Channel Concepts

Chapter 4

This chapter is designed to provide the student with an overview of the air interface, including physical and logical channels. It addresses air interface components, their functions, features, and required specifications.

OBJECTIVES:

Upon completion of this chapter the student will be able to:

- Understand the difference between a physical channel and a logical channel
- Name 3 logical channels
- List one important piece of information sent on each of 3 different logical channel
- Briefly describe the idea of mapping

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4 Channel Concepts

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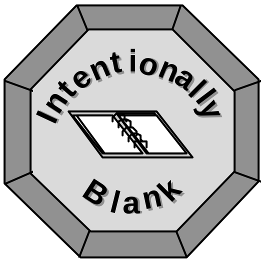
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INTRODUCTION TO PHYSICAL AND LOGICAL CHANNELS

Each timeslot on a TDMA frame is called a physical channel. Therefore, there are 8 physical channels per carrier frequency in GSM.

Physical channels can be used to transmit speech, data or signaling information.

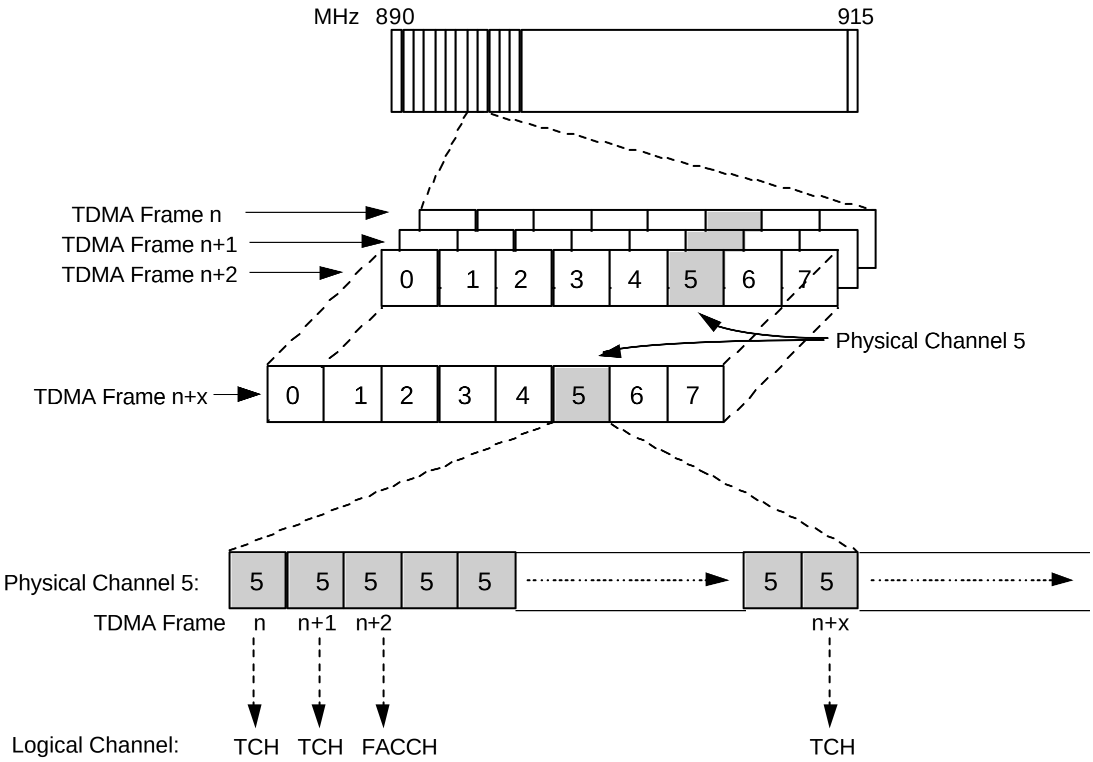


Figure 4-1 The TDMA channel concept

A physical channel may carry different messages, depending on the information that is to be sent. These messages are called logical channels. For example, on one of the physical channels used for traffic, the traffic itself is transmitted using a Traffic CHannel (TCH) message, while a handover instruction is transmitted using a Fast Associated Control Channel (FACCH) message.

LOGICAL CHANNELS

Many types of logical channels exists (see Figure 4-2), each designed to carry a different message to or from an MS.

All information to and from an MS must be formatted correctly, so that the receiving device can understand the meaning of different bits in the message. For example, as seen previously, in the burst used to carry traffic, some bits represent the speech or data itself, while others are used as a training sequence.

There are several types of burst. The relationship between bursts and logical channels is shown in the figure below.

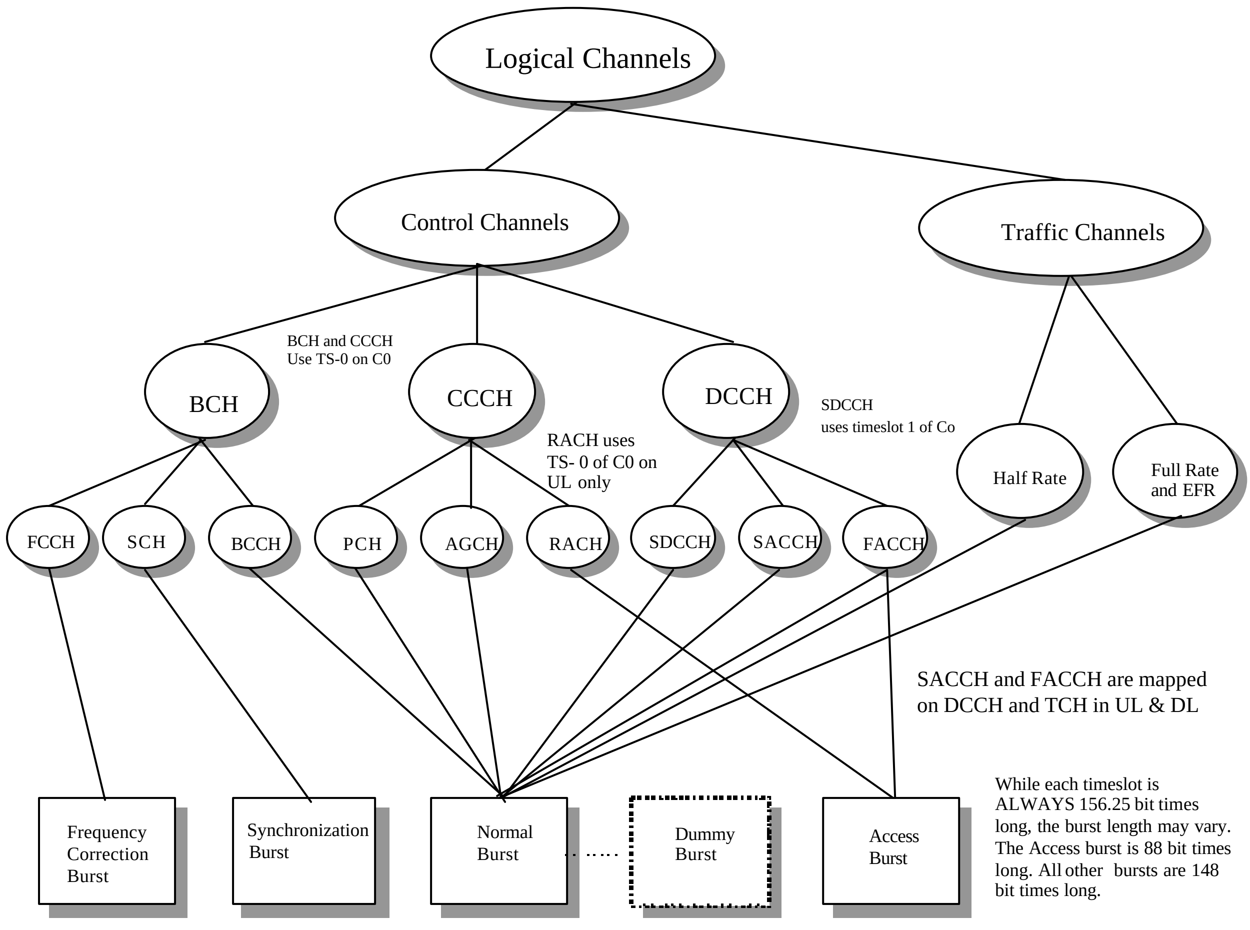


Figure 4-2 Logical channels and bursts

CONTROL CHANNELS

When an MS is switched on, it searches for a BTS to connect to. The MS scans the entire frequency band, or, optionally, uses a list containing the allocated carrier frequencies for this operator. When the MS finds the strongest carrier, it must then determine if it is a control channel. It does so by searching for a particular logical channel called Broadcast Control CHannel (BCCH).

A frequency carrying BCCH contains important information for an MS, including e.g. the current LA identity, synchronization information and network identity. Without such information, an MS cannot work with a network. This information is broadcast at regular intervals, leading to the term Broadcast CHannel (BCH) information.

Broadcast CHannels (BCH's)			
Logical Channel	*Direction*	*BTS*	*MS*
Frequency Correction CHannel (FCCH)	Downlink, point to multipoint	Transmits a carrier frequency.	Identifies BCCH carrier by the carrier frequency and synchronizes with the frequency.
Synchronization CHannel (SCH)	Downlink, point to multipoint	Transmits information about the TDMA frame structure in a cell (e.g. frame number) and the BTS identity (Base Station Identity Code (BSIC)).	Synchronizes with the frame structure within a particular cell, and ensures that the chosen BTS is a GSM BTS - BSIC can only be decoded by an MS if the BTS belongs to a GSM network.
Broadcast Control CHannel (BCCH)	Downlink, point to multipoint	Broadcasts some general cell information such as -Location Area Identity (LAI), -maximum output power allowed in the cell and -the identity of BCCH carriers for neighboring cells.	Receives LAI and will signal to the network as part of the Location Updating procedure if the LAI is different to the one already stored on its SIM. MS sets its output power level based on the information received on the BCCH. The MS stores the list of BCCH carrier frequencies on which Rx. level measurement is done for Handover decision.

Table 4-1 Broadcast channels

When the MS has finished analyzing the information on a BCH, it then has all the information required to work with a network.

However, if the MS roams to another cell, it must repeat the process of reading FCCH, SCH and BCCH in the new cell.

If the mobile subscriber then wishes to make or receive a call, the Common Control CHannels (CCCH) must be used.

Common Control Channels (CCCH)			
Logical Channel	*Direction*	*BTS*	*MS*
Paging CHannel (PCH)	Downlink, point to multi-point	Transmits a paging message to indicate an incoming call or short message. The paging message contains the identity number of the mobile subscriber that the network wishes to contact.	At certain time intervals the MS listens to the PCH. If it identifies its own mobile subscriber identity number on the PCH, it will respond.
Random Access CHannel (RACH)	Uplink, point to point	Receives access-request from MS for call setup/ loc. update/ SMS	Answers paging message on the RACH by requesting a signaling channel.
Access Grant CHannel (AGCH)	Downlink, point to point	Assigns a signaling channel (SDCCH) to the MS.	Receives signaling channel assignment (SDCCH).

Table 4-2 Common Control Channels

At this stage the MS and BSS are ready to begin call set-up procedures. For this the MS and BSS use Dedicated Control CHannels (DCCH's).

Dedicated Control Channels (DCCH)			
Logical Channel	*Direction*	*BTS*	*MS*
Stand alone Dedicated Control CHannel (SDCCH)	Uplink and downlink, point to point	The BTS switches to the assigned SDCCH, used for call set-up signaling. TCH is assigned on SDCCH. (SDCCH is also used for SMS messages to MS).	The MS switches to the assigned SDCCH. Call set-up is performed. The MS receives a TCH assignment information (carrier and time slot).
Cell Broadcast CHannel (CBCH)	DL,point to multi point, mapped on SDCCH	Uses this logical channel to transmit short message service cell broadcast.	MS receives cell broadcast messages.
Slow Associated Control CHannel (SACCH)	Uplink and downlink, point to point	Instructs the MS on the allowed transmitter power and parameters for time advance. SAACH is used for SMS during a call.	Sends averaged measurements on its own BTS (signal strength and quality) and neighboring BTS's (signal strength). The MS continues to use SACCH for this purpose during a call.
Fast Associated Control CHannel (FACCH)	Uplink and downlink, point to point	Transmits handover information.	Transmits necessary handover information in access burst

Table 4-3 Dedicated Control Channels

TRAFFIC CHANNELS

☞ Did you know?

Enhanced Full Rate (EFR) speech coders improve the speech quality offered across one full rate TCH, but still use a full rate TCH logical channel.

Once call set-up procedures have been completed on the control physical channel, the MS tunes to a traffic physical channel. It uses the Traffic CHannel (TCH) logical channel. There are two types of TCH:

- Full rate (TCH): transmits full rate speech (13 kbits/s). A full rate TCH occupies one physical channel.
- Half rate (TCH/2): transmits half rate speech (6.5 kbits/s). Two half rate TCH's can share one physical channel, thus doubling the capacity of a cell.

BURSTS

BURST TYPES

There are five burst types. (See in Table 4-4 and Figure 4-3.)

Burst Type	Purpose	Used by	Contents
Normal	Used to carry information on traffic and control channels	BCCH, PCH, AGCH, SDCCH, CBCH, SACCH, FACCH, TCH	• Two blocks of 57 bits each for traffic • Training sequence (26 bits) • Steal flags (1 bit each) to indicate that FACCH has temporarily stolen 57 bits • Tail bits (always 000) • Guard period: 8.25 bit durations
Frequency Correction	Used for frequency synchronization of the mobile	FCCH	• 142 frequency correction bits • Tail bits • Guard period: 8.25 bit durations
Synchronization	Used for frame synchronization of the mobile	SCH	• Two blocks of 39 bits for TDMA frame structure information • 64 synchronization bits • Tail bits • Guard period: 8.25 bit durations
Access	Used for random and handover access	RACH FACCH	• 41 synchronization bits • 36 bits of access information • Tail bits • Guard period: 68.25 bit durations. A longer GP is used because it is the first transmission from the mobile - no timing advance information is available
Dummy	Used when no other channel requires a burst to be sent and carries no information	All free TS on C0. (1-7)	• Pattern consists of Training sequence and a mixed bit pattern.

Table 4-4 Burst types

THE RELATIONSHIP BETWEEN BURSTS AND FRAMES

The relationship between bursts and frames is shown in the figure below. There are two types of multiframe:

- **26 TDMA frame multiframe:** used to carry TCH, SACCH and FACCH
- **51 TDMA frame multiframe:** used to carry BCCH, CCCH, SDCCH and SACCH.

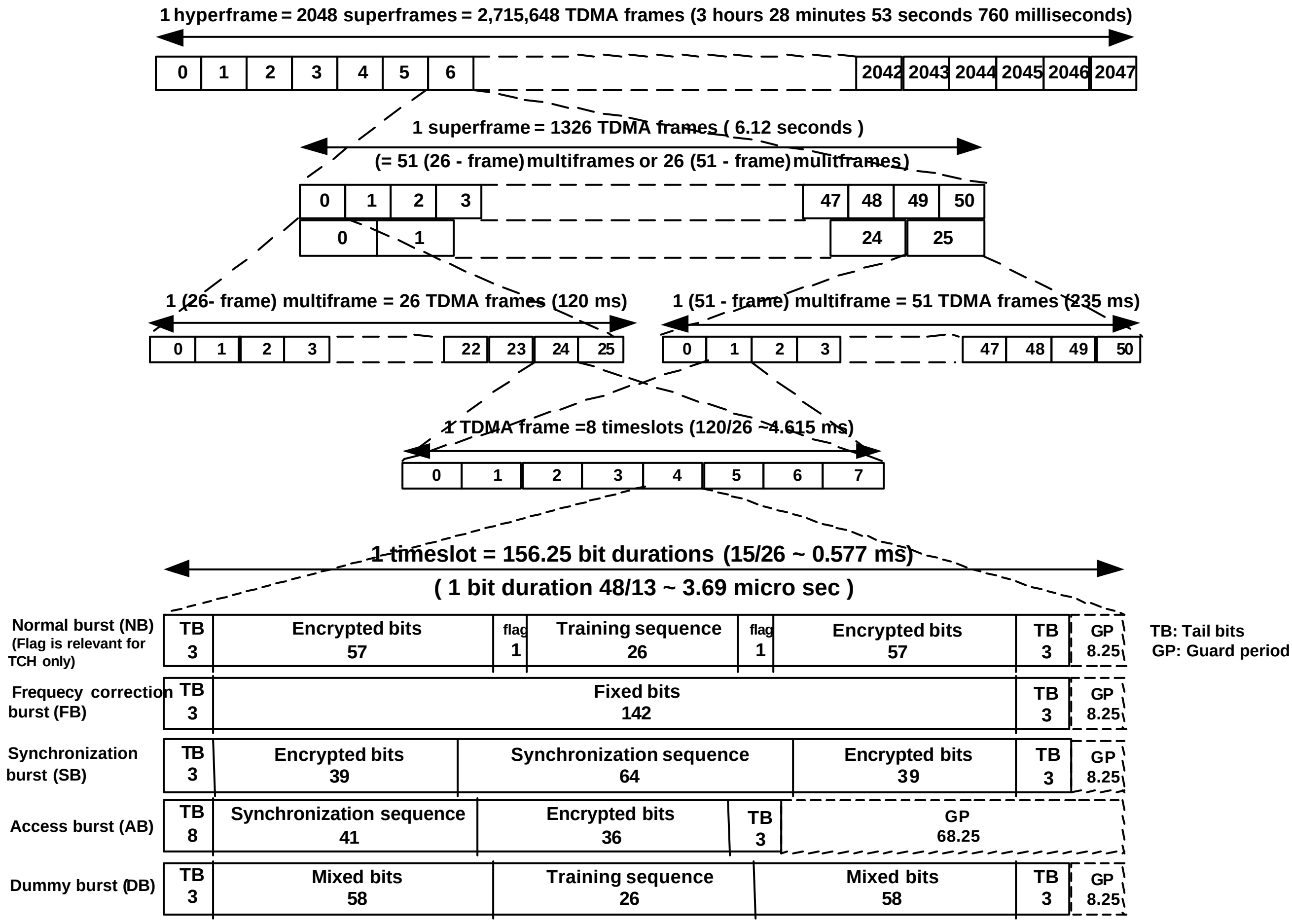


Figure 4-3 Bursts and frames

MAPPING OF LOGICAL CHANNELS ONTO PHYSICAL CHANNELS

Logical channels are transmitted on physical channels. The method of placing logical channels on physical channels is called **mapping.** While most logical channels take only one time slot to transmit, some take more. If so, logical channel information is carried in the same physical channel time slot on consecutive TDMA frames. Because logical channels are short, several logical channels can share the same physical channel, making the use of time slots more efficient.

DCCH on TS-1 or TS-2?

As a general rule TS-1 had been used for DCCH and today most operators are using TS-1 for DCCH. However some operators are using Extended Cells with radius longer than 35km (up to 121km) as described in chapter 3 under heading TIMING ADVANCE. These extended cells require 2 time slots per channel otherwise the adjacent TS may experience interference.

When implementing extended range cells, the timing advance burst is the same length as for normal range cells. However, the provision of 2 timeslots allows for the possibility of increased slippage due to the distance traveled. Hence Ericsson recommend TS-2 for DCCH (note: this is only a recommendation, even though TS-1 is used today all over the world). This would allow TS-0/1 for BCH/CCCH, and TS-2/3 for DCCH in extended cells. **In this book however, TS-1 is used for DCCH in examples and figures.** The radio channel and the time slots for DCCH are defined in the BSC data.

The figure below shows the carrier frequencies for a sample cell, including an additional allocation of a time slot for DCCH in Carrier 1, Timeslot 0 (due to a high call set-up load in the cell).

Carrier \ Time slot	0	1	2	3	4	5	6	7
0	B,C	D	T	T	T	T	T	T
1	D	T	T	T	T	T	T	T
2	T	T	T	T	T	T	T	T
3	T	T	T	T	T	T	T	T

Legend:
B: BCH
C: CCCH
D: DCCH
T: TCH

Figure 4-6 Mapping of control and traffic logical channels to physical channels

CARRIER 0, TIME SLOT 0

Time slot 0 of the first carrier frequency in a cell is always reserved for signaling purposes. In this way, when an MS is determining whether a carrier frequency is a BCCH carrier, it knows where to look.

On the downlink, BCH and CCCH information is transmitted. The only logical channel on the uplink is RACH. By having the uplink free for RACH only, a mobile subscriber can initiate a call at any time.

CARRIER 0, TIME SLOT 1

☞ Did you know?

SMS text messages are transmitted on channels assigned for DCCH. As the use of SMS increases, it is important for operators *to dimension their control physical channels. Ericsson's system enables the automatic reconfiguration of physical channels in the event of high text message traffic.*

Generally, time slot 1 of the first carrier frequency in a cell is reserved for signaling purposes. The only exceptions are cells with high or low traffic load. As can be seen in Figure 4-6, if there is a high traffic load in a cell, it is possible to assign a second (or more) physical channel for the purpose of call set-up (using DCCH). This may be any physical channel other than time slots 0 and 1 on carrier frequency 0.

Similarly, if there is a low traffic load in a cell, it is possible to use physical channel 0 on carrier frequency 0 for all signaling information: BCH, CCCH and DCCH. By doing so, physical channel 1 can be spared for traffic.

Eight SDCCHs and 4 SACCHs can all share the same physical channel. This means that 8 calls can be set-up simultaneously on one physical channel.

CARRIER 0, TIME SLOT 2-7 AND ALL TIME SLOTS ON OTHER CARRIERS IN THE SAME CELL

All time slots in a cell other than those assigned for signaling information are used for traffic, i.e. speech or data. Logical channel TCH is used.

In addition, at regular intervals during a call, an MS transmits to the BTS measurements it has made about signal strength and quality. Logical channel SACCH is used for this, replacing one TCH time slot at a time.

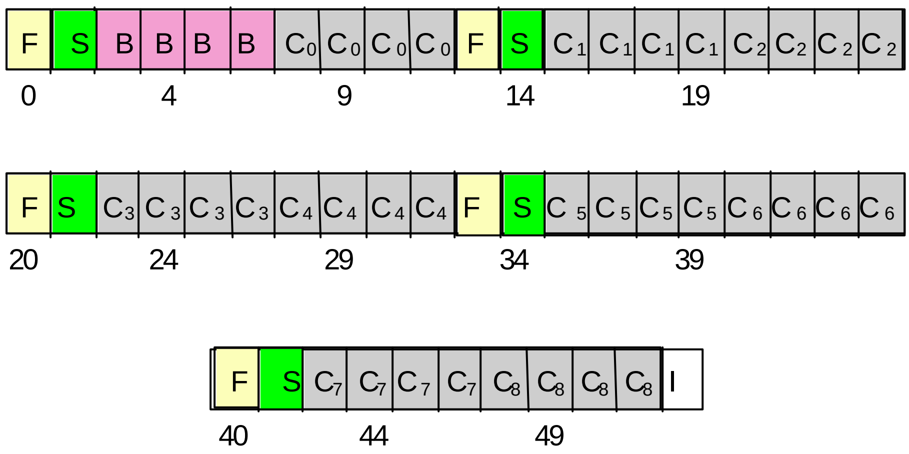
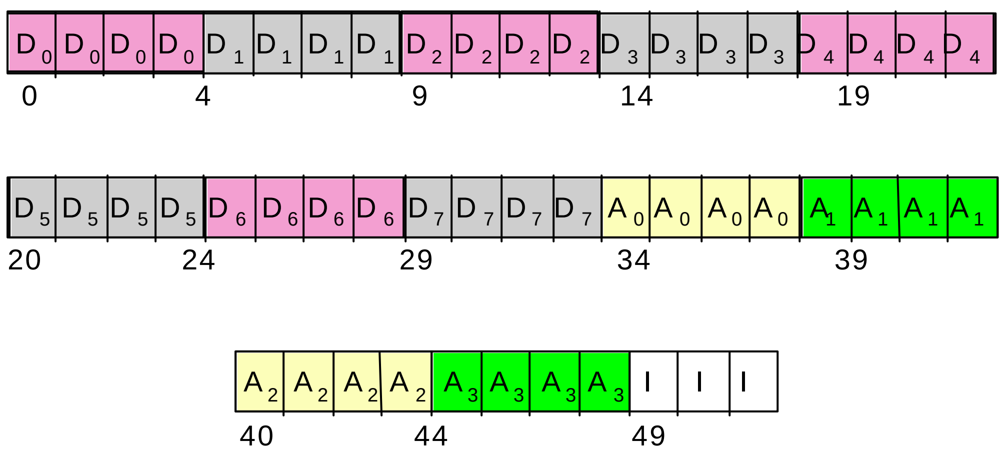


Figure 4-7 Multiplexing of BCH's and CCCHs on TS0



Next 52 frames contain channels A4,A5,A6,A7 in place of A0,A1,A2,A3

Figure 4-8 Multiplexing of SDCCH's and SACCH's on TS1

SDCCH is divided into 8 groups D0-D7 so that it can serve 8 MS's concurrently. A0-A7 are the corresponding SAACH channel groups which are used for TX Power control and TA correction, if necessary, while the MS is located in SDCCH.

SAMPLE TRAFFIC CASE: CALL TO AN MS

The following traffic case describes a call to an MS and highlights the use of some logical channels during the call.

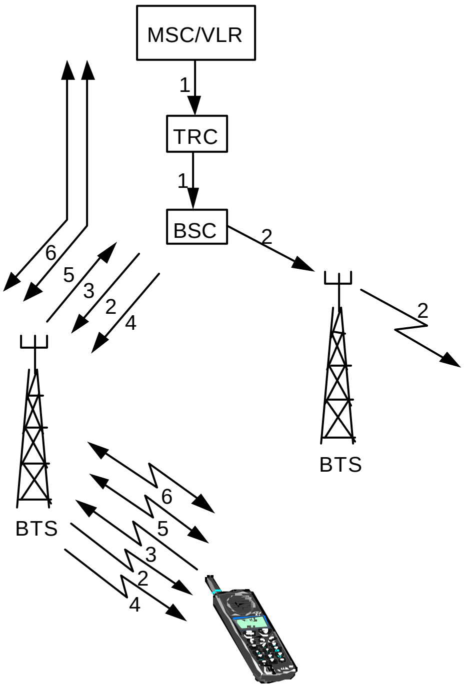
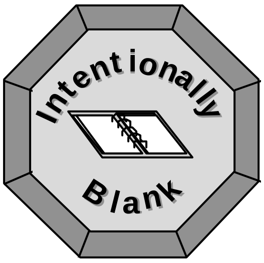


Figure 4-9 Call to an MS

1. The MSC/VLR knows which LA the MS is located in. A paging message is sent to the BSC's controlling the LA.
2. The BSC’s distribute the paging message to the BTS's in the desired LA. The BTS's transmit the message over the air interface using **PCH**.
3. When the MS detects a PCH identifying itself, it sends a request for a signaling channel using **RACH**.
4. The BSC uses **AGCH** to inform the MS of the signaling channel (**SDCCH** and **SACCH**) to use.
5. **SDCCH** and **SACCH** are used for call set-up. A **TCH** is allocated and the **SDCCH** is released.
6. The MS and BTS switch to the identified **TCH** frequency and time slot. The MS generates ring tone. If the subscriber answers, the connection is established. During the call, signals can be sent and received by the MS using **SACCH**.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