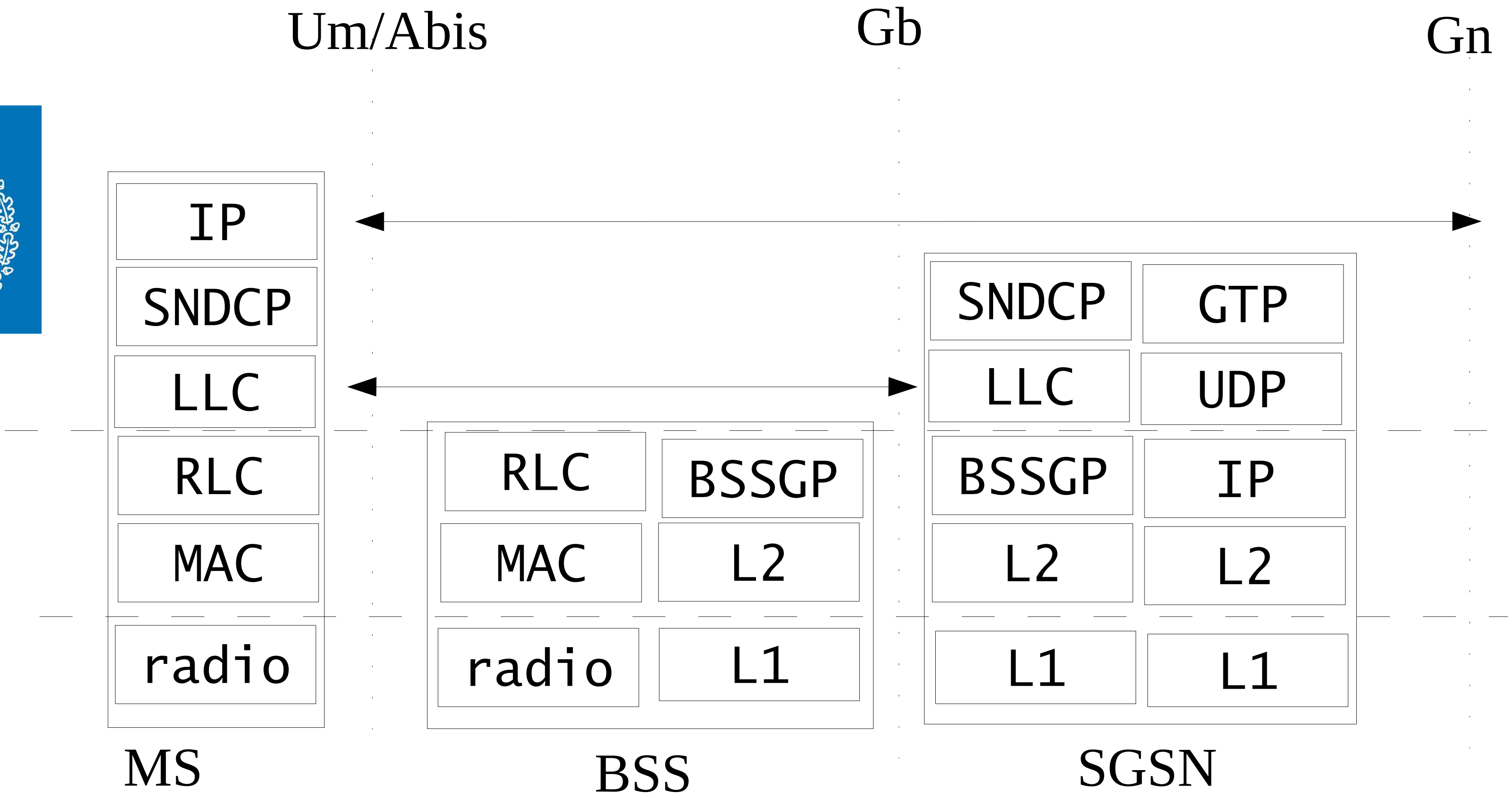
GSM Network and Services

GPRS and EDGE

- RLC/MAC and physical layer

GPRS protocol stack



Who does what

- SNDCP
  - segmentation / reassembly
  - multiplexing of several PDP over one LLC
  - compression of data and/or IP/TCP header
- LLC
  - connection oriented/less MS to SGSN
  - encryption
- RLC/MAC
  - connection oriented/less MS to BSS (PCU in BSC)
  - segmentation / reassembly
  - access control of shared resource

Addresses

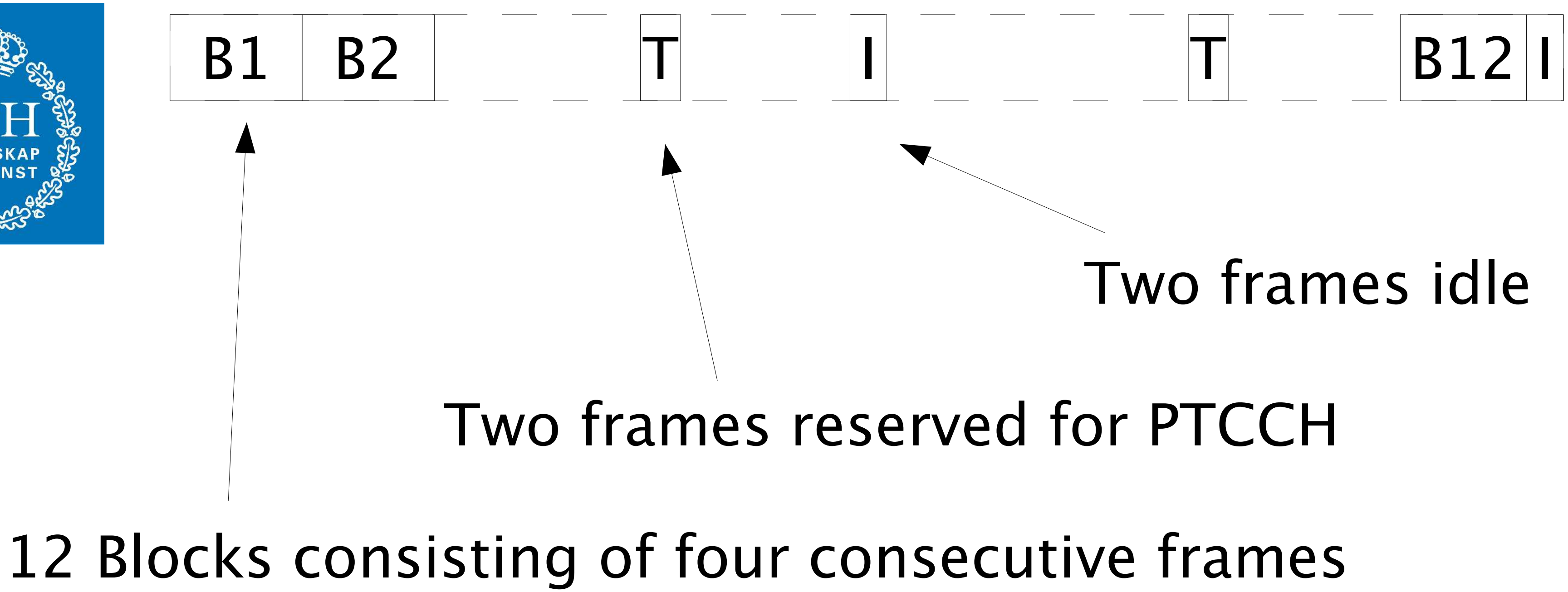
- IP
  - IP: point of presence
- SNDCP
  - NSAPI: which PDP context
- LLC
  - SAPI : SNDCP, GMM, SMS ...
- RLC/MAC
  - TLLI: a mobile, P-TMSI
  - TFI: a RLC connection

RLC/MAC

- The LLC connection is, over Um, realized as a RLC connection identified by a Temporary Logic Link Identifier (TLLI) derived from P-TMSI.
- A RLC connection is realized as a set of Temporary Block Flows (TBF).
- A set of TBF are multiplexed over a shared Packet Data Traffic Channel (PDTCH) and each TBF is identified using a Temporary Flow Identifier (TFI)
- The MAC layer is used control uplink usage of the PDTCH.

PDTCH - multiframe

52 frames



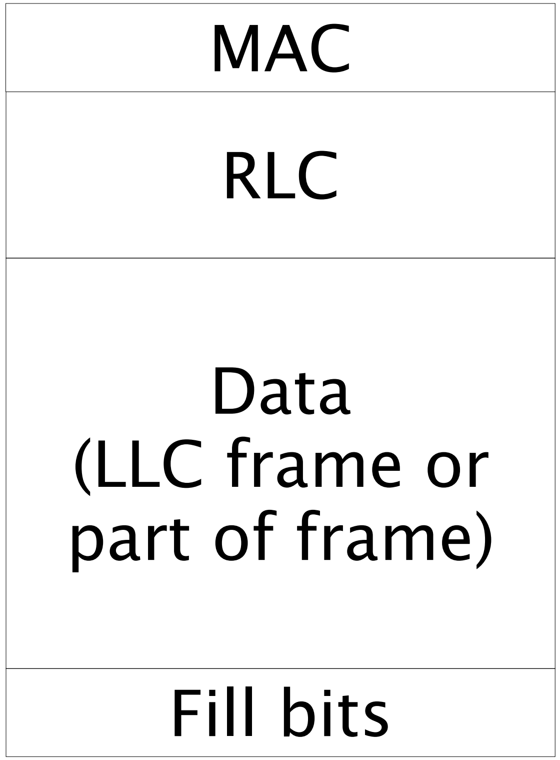
Why 52 frames, why two idle, why PTCCH?

Allocation of resources

- Uplink and downlink PDTCH are independent, a PDTCH is unidirectional.
- A PDTCH is divided into 11 blocks, each block holds one RLC data frame. Each block is allocated to a TBF – owned by a mobile.
- Allocation and sharing of downlink PDTCH is controlled by the network; the network will only have to address the right mobile using TFI.
- Sharing of uplink resources is more problematic since several mobile can compete for the resource.

RLC/MAC data frames

- Total size is: 23, 33, 39 or 53 bytes
- Size depends on the chosen coding scheme.
- Uplink
  – MAC: countdown value, ...
  – RLC: TFI, block #, (TLLI)
- Downlink
  – MAC: USF, ...
  – RLC: TFI, block #, FBI



Allocation of downlink PDTCH

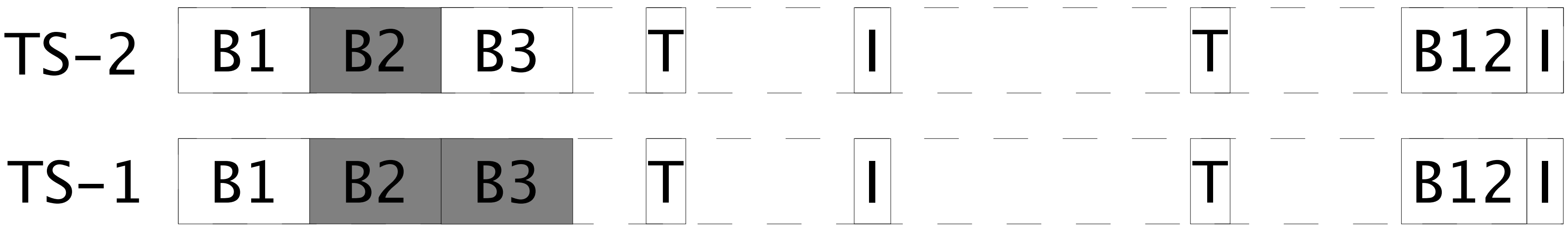
- The BSS can allocate a downlink TBF using one or more downlink PDTCH.
- The mobile needs to listen and decode all frames on each downlink PDTCH.
- If the TFI (5 bits in the RLC header) is recognized the block (for consecutive frames) belong to the mobile.
- Uplink and downlink TBFs are independent.

Allocation of uplink PDTCH

- Fixed allocation
  - A mobile is allocate specified blocks to be used in a sequence of multiframes.
- Dynamic allocation
  - A mobile is allocated a PDTCH but blocks are specified dynamically.
- Extended Dynamic allocation
  - Same, same but better.

Fixed allocation

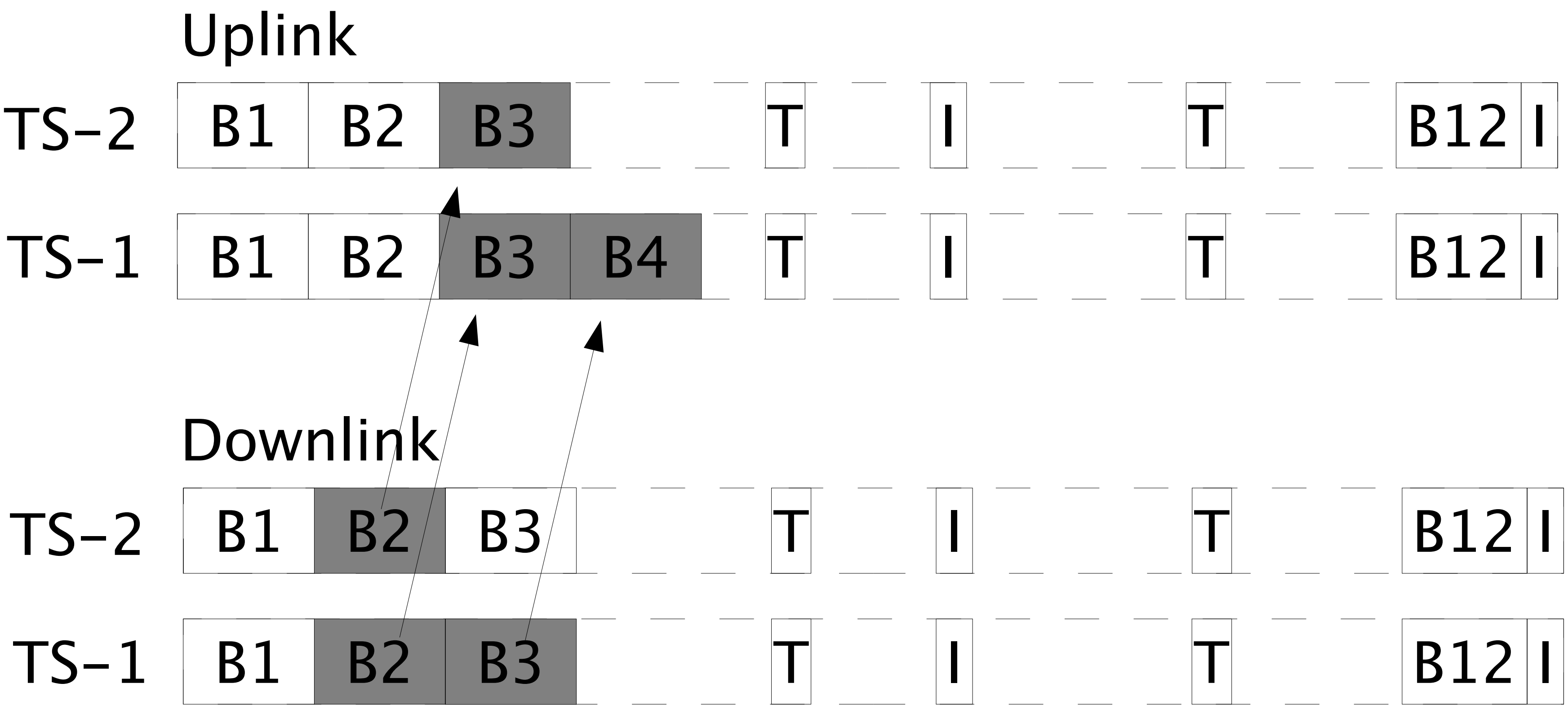
- One or more PDTCH e.g. timeslots since each PDTCH is using one physical channel.
- In the PDTCH, one or more blocks defined by a bit map.
- Example: TS-2 block B2, B3 / TS-3 block B2



Dynamic allocation

- One or more PDTCH channels are allocated but blocks are not fixed.
- Information in the blocks in the downlink PDTCH using timeslot T decide the usage of the next block (or four next blocks) on the uplink PDTCH using timeslot T.
- A mobile needs to listen to the downlik PDTCH in order to know when to use the uplink PDTCH.

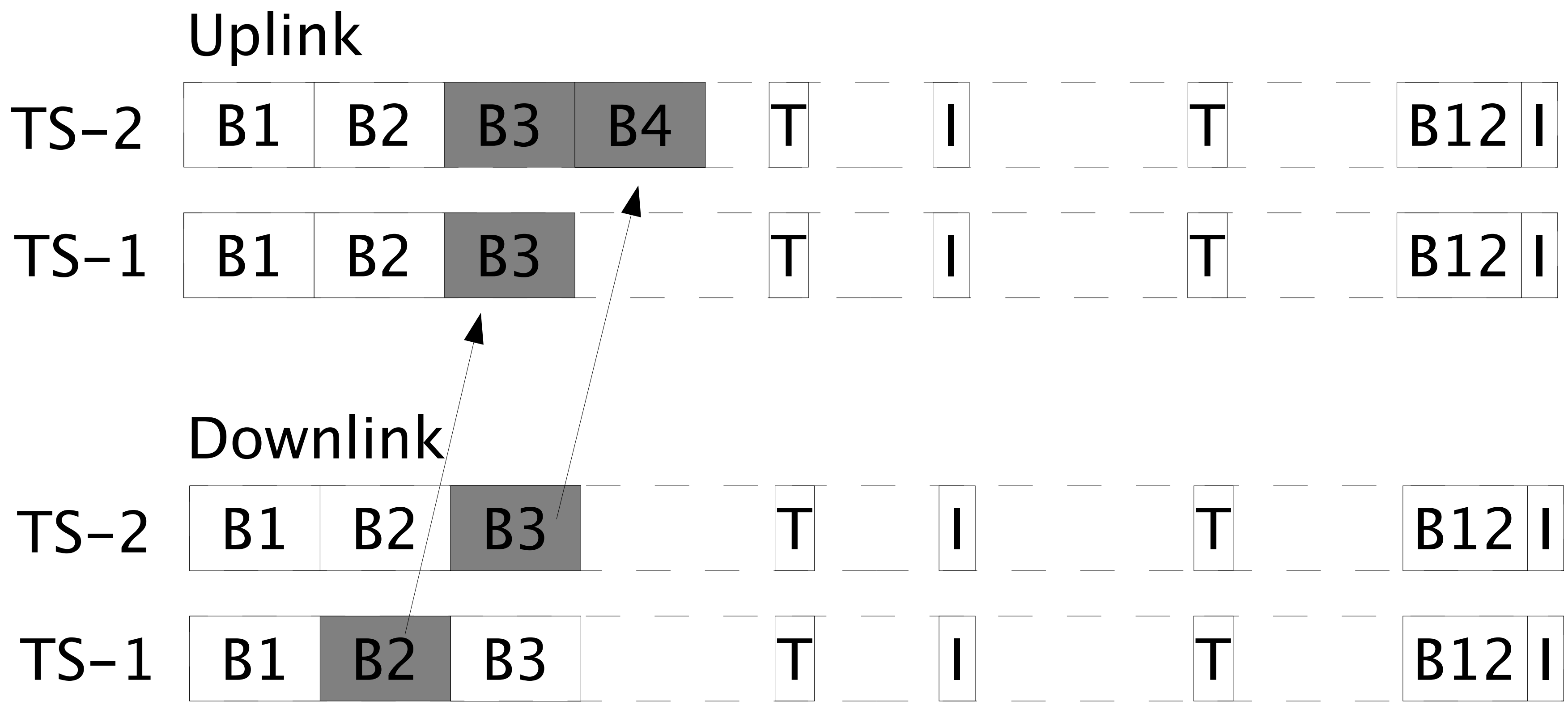
Dynamic allocation



Extended Dynamic Allocation

- A mobile is allocated an ordered set of uplink PDTCH. Allocation of blocks is similar to dynamic allocation but the mobile may also use blocks in all higher PDTCH.
- Extended dynamic allocation will make it easier for a mobile to quickly determine if it can use several uplink resources.

Extended Dynamic allocation



Downlink RLC/MAC

- The downlink MAC header contains a Uplink State Flag (USF, three bits).
- Each mobile is allocated a USF and the USF indicates if the uplink PDTCH can be used.
- USF = 7 indicates that the uplink can be used for PRACH (if no separate PCCCH)

MAC
RLC
Data (LLC frame or part of frame)
Fill bits

USF Granularity

- The USF granularity decides if one or four blocks can be used in the uplink direction.
- Granularity is given in the packet uplink assignment message.

RLC/MAC – countdown/final block

- The network needs to be informed in advance when the mobile is done.
- A countdown value (CV, 4 bits) in the uplink MAC header will reach zero in the last RLC frame.
- A Final Block Indicator (FBI, 1 bit) is set in the downlink RLC header when the network is done.

MAC
RLC
Data (LLC frame or part of frame)
Fill bits

Channel Coding

RLC/MAC frames : 23, 33, 39 or 53 bytes

block coder

convolutional coder

interleaving coder

radio burst

four normal radio bursts
4x114 = 456 bits = 57 bytes

Channel coding

- Four different channel coding schemes that differ in the parameters for block and convolutional coding.
- CS1: 9.05 Kb/s
- CS2: 13.4 Kb/s
- CS3: 15.6 Kb/s
- CS4: 21.4 Kb/s
- When comparing capacity of radio network the figure 8x21.4 = 171.2 Kb/s is often given for GPRS (how likely is this and what's in a RLC frame)

Block coder

- The block encoder adds a fire code (error detection) of 40 or 16 bits, encodes the USF using 3, 6 or 12 bits and adds four tail bits (if passed to the convolutional coder).
- CS1: fire code 40, USF 3
- CS2: fire code 16, USF 6
- CS3: fire code 16, USF 6
- CS1: fire code 16, USF 12, no tail bits!

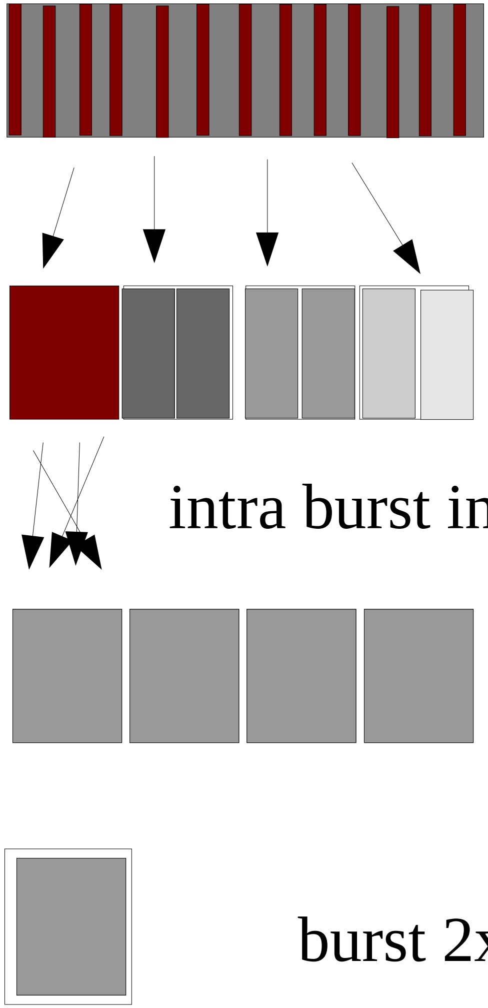
Convolution's coder

- Convolutional coder of rate ½ is used for CS1-CS3. The difference is that in CS2 and CS3 some bits are removed (punctured) before sent. Puncturing results in a total rate of 2/3 or 3/4.
- CS1: ½
- CS2: 2/3
- CS3: ¾
- CS4: ----

Interleaving

- All coding schemes use the same interleave as the SDCCH in GSM e.g. four blocks are interleaved into four radio bursts.
- One PDTCH block of four frames will thus hold one RLC frame.

GPRS interleaving



One RLC frame requires four bursts.

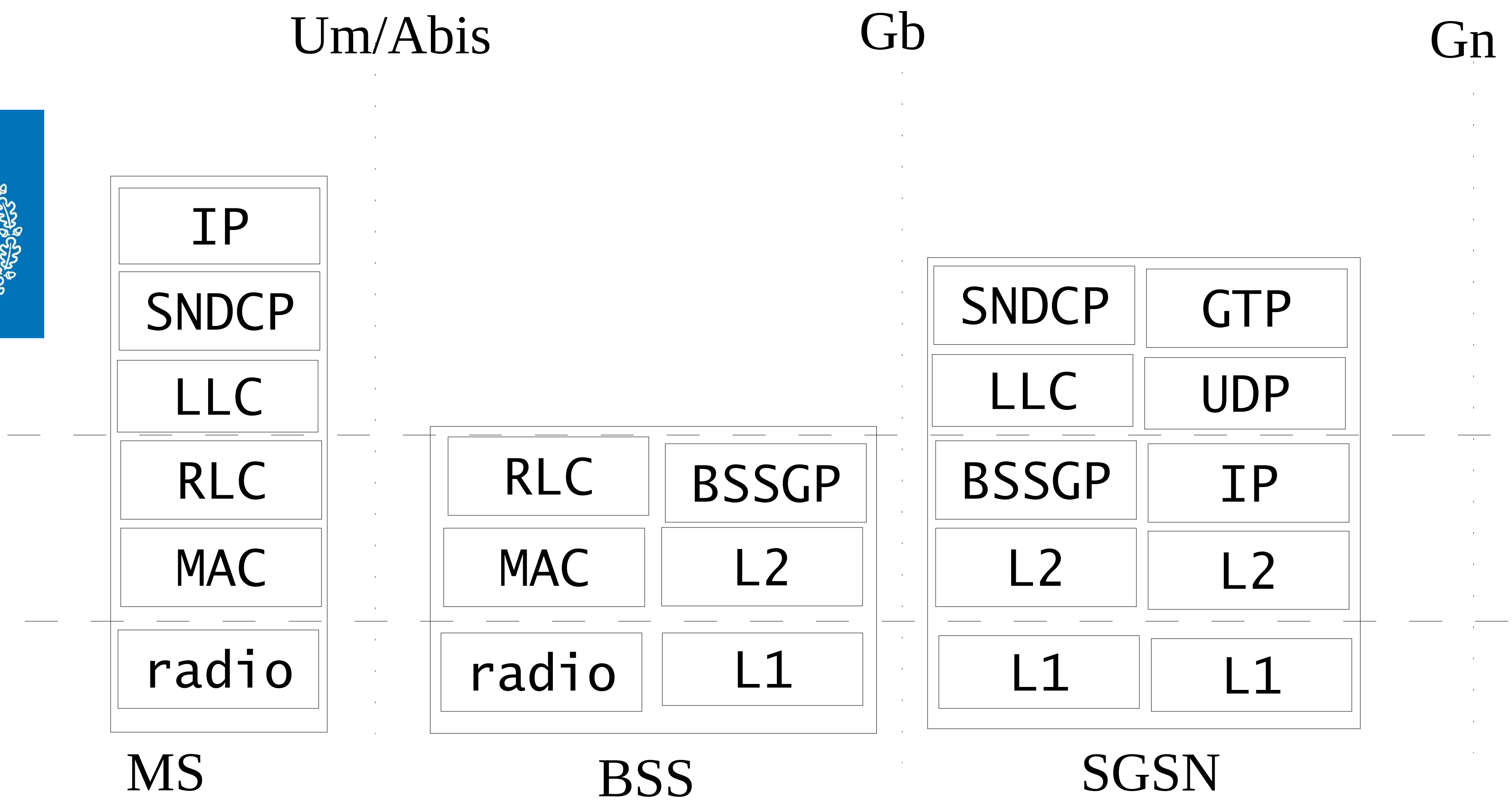
intra burst interleaving

burst 2x57

Question

- How does the receiver know which coding scheme that has been used?
- In GSM it could tell since each logical channel used only one coding scheme and it knew which logical channels it received
- The stealing flags are not needed for FACCH since we don't do any handover!
- Stealing flags (two bits) will tell the receiver which coding scheme to use.

GPRS where is encryption



Encryption

- In GSM ciphering is performed immediately before the burst building. This hides all information in the RR frames.
- Ciphering in GPRS is done on the LLC layer since the headers information of the RLC layer needs to be readable to all mobile that share the same PDTCH.

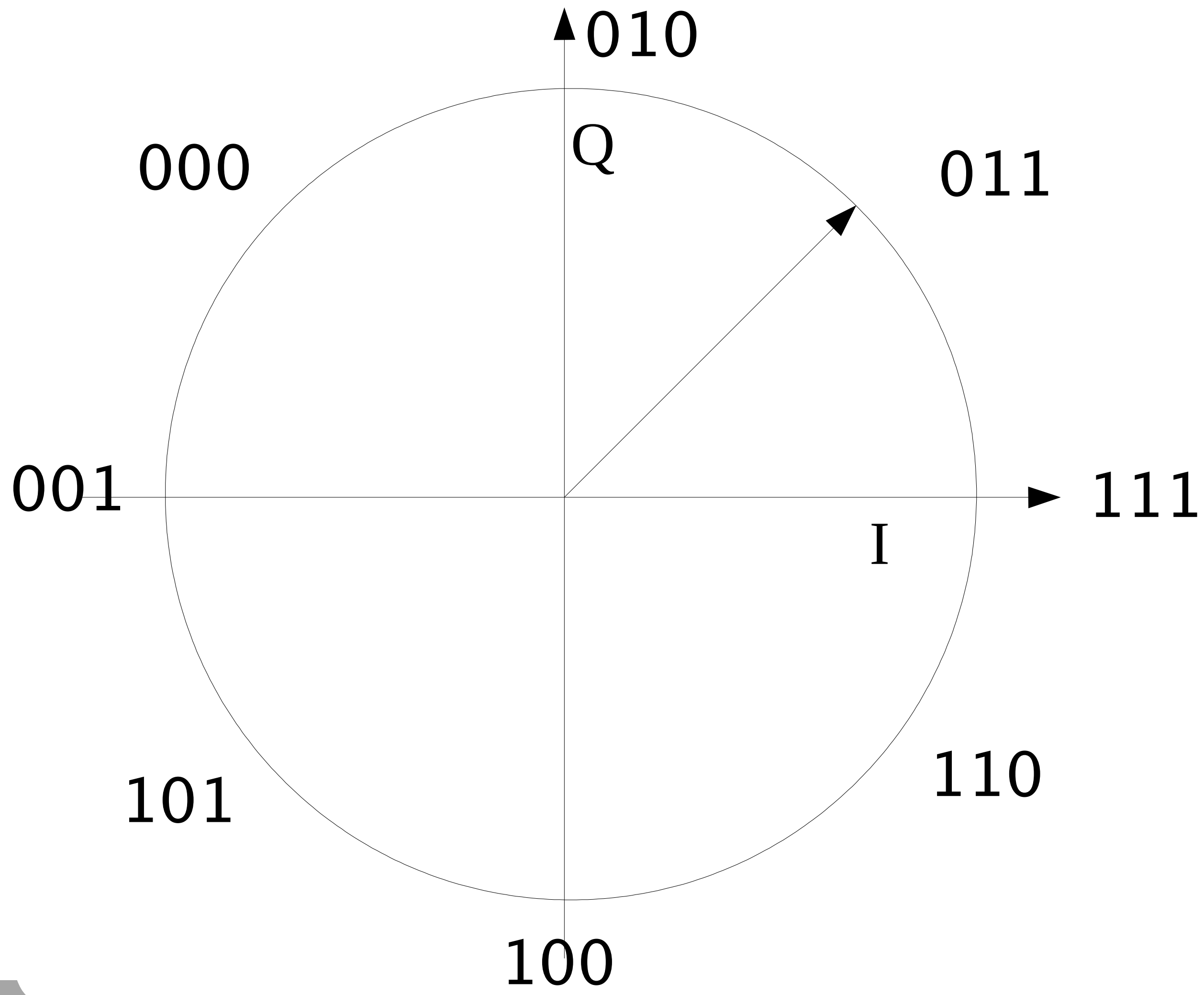
EDGE

- A family name for upgrades of GSM and TDMA IS-136 supporting higher data rates (Enhanced data rate for Global Evolution).
  - Classic EDGE
    - Upgrade of GSM supporting EGPRS and ECSD (upgrade of HSCSD).
  - Compact EDGE
    - The upgrade of TDMA IS-136
    - More aggressive frequency reuse.

EGPRS

- A new radio modulation technique, 8-PSK, that increases the bit rate with a factor 3.
- More aggressive and adaptive coding schemes that provide RLC data rates of up to 59.2 kb/s per timeslot.
- Hmm, 8x59.2 = 473.2 kb/s .... call the marketing department!
- EGPRS is more flexible and more reliable than GPRS. It's not only higher maximum bit rates

8-PSK



8-PSK

- Uses the same signaling rate as GMSK.
- Each symbol is three bits (instead of one as in GMSK).
- Can not be transmitted with as high power, using the same hardware, as GMSK.
- Less reliable detection of phase.
- Range is limited!

Coding Schemes

- MCS-1 – MCS-4:
  - uses GMSK
  - coding rate: 1/2, 2/3, 4/5, 1
  - bit rate: 8.8, 11.2, 14.8, 17.6 kb/s (RLC)
- MCS-5 – MCS-9
  - Uses 8-PSK
  - coding rate: 1/3, 1/2, 3/4, 4/5, 1
  - bit rate: 22.4, 29.6, 44.8, 54.4. 59.2 kb/s (RLC)

Coding families

- A RLC frame that is resent can be resent using a more reliable coding scheme in the same family.
  - Family A MCS-3/6/8/9 (1/2/4 x 37 byte)
  - Family B MCS-2/5/7 (1/4 x 28 byte)
  - Family C MCS-1/4 (1-2 x 22 byte)
- This is an improvement compared to GPRS where retransmissions are done using the same coding scheme.

EDGE

- Expect GSM operators to gradually deploy EDGE. However, most operators in Europe are busy deploying 3G networks and might wait with their EDGE upgrade.
- EDGE will increase data rates but it will not change the number of voice connection that can be handled by a cell. 3G networks are necessary for dense voice usage.