RADIO INTERFACE

Dr. A. Beulah

AP/CSE

Frequency Allocation

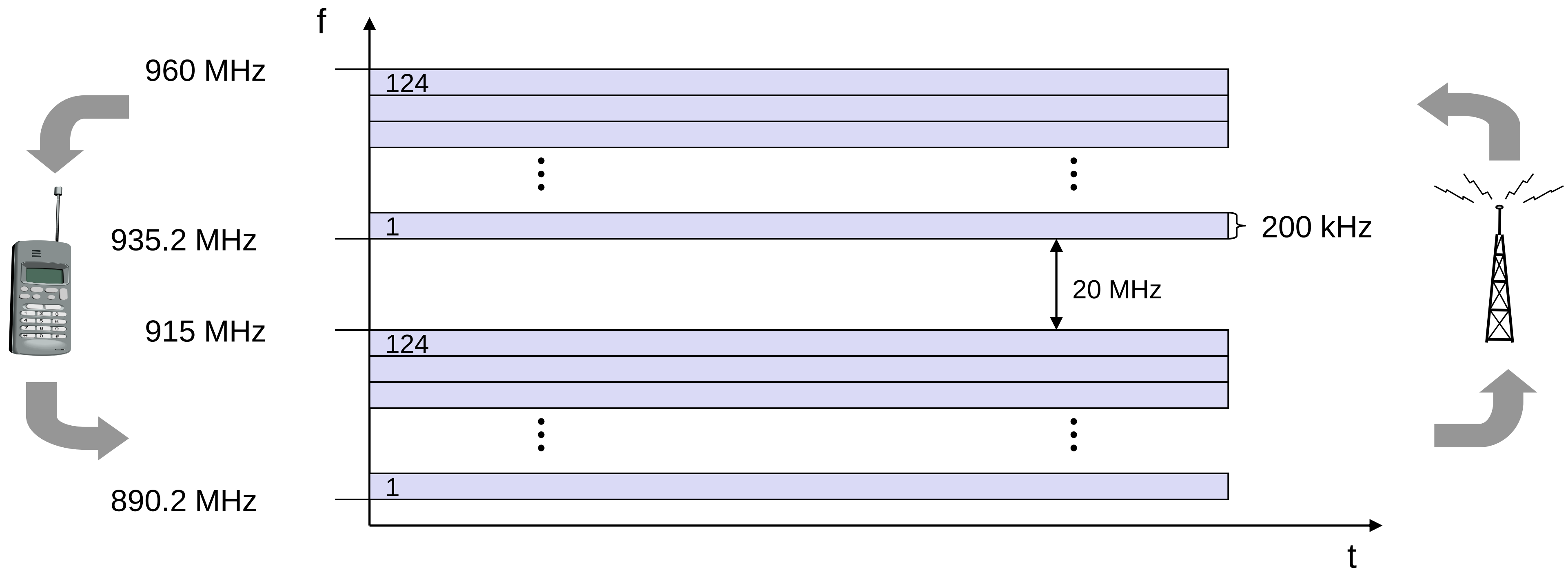
- Important interface in GSM is U_m interface.
- GSM implements SDMA using cells with BTS and assign an MS to BTS
- FDD- Frequency Division Duplex
  - The transmitter and Receiver operates at different Frequencies
- In GSM FDD is used to separate downlink and uplink.
- Media access combines TDMA and FDMA

Frequency Allocation

- GSM 900 →124 channels each 200kHz used for FDMA (total 248 uplink, downlink)
  - Channels 1 and 124 are not used for transmission, due to technical reasons.
  - 32 Channels → are reserved for organizational data.
  - Remaining 90 channels → are used for customers
- GSM 1800 → 374 channels

Frequency Allocation

- GSM 900 MHz



Frequency Allocation

Uplink Frequency (For Transmission)

- From mobile station to base station or from ground control to satellite
- All uplinks use the band between 890.2 and 915

Downlink Frequency (Receiving information)

- From base station to mobile station or from satellite to ground control
- All downlinks use 935.2 to 960 MHz

Frequency Allocation

- Media access Technique used in GSM is TDMA and FDMA.
- Using FDMA
  - A frequency is assigned to each user.
  - For large number of users in a FDMA system, the number of required frequencies is large.
  - Scalability Problem → The limited available frequency and the fact that a user will not free its assigned frequency until the user does not need it anymore.
- Using TDMA
  - Allows several users to share the same channel.
  - Each subscriber multiplexes the shared channel, scheduling their frame for transmission.
- Usually TDMA is used with an FDMA structure.

Frequency Allocation

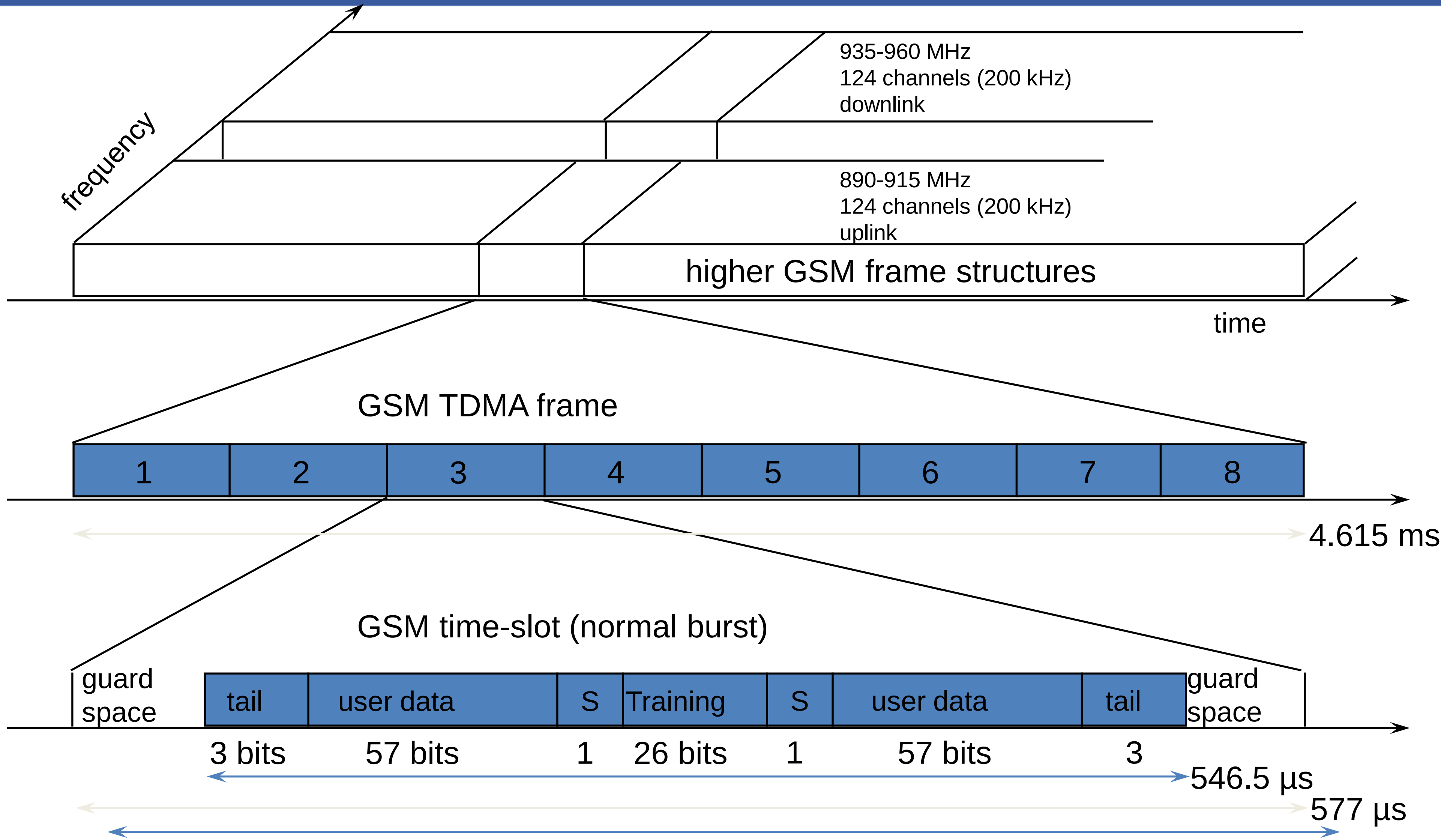
Allocation of uplink and downlink Frequency

- According to FDMA, the base station, allocates a certain frequency for up and downlink to establish a with a mobile phone
- Up and downlink have a fixed relation
- If the uplink frequency is $f_u = 890\ \text{MHz} + n \cdot 0.2\ \text{MHz}$, the downlink frequency is $f_d = f_u + 45\ \text{MHz}$, i.e., $f_d = 935\ \text{MHz} + n \cdot 0.2\ \text{MHz}$ for a certain channel n.
- The base station selects the channel. Each channel (uplink and downlink) has a bandwidth of 200 kHz
- This illustrates the use of FDM for multiple access (124 channels per direction are available at 900 MHz) and duplex according to a predetermined scheme.

Frequency Allocation

- Each of 248 channels is additionally separated in time via GSM TDMA Frame
  - ie 200kHz carrier is subdivided into frames that are repeated continuously.

GSM FDMA -TDMA



GSM FDMA -TDMA

- A 25 MHz frequency band is divided, using a FDMA scheme, into 124 carrier frequencies with a 200khz spacing.
  - 915 -890 (25)
  - 960 -935 (25)
  - 25000/200 = 125 channels
- A 25 Mhz frequency band can provide 125 carrier frequencies
- The *first* carrier frequency is used as a *guard-band* between GSM and other services working on lower freq.

- Each frequency is time-divided using a TDMA scheme.
- This scheme splits a 200kHz channel, into 8 *bursts*.(GSM Time Slots) . Data is transmitted in form of Bursts.
- A burst is the unit of time in a TDMA system, and it lasts approximately 0.577ms or 577µs
- Remaining 30 µs gaurd band
- Thus a TDMA lasts *4.615ms*. Each burst is assigned to a *single* user.

GSM FDMA -TDMA

- A normal burst is only 546.5 µs long.
- Each burst contains 148 bits.
- Remaining 30.5µs is used as guard space to avoid overlapping with other burst.
- Within 577µs 156.25 bits can be allotted.
- Therfore
  - Each TDM channel has a data rate of 33.8kbps
  - Each Radio carrier frequency transmits 270kbps over U_m interface

Burst structure

- The *tail bits* (T) are a group of 3 bits set to zero and placed at the *beginning* and the *end* of a burst. Used to enhance the receiver performance.
- The *training sequence* has a length of *26 bits*. It synchronizes the receiver to the current path propagation characteristics and select strongest signal in the multipath propagation.
- The coded data bits corresponds to two groups, of *57 bits* each, containing signaling or user data.
- The stealing flags (S) indicate, to the receiver, whether the data bits are data or signaling traffic.
- The *guard period* (GP), with a length of *8.25 bits*, is used to avoid a possible overlap of two mobiles.

Burst structure

Different types of bursts can be distinguished in GSM:

- Frequency-correction
  - Allows MS to correct local oscillator to avoid interference with neighboring channels.
- Synchronization
  - It has the same length as the normal one but a different structure.
  - Synchronizes MS with BTS
- Random access
  - shorter than the normal burst.
- Normal Burst
  - burst used to carry speech or data information.
  - It lasts approximately 0.577 ms and has a length of 156.25 bits.
- Dummy Burst
  - If no data is available for a slot dummy burst is used.

Logical Channel

- In GSM Channels are separated into Physical and Logical Channel
- The Physical channels are determined by the timeslot (8*124 physical channels)
- A physical channel consists of a slot, repeated every 4.615 ms.

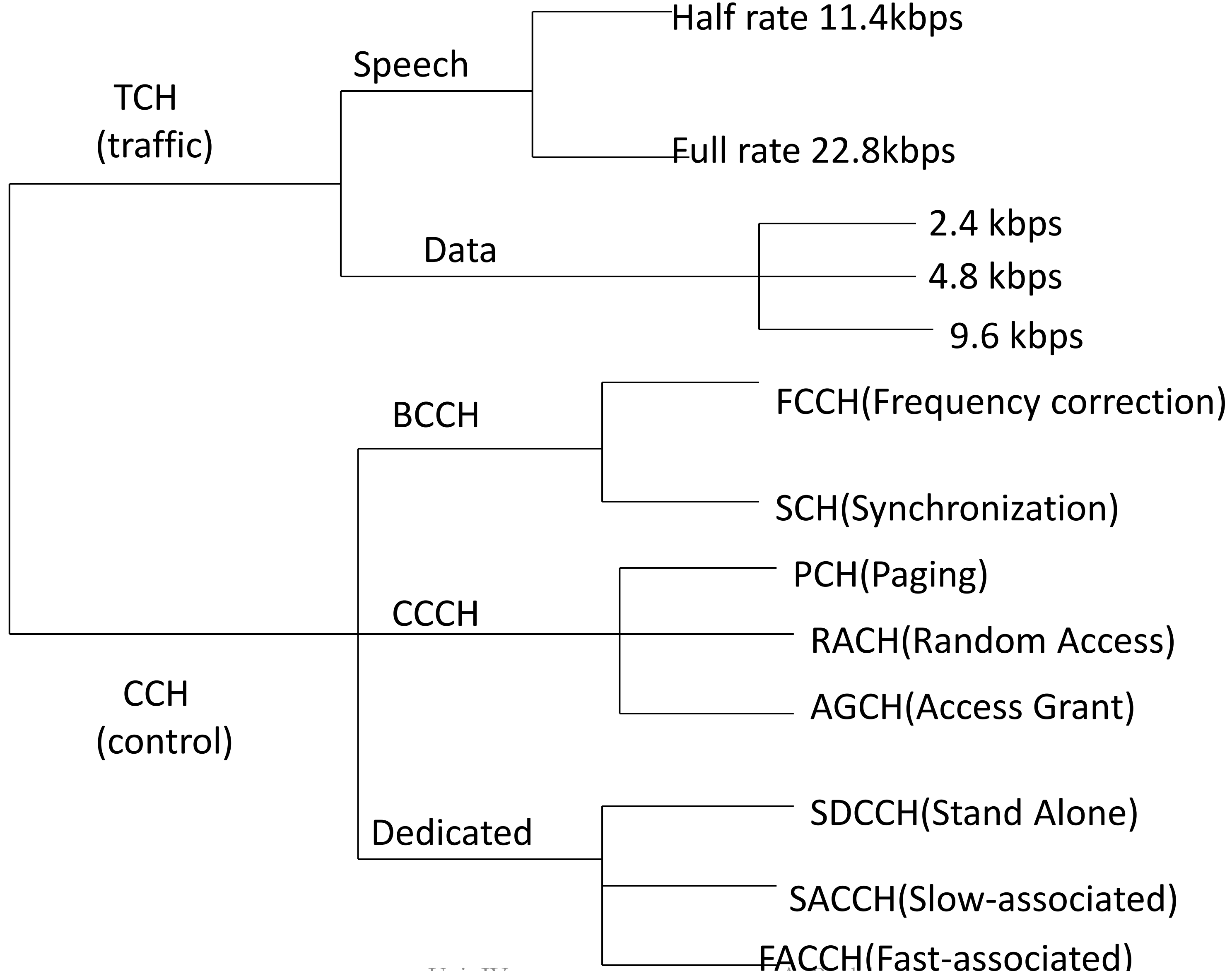
Logical Channel

- The logical channels are determined by the information carried within the physical channel.
- Example: A logical channel C1 that only takes up every fourth slot and another logical channel C2 that uses every other slot.
- Both logical channels could use the same physical channel with the pattern $C_1C_2xC_2C_1C_2xC_2C_1$ etc.

Logical Channel

- A logical channel is defined by its frequency and the position of its corresponding burst within a TDMA frame.
- In GSM there are two types of Logical channels:
  - Traffic channels (TCH)used for speech and data.
  - Control channels (CCH) used for network management messages and channel maintenance tasks.

Channel Structure



Traffic channels (TCH)

- Used for user data (Ex: speech and fax)
- 2 Categories
  - Full Rate TCH → TCH/F
  - Half Rate TCH → TCH/H

Full-rate traffic channels (TCH/F)

- Data rate of 22.8 Kbps, with a useable rate of 9.6 Kbps for data (or approximately 13 Kbps for speech).
- 13 kbit/s were required for speech, whereas the remaining capacity of the TCH/F (22.8 kbit/s) was used for error correction (TCH/FS).
- A newer codec, enhanced full rate (EFR), provides better voice quality than FR as long as the transmission error rate is low. The generated data rate is only 12.2 kbit/s.
- Data transmission in GSM is possible at many different data rates,
  - e.g., TCH/F4.8 for 4.8 kbit/s, TCH/F9.6 for 9.6 kbit/s, and, as a newer specification, TCH/F14.4 for 14.4 kbit/s.
  - These logical channels differ in terms of their coding schemes and error correction capabilities.

Half-rate traffic channels (TCH/H)

- Data rate of 11.4 Kbps, with a useable rate of 4.8 Kbps for data
- Improved codes allow for better voice coding and can use a TCH/H.
- However, speech quality decreases with the use of TCH/HS(half rate speech) and many providers try to avoid using them.
- **The standard codecs for voice are called full rate (FR, 13 kbit/s) and half rate (HR, 5.6 kbit/s).**

Control Channels

- Control Channels are used to
  - Control media access
  - Allocation of Traffic channels
  - Mobility Management
- Types of Control Channels
  - Broadcast Control Channel (BCCH)
  - Common Control Channels (CCCH)
  - Dedicated Control Channels (DCCH)

Broadcast Control Channel (BCCH)

- Unidirectional Channel
- **BTS uses this channel to signal information to all MSs within a cell.**
- Information Transmitted are
  - Cell Identifier
  - Options available within the cell (Frequency hopping)
  - Frequencies available inside and in neighboring cells.
- Frequency Correction Channel(FCCH)
  - BTS sends information for frequency correction via FCCH.
- Synchronization Channel (SCH)
  - BTS sends time synchronization through SCH.
- FCCH & SCH are sub channels of BCCH

Common Control Channels (CCCH)

- Bidirectional Channel.
- **All information regarding connection setup between MS and BTS is exchanged via the CCCH**
- Helps to establish the calls from the mobile station or the network.
- Paging Channel (PCH)
  - BTS uses PCH to alert the MS of an incoming call. (paging)
- Random Access Channel (RACH)
  - If MS wants to setup a call, it uses the RACH to send data to the BTS.
  - Uses multiple access as slotted ALOHA.
- Access Grant Channel (AGCH)
  - BTS uses AGCH to signal an MS that it can use a TCH (traffic channel) or SDCCH (standalone DCCH) for further connection setup

Dedicated Control Channels(DCCH)

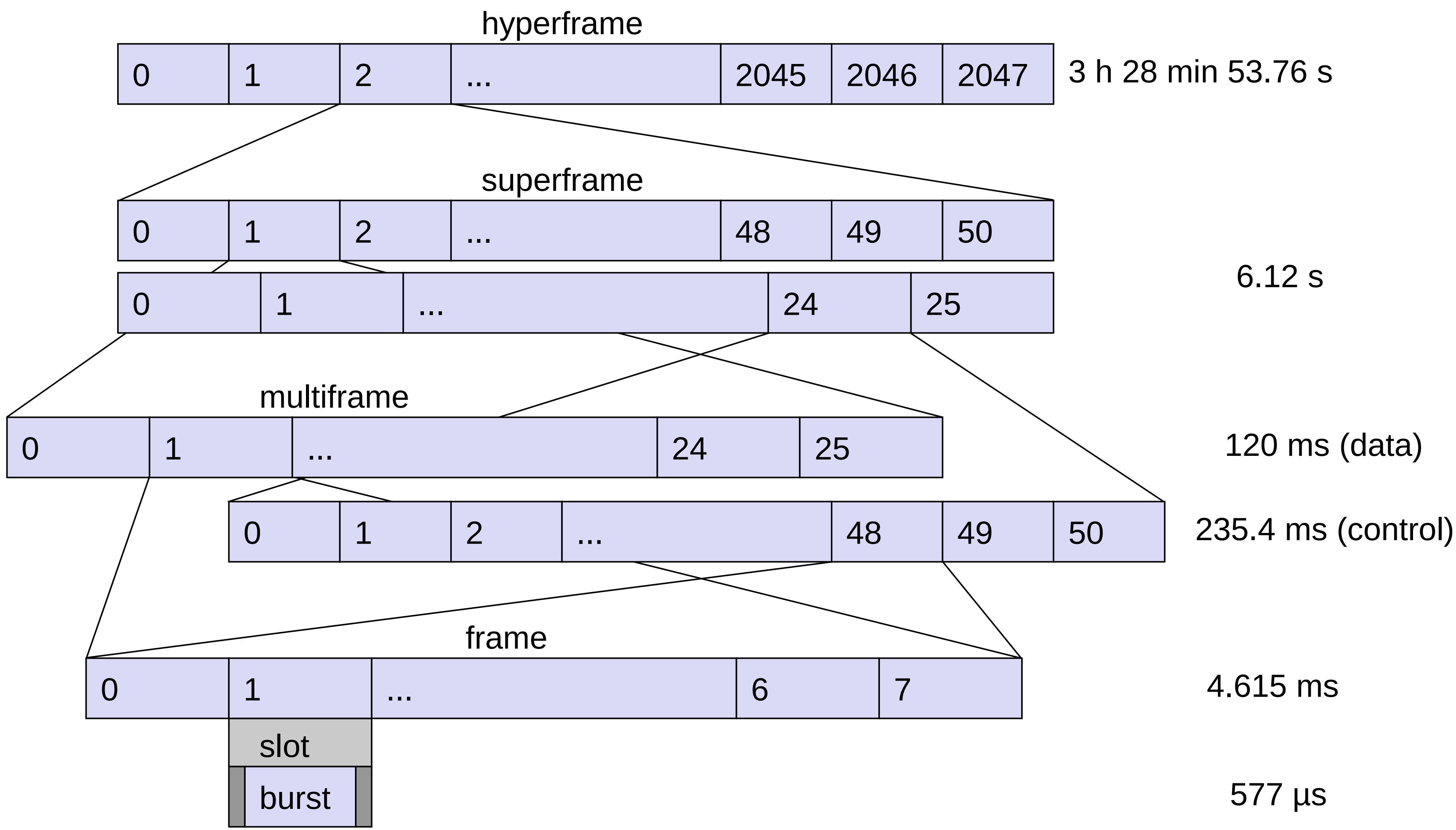
- Bidirectional Channel.
- **Used for message exchange between several mobiles or a mobile and the network.**
- Standalone Dedicated Control Channel (SDCCH):
  - MS uses SDCCH to exchange signaling in the downlink and uplink.
- Slow Associated Control Channel (SACCH):
  - Used for channel maintenance and control.(used to exchange system information, such as the channel quality and signal power level)
- Fast Associated Control Channels (FACCH)
  - Replace all or part of a traffic channel when urgent signaling must be transmitted.
- The FACCH channels carry the same signaling as SDCCH channels.

Logical Channels

- However, these channels cannot use time slots arbitrarily
  - GSM specifies a very elaborate multiplexing scheme that integrates several hierarchies of frames.
- If a simple TCH/F is used for user data transmission, each TCH/F will have an associated SACCH for slow signaling.
- If fast signaling is required, the FACCH uses the time slots for the TCH/F.
- A typical usage pattern of a physical channel for data transmission now looks like this (with T indicating the user traffic in the TCH/F and S indicating the signalling traffic in the SACCH):

  TTTTTTTTTTTTSTTTTTTTTTTTx
  TTTTTTTTTTTTSTTTTTTTTTTTx

GSM Frame Hierarchy



GSM Frame Hierarchy

- Multiframe
  - 26 slots
  - 12 slots with user data followed by a signaling slot, again 12 slots with user data then an unused slot.
  - 24 out of 26 physical slots are used.
  - This periodic pattern of 26 slots of frames is called as Traffic multiframe.

GSM Frame Hierarchy

Superframe

- 51 multiframes with 26 frames.

Hyperframe

- 2048 superframes constitute a hyperframe

Test your Knowledge

- What multiplexing schemes are used in GSM and for what purpose? Think of other layers apart from the physical layer.

Summary

- Radio Interface
  - Physical Channel
  - Logical Channel

References

Behrouz A. Forouzan, Data Communications and Networking, Fifth Edition TMH, 2013.