IoT, Course introduction

Internet of Things a.a. 2019/2020

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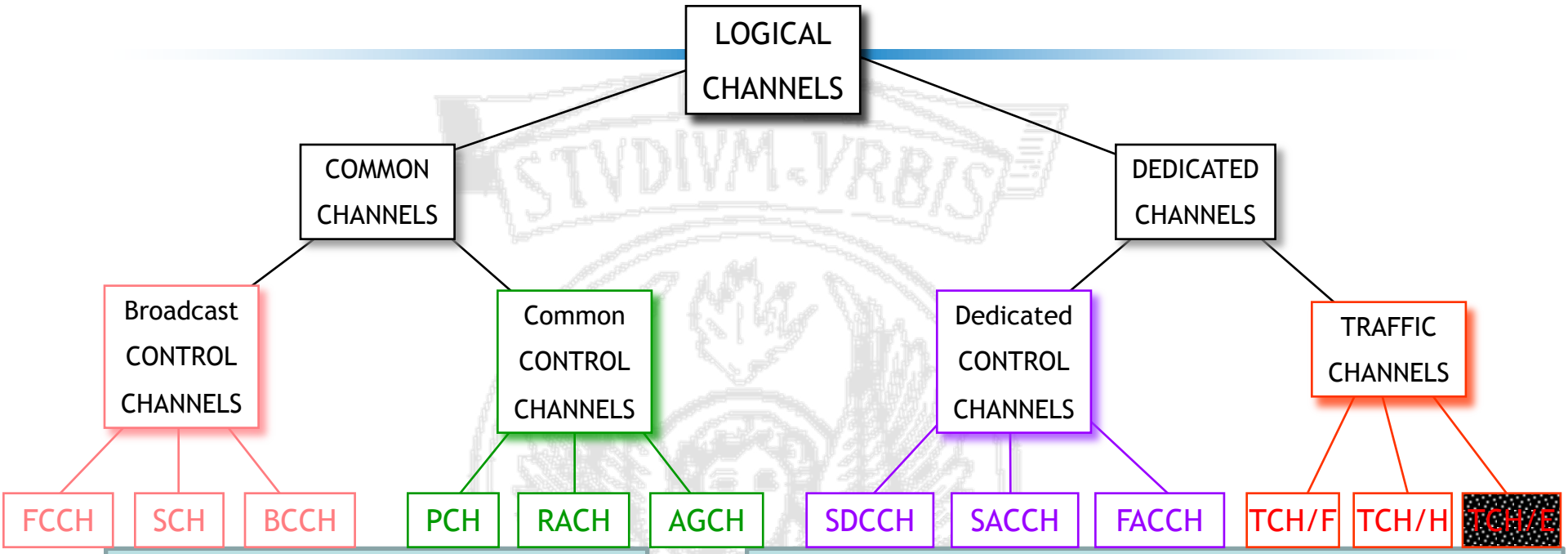
Logical Channels

- Uniquely identify the type of information they carry:
  - Signaling (e.g., synchronization info, ...)
  - Data traffic
- Channels types:
  - Traffic channels vs. control channels
  - Common channels vs. dedicated channels

Logical Channels

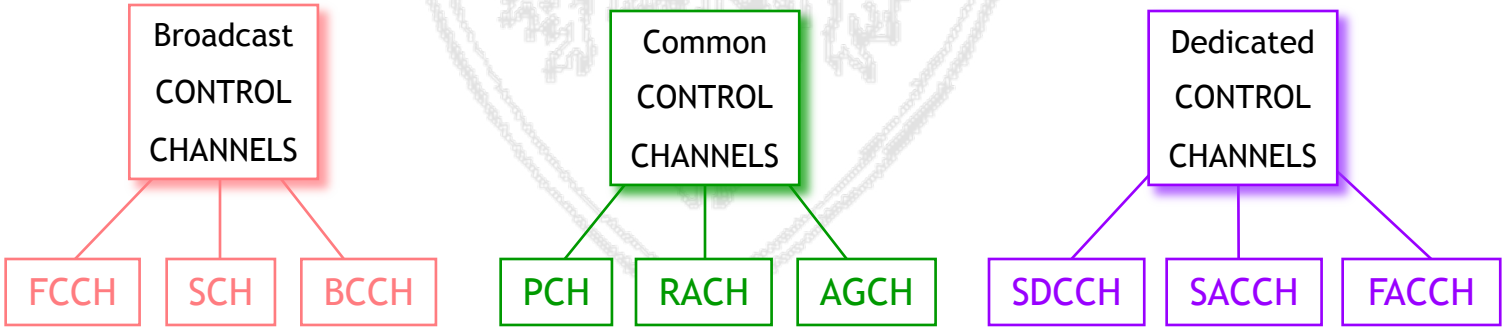


FCCH=Frequency Correction CHannel
SCH=Synchronisation Channel
BCCH=Broadcast Control CHannel
PCH=Paging CHannel
RACH=Random Access CHannel
AGCH=Access Grant CHannel

SDCCH=Stand-alone Dedicated Control CHannel
SACCH=Slow Associated Control CHannel
FACCH=Fast Associated Control CHannel
TCH/F=Traffic CHannel Full rate
TCH/H=Traffic CHannel Half rate
TCH/E=Traffic CHannel Enhanced Full rate

Control Channels-CCH

- Control channels carry signaling information (14 types of control channels are defined!!)
- Three main categories of CCH:
  - Broadcast Channels (BCH): unidirectional downlink channels providing general information about the network
  - Common Control Channels (CCCH): carry information for initiating a connection (shared between multiple connections)
  - Dedicated Control Channels (DCCH): carry signaling information specific for a single connection



Broadcast Channels - BCH

- FCCH (Frequency Correction Channel): downlink channel used to correct MS frequency, 148 bits without coding
- SCH (Synchronization Channel): carry the Base Station Identity Code (BSIC) and the frame number (FN), 25 bits + channel coding
- BCCH (Broadcast Control Channel): carry general information that are broadcasted to all user of a base station, 184 bytes after coding (parameters of the frequency hopping algorithm, number of common control channels allocated, number of blocks for the AGCH channel, info on adjacent cells, Location Area Code etc.).

Broadcast CONTROL CHANNELS

Common Control Channels - CCCH

- PCH (Paging Channel): downlink channel used by the BTS to notify an incoming call to a MS, broadcasted over a LA
- RACH (Random Access Channel): uplink channel used by a MS to request access to the network (Location Update, call request). Prone to collisions.
- AGCH (Access Grant Channel): downlink channel carrying reply to RACH requests.

Common
CONTROL
CHANNELS

Random Access Channel (RACH)

- Access to the RACH channel is random, i.e., not coordinated with other MSs
- The RACH channel is thus prone to collisions
- Access messages that are correctly received by the BS are acknowledged on the AGCH channel
- RACH messages include a temporary pseudo-random sequence that is included on the acknowledgment sent on the AGCH channel

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- Transmissions on the RACH channel use the *Slotted-ALOHA* protocol

Dedicated Control Channels – DCCH

- SACCH (Slow Associated Control Channel): bidirectional channel used to exchange connection metrics between MS/BS and BS/MS (e.g., received signal strength, quality….). Multiplexed with user traffic (184 bits)
- FACCH (Fast Associated Control Channel): used for exchange of time critical information (urgent handover request). The FACCH transmits control information by "stealing" capacity from the associated traffic channel.
- SDCCH (Stand-alone Dedicated Channel): stand-alone dedicated control channel that is assigned after a RACH request (authentication messages, call set-up…)

Dedicated CONTROL CHANNELS

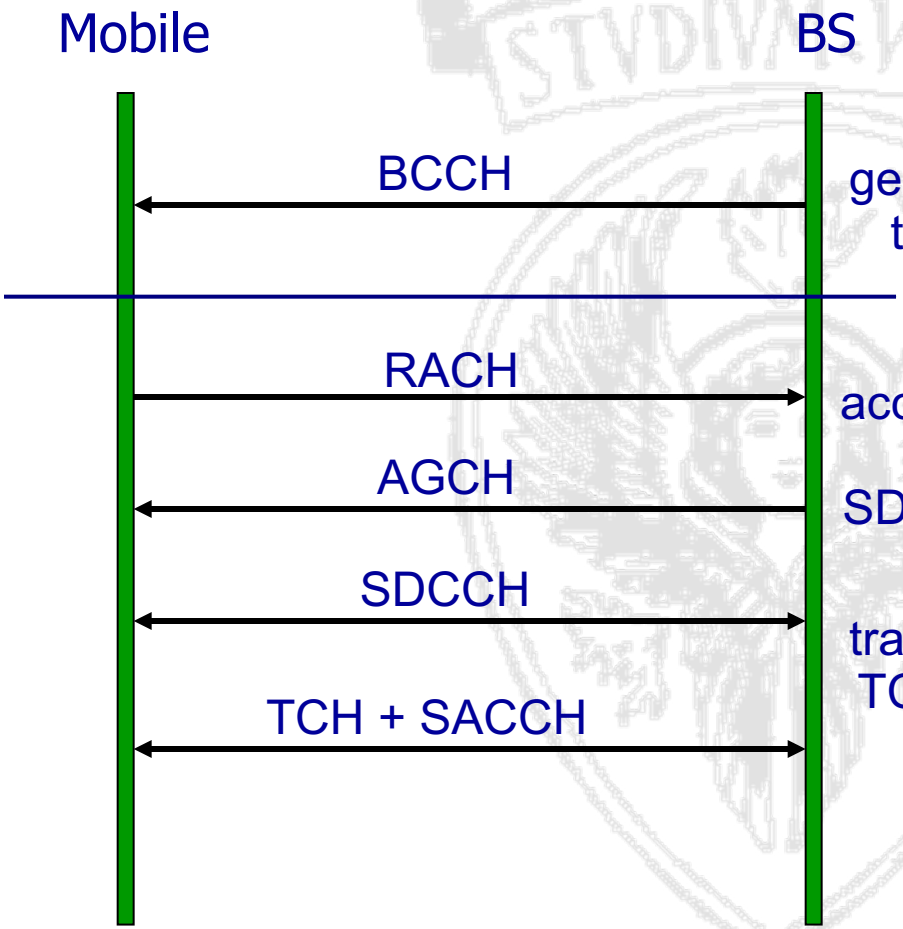
Slow Associated Control Channel (SACCH)

- Downlink:
  - Power control commands
  - BCCH information (that can no longer be decoded by the MS after it switches to the traffic channel)
- Uplink: MS measurements report:
  - RXLEV-SERVING-CELL (signal strength from own BTS) RXQUAL-SERVING-CELL (downlink BER)
  - RXLEV-NCELL “N” (signal strength from adjacent cells)
  - BCCH-FREQ-NCELL “N” (# BCCH carrier of adjacent cells)
  - BSIC-NCELL “N” (BSIC of adjacent cells)

Dedicated CONTROL CHANNELS

Set-up of a traffic channel

The MS tunes to a BTS and synchronizes with the frame structure in its cell by using FCCH, SCH, and BCCH.



general information about the network, the cell in which the MS is currently located and adjacent cells

access request

SDCCH assignment

traffic signaling + TCH assignment

SACCH info

The following signalling messages are sent on the downlink SACCH:

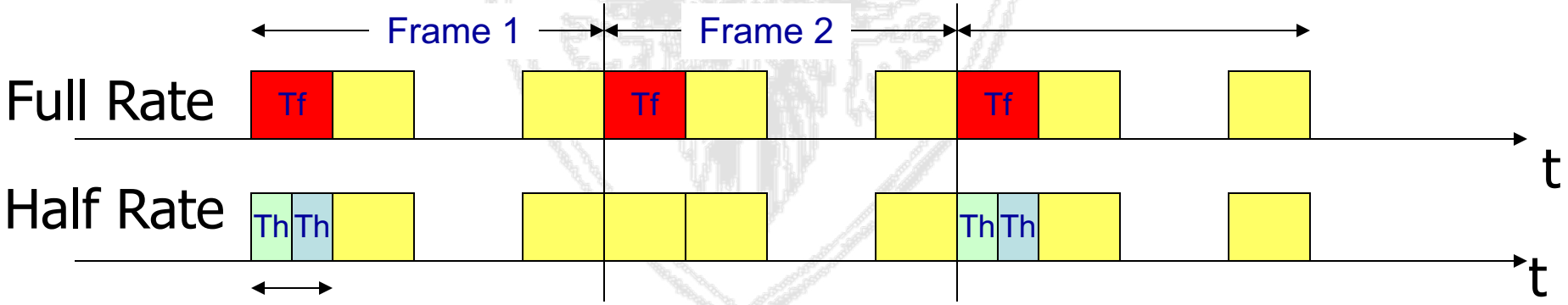
- power command,
- time advancement,
- frequency hopping sequence,
- frequencies used by adjacent channel.

he uplink SACCH contains values of:

- Frame–Error Rate (FER) of the downlink traffic channel,
- Received signal level from neighbour cells.

Traffic Channels-TCH

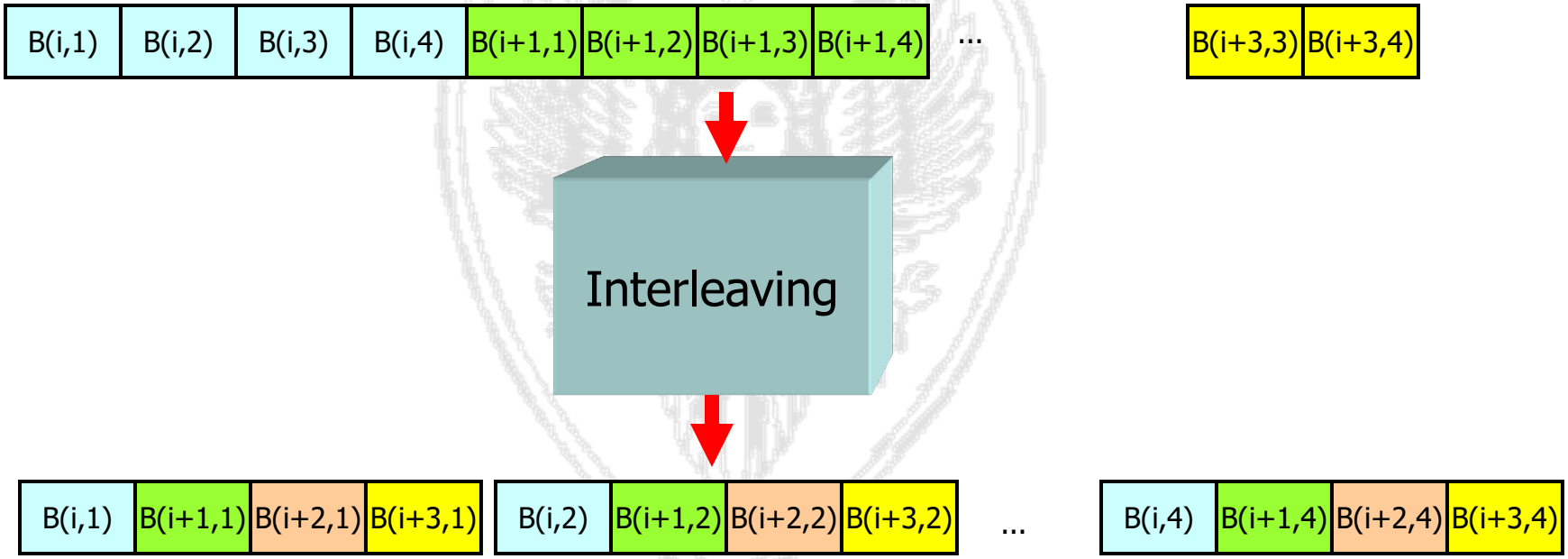
- Traffic channels (TCH) carry speech and data
- Two types of TCH:
  - Full Rate channels: gross rate of 22,8 Kb/sec (including coding incorporated for error protection)
  - Half Rate channels: gross rate of 11,4 Kb/s



Channel coding: voice channel at 13 Kb/s

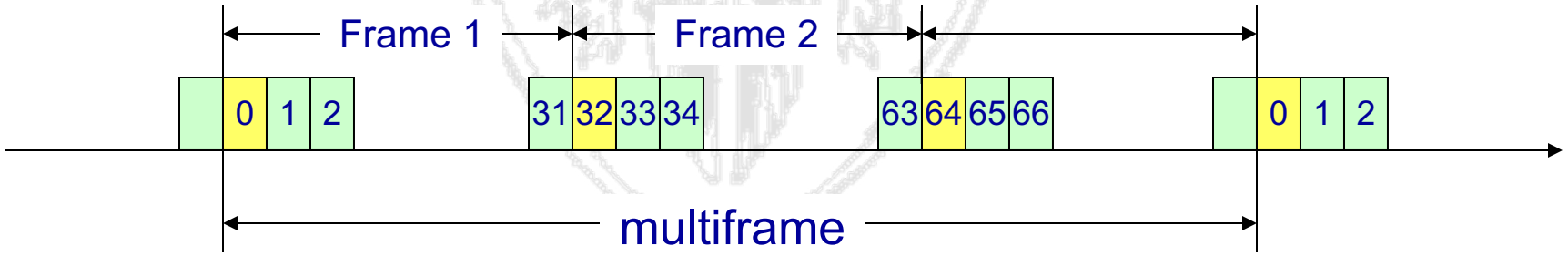
- Bit of the 4 physical blocks of 114 bit are not the contiguous output of the coding process
- Instead, bits are interleaved:

Interleaving



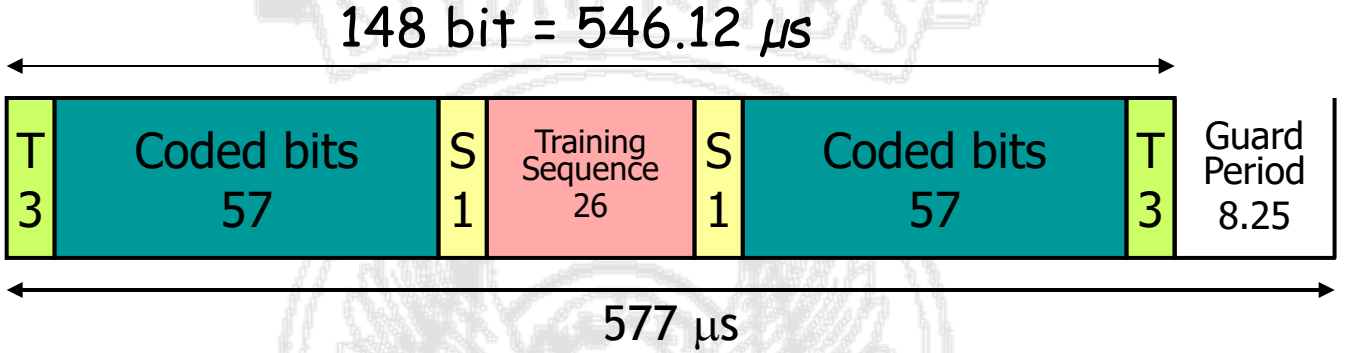
Mapping of logical channels onto physical channels

- Signaling requires lower bit rates than user transmissions (it wouldn't be efficient to assign a whole slot per frame to signaling)
- Actual transmission rate may be reduce by using **multiframes**
- IDEA: slots are associated with IDs, and may be assigned over a period of multiple frames, i.e., over a multiframe



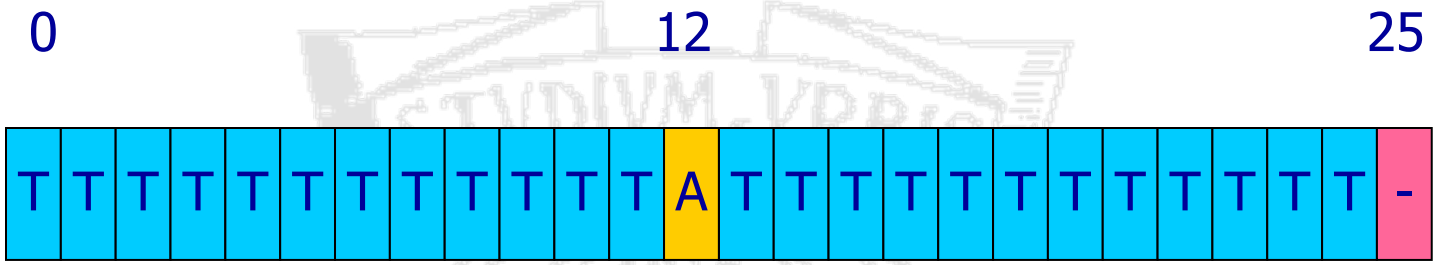
Multiframe example: SACCH

- A normal data burst carries 114 bits of data



- A channel using one slot per frame has a rate of 114 [bit]/4.6 [ms]=24.7 Kb/s
- Coded speech is transmitted at a rate of 22,8 Kb/s
- 1,9 Kb/s are not used, equal to 1 SLOT every 13 frames
- SACCH: 1 SLOT every 26 frames = rate of 950 bit/sec.

SACCH Signaling channels

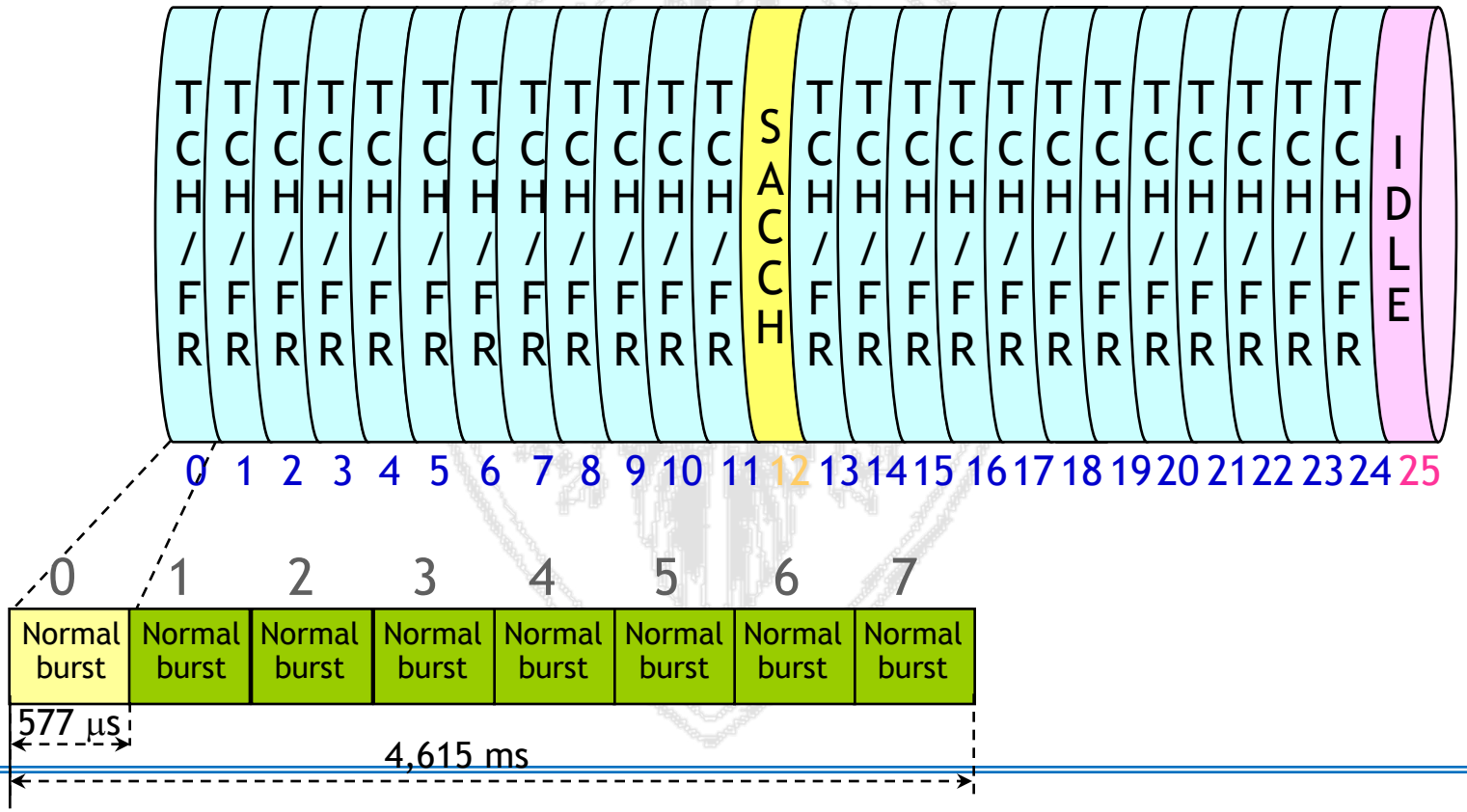


- The figure shows mapping of a full-rate traffic channel (TCH) (T) and its Slow Associated Control Channel (SACCH) (A) onto one physical channel
- SACCH is used for measurements exchange and commands
- A super-frame of 26 frames (120 ms) is used.

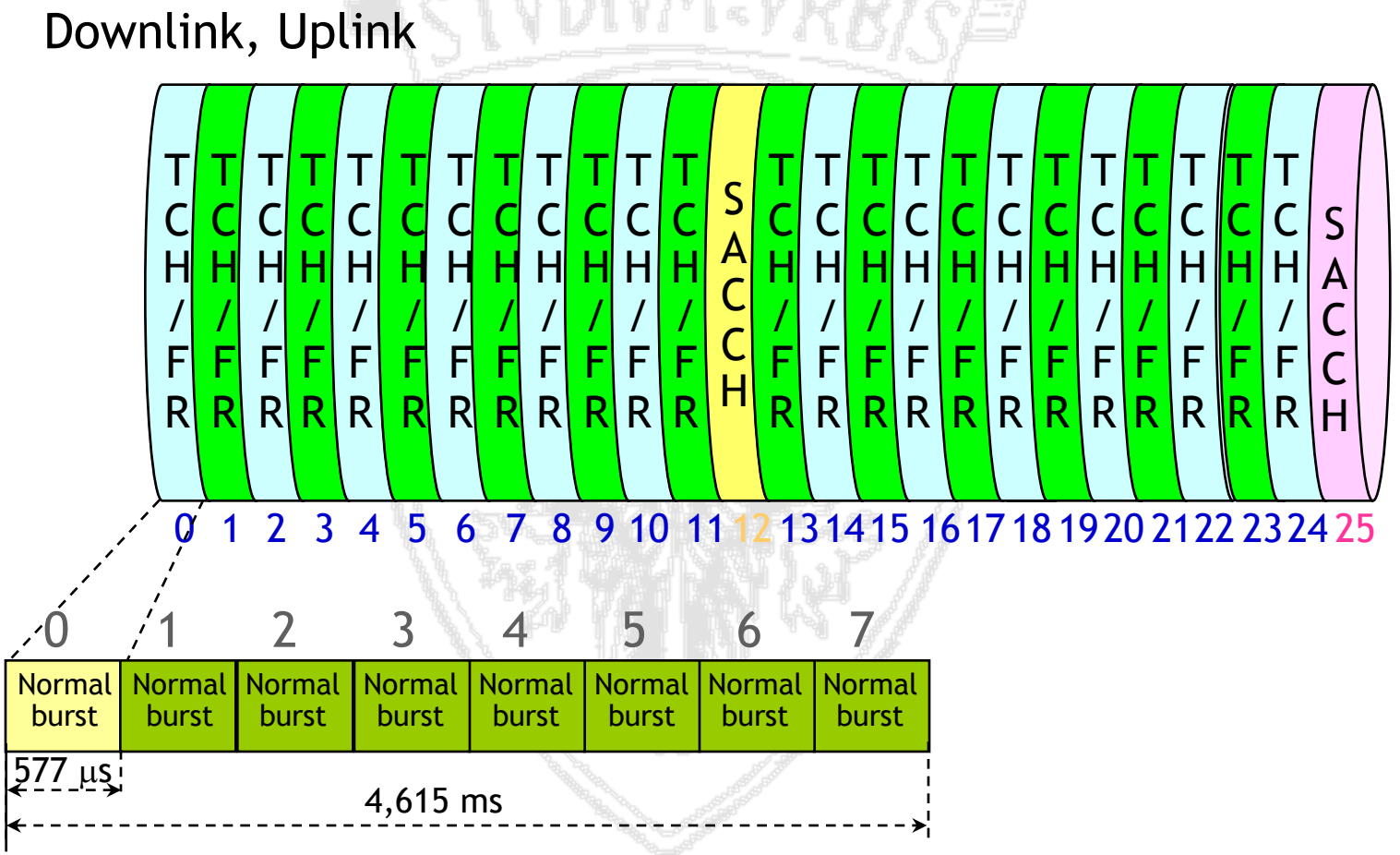
Multiframe TCH full duplex

- *A temporal diagram is the sequence of slots of the same traffic channel, i.e., of a slot of a frame*

Downlink, Uplink

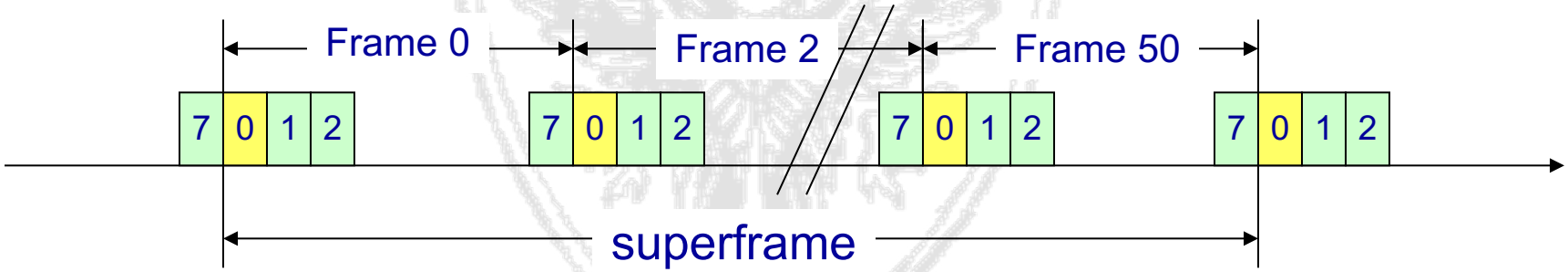


Multiframe TCH half duplex



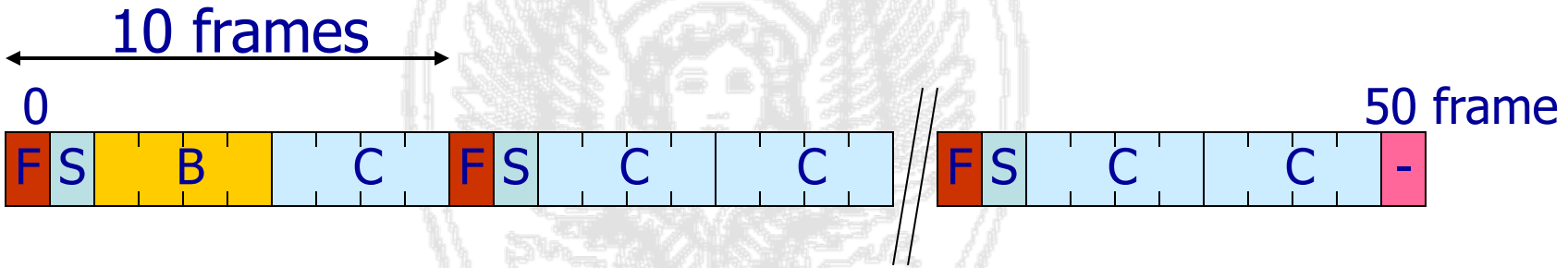
Common signaling channels

- A given slot (slot 0) over a given carrier (C0 or main carrier) among those associated to the cell is used to obtain one or multiple channels that use a multiframe containing 51 frames (235.38 ms).
- In downlink, the main carrier is always transmitted at a power higher than the other carriers, which allows a MS to synchronize with the main carrier and to receive the information it needs for tuning to the BS.

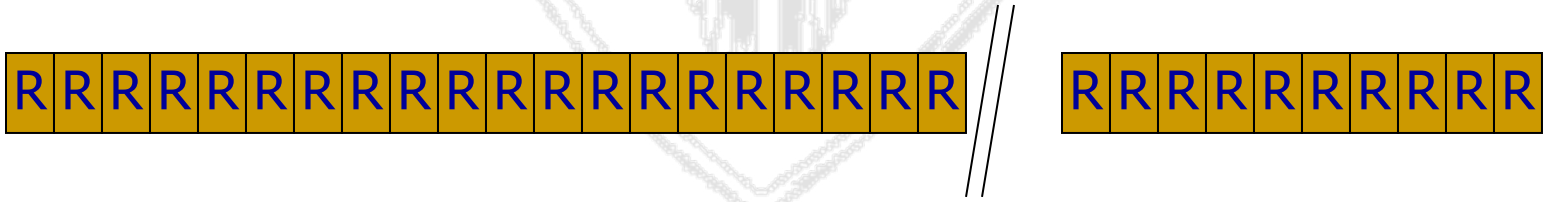


Common signalling channels

- Downlink channels:
  - Frequency Channel (FCH)
  - Synchronization Channel (SCH)
  - Broadcast Control Channel (BCCH)
  - Common Control Channel (PCH, AGCH in downlink)



- Uplink: Random Access Channel (RACH)

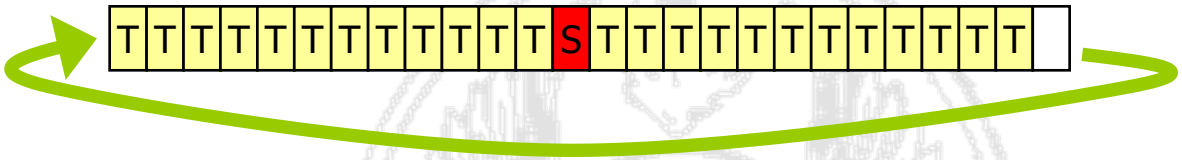


SDCCH channel

- Another slot is used to obtain 8 Stand-Alone Dedicated Control Channel (SDCCH) (S)
- Used for setup and other messages (SMS)
- The 8 channels are obtained by using 3 slots each within the super-frame of 26 slots

Why 26 and 51?

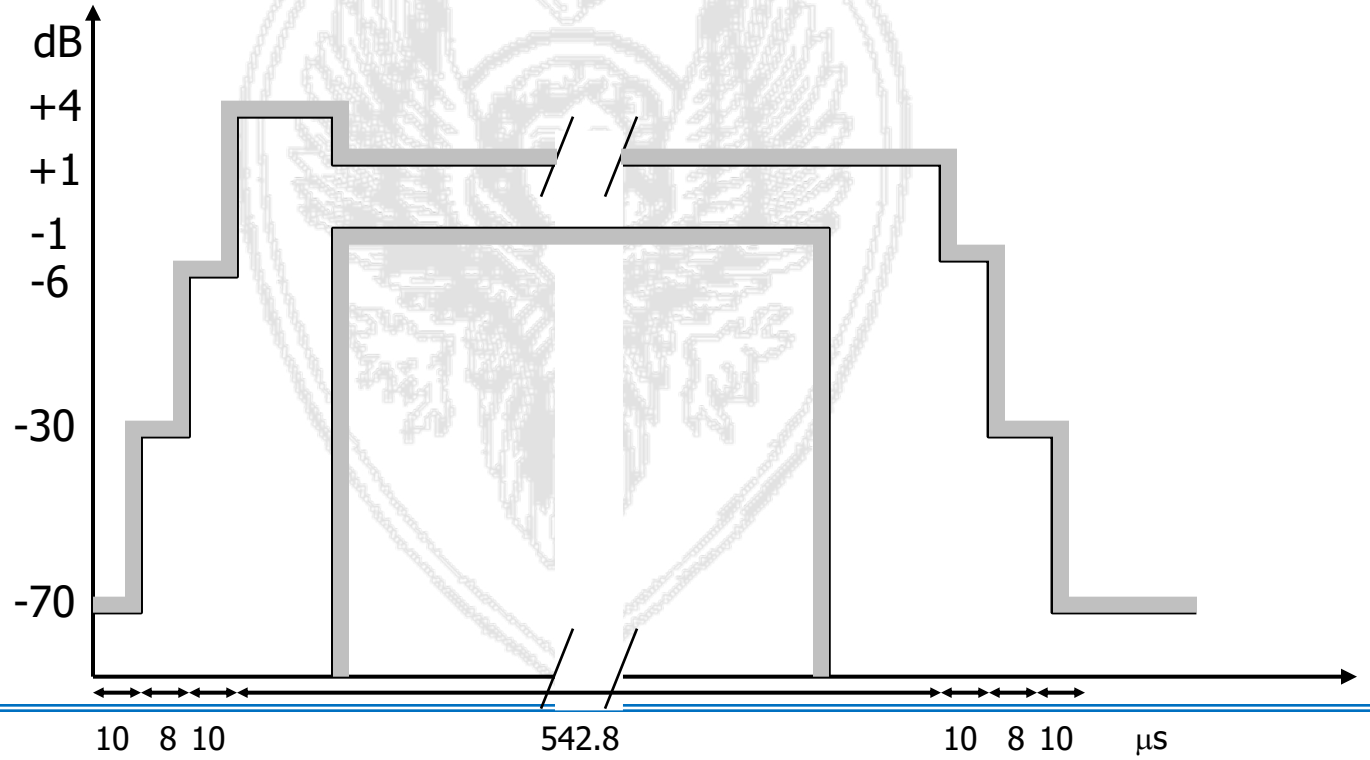
Last frame (idle) in TCH multiframe (Frame #25) used as “search frame”!



- An active call transmits/receive in 25 frames, except the last one.
- in this last frame, it can monitor the BCCH of this (and neighbor) cell
- this particular numbering allows to scan all BCCH slots during a superframe

Physical blocks (Bursts)

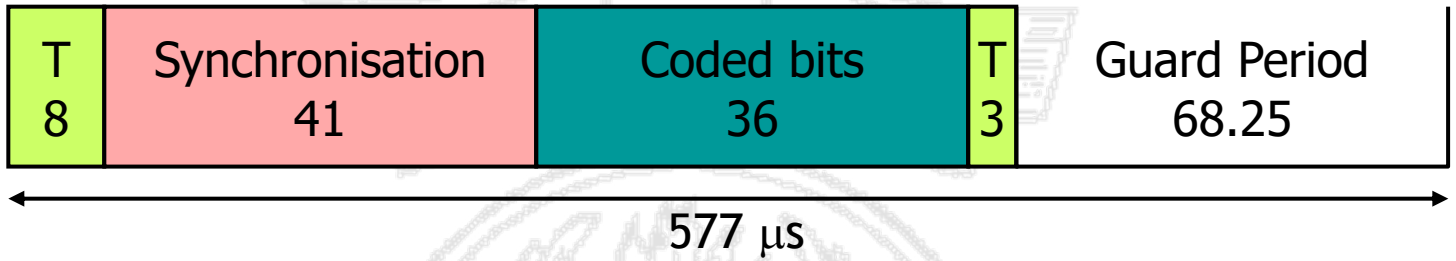
- The physical block is the information transmitted during a slot
- Due to TDMA, each block is an autonomous transmission entity, which should be transmitted at the appropriate power level to avoid interference with adjacent slots



Bursts Classification

- Normal Burst
  - Used for user transmissions (speech or data) over traffic channels
- Access Burst
  - Used to transmit information over the Random Access CHannel - RACH
  - First-time access
- Longer guard period (68,25 bit durations) to avoid overlapping of the the transmission from different mobiles; remember that mobile users do not know the timing advance at the first access (or after handover). The guard period is computed assuming a maximum cell size of 35Km.

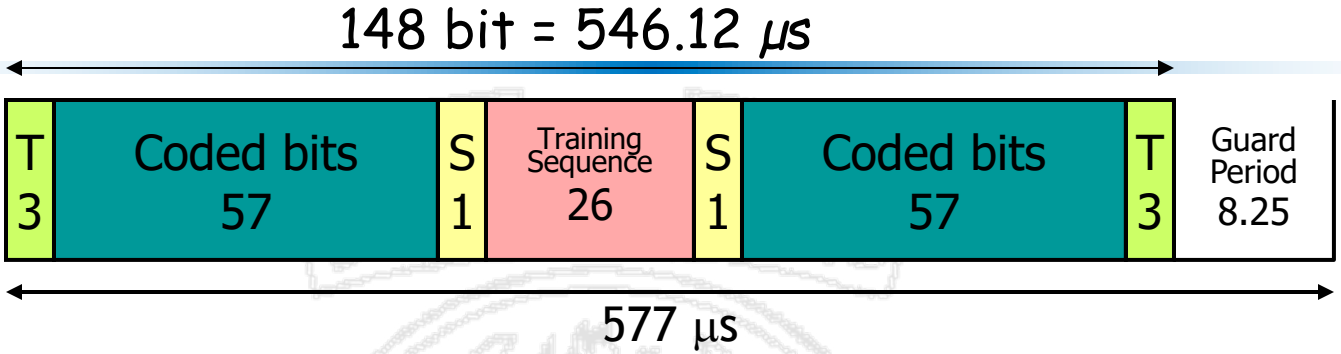
Access Burst



- Used by the MS on the random access channel at the first access
- Asynchronous access, no timing advance check
- It contains 156.25 bits
  - 8 tailing bits
  - 41 synchronisation sequence
  - 36 coded bits
  - 3 tailing bits
  - 68.25 bits guard period

To estimate timing advance

Normal Burst

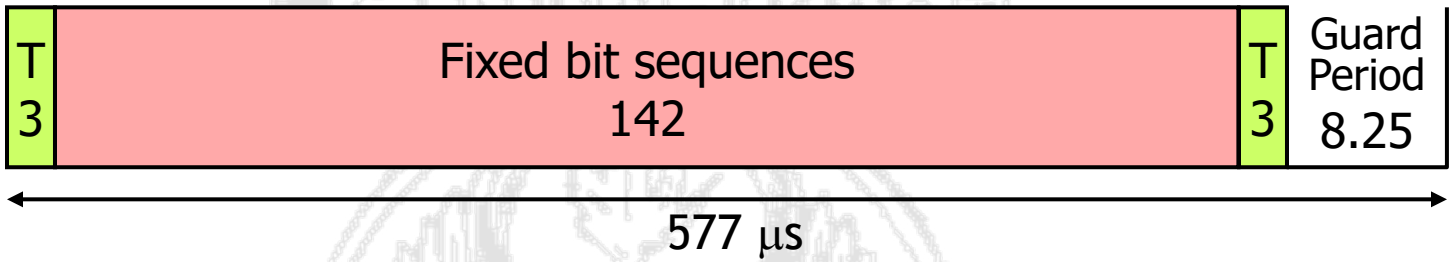


- T-bits: tail bits always set to 0
- S-bits: (stealing bits) indicate whether the burst contains user data or signaling information (SACCH or FACCH channels, only one of the two blocks may contain signaling information in case of FACCH)
- Coded Data: user bits (speech, data, etc.), 114 bit with channel coding, corresponding to 13 kbit/s for speech and to 9.6 kbit/s or lower for data (due to the channel coding using more bits)
- Training Sequence: control bits used for the equalization and tuning of the transmitters
- GP: guard period

Bursts Types

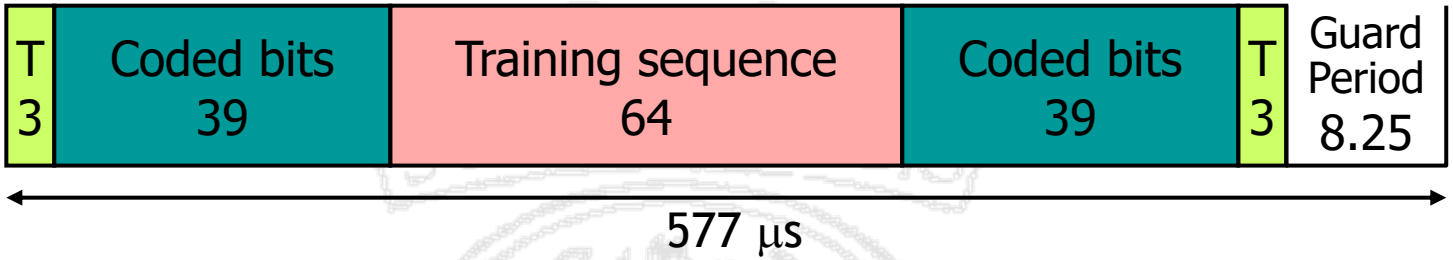
- Frequency Correction Burst
  - Used over the Frequency Correction Channel - FCCH
  - 142 bits set to “0”
  - Correct the frequency of the MS’s local oscillator, effectively locking it to that of the BTS
- Synchronisation Burst
  - Used to transmit information about synchronization for slots and frames
- Dummy Burst
  - It contains no information, only padding bits
  - Used when there is no information to be carried on the unused timeslots of the BCCH Carrier (downlink only)

Frequency Correction Burst



- 148 + 8.25 bits
  - 2 x 3 tail control bits
  - 142 fixed bit sequences
    - ✓ All bits set to 0
    - ✓ a pure sine wave is transmitted, which is the frequency with which the MS has to tune with
  - 8,25 bits guard period

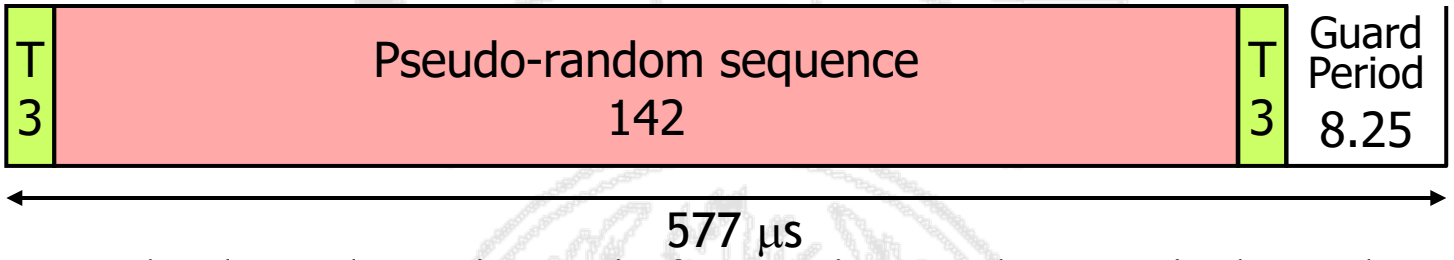
Synchronisation Burst



- 148 + 8.25 bits
  - 2 x 3 tail control bits
  - 2 x 39 coded bits
    - ✓25 bit information
    - ✓78 bit with coding
    - ✓Split into two pieces of 39 bit
  - 64 bit di training sequence
  - 8.25 bit guard period

Critical information, must be protected and correctly decoded

Dummy Burst



- Used when there is no information to be carried on the unused timeslots of the BCCH Carrier (downlink only).
- Measurements on signal strength must be carried out independently of whether there are data to transmit.
- Contains 148 + 8.25 bits
  - 2 x 3 tail control bits
  - 142 pseudo-random sequence
  - 8.25 bits guard period