GSM Network and Services

Channel coding

- from source data to radio bursts

Channel coding

- Wireless transmission of bits in a mobile environment is not very reliable. The bit error rate (BER) is typically 1/10 to 1/1000. This is a more than a factor 1000 worse than the Ethernet that we are used to.
- In order to create a reliable connection we need to be very careful and protect the data as much as possible.
- We can not rely on error detection and retransmission!

Channel Coding

Voice/Data/Signaling

block coder

convolutional coder

interleaving coder

radio burst

Block coder - voice

- The voice coder results in 260 bits divided into 182 class I and 78 class II.
- The class I bits are divided into I-A of 50 bits and I-B of 132 bits. The I-A sequence is protected by a 3 bit CRC value.
- The resulting class I sequence is tailed with four zeros and passed to the convolutional coder.
- The class II bits are passed directly to the interleaving coder.

Block coder - signaling

- Most signaling messages are 184 bits long. These messages are protected by a 40 bit Fire code. The Fire code is used only for error detection.
- Other signaling messages:
  - acces req: 8 bits protected by 6 bits CRC
  - synch: 25 bits protected by 10 bits CRC
- All signaling messages are tailed with four zeros for the convolutional coder.

Convolutional coder

- A convolutional coder will spread the information in a bit sequence so each information bit is encoded in several code bits. Each code bit holds partial information of a sequence of information bits.
- The rate of a convolutional coder describes how many code bits are produced per information bits.

Convolutional coder

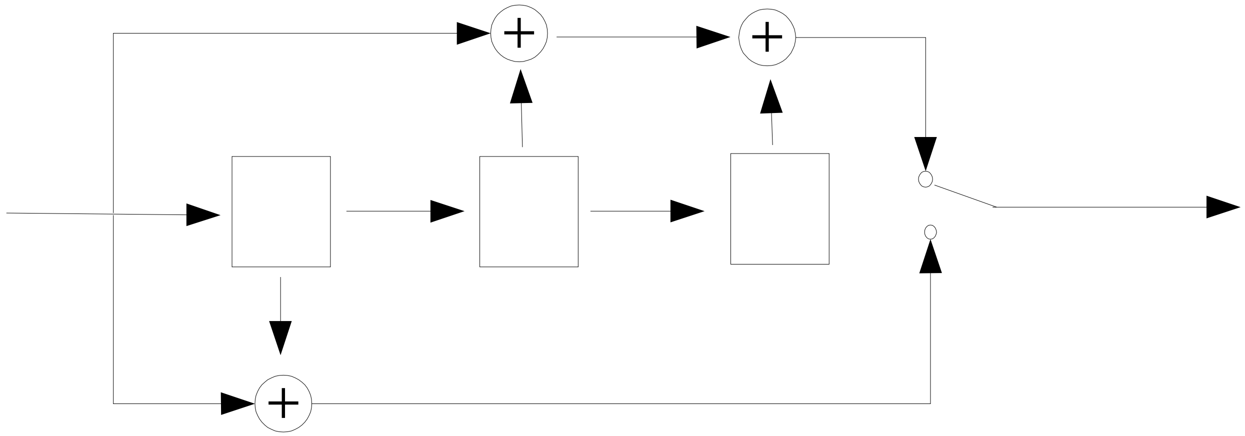
information bits

0 1 0 1 1 0 1 0 1 1 0 0 0

0 1 0 1 1 0 1 0 1 1 0 1 0 0 1 0 1 1 0 1 0 1 1 0 1 0

coded bits

Convolutional coder



K is the *memory* of the coder and defines for how many coded bits an information bit is spread over.

The rate *r* of the coder is the ratio of information bits per coding bits (typically 1/2 or 1/3)

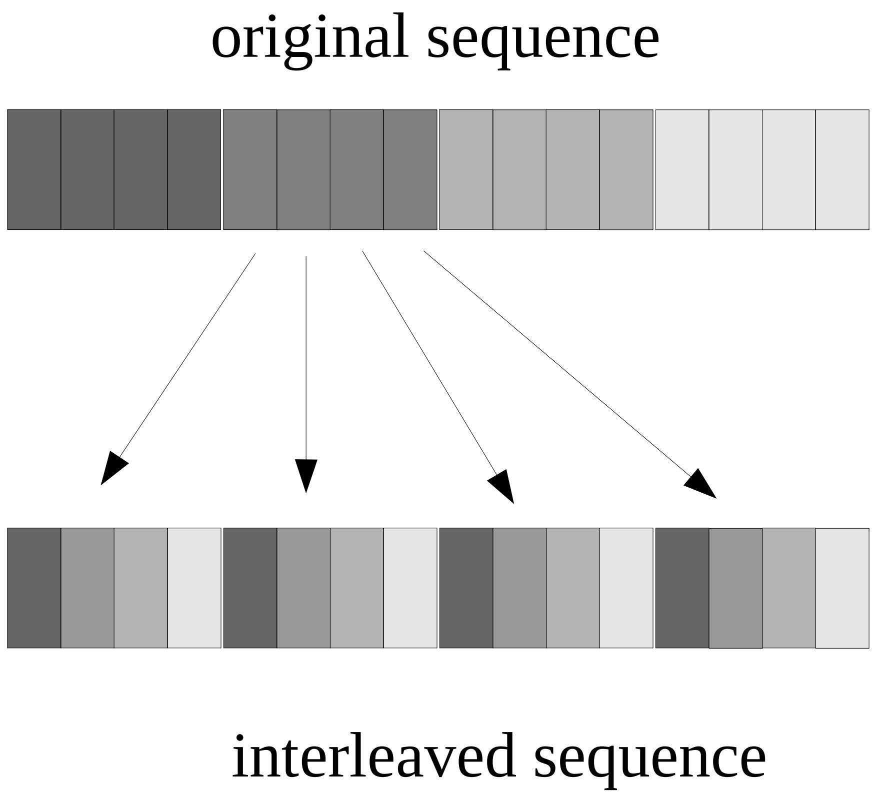
Convolutional coder

- Voice full rate (class I bits): K = 4, r = 1/2
- Voice half rate (class I bits): K = 4, r = 1/3
- Signaling: K = 4, r = 1/2
- After the convolutional coder all messages are 456 bits except half rate voice, access request and synchronization.
- 456 bits would fit very nicely into four (114 bits) normal bursts but life is never that simple.

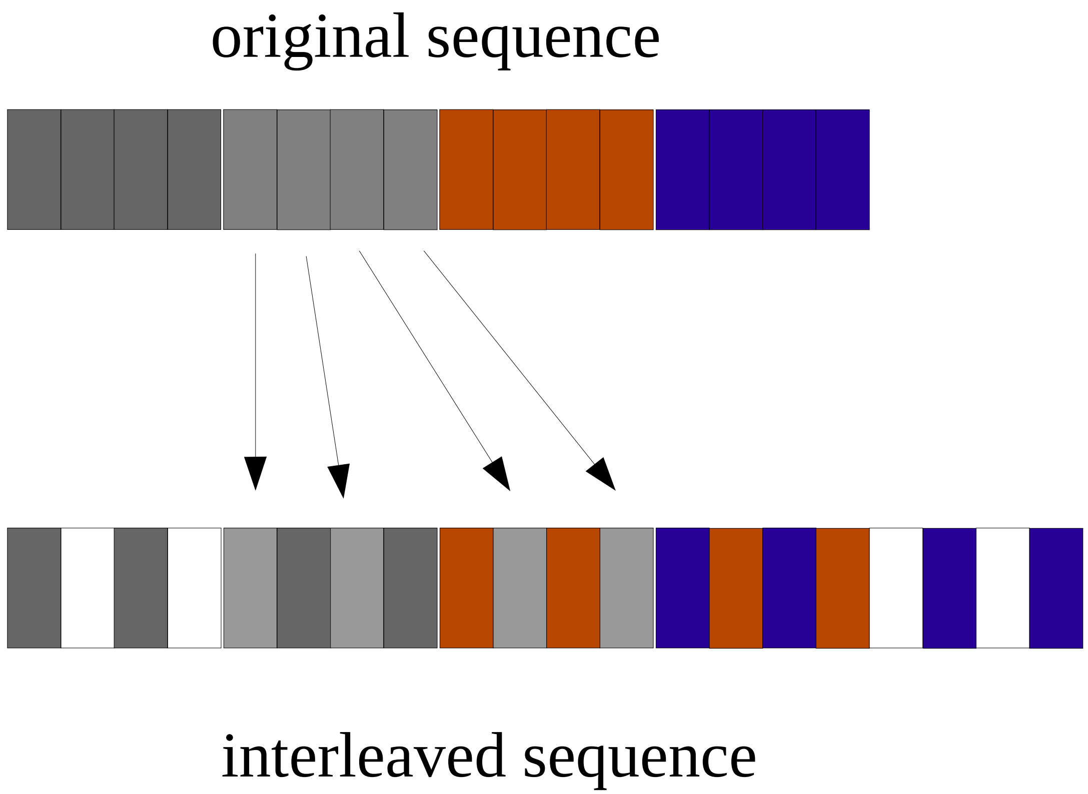
Interleaving

- Errors in a wireless links comes in burst. This is exactly the scenario that convolutional coders and CRC does not like.
- Interleaving is the process of distributing consecutive bits of a block into different sub blocks. If a sequence in one sub block is corrupted then these bits will not be consecutive in the original block.

Block Interleaving



Diagonal Interleaving



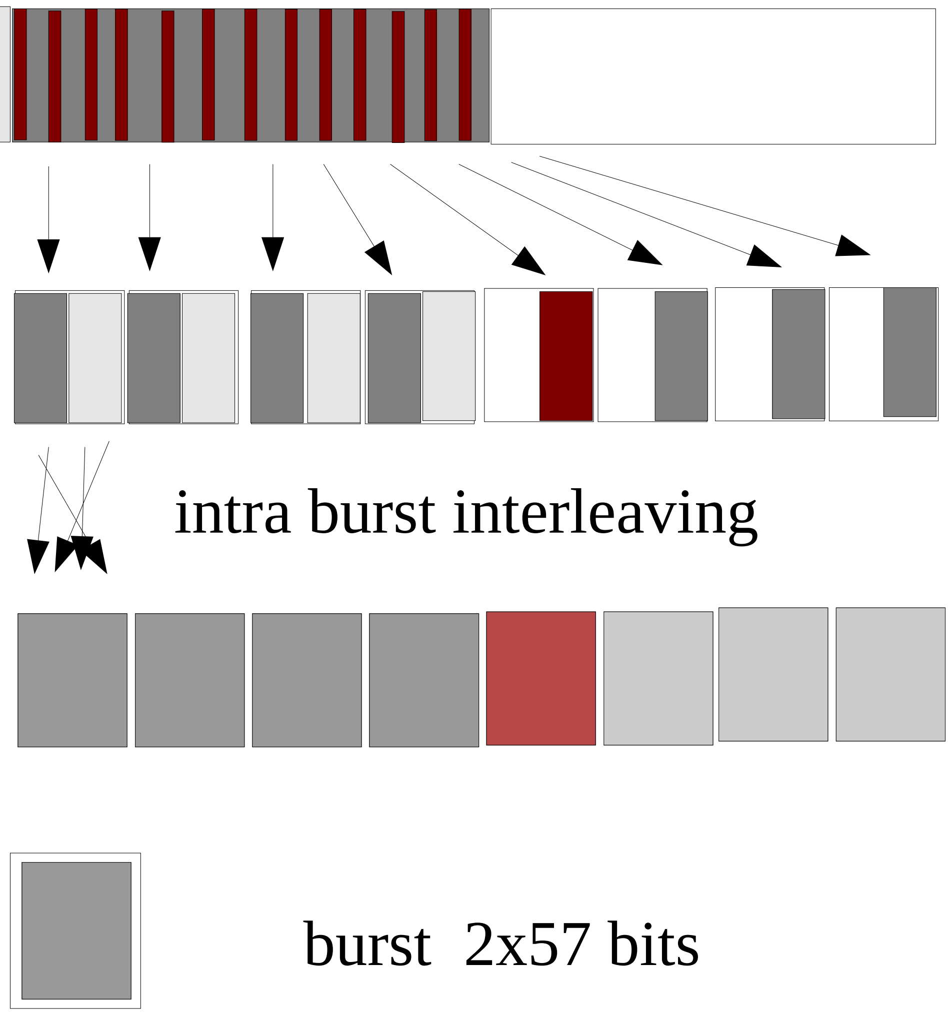
Interleaving

- Pros:
  - Burst of errors are distributed to single bit errors that the convolutional decoder can handle.
  - The bit rate is not changed.
- Cons:
  - Sending of messages is delayed with the interleaving depth. Important data will have a large depth and therefore a long delay.

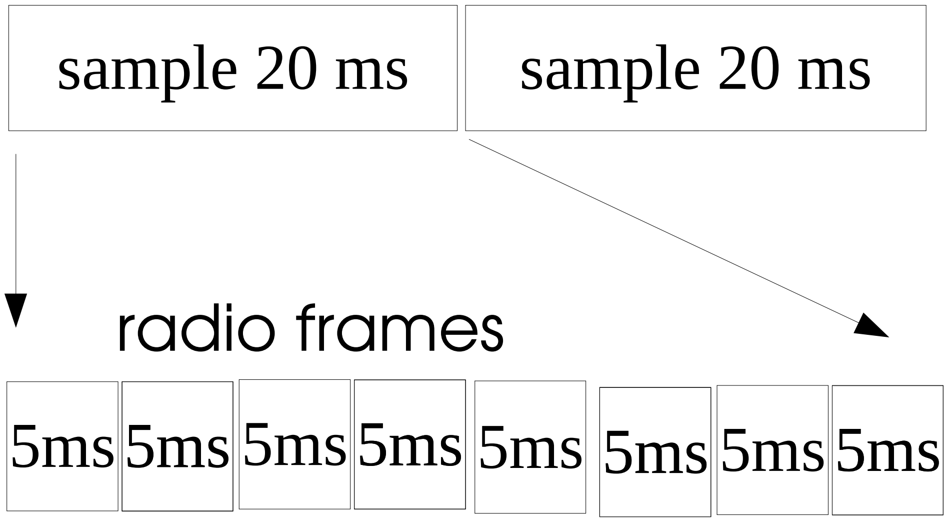
Interleaving of voice

- A voice block of 456 bits is diagonally interleaved over 8 sub blocks of 114 bits each.
- Every eight information bit goes into a separate sub block.
- The bits in a sub block are interleaved again in a *burst interleaving.*
- Each sub-block fits in to a normal burst.

Voice interleaving



Voice interleaving delay

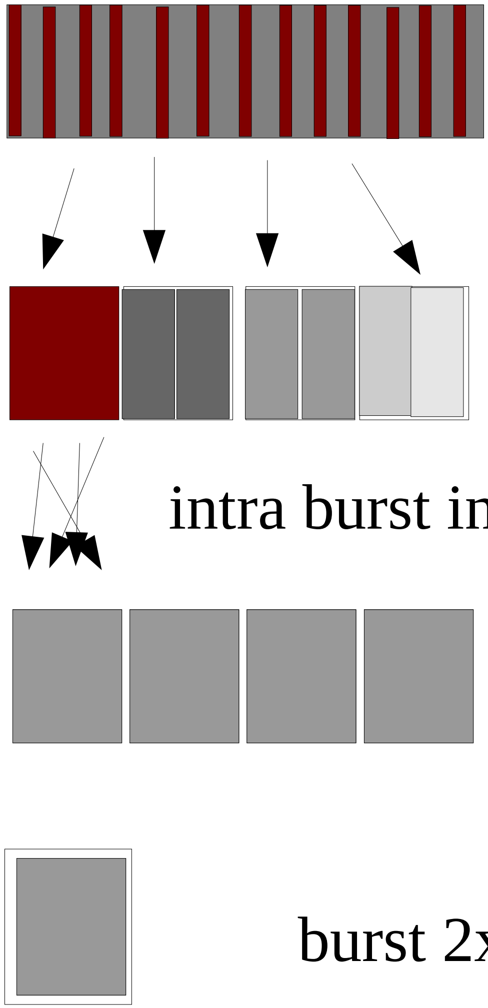


interleaving depth of 8 causes
delay of another 20 ms.

Interleaving of signaling messages

- Most signaling messages have an interleaving depth of four and uses block interleaving.
- Access request and synchronization must be sent in one burst and are therefore not interleaved.
- FACCH have an interleaving depth of eight and are interleaved with the traffic channel.

Signaling interleaving

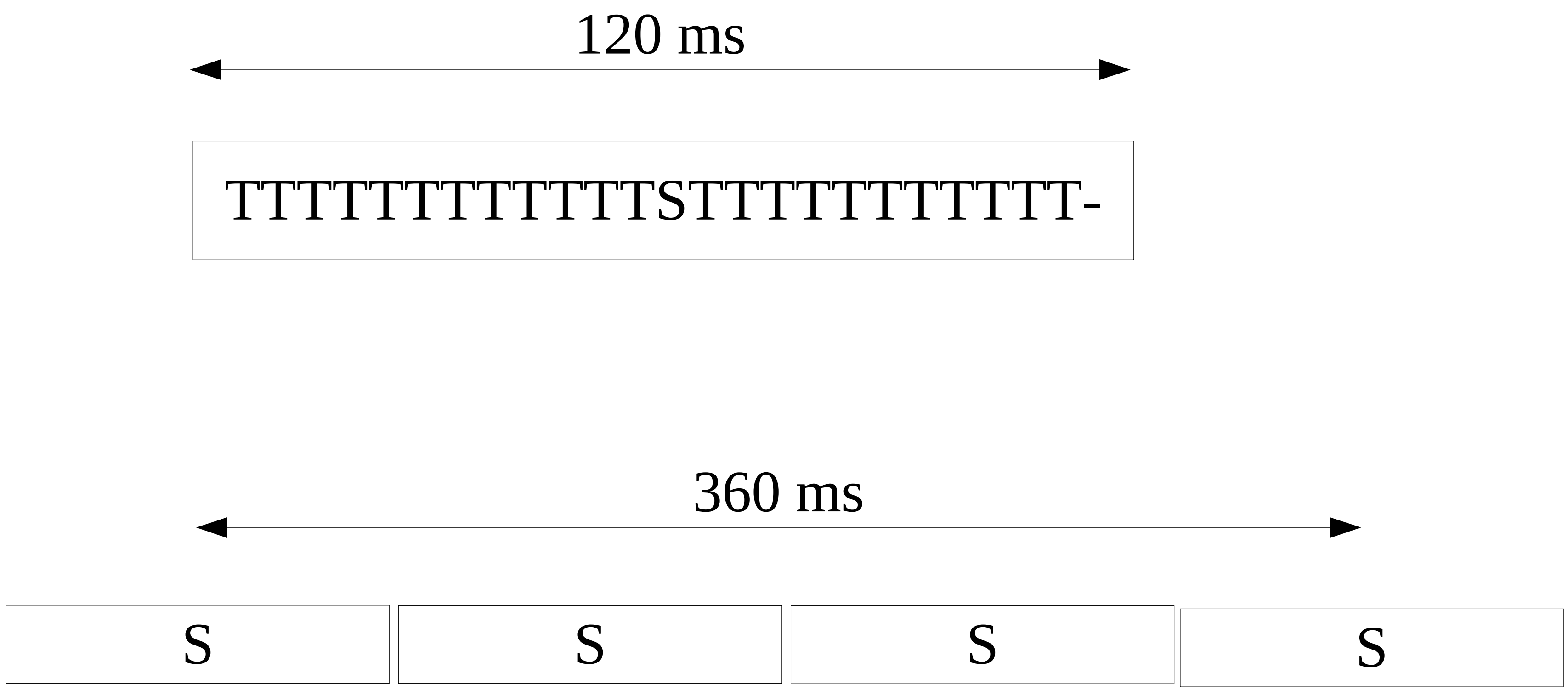


One message requires four bursts.

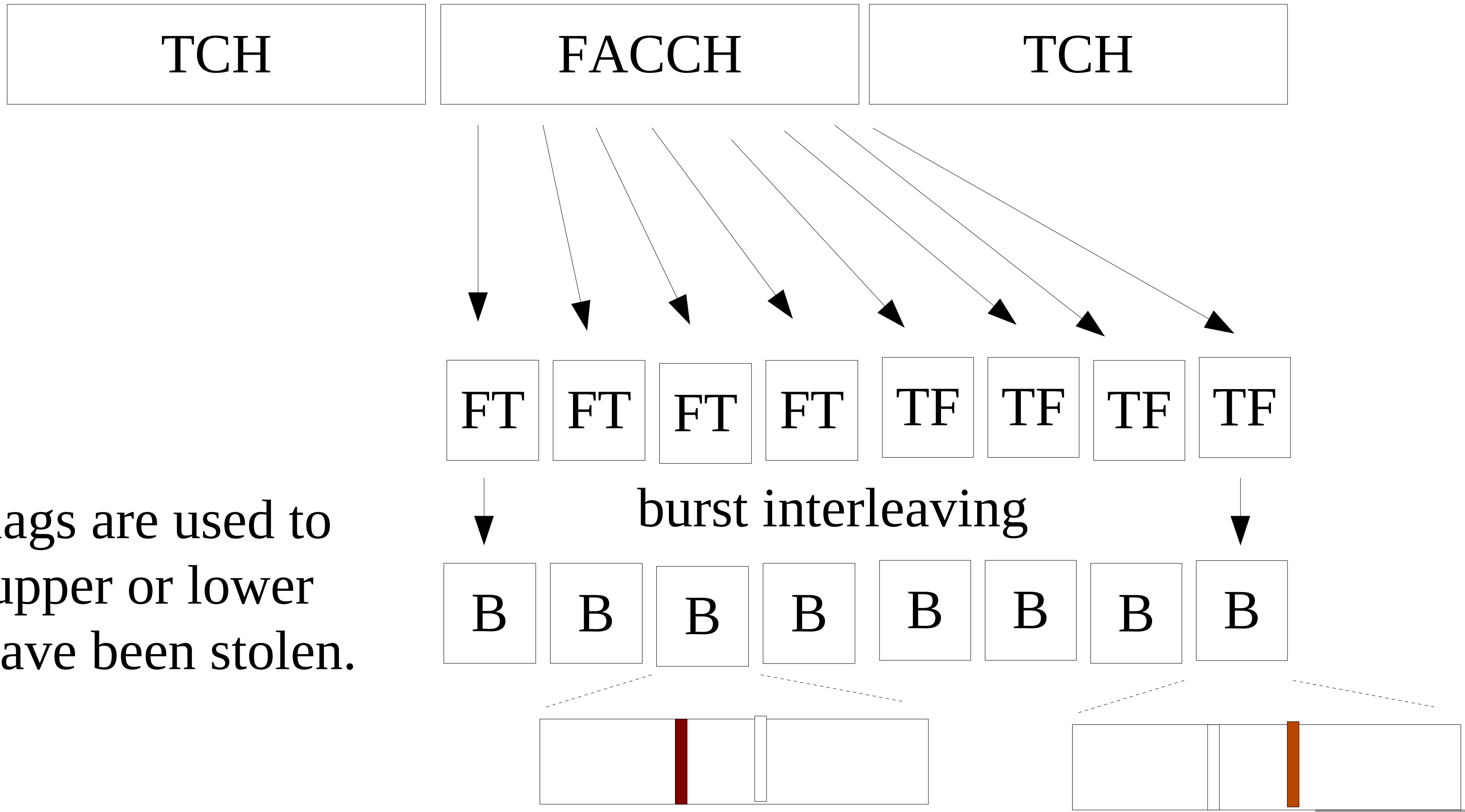
intra burst interleaving

burst 2x57

SACCH delay



FACCH interleaving



Two stealing flags are used to indicate if the upper or lower data segment have been stolen.

Channel Coding

Voice/Data/Signaling

260 bits voice or 184 bits signaling

block coder

78+189 bits voice or 228 bits signaling

convolutional coder

456 bits

interleaving coder

8 half blocks

radio burst