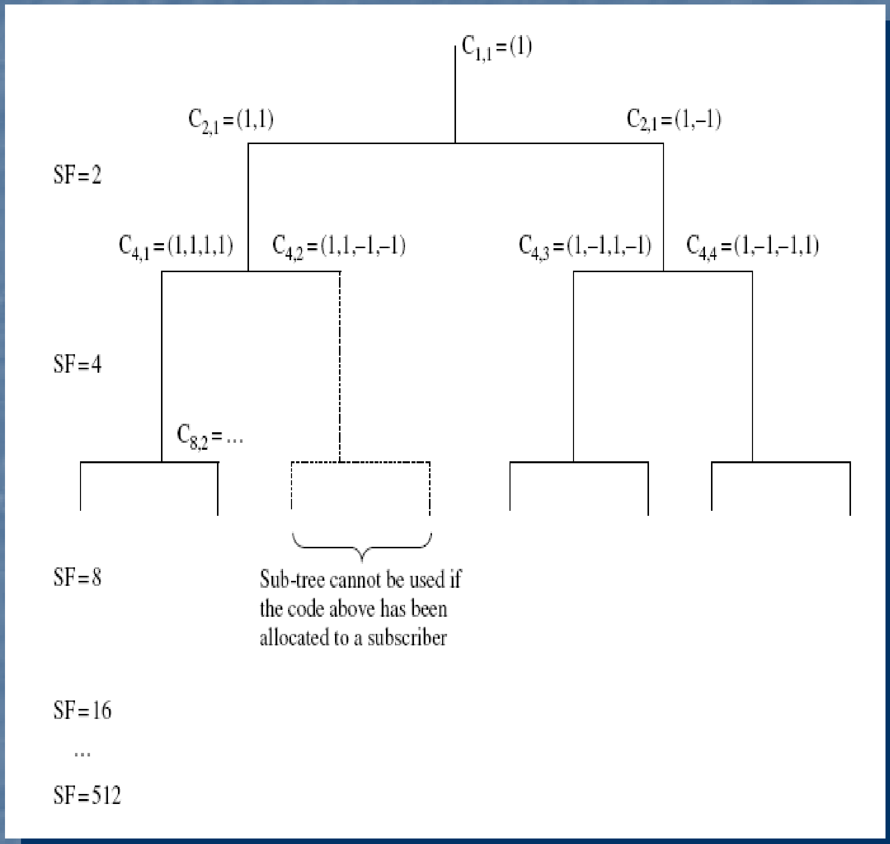
Spreading or Channelization operation

- Separation of downlink connections
- Orthogonal Variable Spreading Factor (OVSF)
- Chip rate of 3.84 Mcps
- Length varies from 4 to 256 chips
- Code generation similar to Walsh-Hadamard but expansion in the form of branches of a tree
- Optimized for data rate adaptation by employing concept of Spreading Factor (SF)

cont'd

- Lower SF means Higher data rate
- Higher SF translates into Lower data rate
- Every branch has different Spreading factor, with the preceding branch having a lower SF than the proceeding branch
- Every code of each branch has fixed spreading factor

- While one code from a particular branch is used, longer codes from the same branch can't be used
- Reason is that codes below are not orthogonal to code above a branch.



Scrambling

- Separation of sectors (cells) in Downlink
- Constructed as the modulo 2 sum two *m*-sequences generated by means of two generator polynomials of degree 18
- Chip rate of 3.84 Mcps (Clock freq is 3.84 MHz)
- Length of codes is 38 4000 chips
- All generated codes, 2^{18}-1, are not used
- First 512 codes are used as Primary Scrambling Codes (PSC) in
- Next 15 codes as possible Secondary SCs
- However, usage of Secondary SCs is not advised

- Modulation
  - QPSK
  - Same gain for I and Q components
- Pulse shaping
  - Root-raised cosine (RRC) filter with ß=0.22
  - Bandwidth of 5 MHz
  - Pulse Shaping is applied to reduce spectrum occupancy
  - RRC filter used at both the transmitter and the receiver
  - At the receiver, it has an over-sampling factor equal to (2X,4X, 6X or 8X) the rate of incoming signal

- Rake receiver
  - 3GPP does not define receiver algorithm, it is up the RF engineers to implement Rake receiver
  - Consists of several branches (Rake Fingers) each of them assigned to a different receive paths
    - Diversity reception “echoes” : sum of attenuated and delayed versions of the transmitted signal
    - Handoff
  - The outputs of the different Rake fingers are aligned in time and coherently combined
    - Convert destructive interference into constructive interference

- Rake receiver
  - Downsampler
    - Downsample to an Intermediate frequency after oversampling by the RRC filter
  - Decorrelators for Data and Pilot
    - A path searcher de-spreads the incoming time series data
    - It completes this operation many times using different time delays (or code offsets)
  - Channel Estimation
    - By comparing receiving pilot signal with reference signal.
    - Low Pass filter is introduced is smooth noise estimates.

- Rake receiver
  - Data Derotation or Phase Correction
    - Using channel estimates data is phase corrected

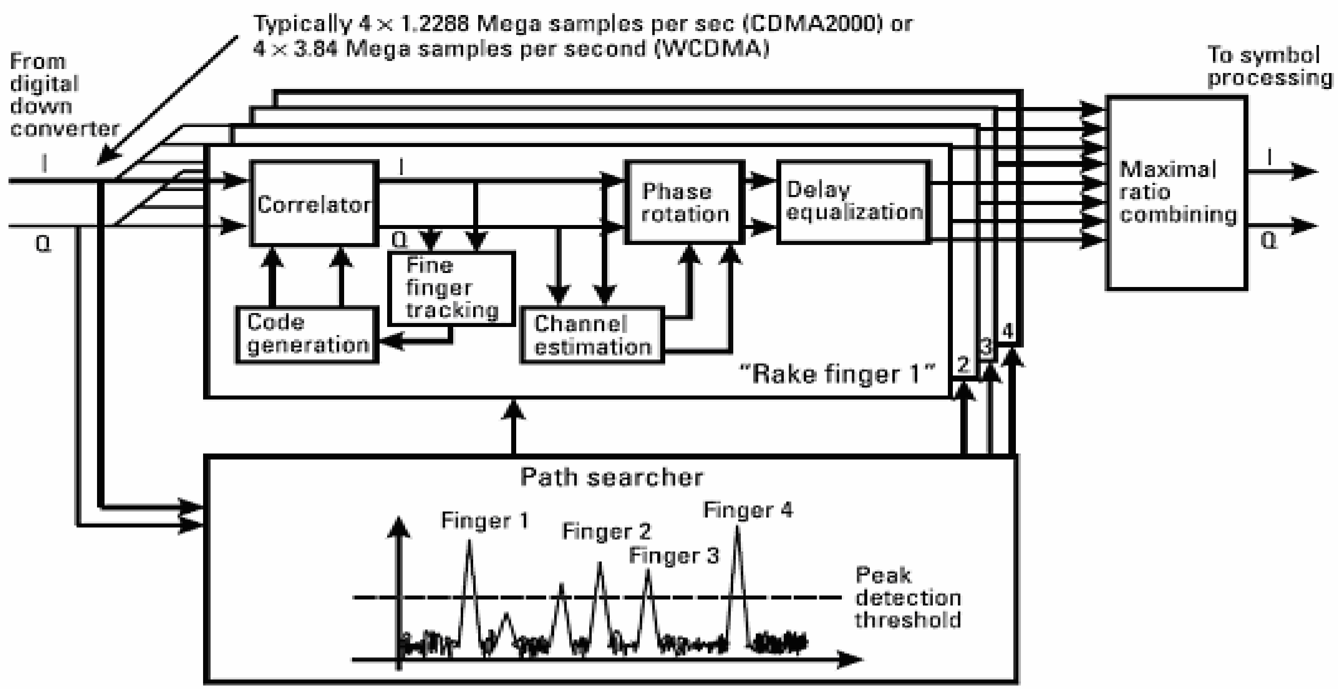


Figure Rake receiver.

Simulation and Results

Lets go to Matlab