

EFREI M1

Mobile Networks

GSM Networks

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GSM Networks-1

- The GSM radio interface:
 - Radio interface basics
 - Structure of the GSM radio interface

GSM Networks-2

- GSM Architecture
 - Call routing
 - Location Updating and Cell Selection
 - Dedicated Channel Assignment
 - GSM Protocol Structure

GSM Networks-3

- GSM Features
 - Handover
 - Power Control
 - Security
 - Call Establishment
 - Short messages
 - Data Services
 - Voice Services
 - GSM for PMR
- Advanced GSM Features
- GSM Issues

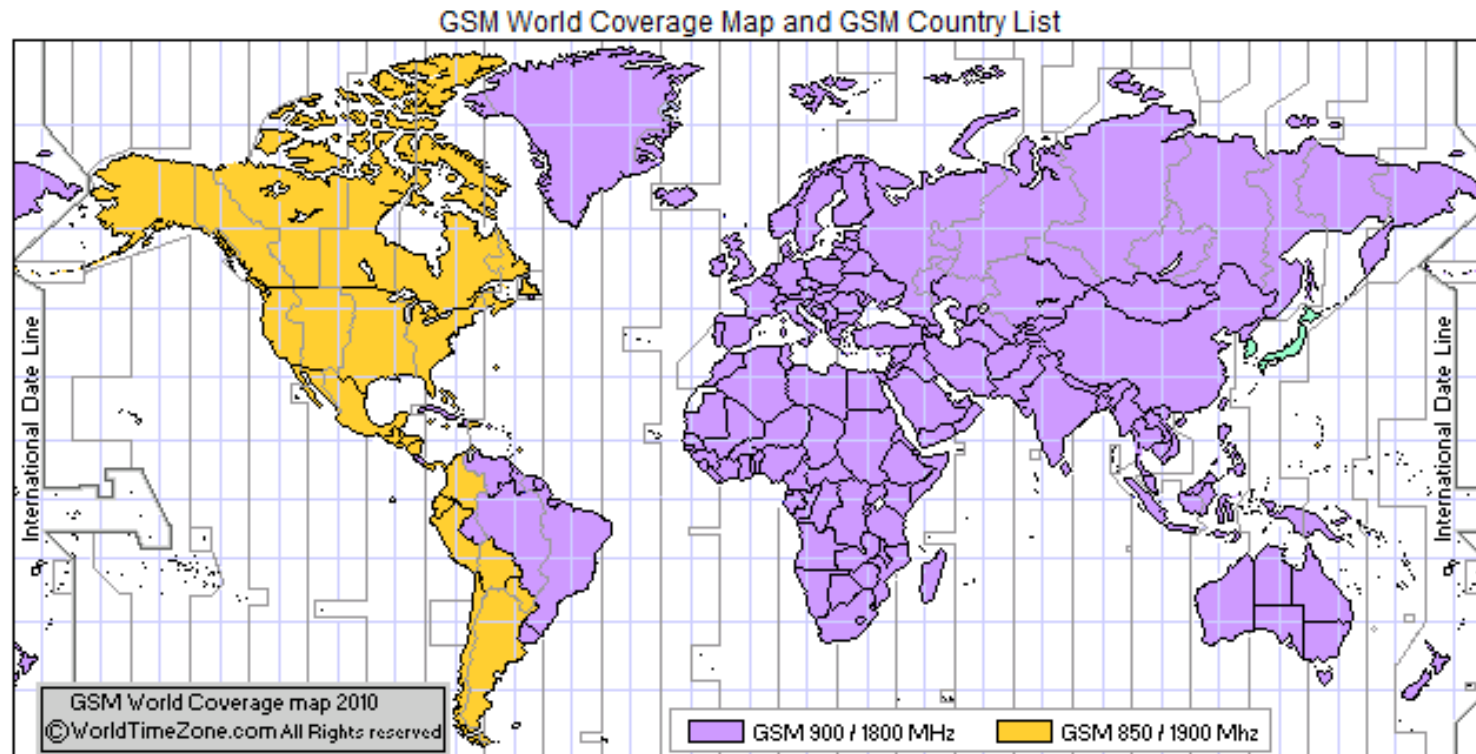
GSM Bibliography

- The GSM system for mobile communications; *Michel Mouly and Marie-Bernadette Pautet*, [Telecom Publishing 1992]
- GSM Architecture, Protocols and Services. Jörg Eberspächer et al. [Wiley 3rd edition 2009]
- GSM Networks: Protocols, Terminology, and Implementation. *Gunnar Heine* [Artech House, 1999]
– <http://www.scribd.com/doc/34043300/Gsm>
- GPRS in practice, a companion to the specifications *Peter McGuiggan* [John Wiley & Sons Ltd 2004]
- <http://www.3gpp.org/-specifications->

GSM Networks-1

- The GSM radio interface:
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 - Structure of the GSM radio interface
- GSM Architecture
 - Call routing
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 - Dedicated Channel Assignment

Main GSM frequency zones



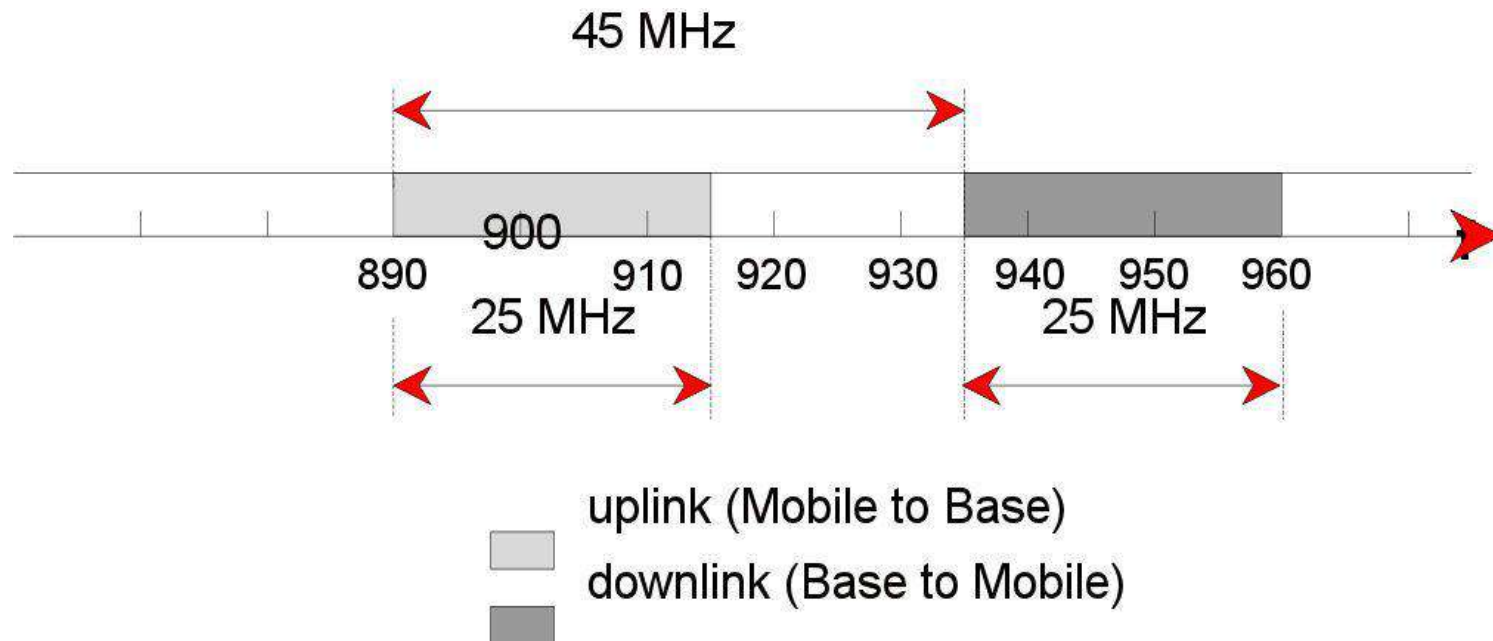
GSM 900 / GSM 1800 MHz are used in most parts of the world: Europe, Asia, Australia, Middle East, Africa.

GSM 850 / GSM 1900 MHz are used in the United States, Canada, Mexico and most countries of S. America.

Near Universal Global Coverage (except Japan and Korea)
leads to Economies of Scale / Global Roaming



The first GSM band (CEPT)

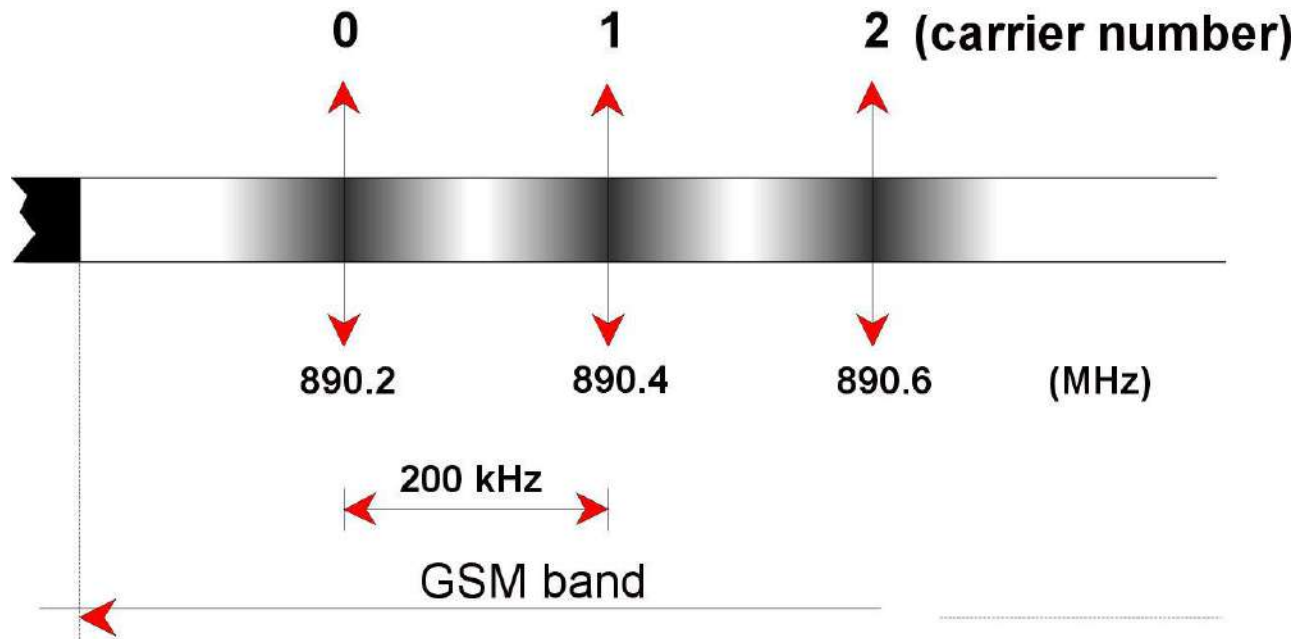


Source: Mouly & Pautet

Frequency Division Duplex (FDD)



Frequency Carriers

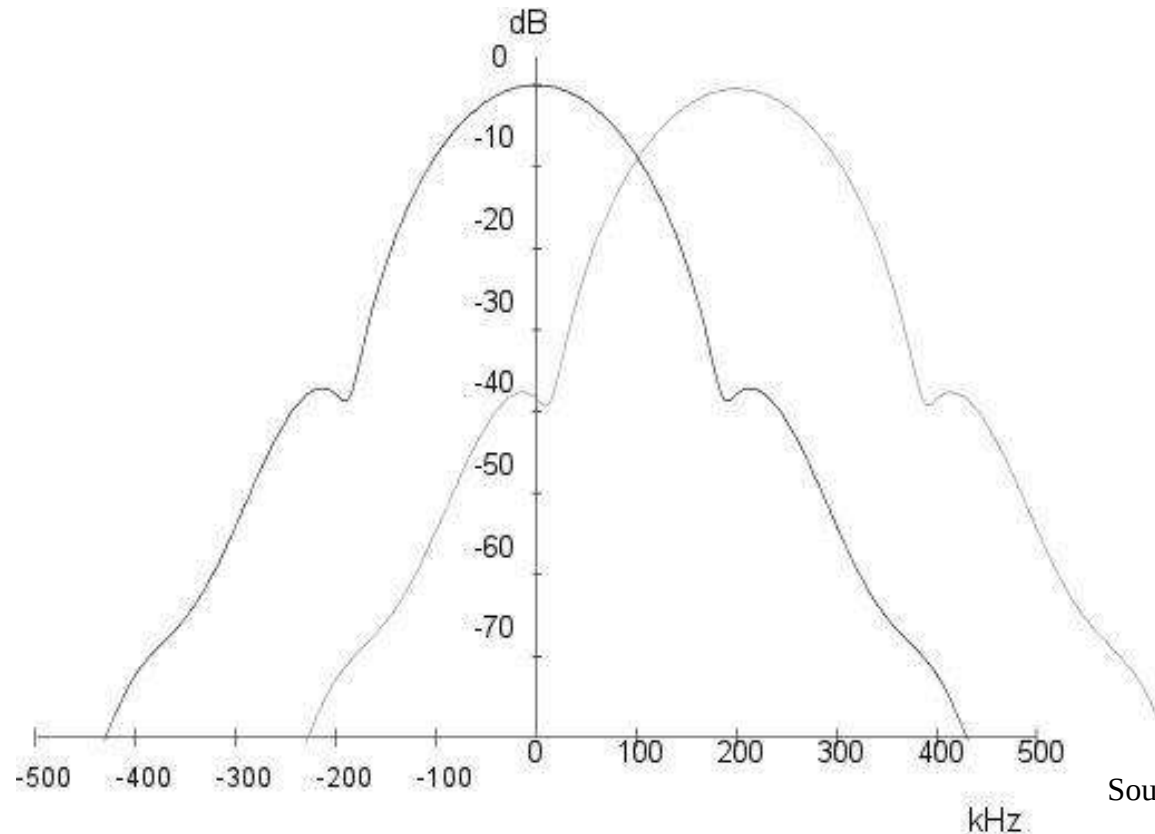


Source: Mouly & Pautet

Each radio carrier is modulated by the GSM channel data



GMSK modulation spectrum

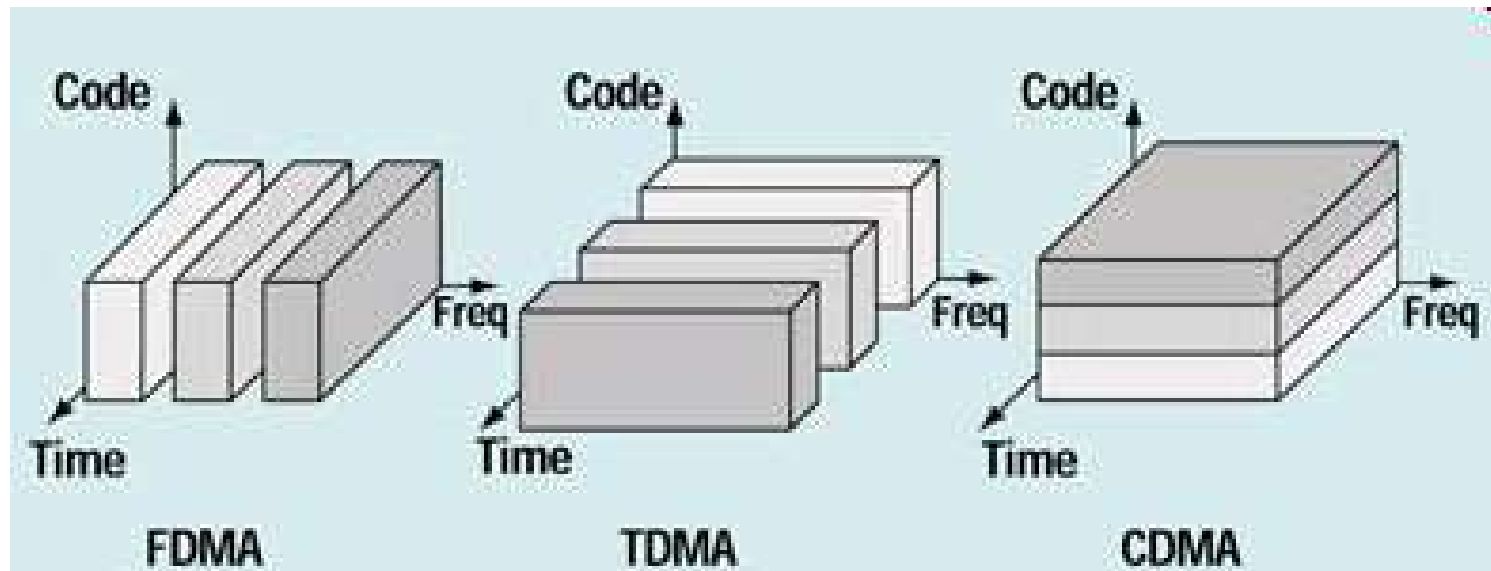


Source: Mouly & Pautet

Gaussian Minimum Shift Keying (GMSK) spectrum for GSM. Note the spectrum overlap of two adjacent (200kHz spacing) GSM channels is non-negligible => frequency planning.



Multiple Access Schemes

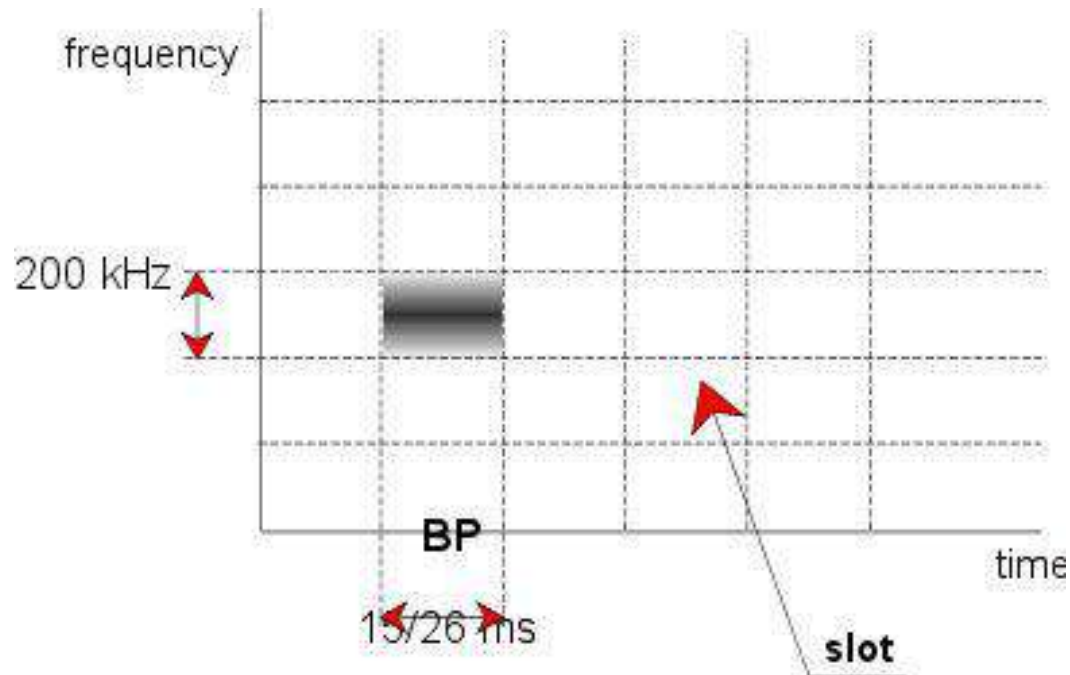


3 users multiplexed in each scheme

GSM uses all three schemes, but is principally classed TDMA



GSM TDMA

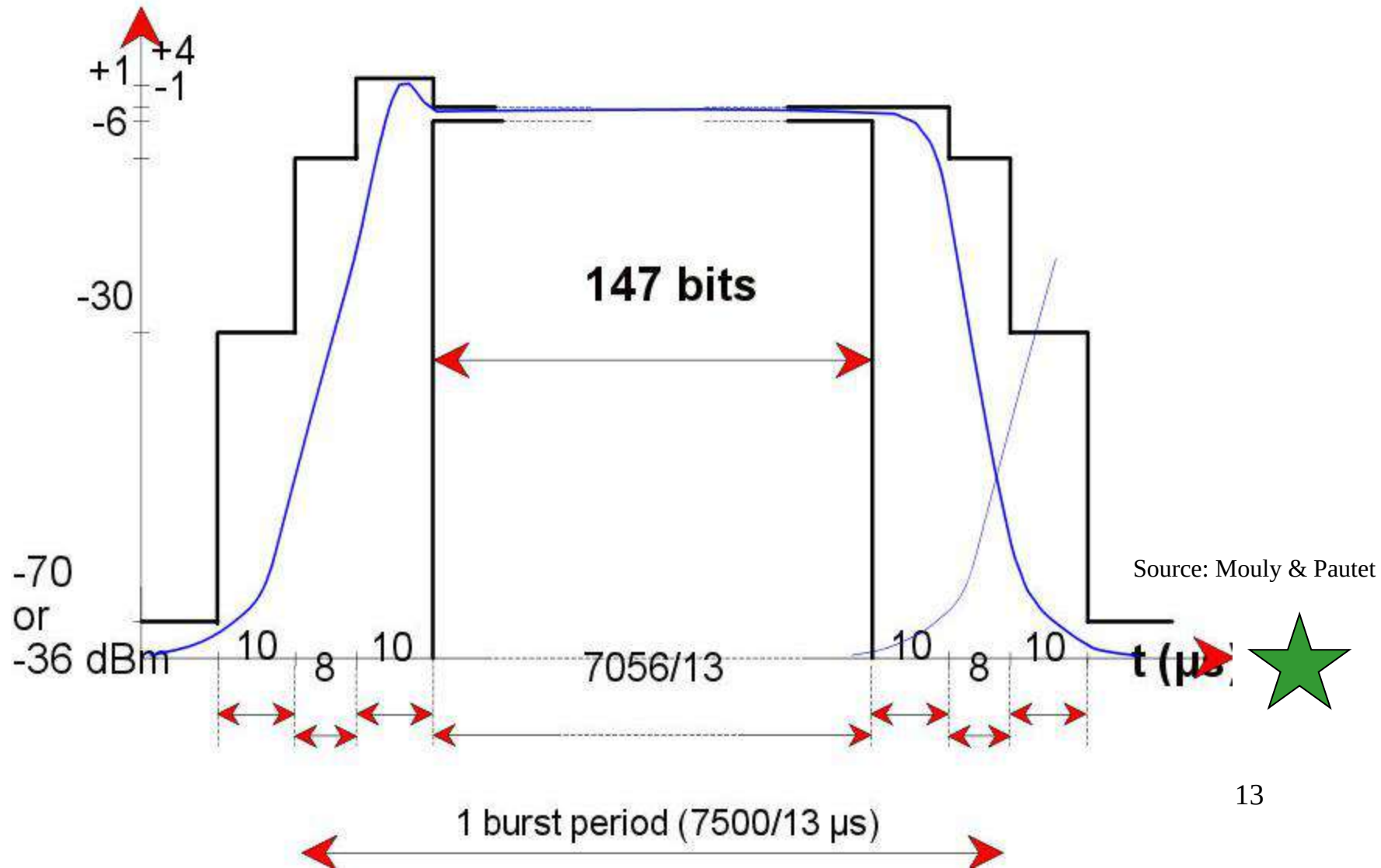


Source: Mouly & Pautet

A slot lasts about $577\mu\text{s}$ in the time domain and occupies a bandwidth of 200kHz in the frequency domain. Each slot contains a burst of data (normally 116 information bits plus training +header/tail)



GSM Normal Burst

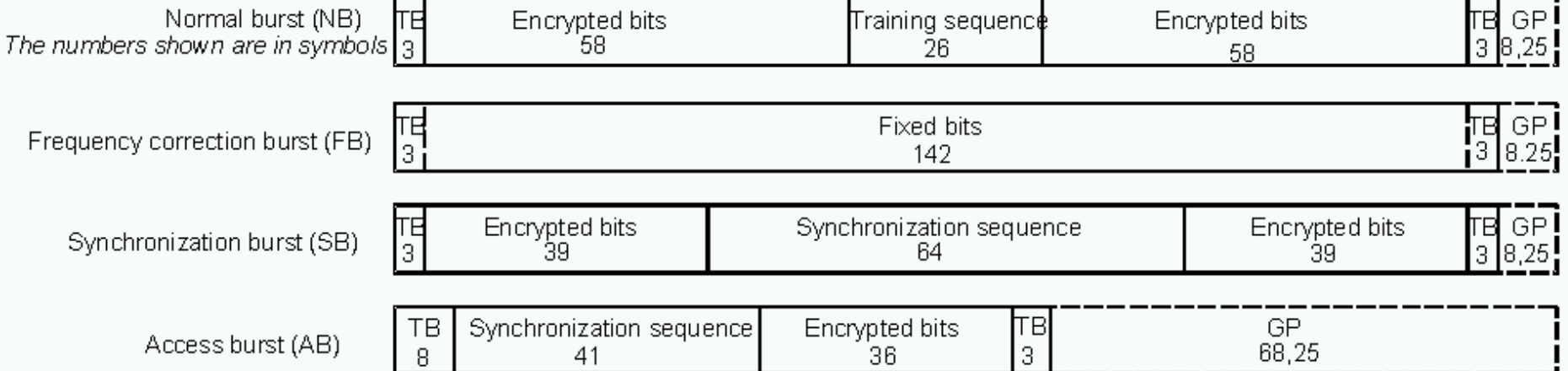


Burst composition

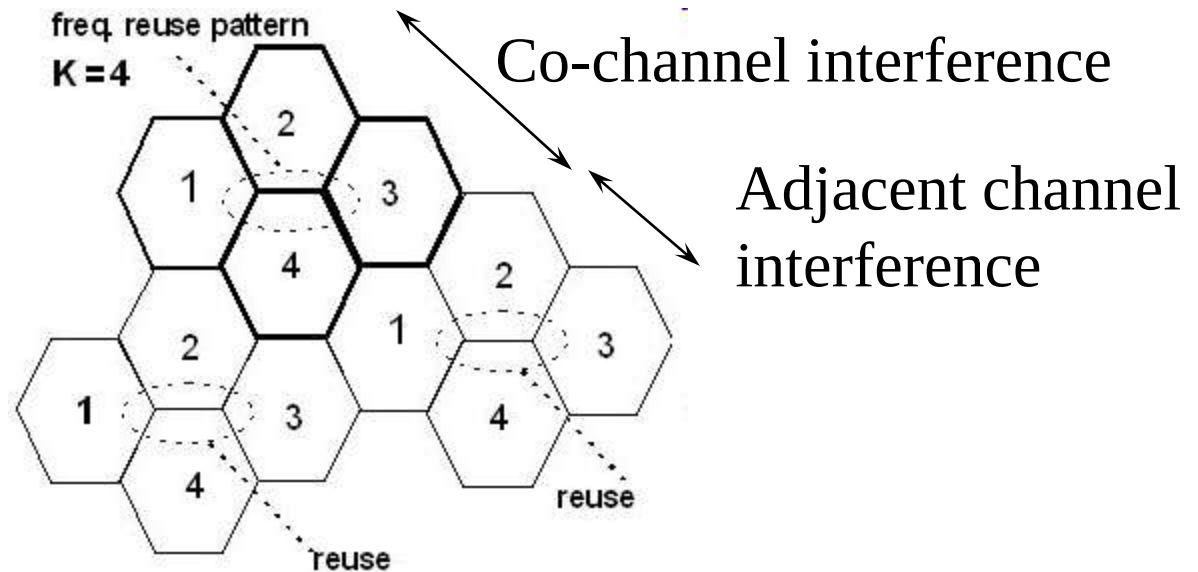
1 time slot = $15/26$ or 0.577ms (156.25 symbol durations)

← 1 symbol duration = $48/13$ or 3.69μs →

(TB: Tail bits - GP: Guard period)



GSM Frequency planning



Source: Mouly & Pautot



GSM key radio parameters

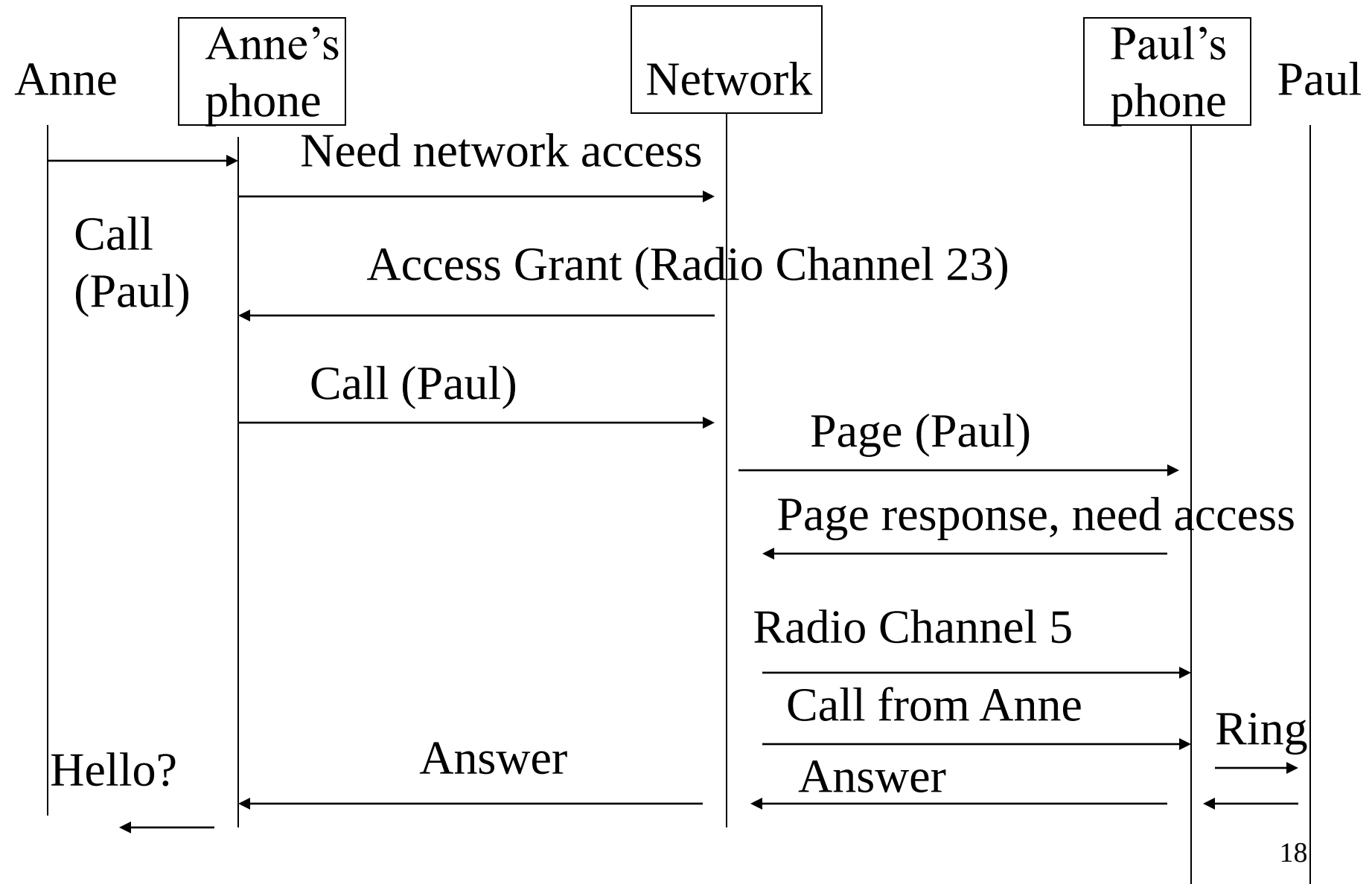
- FDD in UHF band (300-3 000MHz) {400-1900}
- FDMA 200 kHz carrier spacing
- TDMA 8 time slots per carrier, 120ms/26 frame
- Slow frequency hopping (hop interval > slot)
- GSM symbol rate: 270.833 kbps (13/48 MHz)
- GMSK modulation (8PSK+ for EDGE)



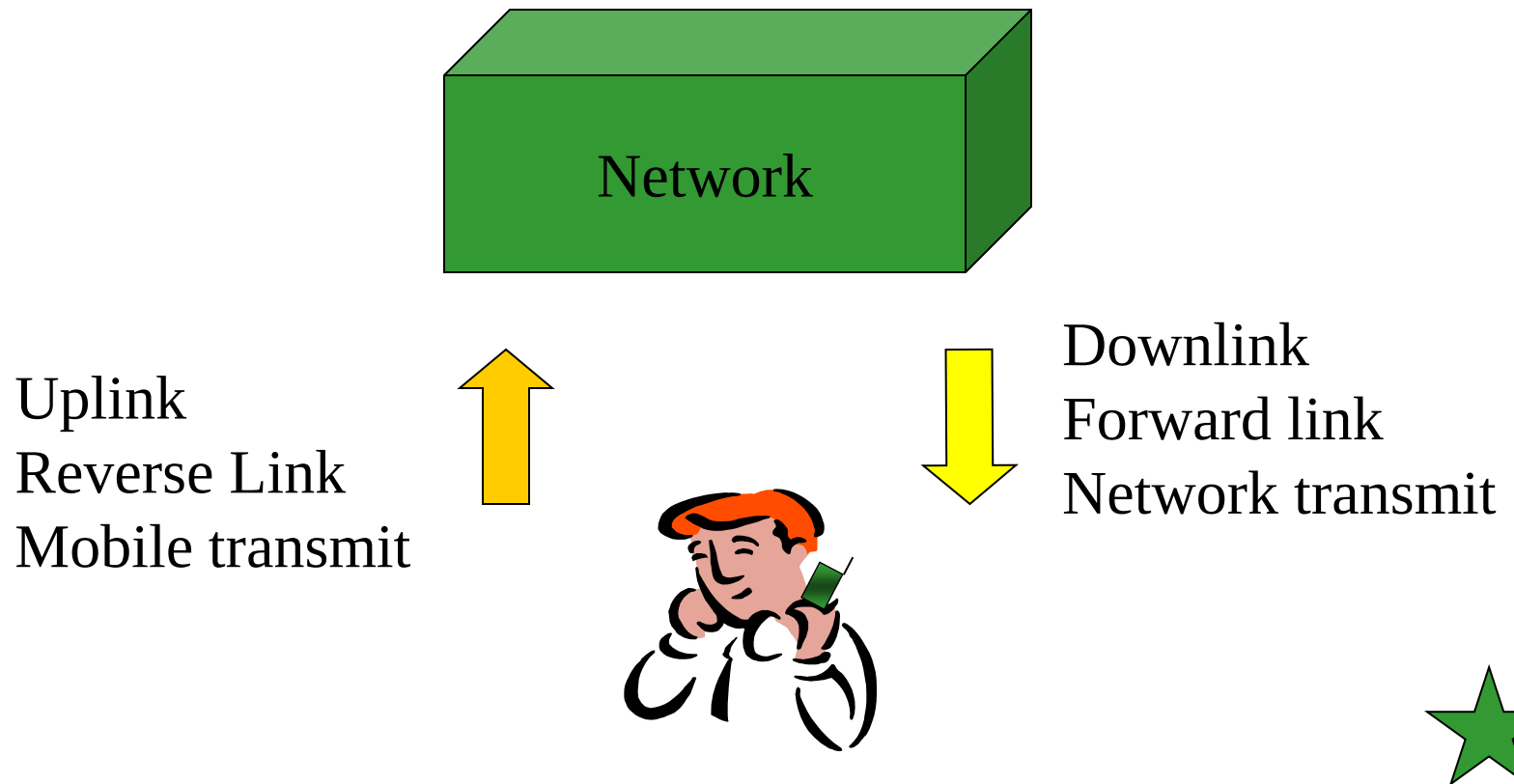
Engineering Problem No.3: Structure of radio interface

- Problem Statement:
 - How to organise the communication bandwidth to and from mobile stations in order to optimally meet user communication needs?
 - Needs include voice and data calls, messages, mobility updates, handovers, local information
 - Bandwidth requirements change in time
 - Need to connect with other networks

Simplified Radio Protocol for call setup

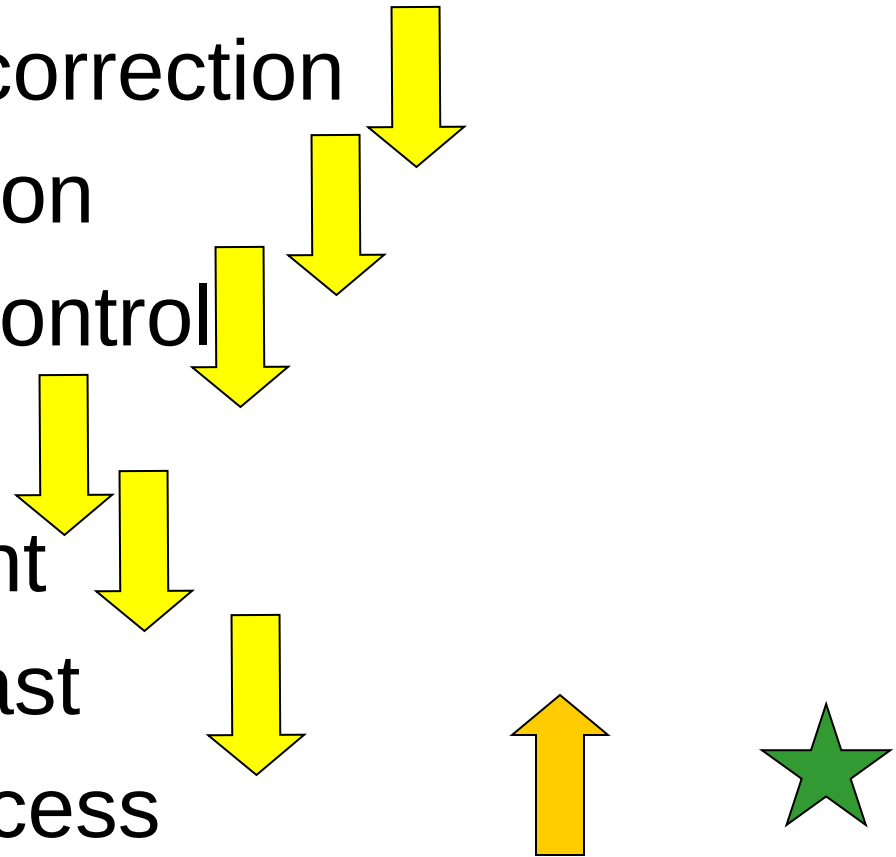


Direction of Communication



GSM Common Channels

- FCCH: Frequency correction
- SCH: Synchronization
- BCCH: Broadcast control
- PCH: Paging
- AGCH: Access grant
- CBCH Cell Broadcast
- RACH: Random access



Common Channels:usage

- FCCH and SCH: allow mobiles to synchronise to network (SCH also provides a basic cell identity: the BSIC)
- BCCH: operational network cell information
- PCH: Alerts mobiles on incoming calls
- RACH: Mobiles request access
- AGCH: Access granted
- CBCH: network cell information for users

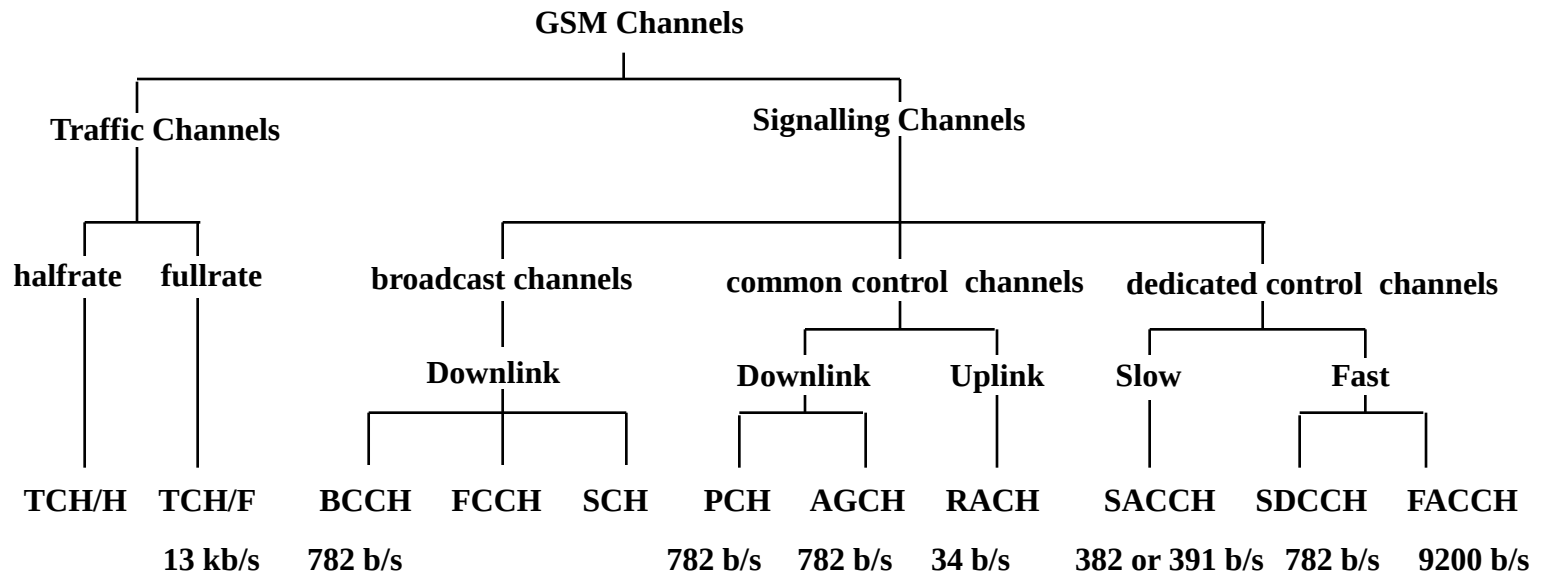


GSM Dedicated Channels

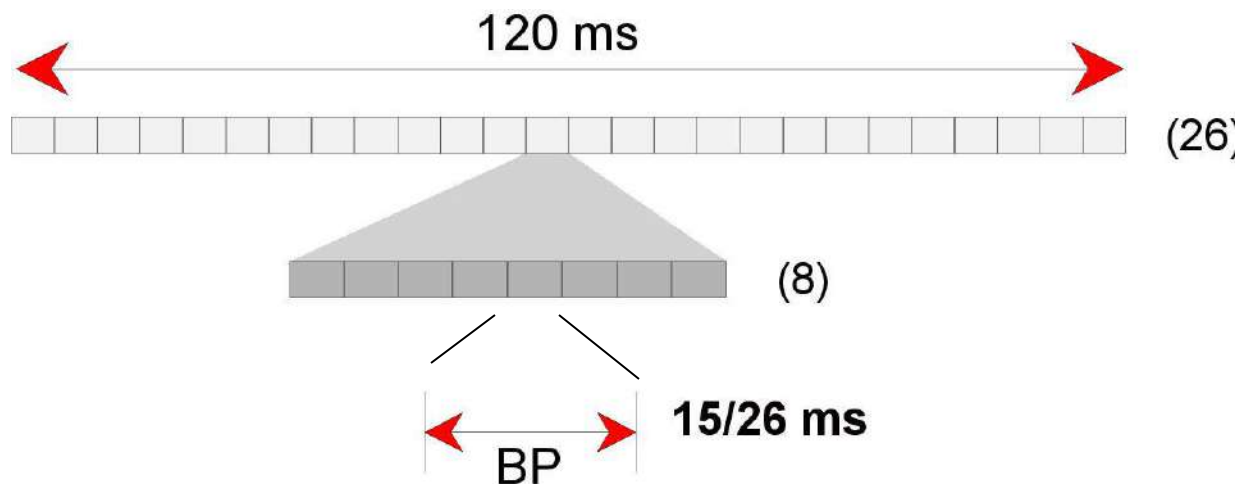
- Traffic channels:
 - Full (TCH/F) rate speech (13kbps) or data
 - Half (TCH/H) rate speech (6.5kbps) or data
- SDCCH: Stand-alone dedicated control: principal signalling channel
- SACCH: Slow associated control: radio measurements et alia, during call
- FACCH: Fast associated control: “in band” signalling for handover et alia, during call



GSM Channel Classification



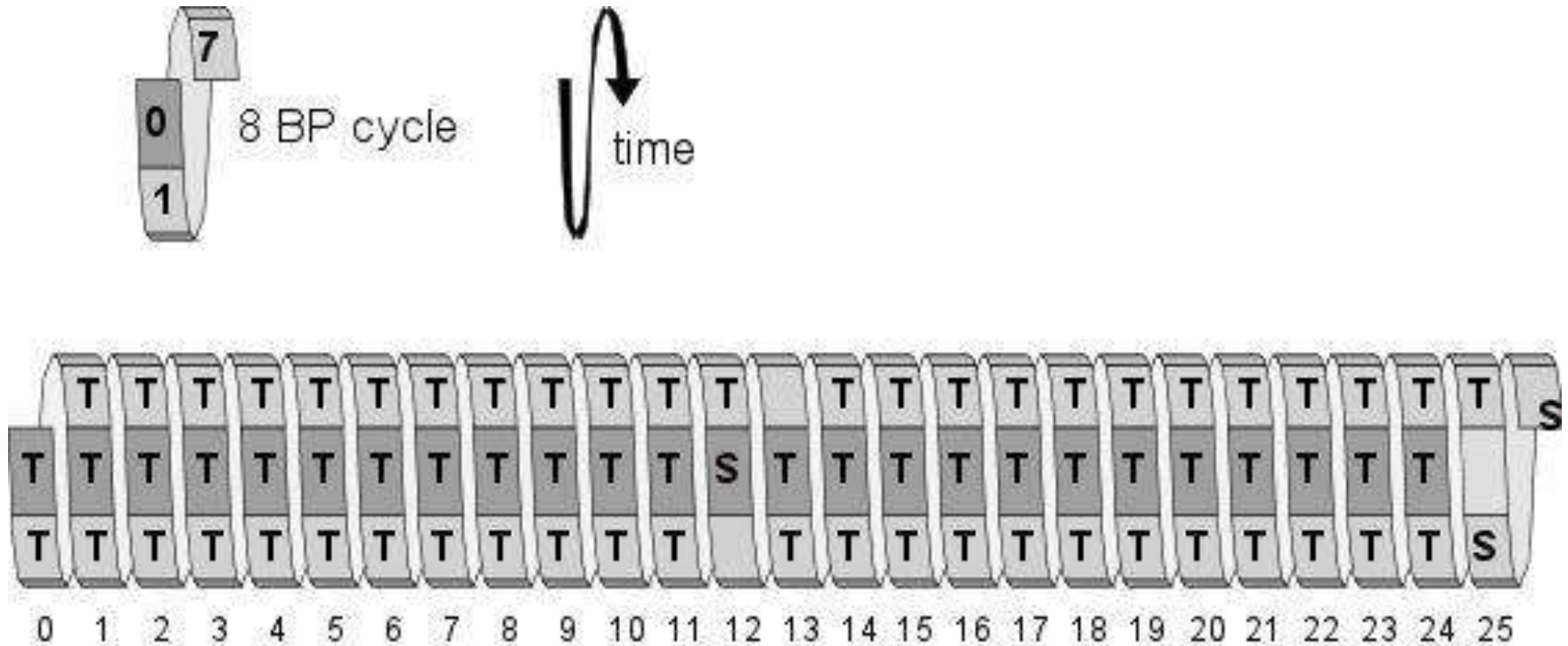
Radio Channel Multiplex-1



Source: Mouly & Pautet

The Burst Period (BP) is derived from a 26-frame multiplex of a 120ms frame; synchronises with core network transmission

Traffic Channels TCH/F, SACCH

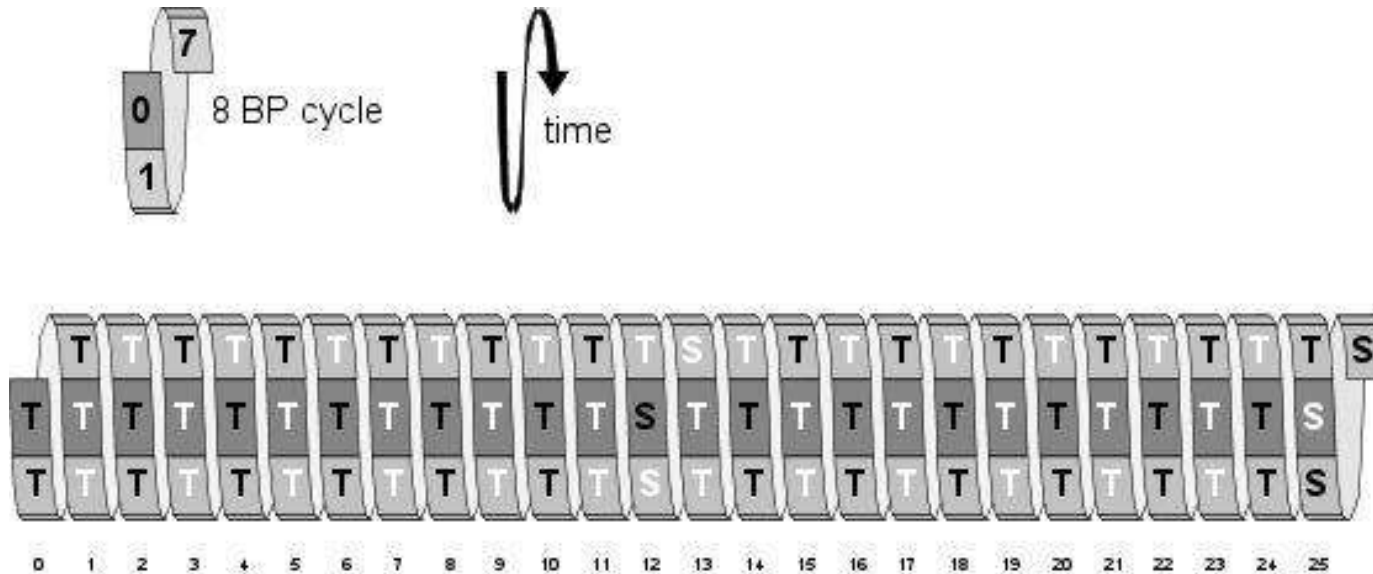


Traffic channels use a cycle of 26x8 slots (120ms)

Source: Mouly & Pautet



TCH/H

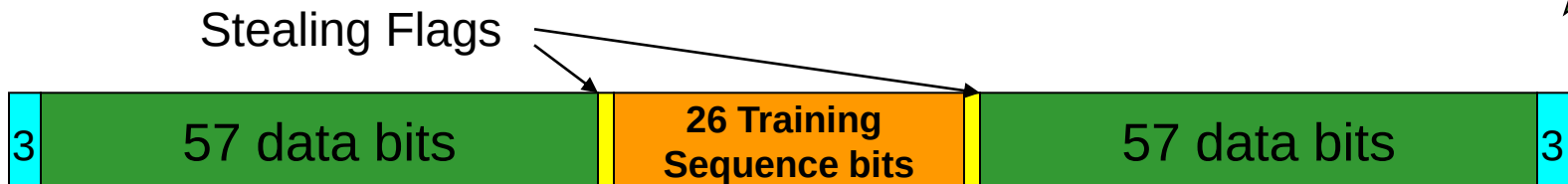


T	S	TCH/H and associated SACCH for sub-TN 0
T	S	TCH/H and associated SACCH for sub-TN 1

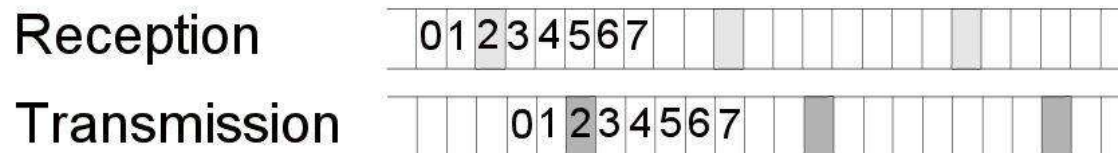
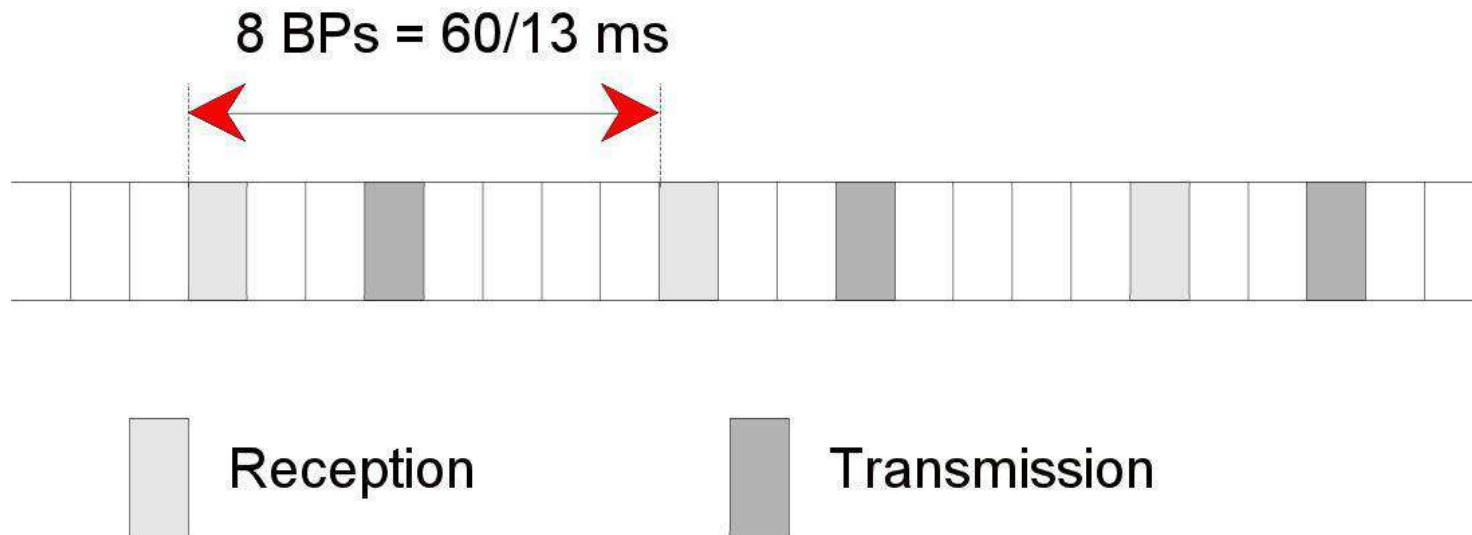
Source: Mouly & Pautet

Stealing Flags

- The user bits in a burst are divided into two 57-bit “half-burst” groups
- To each half burst is added a “stealing flag” SF
- SF=0 indicates user traffic (voice/data)
- SF=1 indicates the half-burst has been “stolen” from user traffic for signalling (FACCH)
- Note: Half bursts are handled separately (see interleaving)



Time Duplex

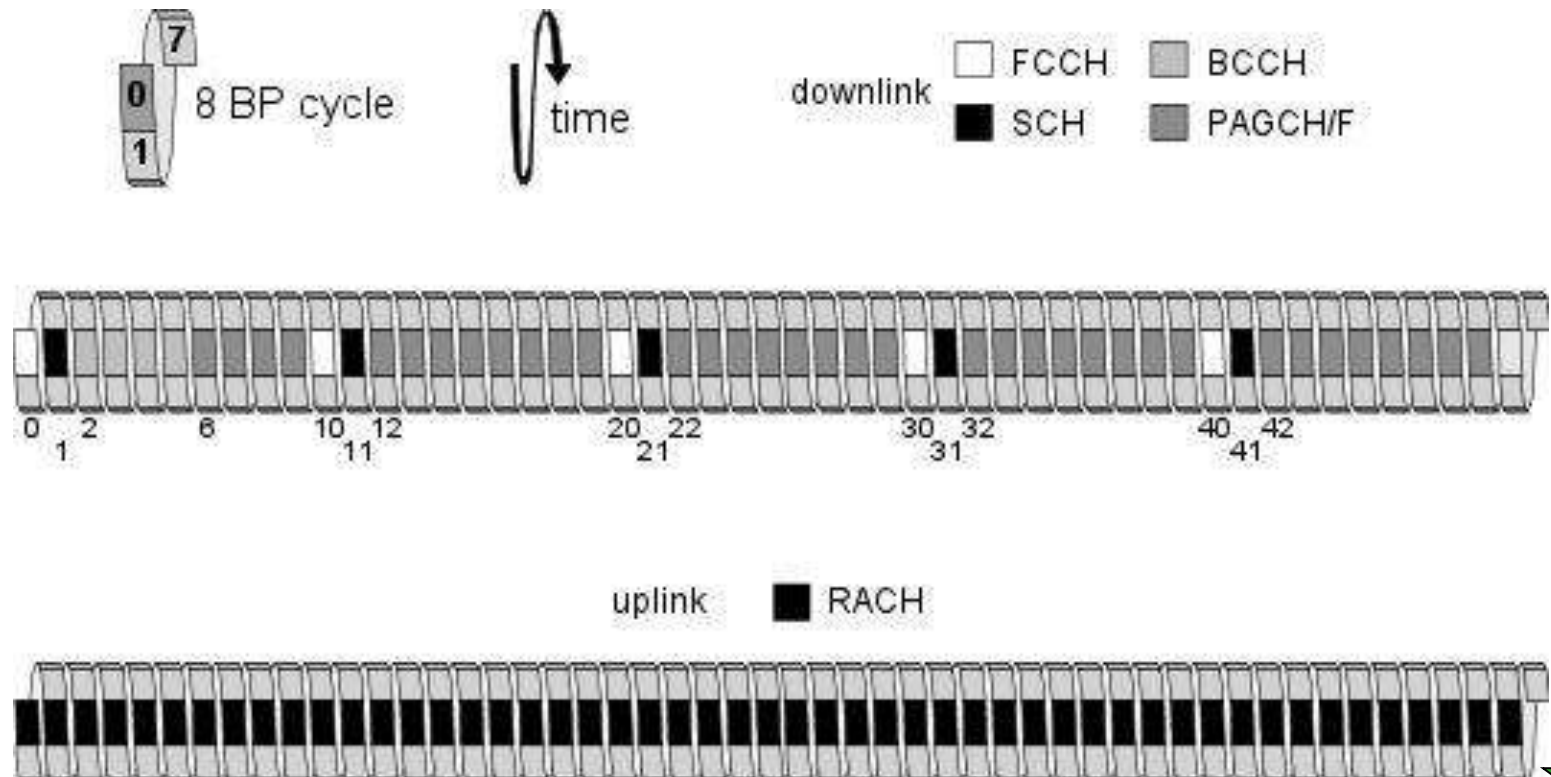


Source: Mouly & Pautot



GSM mobiles always offset reception and transmission

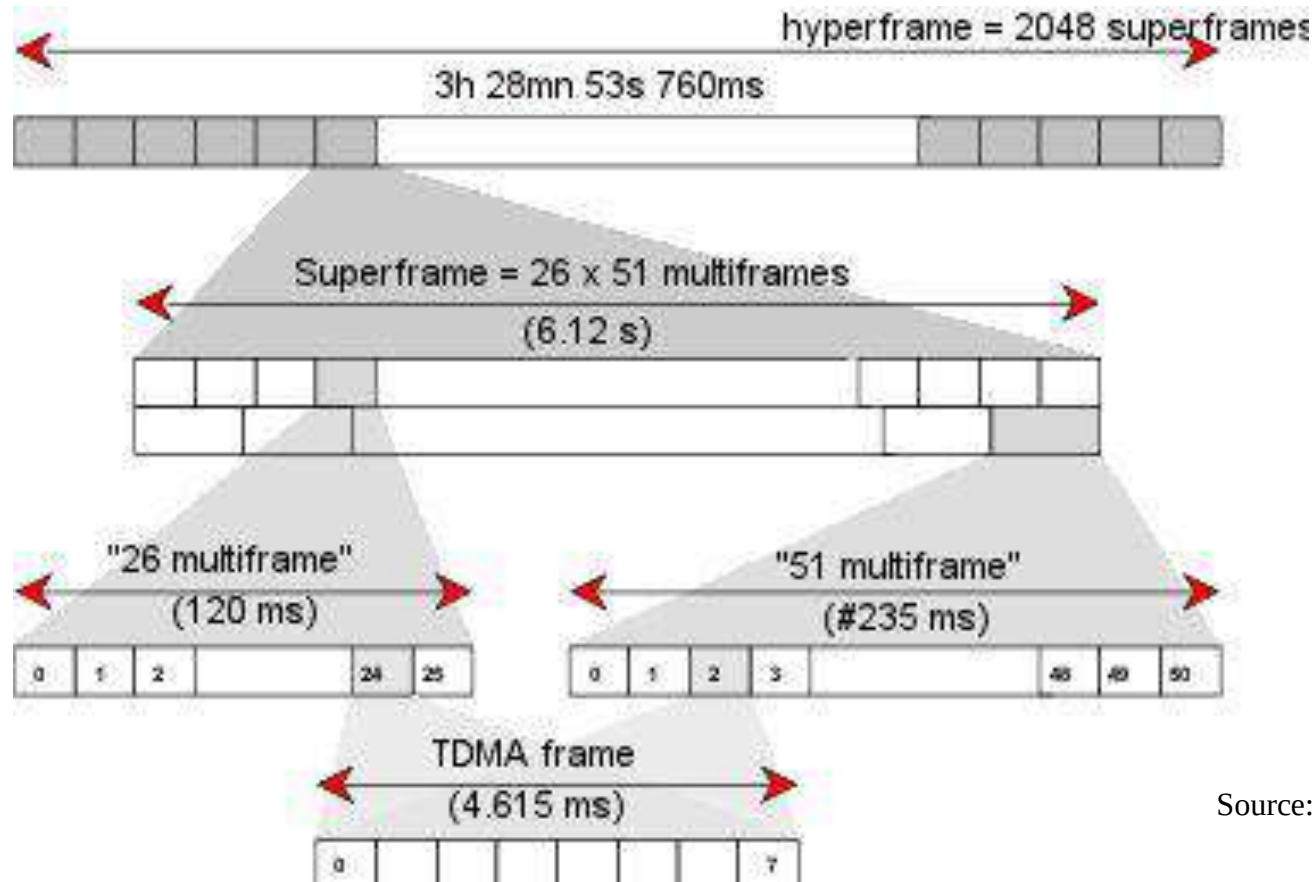
Common Channel Organisation



Typical only; allocations vary according to traffic needs
 Note: PAGCH= PCH+AGCH; /F= full rate traffic



Multiframe structure



Source: Mouly & Pautot



Structure of radio interface: EP3 Solution

- Engineering Problem:
 - How to organise the communication bandwidth to and from mobile stations in order to optimally meet user communication needs?
- Solution:
 - Provide a selection of channel types with structures and capacity appropriate to their use, harmonised with the spectrum allocated



EP 3.1 GSM Speech

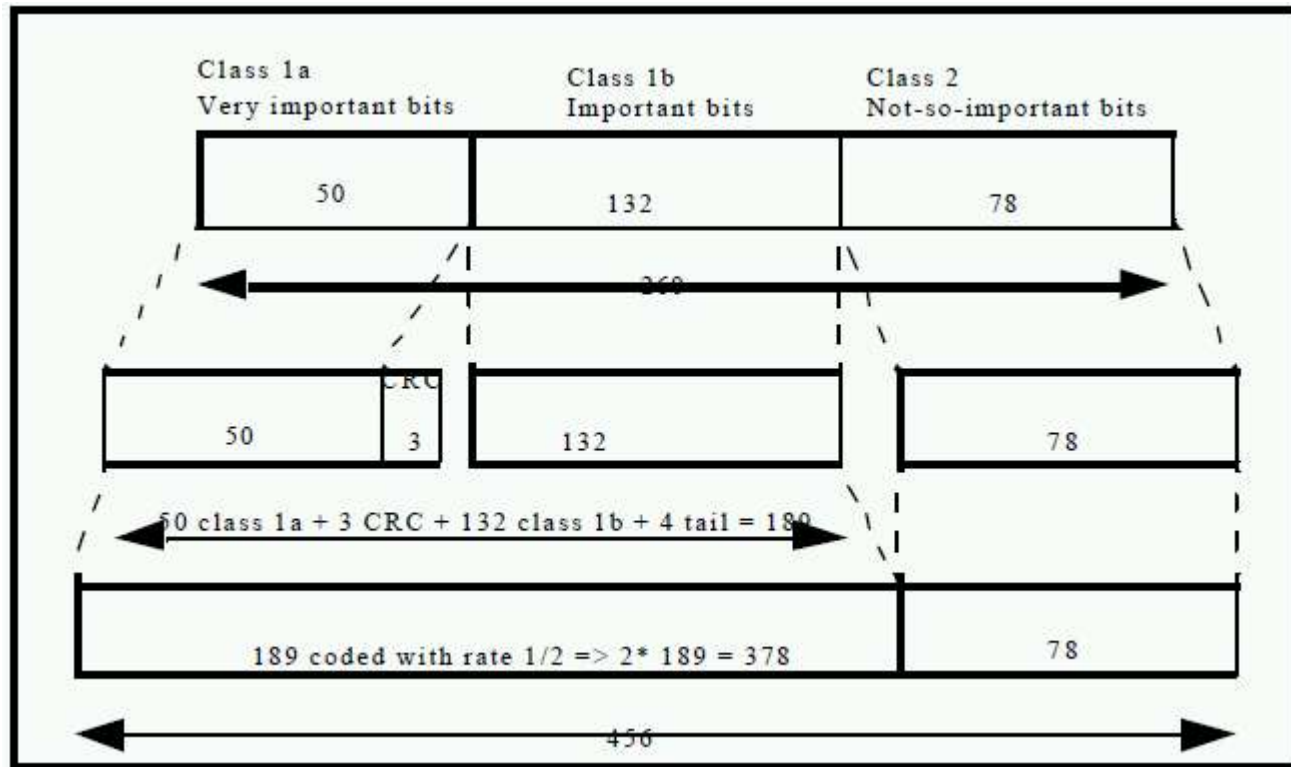
- Problem:
 - Radio is a scarce resource
 - S/N levels mean that simple coding would give poor quality at edge of cell
 - Some speech components need more protection than others
 - Radio channel may contain long bursts of errors

Discontinuous Transmission (DTX)

- Parties in a conversation speak generally less than half the time
- Voice Activity Detection allows detection of pauses in speech
- In these “silent” pauses, the transmitter sends a “comfort noise” pattern, then stops sending (apart from SACCH) until voice restarts
- Reduces interference to other users (thus provides capacity gain) and saves on mobile battery life



Speech channel coding



Channel coding for GSM FR speech: 260 bits of the 20ms frame are encoded to protect the most important parts.



Interleaving: Principle

original message

VoyageAvecUnAneATraversLesCevennes

received message corrupted by 6-bit-long error burst (bits 8-13)

VoyageA%%%%%neATraversLesCevennes

original message interleaved (shift 5)

VvervoeAseycTLnaUrengnaseeAvCsAnee

received interleaved message corrupted by error burst (bits 8-13)

Vvervoe%%%%%%%%LnaUrengnaseeAvCsAnee

de-interleaved received message

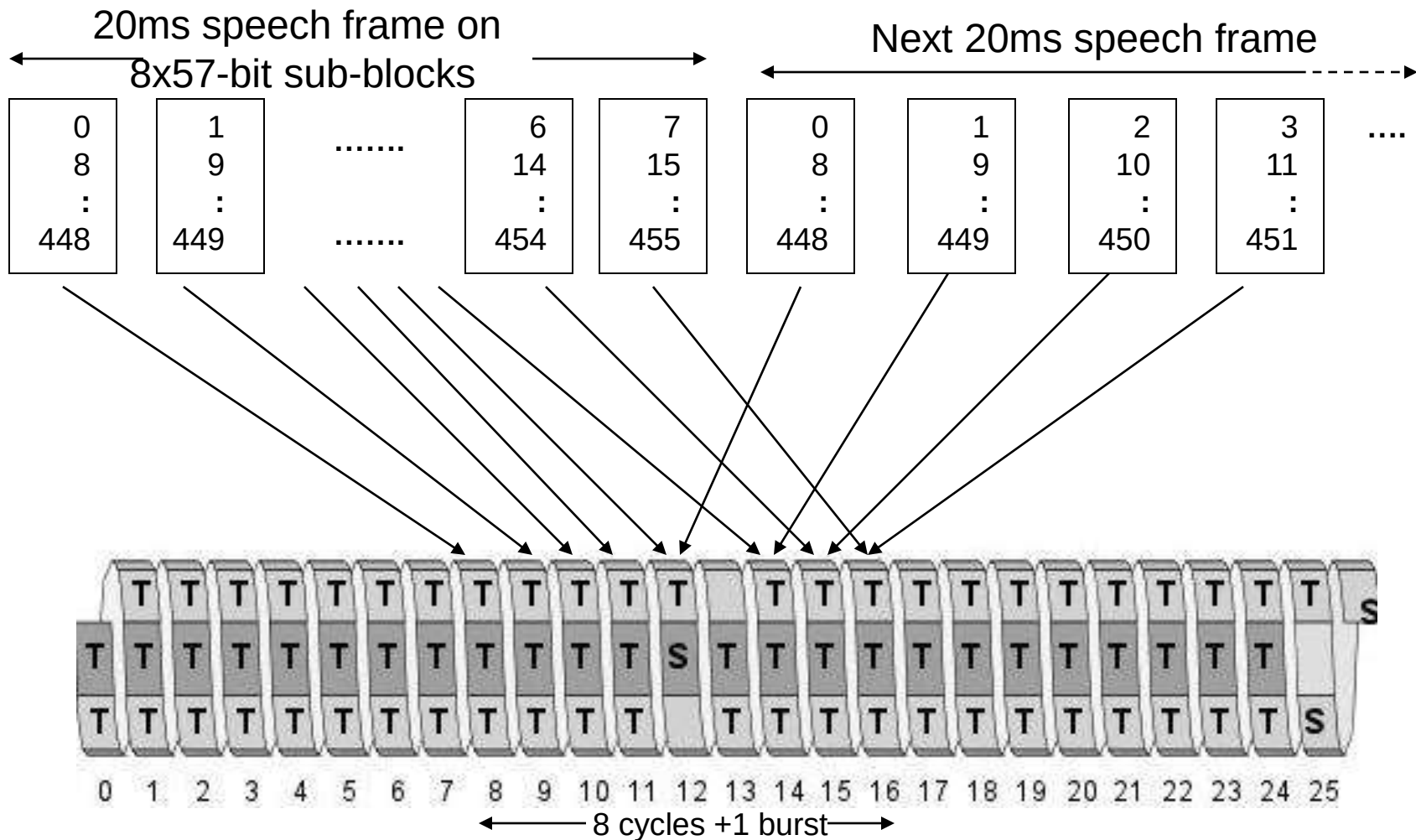
Vo%ageAve%UnAne%%raver%LesC%vennes



Interleaving: GSM TCH speech

- For dedicated channels, each 456-bit block of L1 data is divided bitwise into 8 sub-blocks of 57 data bits
- Bits of two sub-blocks are mapped onto odd and even number bits of a burst
- On dedicated signalling channels, each 456-bit block is sent on 4 successive bursts (114 bits each)
- On FR speech channels, each burst carries two 57-bit sub-blocks of data from two different 20ms speech segments, as even and odd bits

Speech interleaving on TCH/F



Bits from each 20ms frame spread over 57 or 65 BP=37.5ms

Interleaving: TCH Speech: result

- Even if some bursts are totally lost, most of a speech frame can usually be recovered
- However, the cost is delay: each speech frame takes 8 bursts spread over 8 TDMA frames (9 if 1 SACCH) to transmit, $8 \times 8 + 1$ burst periods, around 37.5ms.
- So a mobile-mobile call suffers four times this (plus other delays) in one-way delay

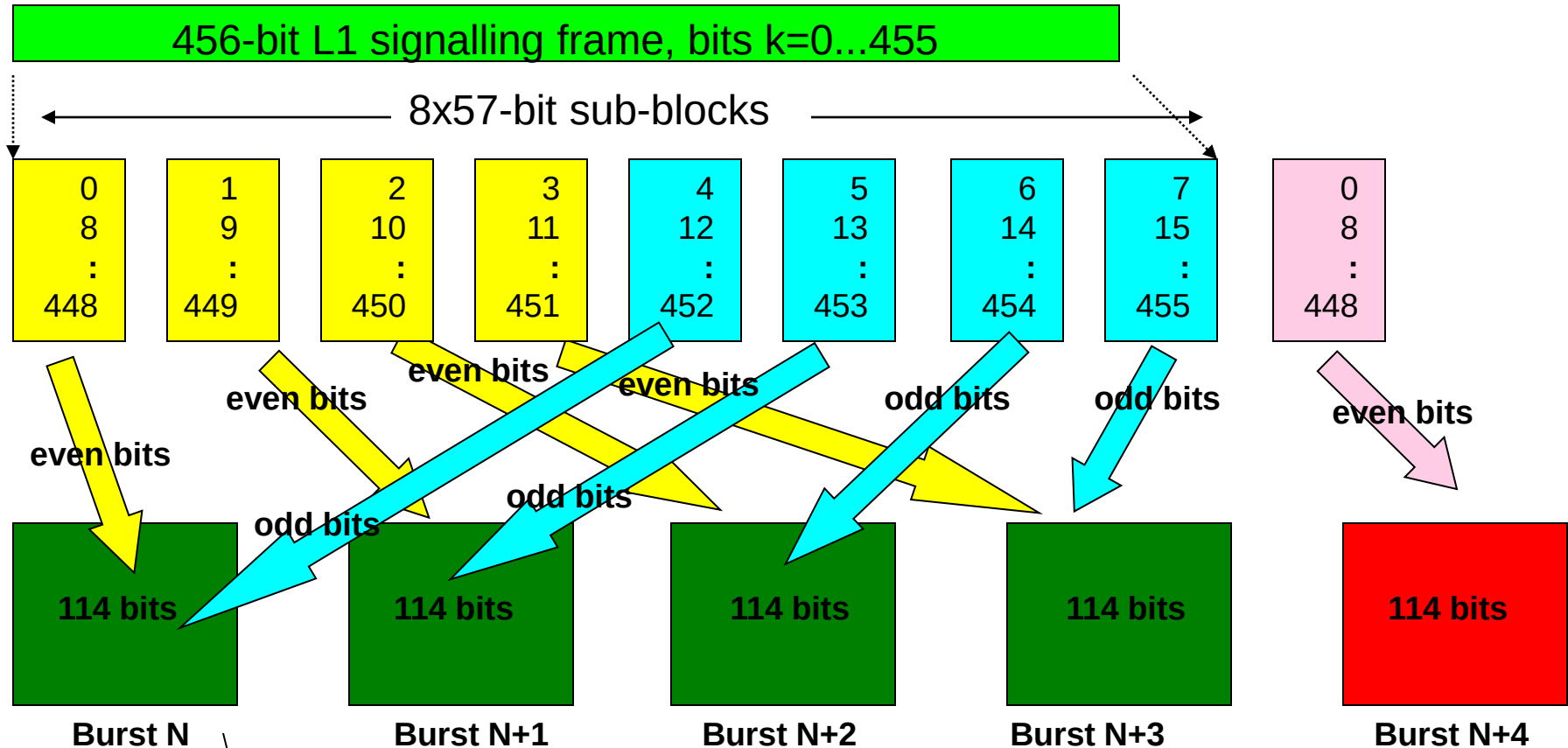


EP 3.1 Solution: GSM Speech

- Problem:
 - Radio is a scarce resource
 - S/N levels mean that simple coding would give poor quality at edge of cell
 - Some speech components need more protection than others
 - Radio channel may contain long bursts of errors
- Solution:
 - DTX reduces interference, hence capacity gain
 - Use speech specific codec
 - Interleaving



Interleaving on SACCH, SDCCH



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