# Abis Interface

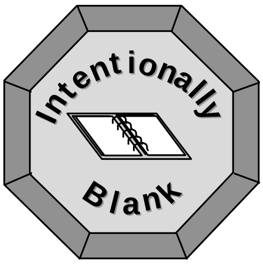
## Chapter 7

This chapter is designed to provide the student with an overview of the Abis interface.

## OBJECTIVES:

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

- describe how the information carried between BSC-RBS is mapped onto the PCM lines between them.
- describe the general format of the layer 2 protocol (LAPD) messages used on Abis.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# 7 Abis Interface

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# ABIS - GENERAL

To review, the two nodes in the Base Station System (BSS) are called:

**Base Station Controller (BSC) -** The BSC controls all the radio related functions in the system. The BSC equipment is an AXE application in Ericsson's GSM system.

**Base Transceiver Station (BTS) -** This is the equipment that handles the radio traffic in one cell. Ericsson refers to it as the Radio Base Station (RBS).

Abis is the name of the interface connecting the BSC and RBS nodes in the BSS See Figure 7-1 and Figure 7-2.

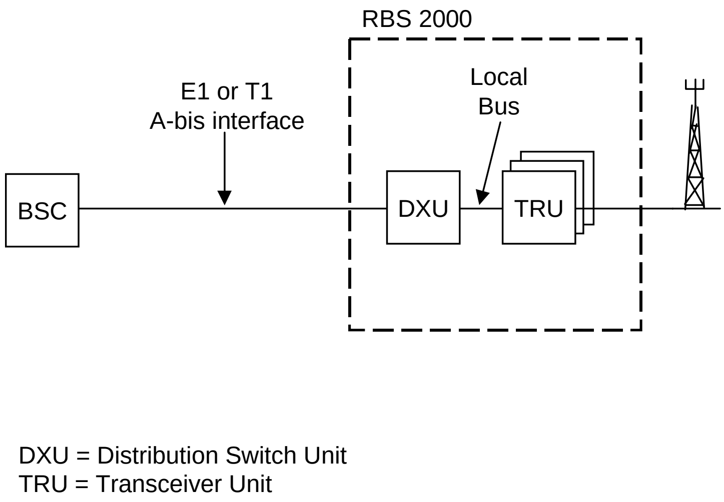



*Figure 7-1 BSS with RBS 2000.*

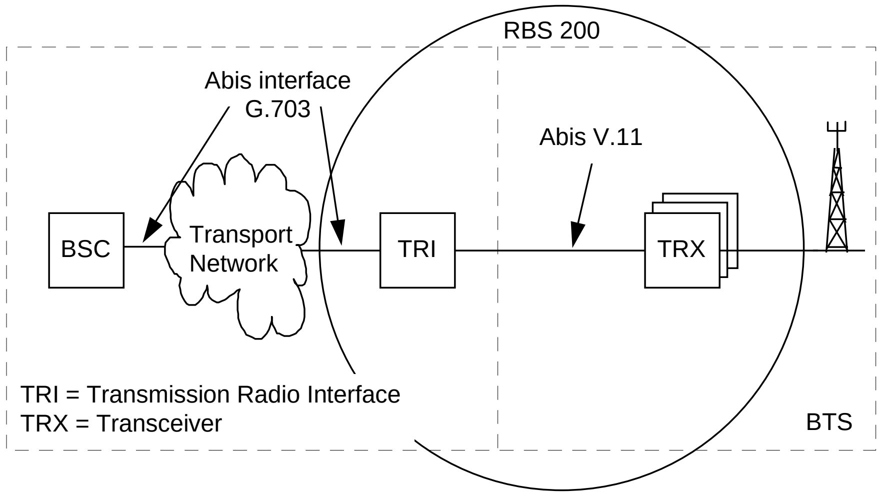



*Figure 7-2 BSS with RBS 200.*

Information transferred over the Abis interface includes:

- synchronization information
- TRH - TRXC signaling
- traffic (speech, data, fax, etc.)
- in-band signaling
- DXU and TRI signaling

## SYNCHRONIZATION INFORMATION

In the RBS there is a synchronization function needed for air time slot synchronization. It provides a reference both for RF generation and clocking of the time base counters. Short term stability of the timing is achieved by the RBS itself.

For GSM 900 and GSM 1800 networks, the long term stability of the RBS relies on an external synchronization reference received over the Abis PCM interface. For GSM 1900 networks, an optional synchronization reference is used to achieve long term stability. The reference is taken from an optional synchronization function in the RBS.

## TRH-TRXC SIGNALING

TRH-TRXC signaling refers to all signaling between the BSC and BTS. Either the signaling is aimed at the air interface such as FACCH signaling or signaling is aimed at a specific TRXC.

## TRH

The TRansceiver Handler (TRH), which resides in the BSC, is a functional concept consisting of application hardware and software. The hardware consists of one circuit board called TRHB. The software is located in the central and regional processors in the control system. TRH terminates the physical connection to the BTS.

A TRH handles eight physical connections or devices ($8 \cdot 64$ kbps). Seven out of these devices can maintain LAPD data links used for signaling to the BTS, and one device is used for supervision and testing. The devices are connected to the transceivers (TRXs) in the BTS via the Group Switch (GS).

## TRXC

The TRansceiver Controller (TRXC) is the control part of the transceiver. Signaling messages can either be sent TRH-TRXC or TRH-MS, the latter referring to messages transparently handled by the TRXC. If no LAPD concentration is used, one time slot on the Abis link is needed to carry the TRH-TRXC signaling for each transceiver.

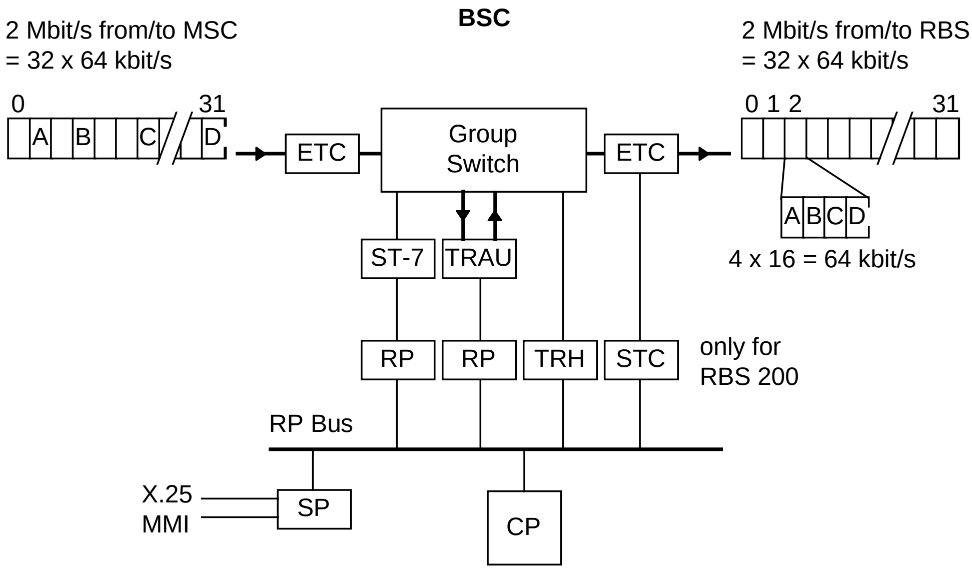
**Note:** The TRXC function in RBS 2000 is implemented in the TRU.

## *TRAFFIC*

## Speech Processing Functions

In Ericsson’s GSM system, transcoding of speech and rate adaptation of data is performed in the BSC by the Remote Transcoder (RTC) located in the Transcoder and Rate Adaptation Unit (TRAU). However, the control is handled by the Remote Transcoder Handler (RTH) in the BTS. This arrangement is called remote transcoding. Another option described in the GSM recommendations is local transcoding, which involves having the transcoding and rate adaptation of data performed in the BTS.

With remote transcoding, the bit rate is reduced and four channels on the A interface can be sub multiplexed in one PCM time slot on Abis. See Figure 7-3.




| | | | |
|---|---|---|---|
| ST-7 | Signaling Terminal No 7 | CP | Central Processor |
| ETC | Exchange Terminal Circuit | SP | Support Processor |
| STC | Signaling Terminal Central | MMI | Man Machine Interface |
| RP | Regional Processor | | |

*Figure 7-3 Sub-multiplexing in BSC.*

Figure 7-4 provides an overview of the speech processing functions in GSM. The transmit side is located on the upper half of the figure. The receive side is located on the lower half. Note that there is a main difference between the MS side and the BSS side. The BSS side receives a PCM coded speech signal from the network, whereas the MS receives an analogue signal from the microphone in the MS.

The speech processing functions consist of the following main parts:

- Speech transcoding - reduces the bit rate from 64 kbps to 13 kbps
- Discontinuous Transmission (DTX) and Voice Activity Detection (VAD)
- Comfort noise functions - generates background noise parameters to be used with DTX operations
- Speech frame substitution - replaces lost frames with previous frames

## Speech Transcoding

As shown in Figure 7-4, the speech encoder takes as its input a 13 bit uniformly quantized PCM signal, with a sampling frequency of 8 kHz. This speech signal comes from either the audio part of the MS or from the PSTN via an 8 bit logarithmic quantized A-law or μ-law to 13 bit uniformly quantized PCM conversion.

**Full Rate Speech Coder:**

The output from the full rate (FR) speech coder contains 260 bits for every 20 ms, corresponding to a bit rate of 13 kbps. The coding scheme is called Linear Predictive Coding-Long Term Prediction-Regular Pulse Excitation, referred to as LPC-LTP-RPE. There is a detailed description of the speech coder in the GSM recommendations.

Most of the bits describing the LPC and LTP parameters are classed as Ia and Ib. Most of the class II bits originate from the RPE bits describing the excitation sequence. Class Ia bits are protected not only with an error correction code but also with an error detection code. Class Ib bits are protected with an error correction code only while class II bits are unprotected. For details see chapter 6 “Um interface”.

**Enhanced Full Rate Coder and Half Rate Coder:**

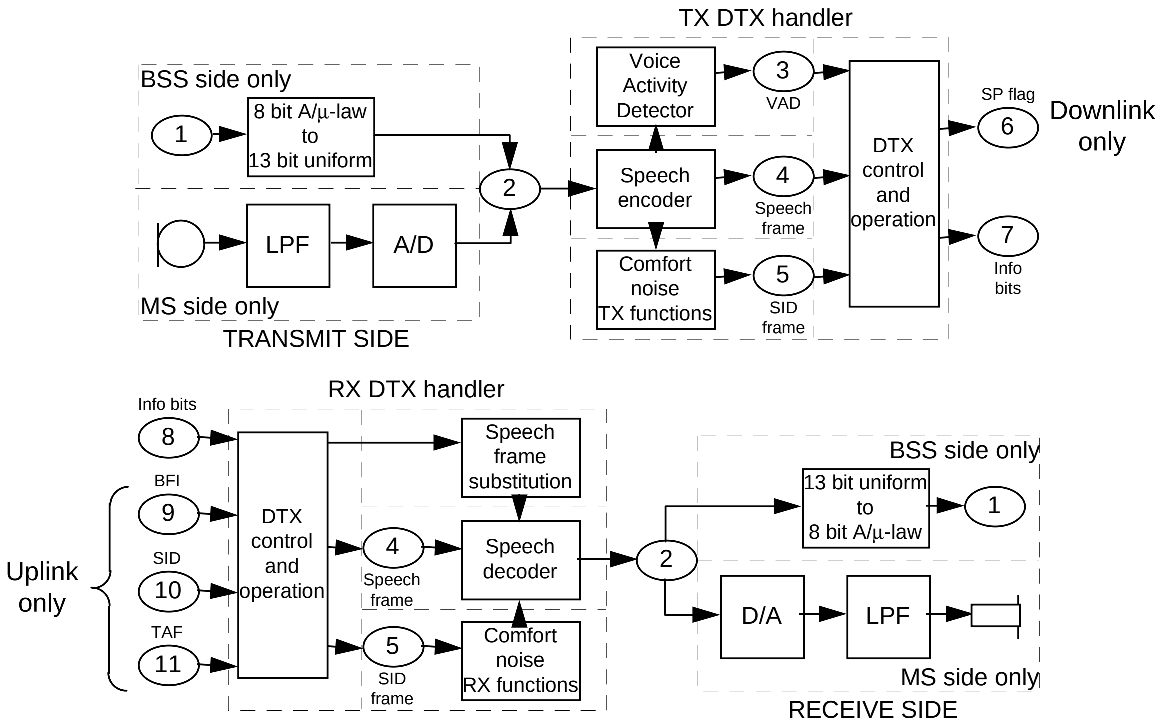
The LPC-LTP-RPE coder used in FR speech coding is altered so that the residual part of the speech signal is described using a code book instead of the RPE description. The family of coders using this method is called Code Excited Linear Prediction, (CELP). New parameter descriptions of the LPC and the LTP parts of the speech are used.

With the introduction of the Enhanced Full Rate (EFR) speech encoders, speech connections with a quality matching that of the fixed network can be offered.

With the introduction of the Half Rate (HR) speech coder the number of TCHs for a given number of transceivers will double compared to the FR case. One HR TCH uses a certain TS all odd TDMA frames while another HR TCH uses the TS all even TDMA frames. The HR speech encoding is performed with a HR transcoder.

The transcoders implementing the HR, the FR and the EFR speech encoding algorithms are placed in a pool, i.e. the transcoder resource for each speech connection is allocated at call set up. From the transcoder pool, which is located in the BSC, transcoder resources are seized on a per call basis. Seizing transcoder resources on demand results in an efficient utilization of the installed transcoder hardware.

A transcoder resource can be seized from one out of 3 different transcoder pools. The system is prepared to support up to 32 transcoder pools but the system limit is currently 3 since there are only 3 types of speech coders defined.




(1) 8 bit A/µ-law PCM, 8000 samples/s
(2) 13 bit uniform PCM, 8000 samples/s
(3) Voice activity flag
(4) Encoded speech frame, 50 samples/s, 260 bits/frame (Full rate speech coder)
(5) Silence Descriptor (SID) frame, 260 bits/frame beginning with 95 zeroes
(6) Speech flag, indicates whether information bits are speech or SID information (Downlink only)
(7) Information bits delivered to the radio subsystem
(8) Information bits received from the radio subystem
(9) Bad Frame Indication (BFI) flag (Uplink only)
(10) Silence Descriptor (SID) flag (Uplink only)
(11) Time Alignment Flag (TAF), marks the position of the SID frame within the SACCH multiframe (Uplink only)

*Figure 7-4 Overview of the speech processing functions.*

## Discontinuous Transmission (DTX) and Voice Activity Detector

During a normal conversation, the two subscribers alternate speaking. On average, each direction of transmission is occupied 50% of the time. Discontinuous transmission is a mode of operation where the transmitters are switched on for frames containing useful information only. This is performed because:

- In the MS to prolong battery life or enable a smaller battery to be used for a given operational duration.
- Both uplink and downlink, to reduce the average interference level, leading to better spectrum efficiency.

The DTX mechanism is implemented in the DTX handlers. One unit found in the DTX is the Voice Activity Detector (VAD).

The VAD determines whether a specific block of 20 ms from the speech coder contains speech or not. It estimates the energy level and presence of vocal cord pulses. The energy of the filtered input signal is compared to a threshold, and speech is assumed to be present if the threshold is exceeded. See Figure 7-5.

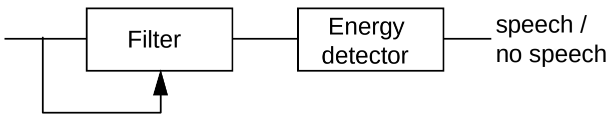



*Figure 7-5 Voice activity detector.*

The level of noise encountered in mobile environments may change. The spectrum of the noise can also change and varies greatly between different vehicles. Because of these changes the VAD threshold and filter coefficients must be adapted constantly.

The threshold must be sufficiently above the noise level to provide reliable detection and to avoid noise being mistakenly identified as speech. However, the threshold can not be so close to the noise level that low level parts of the speech are mistakenly identified as noise.

The threshold and the adaptive filter coefficients are only updated when speech is not present. It is potentially dangerous for a VAD to update these values on the basis of its own decision. The adaptation therefore occurs only when the signal appears stationary without having the pitch component which is inherent in voiced speech and information tones.

### *Comfort Noise Insertion*

When transmission is on, the background noise is transmitted with the speech. As the speech carrying bursts end, the reconstructed sound drops to a very low level and is interpreted as silence by the listener. Such a step modulation of background noise is very annoying and reduces the speech quality if presented to a listener without modification.

The noise contrast effect is reduced in the system by insertion of an artificial noise, called comfort noise, at the receiving end when speech is absent. The parameters needed for generation of the comfort noise are sent as background noise parameters during speech free periods. The functions for evaluation of the background noise and generation of comfort-noise are located in the DTX-handlers.

The frames containing the estimated background noise are called SID-frames (SID=Silence Descriptor) and they are sent in blocks of 8 bursts, within every SACCH period. A complete SACCH period contains 104 TDMA frames. Out of these 104 TDMA frames, 8 are SID-frame bursts and 4 are SACCH bursts. This means only 12 bursts are transmitted, each SACCH period, instead of 100 if DTX is not used.

### *Lost Speech Frame Substitution and Muting*

In the receiver, frames may be lost due to transmission errors or frame stealing by FACCH. In order to mask the effect of an isolated lost frame, a scheme is used in the DTX handler where the lost speech frame is substituted by a predicted frame based on the previous frame. Insertion of silent frames is not recommended since it will seriously decrease the speech quality. If several consecutive frames are lost, some muting technique must be used to indicate to the listener that the transmission has been interrupted.

## IN-BAND SIGNALING

In-band signaling is a non-GSM specific term for sending signaling information over a speech channel. In GSM on Abis interface in-band signaling is used between the Remote TransCoder (RTC) performing the speech coding in the BSC, and the Remote Transcoder Handler (RTH) which controls the RTC from the BTS. The name for this signaling originates from cases when signaling is placed in the speech frequency band.

If the speech coder is placed in the BTS (local transcoding), then one PCM time slot on Abis carries only one 64 kbps traffic channel. With remote transcoding, there is room for four sub-multiplexed traffic channels in one PCM time slot using $4 \cdot 13 =$ 52 kbps out of the available 64 kbps. The remaining 12 kbps (3 kbps per subchannel) are used for in-band signaling.

The total amount of signaling information that is included is 60 bits per frame of 20 ms. This means a total of 320 bits every 20 ms (260 bits are for speech) giving a total bit rate of 16 kbps. The in-band information can be for example:

- frame type indicating whether the frame contains speech, data, O&M or if it is idle (DTX)
- channel type which can be full rate, enhanced full rate or half rate

Bad Frame Indicator (BFI) and SID are two identities that are used only in the uplink direction from the channel decoder in the BTS to the speech decoder in the BSC.

The binary BFI flag indicates whether the speech frame is considered to contain meaningful information or not. BFI=1 indicates that bit errors have been detected among the class Ia bits, and that this burst is to be substituted with the previous 20 ms speech frame.

The two SID bits indicate if the channel decoder has detected the SID code word in the frame. The SID code word consists of 95 bits which are all zero. They are not needed to transfer background noise. Rather, they function as a marking flag for background noise.

The silence descriptor indicates how many of these 95 bits are found to be zero where:

- SID=2 means more than 93 zeroes
- SID=1 means between 93 and 79 zeroes
- SID=0 means less than 79 zeroes

The combination of BFI and SID determines whether or not this frame is good, and whether or not it contains speech. The relationships are shown in Figure 7-6. Note that these bits do not apply to data or O&M frames.

| BFI | SID | | |
|---|---|---|---|
| | 2 | 1 | 0 |
| 0 | valid SID | invalid SID | Good speech frame |
| 1 | | | Unusable frame |

*Figure 7-6 Relationship between SID, BFI and good speech frames.*

In the downlink direction, there is a speech flag (SP) instead indicating whether the burst contains speech or is idle (DTX). This information is, relevant for the transmitting side in the BTS. The SP flag is indicated in Figure 7-4.

## DXU AND TRI SIGNALING

In the RBS there is a unit responsible for distributing the information coming from the BSC to the correct TRU/TRX. This unit is called DXU for RBS 2000 and TRI for RBS 200. It is controlled from the BSC via signaling over the Abis interface.

# ABIS - RBS 200

In RBS 200 there is a unit called Transmission Radio Interface (TRI) which acts as a drop/insert switch. Logically, it belongs to the BSC (Link Handling Subsystem), but physically it resides in the base station. This implies that when RBS 200 is employed, the Abis interface is divided into two parts:

- Abis G.703 - used between BSC and TRI
- Abis V.11 - used between TRI and BTS

See Figure 7-7.

The TRI enables cascade coupled base stations. The cascading makes more efficient use of the transmission lines between the BSC and the BTS.

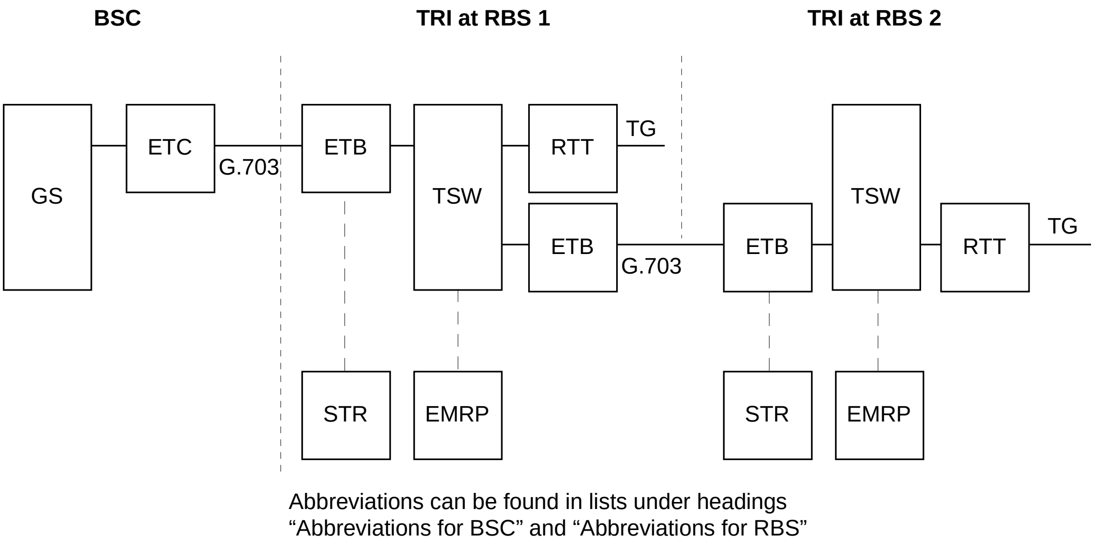



*Figure 7-7 Cascade coupled base stations, RBS 200.*

The Transceiver Group (TG), see Figure 7-8, is an entity in the RBS that contains up to 16 TRXs connected to the same transmitter antenna. One TG serves one cell.

The Transceiver Group Controller (TGC) is a function that handles common control functions in the TG. In the GSM recommendations TGC is called Basic Control Functions (BCF). The common control functions are distributed throughout the entire TG, but controlled from the TGC. These common control functions control for example, the Timing Module (TM), the Transmitters (RTX) and the O&M bus.

Each TRXC in any TG can act as a TGC, but only one can be active at a time. Determining which TRXC is to be defined as the TGC is carried out through software in the BSC. The TGC is identified by a unique Terminal Endpoint Identifier value (TEI) which is described in the LAPDm section of this chapter.

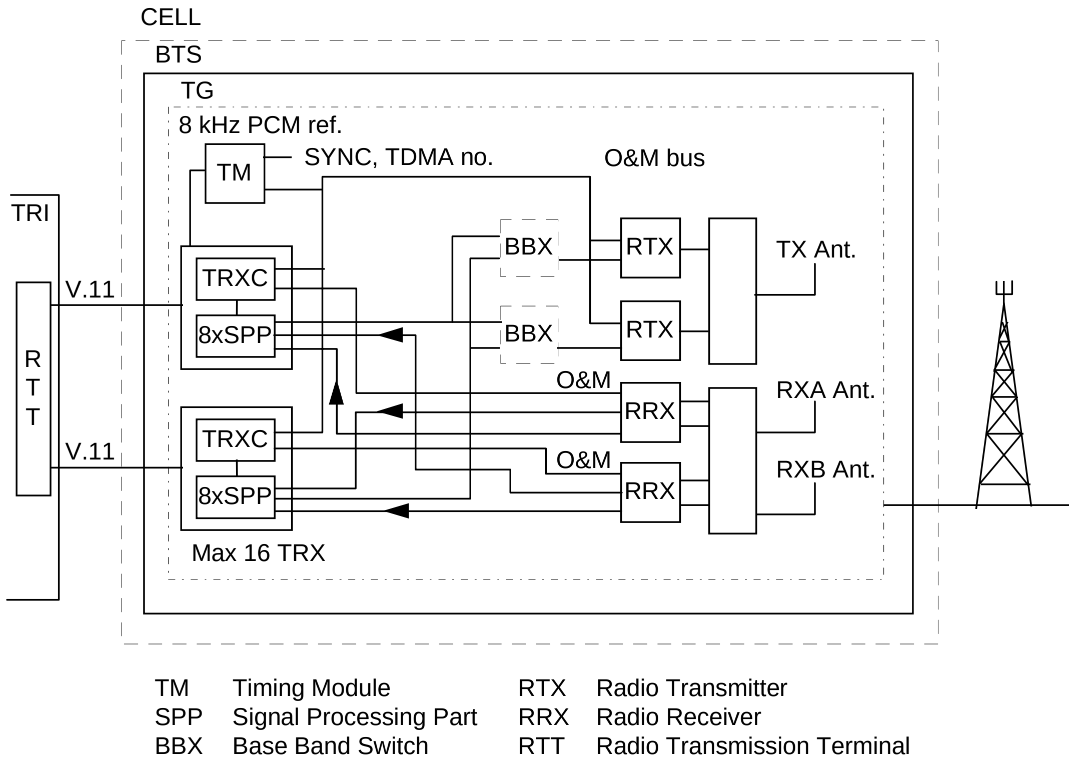



*Figure 7-8 BTS configuration.*

## SIGNALING LAYER 1, G.703

As mentioned for RBS 2000, Abis G.703 is a 2 Mbps PCM interface. The physical channel is divided into 32 time slots, each carrying a bit rate of 64 kbps. The setup in GSM 900/GSM 1800 with RBS 200 is:

- Time slot 0 is always used for synchronization
- Time slot 16 is used for signaling between BSC and TRI

The other time slots are used for:

- Traffic (speech or data) and in-band signaling
- TRH-TRXC signaling

Figure 7-9 shows how the PCM link is used when transcoding and rate adaptation is performed locally in the BTS, and remotely (as for GSM 900/GSM 1800) in the BSC. In the case shown in Figure 7-9, there is no LAPD concentration. See LAPD concentration for RBS 200.

The total number of TCHs is:

- 80 for remote transcoding (10 TRXs)
- 24 for local transcoding (3 TRXs)

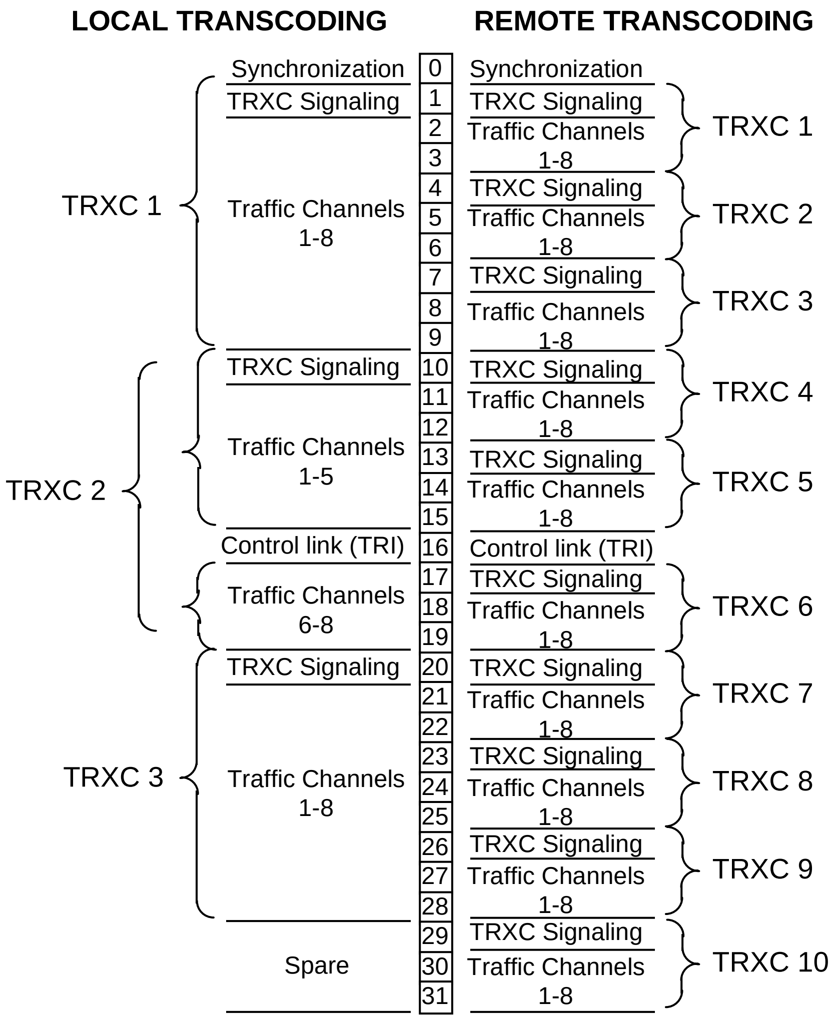



*Figure 7-9 Configuration of PCM link between BSC and RBS 200.*

## SIGNALING LAYER 1, V.11

Abis V.11 is a balanced interface used between TRI and TRXC. See Figure 7-10. Four TRXCs can be connected to one Radio Transmission Terminal (RTT) if remote transcoding is used.

TS 0 on the Abis G.703 contains synchronization information for the TRI. This information is extracted and sent to the TRXC that controls common functions in the TG. The PCM reference is an 8 kHz signal which is sent to the timing module. Another line from the RTT card to the TRXC is the 2.048 Mbps clock for data clocking. There is also a bi-directional PCM link used for signaling information between TRH and TRXC as well as for traffic to and from the MS.

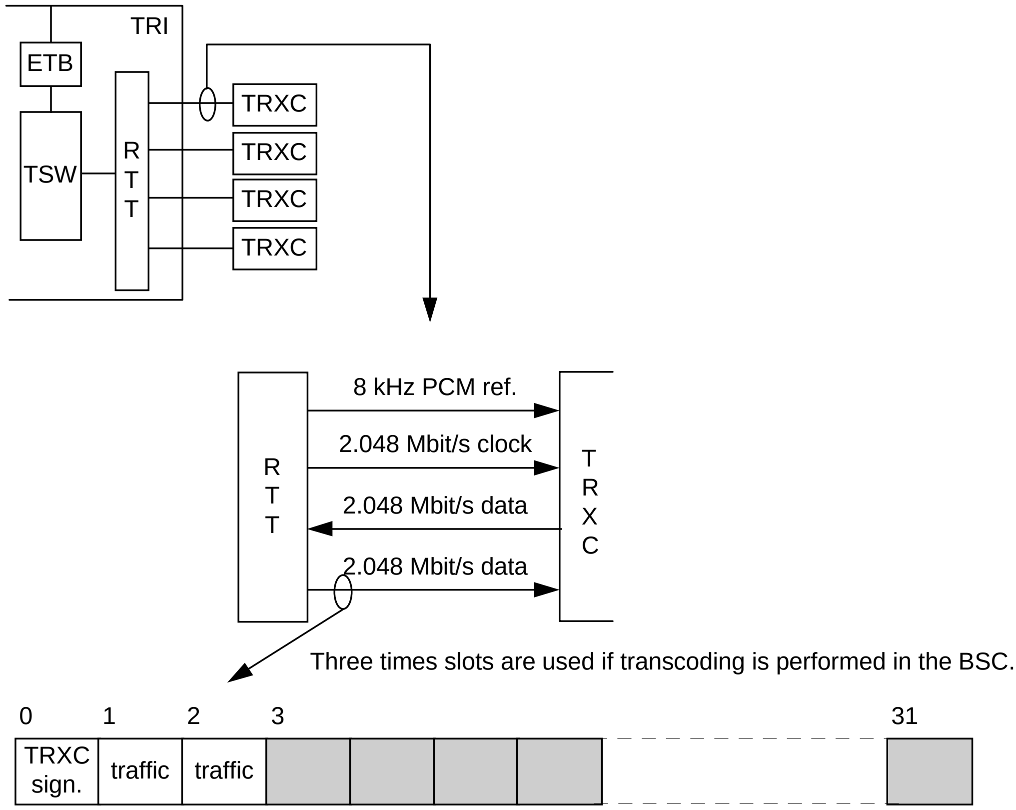



*Figure 7-10 Abis V.11.*

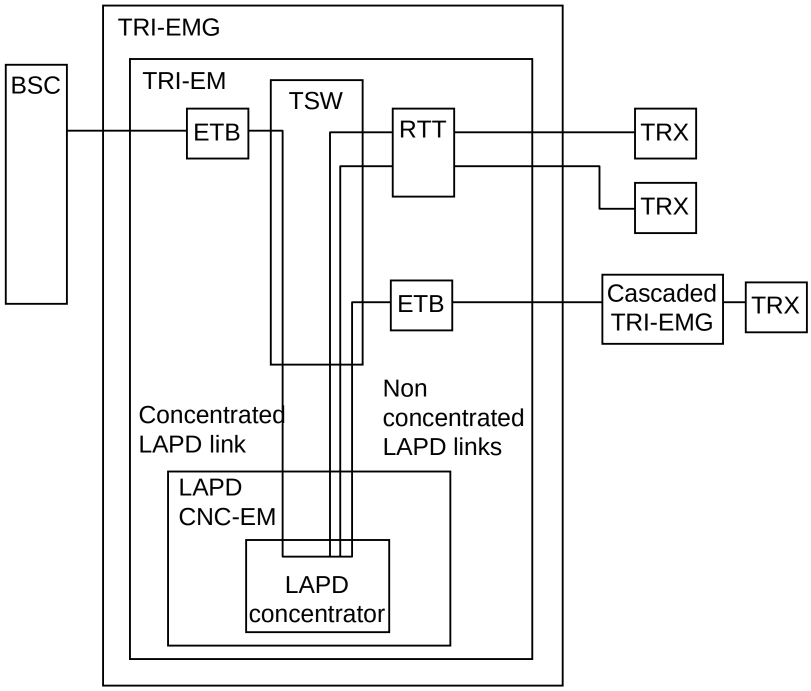
Only three time slots are used on Abis V.11 if transcoding is performed in the BSC. The remaining 29 time slots are idle.

In the case of cascaded sites, the first TRI regenerates synchronization information which is sent on TS 0 to the next TRI.

## LAPD CONCENTRATION FOR RBS 200

TRXs belonging to the same TG or different TGs, can share the same 64 kbps PCM time slot. There is no requirement that the TGs must reside at the same site. LAPD concentration, however, is only allowed at the first BTS in a cascaded topology.

**A concentrated LAPD link** is a LAPD link between a BSC and a LAPD concentrator. It is used for transferring signaling messages to and from several TRXs. At the BSC the concentrated link terminates in the TRH. In the BTS, it terminates in APZ hardware. This hardware is called Extension Module Regional Processor Speech bus (EMRPS) and handles the LAPD concentration. EMRPS is located in the TRI and is used as LAPD concentrator board. In Figure 7-11 the RBS 200 set-up is shown. There is no automatic replacement of faulty LAPD concentrator boards. However, there may be redundant LAPD concentrator boards installed in the TRI. A redundant board may replace a faulty board by manual reconfiguration from the BSC.




| | |
|---|---|
| BSC | Base Station Controller |
| ETB | Exchange Terminal Board |
| LAPD | |
| CNC-EM | LAPD Concentrator-Extension Module |
| RTT | Radio Transceiver Terminal |
| TRX | Transceiver |
| TRI-EM | Transmission Radio Interface-Extension Module |
| TRI-EMG | Transmission Radio Interface-Extension Module Group |
| TSW | Time Switch |

*Figure 7-11 Concentration of three non concentrated LAPD links to one concentrated LAPD link.*

**A non concentrated LAPD link** is a LAPD link between a TRX and a LAPD concentrator.

For the concentrated LAPD link, a semi-permanent path through the TRI time switch is set-up between the LAPD concentrator board and the ETB turned towards the BSC. This is shown in Figure 7-11. For the non-concentrated LAPD links, semi-permanent paths are set-up between the LAPD concentrator board and the RTT, for links to or from TRXs handled by local BTSs. In the case where the link is between the concentrator board and a TRX handled by a cascade connected RBS, a semi-permanent path is set-up between the LAPD concentrator board and the ETB turned towards the next site.

TRXs whose signaling is concentrated together must use different TEI values. This is valid for both TRXC TEI and TGC TEI. See the LAPD section of this chapter for an explanation of TEI. The address part of the received messages on a concentrated LAPD link are checked. The messages to each TRX are forwarded via one of the non concentrated LAPD links, depending on the TEI value that is included in the address field. Received messages on a non concentrated LAPD link are sent to the BSC via a concentrated LAPD link, if the messages contain a TEI value that is defined for the non concentrated LAPD link.

## BSC - RBS 200 INTERWORKING

The signaling between the BSC and the RBS 200 is rather complex. Here there is signaling to both the TRI and to the TRXs. Figure 7-12 illustrates both the speech paths and the signaling paths. The speech is speech coded in the TRAU in BSC, where the bit rate is reduced from 64 kbps to 16 kbps.

The signaling to the TRI comes from the Signaling Terminal Central (STC) in the BSC to the Signaling Terminal Regional (STR) in the RBS. This signaling link here is called Control Signaling Link (CSL). The signaling information on $CSL_1$ tells the TRI where to direct the different time slots. The TRI extracts the information for this RBS and passes the remaining information to the next TRI in a cascade connected RBS.

The STC-STR information on $CSL_2$ for the cascade connected TRI is sent on any TS except TS 0 and TS 16 on the first Abis interface. The first TRI puts the STC-STR information sent on $CSL_2$ onto TS 16 of the outgoing PCM link. The cascade connected TRI then extracts the signaling information from TS 16 of the incoming PCM link.

The signaling for the different TRXCs is put into the appropriate time slots by the TRH, which terminates the LAPD protocol in the BSC.

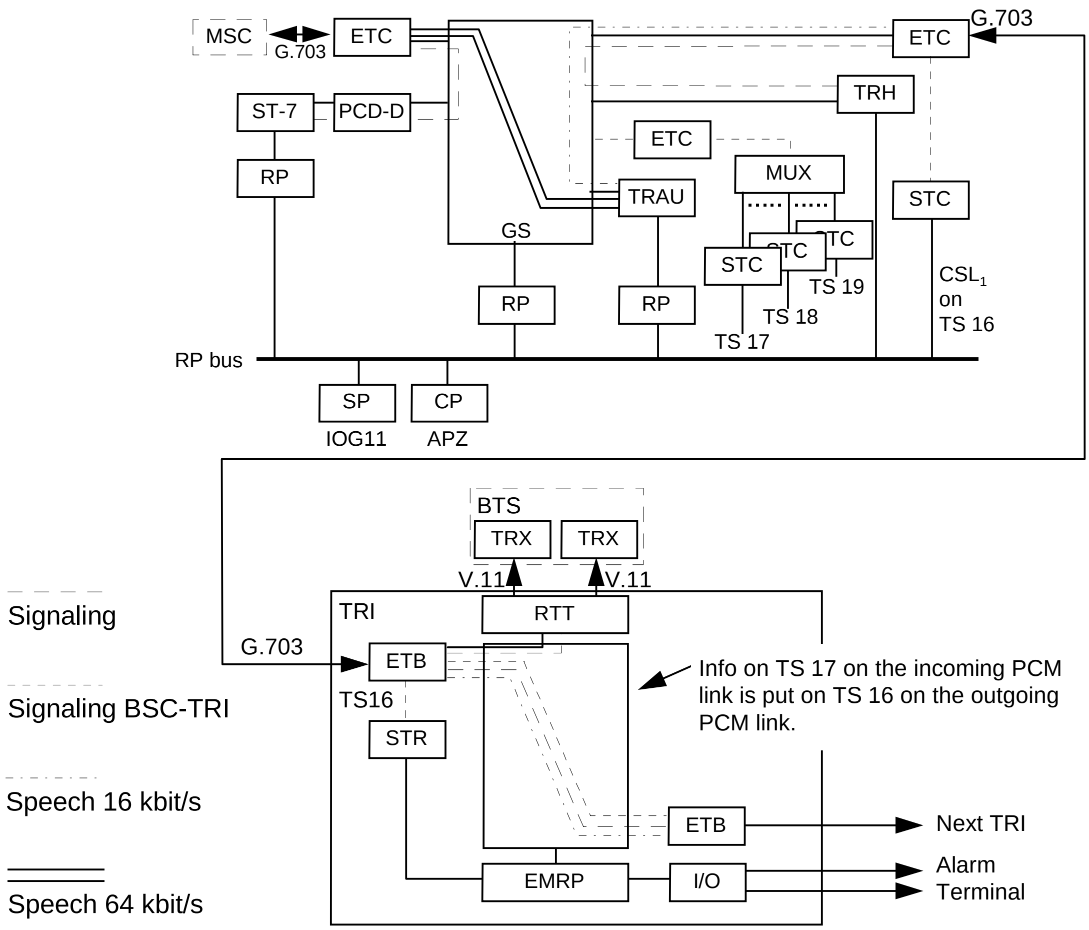



*Figure 7-12 BSC - RBS 200 interworking.*

## BSC Abbreviations

**CP** Central Processor - performs program control and data handling.

**ETC** Exchange Terminal Circuit - terminates the PCM link and is the interface between the GS and the PCM link.

**GS** Group Switch - provides the BSC switching capability. It is used to route calls to the desired base stations and for switching of internal handovers.

**TRAU** Transcoder and Rate Adaptation Unit - performs the transformation between 64 kbps and 16 kbps. Four TCHs can be sub-multiplexed into one 64 kbps link between the BSC and the BTS.

**TRH** Transceiver Handler - terminates the Abis interface.

**RP** Regional Processor - performs capacity demanding work such as protocol handling.

**ST-7** Signaling Terminal - terminates the CCITT No. 7 interface.

**STC** Signaling Terminal Central - used to extend the APZ control functions to a remote STR located in the TRI.

**SP** Support Processor.

## RBS Abbreviations

**BTS** Base Transceiver Station (GSM term) - the equipment that handles traffic in one cell.

**EMRP** Extension Module Regional Processor - controls the time switch.

**ETB** Exchange Terminal Board - interface between the PCM link and the TSW. Performs the same functions as the ETC in BSC.

**I/O** Input/Output terminal for external alarms or local maintenance terminal.

**RTT** Radio Transmission Terminal - distributes the PCM TSs from the TSW to different TRXs.

**SRSM** Sub Rate Switch Module, in BSC.

**STR** Signaling Terminal Regional.

**TRI** Transmission Radio Interface.

**TRX** Transceiver (Transmitter and Receiver) - Radio equipment handling one carrier wave.

**TSW** Time Switch. Used for drop and insertion of time slots on the PCM links.

# ABIS - RBS 2000

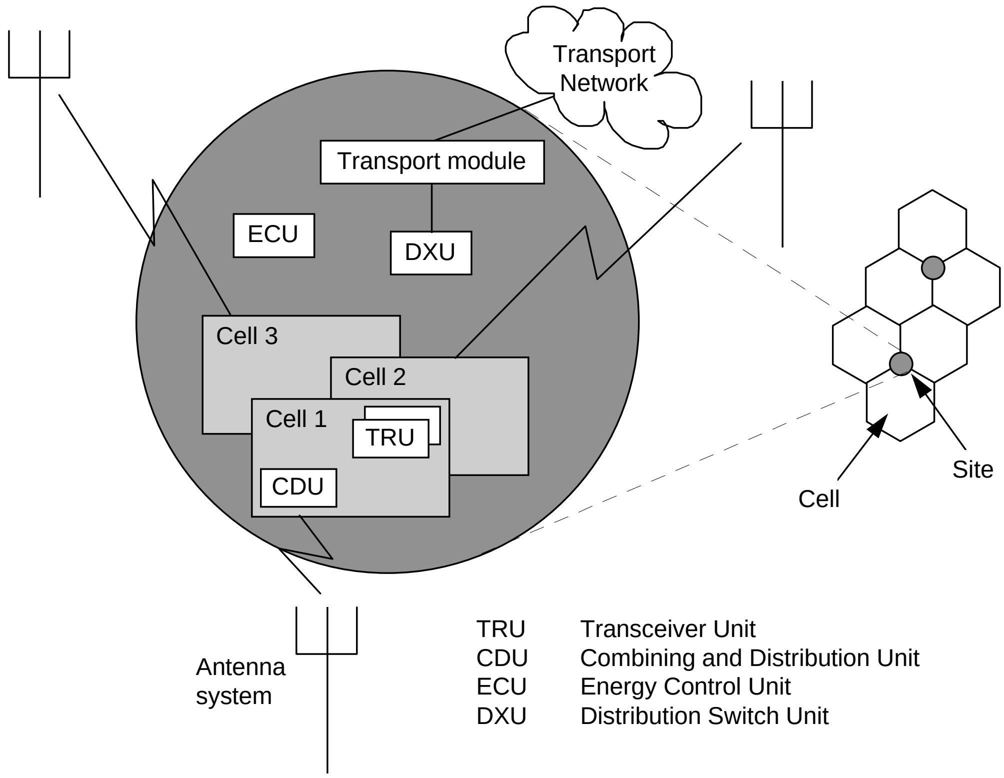



*Figure 7-13 An RBS 2000 site with three cells.*

The Radio Base Station 2000 (RBS 2000) is Ericsson's second generation of radio base stations developed to meet the GSM specification for BTSs. See Figure 7-13.

## *HARDWARE ARCHITECTURE*

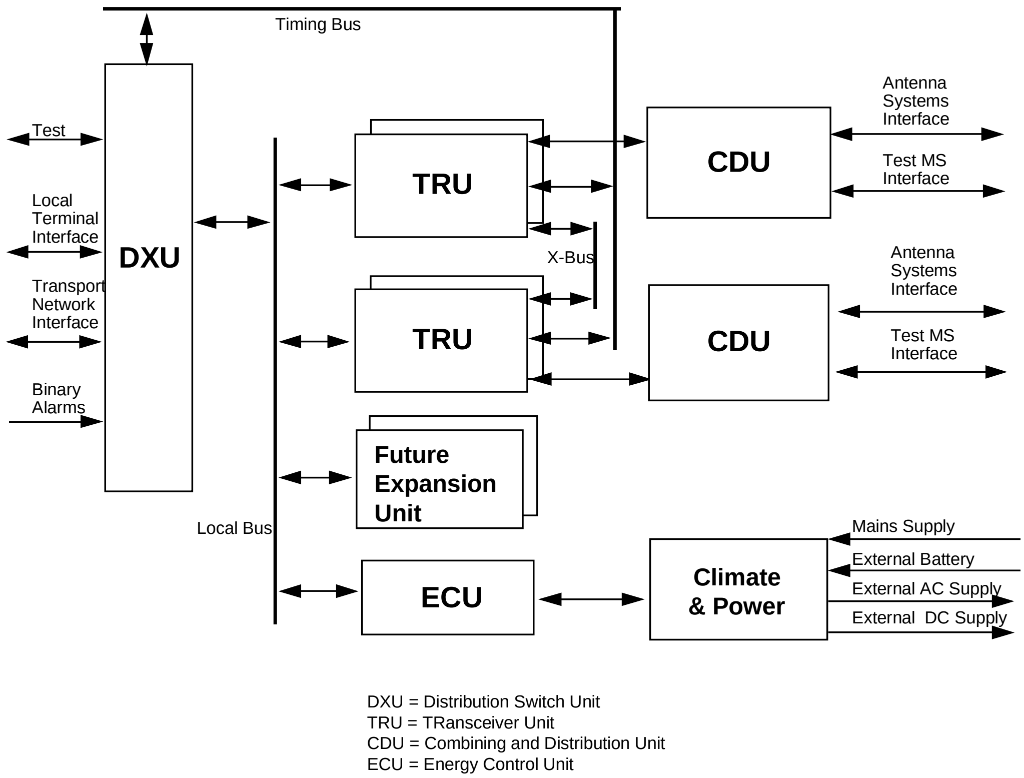



*Figure 7-14 RBS 2000 serving two cells.*

**Distribution Switch Unit (DXU)**

- Manages the Abis link resources
- Passes traffic TSs to the TRUs (Interface Switch (IS))
- Timing Function (TF)

**Local bus system**

- Communication link between DXU and other Replaceable Units (RUs)

**X-bus system**

- Enables baseband hopping

**TRansceiver Unit (TRU)**

- Transmitting, receiving and signal processing for TS handling

**Combining and Distribution Unit (CDU)**

- Combines and divides to/from antennas

**Energy Control Unit (ECU)**

- Controls both power and climate (heating/cooling)

## SIGNALING LAYER 1, CCITT G.703/ANSI T1.403

CCITT G.703 is a 2 Mbps PCM interface used in GSM 900/GSM 1800. See Figure 7-15. The physical channel is divided into 32 time slots, each carrying a bit rate of 64 kbps.

ANSI T1.403 is a 1,5 Mbps PCM interface used in GSM 1900. See Figure 7-15. The physical channel is divided into 24 time slots, each carrying a bit rate of 64 kbps.

In GSM 900/GSM 1800 (see Figure 7-15):

- Time slot 0 is always used for synchronization.

In Ericsson's GSM system:

- Two time slots carry traffic information (speech or data) with the in-band signaling to each TRU.
- One time slot is used for carrying the TRH-TRXC signaling to each TRU. The DXU signaling is transferred with the TRH-TRXC signaling to one of the TRUs (the first TRU is default).

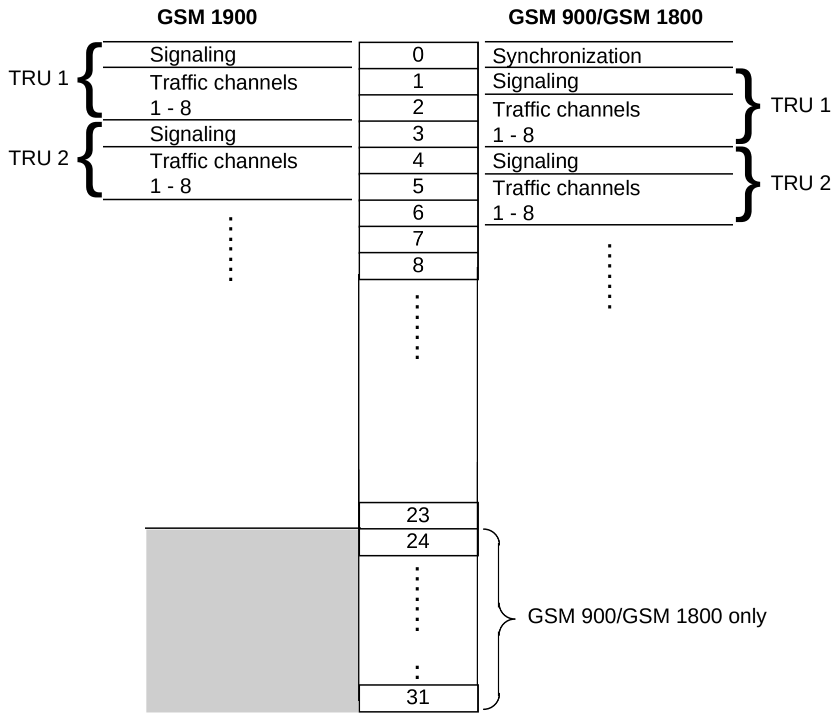



*Figure 7-15 Abis with RBS 2000.*

## LAPD CONCENTRATION FOR RBS 2000

LAPD concentration means that the TRH-TRXC signaling to two or more TRUs share the same 64 kbps PCM time slot on the G. 703 part of the Abis interface. This means the utilization of the BSC to BTS transmission resources improves.

The feature is introduced in the signaling between a BSC and BTSs for RBS 2000. LAPD concentration is most useful at larger sites with low traffic and not so many SMSs, typically with more than 2 TRXCs per cell.

The number of data links that can be established on a 64 kbps physical connection is increased. The maximum concentration factor allowed is four, meaning that four TRXCs can share one physical connection for signaling. A concentrated link is compared to a non-concentrated link in Figure 7-16.

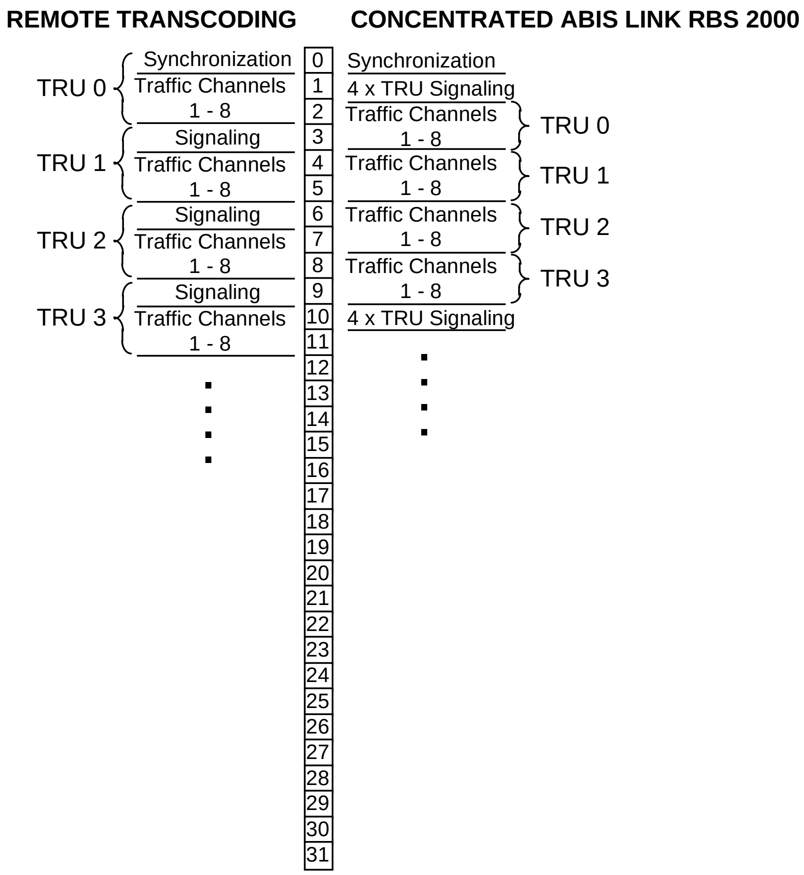



*Figure 7-16 Configuration of PCM link between BSC and RBS 2000.*

## LAPD MULTIPLEXING FOR RBS 2000

To further improve the utilization of BSC to BTS transmission resources, LAPD multiplexing is used in the communication between a BSC and BTSs. LAPD multiplexing allows signaling and speech or data to be multiplexed on the same 64 kbps PCM time slot. The signaling path can use a 16 kbps or 32 kbps subrate physical channel on a 64 kbps PCM time slot. One example using capacity corresponding to air TS 0 and 1 respectively is shown in Figure 7-17. The feature LAPD multiplexing requires a subrate switch to be installed in the BSC as illustrated in Figure 7-18. The example in Figure 7-17 shows how a 32 kbps and a 16 kbps TRH signaling links share one PCM TS with a 16 kbps speech channel.

| PCM TS1 | PCM TS2 | | | | PCM TS3 | | | |
|---|---|---|---|---|---|---|---|---|
| SIGNALING | TS0 | TS1 | TS2 | TS3 | TS4 | TS5 | TS6 | TS7 |

Without LAPD multiplexing

| PCM TS1 | PCM TS2 | | | | PCM TS3 | | | |
|---|---|---|---|---|---|---|---|---|
| 64 KBPS FREE FOR OTHER USE | SIG NAL | SIG NAL | TS2 | TS3 | TS4 | TS5 | TS6 | TS7 |

With LAPD multiplexing

*Figure 7-17 Example of A-bis PCM TS 1, 2 and 3 using LAPD multiplexing.*

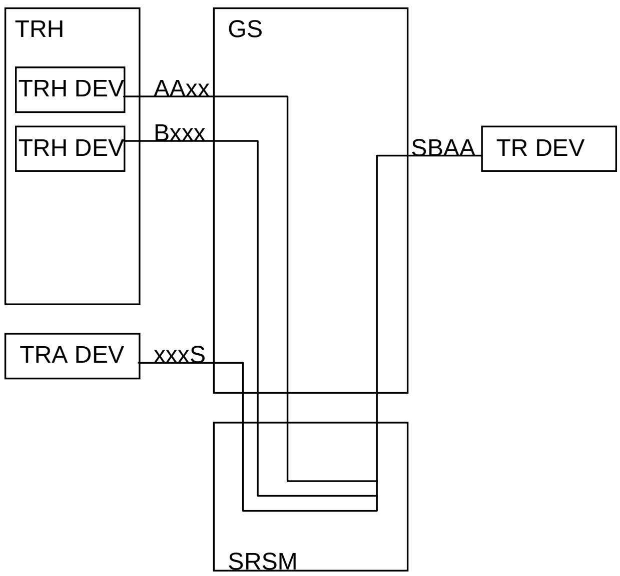



*Figure 7-18 Example of LAPD multiplexing in the BSC.*

## BSC - RBS 2000 INTERWORKING

The signaling through and between the BSC and the RBS 2000 is quite complex because there is signaling both to the DXU and to the transceivers. Figure 7-19 illustrates both the speech paths and the signaling paths. The speech is coded in the TRAU in BSC where the bit rate is reduced from 64 kbps to 16 kbps. The signaling to the DXU is mapped over the LAPD protocol. The signaling for the different TRUs is put into the appropriate time slots by the TRH, which terminates the LAPD protocol in the BSC.

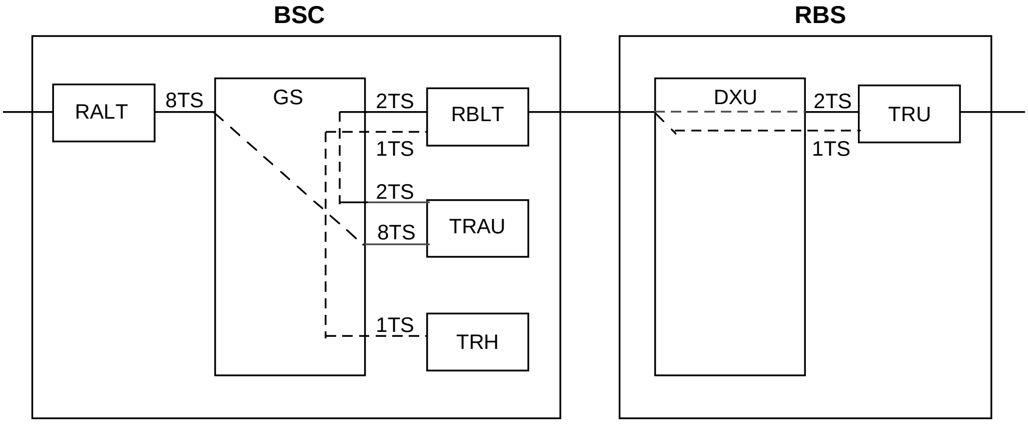



*Figure 7-19 BSC - RBS 2000 interworking.*

## *COMPARISON BETWEEN RBS 2000 AND RBS 200*

| Units in RBS 2000 | Function | Units in RBS 200 |
|---|---|---|
| **DXU** | • Interface to the 2/1.5 Mbit/s link<br>Switches the right TS to the right TRX<br>• Timing reference<br>• Handling the database including all HW info in the RBS | TSW in TRI<br><br>Timing units |
| **TRU** | Contains all functionality for handling 8 TS:<br>• Single Processor<br>• Radio receiving<br>• Radio transmitting<br>• Power amplifier | 13 units:<br>8 SPP, TRXC,<br>RRX;<br>RTX,<br>Power Filters,<br>PSU (TRXC) |
| **ECU** | Controls & Supervises power & climate | PCU |
| **CDU** | • Combining transmitted signals<br>• Distributing received signals | Combiner,<br>RXDA, RXD |

*Figure 7-20 Comparison between RBS 2000 and RBS 200.*

# LAYER 2, LAPD

## GENERAL

All signaling messages on the Abis interface use the Link Access Procedures on the D-channel (LAPD protocol), originating from ISDN terminology. LAPD provides two kinds of signaling:

- unacknowledged information transfer with no guarantee that the information is successfully delivered. For example, the Measurement report.
- acknowledged information transfer, where each signal is acknowledged when the frame has reached the destination successfully.

The acknowledged mode is the most common method and is described in this chapter.

LAPD is a layer 2 protocol that operates at the data link layer of the OSI architecture. The LAPD protocol follows the CEPT recommendations T/S 46-20 with GSM exceptions and modifications.

### Link Handling

LAPD link handling is a basic function to provide data links on the 64 kbps physical connections between BSC and BTS. Links are provided for operation and maintenance (O&M) of the links, for O&M of the BTS equipment and for transmission of layer 3 Abis messages, as shown in Figure 7-21 describing the logical configuration on Abis.

### Link Establishment

The LAPD data links are initially established on physical connections between the BSC and the BTS at installation or at system extensions. A physical connection is used for signaling to one or more BTS Terminal Equipment pieces (TE).

The TEs are tied to a physical connection and identified by the Terminal Endpoint Identifier (TEI) hardware strapped to the back plane (by operator personnel when installing the equipment) and when applicable assigned by operator command. A Layer 2 Management Link (L2ML) is automatically provided on all physical connections. Each is provided with an OML and each radio signaling entity with a Radio Signaling Link (RSL).

## Identification of Data Links

Each physical connection can support a number of data links (logical connections). On each physical connection each data link is identified by a unique TEI/SAPI pair described below.

**TEI** Terminal Endpoint Identifier - the signaling links over the Abis interface are addressed to the different physical entities by the TEI.

**SAPI** Service Access Point Identifier - different functional entities within one physical entity are addressed by the SAPI (SAPI has six bits in LAPD).

Three information categories or link types according to GSM recommendations are supported:

**SAPI=0 RSL** Radio Signaling Link - serves the traffic management procedures of layer 3. On this link, the Abis layer 3 messages are sent.

**SAPI=62 OML** Operation & Maintenance Link - serves the network management procedures of layer 3. Used for BTS O&M messages.

**SAPI=63 L2ML** Layer 2 Management Link - The link serves the L2 management procedures. It is used for management of the data links sharing a physical connection. When the TRXs have fixed values, the TEI assignment and management procedures are not needed.

Each PCM time slot dedicated for TRH-TRXC signaling carries three logical channels:

- RSL for traffic messages
- OML for the BTS equipment
- L2ML for O&M of the links

If the TRXC concerned is the TGC, then an extra logical OML link is carried. See Figure 7-21. It also has TEI 58 (RBS 200) or TEI 62 (RBS 2000) in addition to its ordinary TEI value.

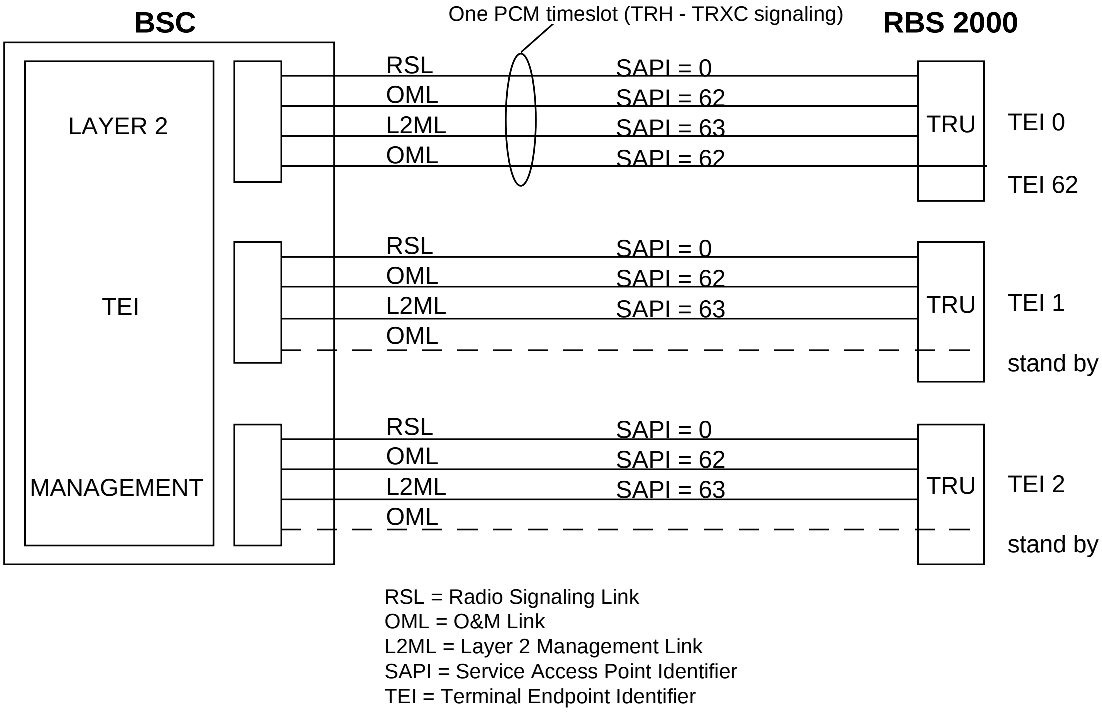



*Figure 7-21 Logical configuration of Abis interface.*

## Data Transmission

On the established data links, flow control and retransmission are performed to ensure that services are provided to layer 3 during data transmission. The flow control handles sequence control, control of the number of missing frames and receiver busy conditions. The number of retransmissions of a frame is limited by a system parameter.

## Link Supervision

To provide a reliable and efficient transmission of the LAPD frames, detection of layer 2 protocol errors and detection of link failures are performed to supervise the links.

## Link Release

The LAPD protocol includes functions to perform data link release as a service to upper layers.

## LAPD FRAME STRUCTURE

A flag, 0111 1110 (hex 7E), delimits a frame. Only one flag is enough between consecutive frames. The receiving end looks for the flag 0111 1110 to find the beginning of a frame. To avoid a flag occurring inside a frame, a technique called bit stuffing is used, see Figure 7-22. A mechanism in the transmitter inserts a "0" after five consecutive "1" in between the flags. The receiver removes the extra "0".

| Information | Send | Receive | Information |
|---|---|---|---|
| 1111110 | 11111010 | remove 0 | 1111110 |
| 11111010 | 111110010 | remove 0 | 11111010 |

*Figure 7-22 Bit stuffing.*

The LAPD frame format of the Information frame is illustrated in Figure 7-23. The address field includes the SAPI, which equals 0 for RSL messages and 62 for OML messages; and the TEI value, which points out the TRX. The control field differs depending on whether it is between acknowledged and unacknowledged mode.

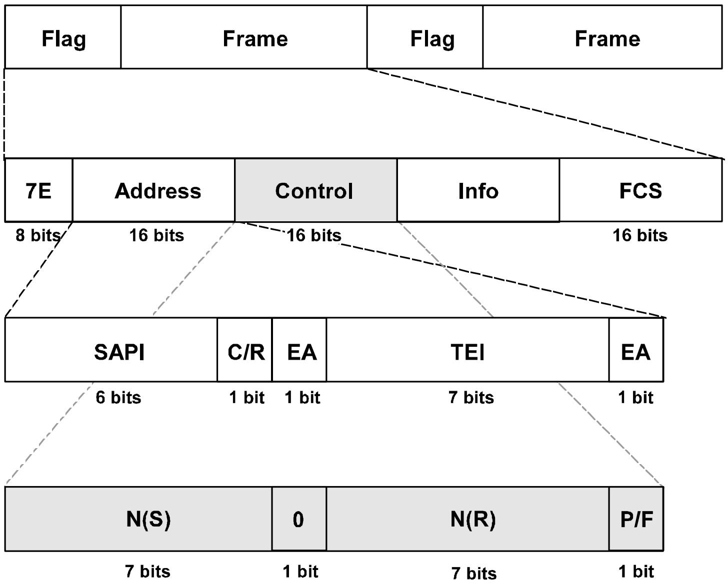
In acknowledged mode, the control field contains N(S) and N(R), which are the send and receive sequence numbers. N(S) indicates the sequence number of the transmitted frame, and N(R) indicates the sequence number of the frame the receiver expects next.

Sequence numbers are used in implementing a flow control protocol called "Sliding window". This protocol allows the sender to transmit a certain number of frames (called the window size) without waiting for acknowledgments for each frame. For example, if the window size is 3, then the sender can transmit frames 0, 1 and 2 without waiting for an acknowledgment. Frame 3, however, cannot be sent until an acknowledgment for frame 0 is received.

The functions of C/R and P/F bits are identical to the ones described for LAPDm.

For unacknowledged transfer, the control field contains only fixed bits.

A maximum of 260 octets can be sent over LAPD, including the header. For a DL message the header is removed by LAPD in the BTS, and the remaining octets compose the layer 3 message to be handled by the BTS. In the case of a transparent message, the BTS removes the header and sends the remaining octets containing layer 3 information to the MS.




C/R = Command/Response
EA = Extended Address
FCS = Frame Check Sum
Info = Layer 3 information, RSL or OML messages, max. 249 octets plus a LAPD header
N(R) = Receive sequence number
N(S) = Send sequence number
P/F = Poll / Final bit
SAPI = Service Access Point Identifier
TEI = Terminal Endpoint Identifier

*Figure 7-23 LAPD frame.*

## APPLICATION PARAMETERS

The LAPD system parameters mentioned below are associated with each individual SAP. The parameter values are specified for LAPD within GSM:

- The time starting from the end of a transmitted frame until retransmission is initiated has the default value 240 ms.
- The default maximum number of retransmissions of a frame is 3.
- The maximum number of octets in an information field is 249.
- The default maximum number of sequentially numbered I frames that may be missing (window size) is 2 for the RSL links. For OML and L2ML links the parameter has the fixed value 1.

- The maximum time allowed without frames being exchanged, on established links, is 10 seconds.

## COMPARISON BETWEEN LAPD AND LAPDm

Figure 7-24, shows the main differences between LAPD and LAPDm.

A long message in a LAPD frame is segmented and put into LAPDm frames. On the Abis interface, two messages can be sent on the RSL before an acknowledgment is required. LAPDm is a ping-pong protocol where each message is acknowledged before the next is sent.

There is no OML over the radio interface.

A frame is discarded if the error detection function on the receiving side indicates a fault. In LAPD, this control is made by a layer 2 function which adds a Frame Check Sum (FCS). In LAPDm, layer 1 adds a FIRE code (a block code) for error detection and performs convolution coding for error protection.

At the Um interface there is error protection both at layer 1 and layer 2. A layer 1 fault at reception can be that SACCH messages cannot be decoded. An error in the data link layer can for example, be too many consecutive T200 time-outs.

The result of a layer 1 error is an abort indication or an error indication.

An error in the data link layer indicates to the RR as a Release Indication.

| | **Abis<br>LAPD** | **Um<br>LAPDm** |
|---|---|---|
| **L3 INFO size in each frame** | max. 249 octets | max. 18-22 octets |
| **Window size** | 1 OML, 2 RSL | 1 |
| **Error detection** | At Layer 2 within LAPD<br>L2 adds FCS | At Layer 1<br>L1 adds FIRE code and convolution coding |

*Figure 7-24 LAPDm versus LAPD.*

# LAYER 3

A model of layer 3 for the Abis interface (BTS side) is shown in Figure 7-25.

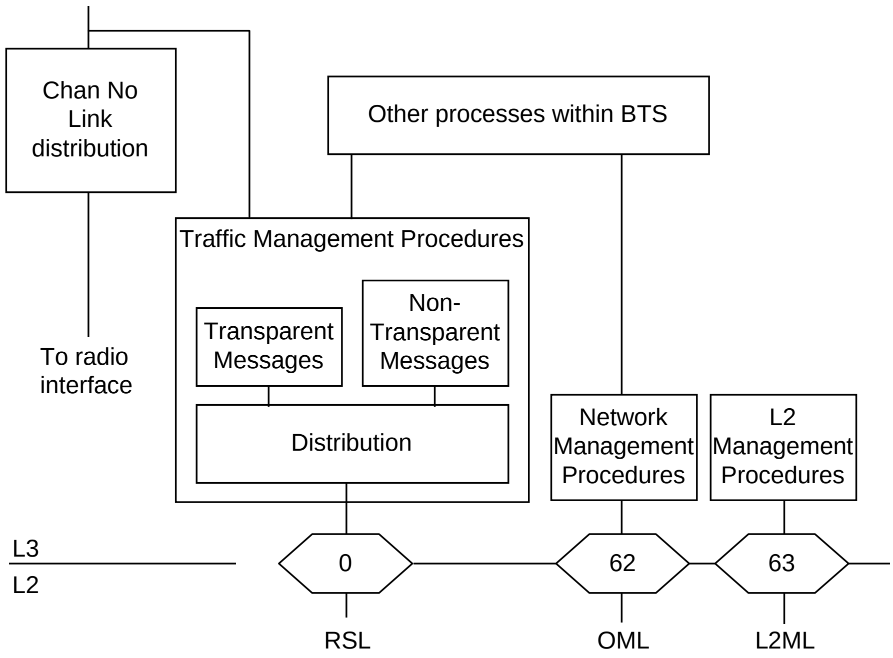



*Figure 7-25 L3 model.*

CM and MM messages sent on RSL are not interpreted by BSC or BTS. They are transferred transparently over the Abis interface.

Most of the RR messages are handled as transparent messages by the BTS. However, as discussed in the chapter “Um interface”, some of them must be interpreted by the BTS. For example paging, start ciphering, random access. The BTS Management (BTSM) entities contain procedures for handling these messages as well as other procedures for managing the BTS. In the BTS there is mapping between BTSM and the relevant RR messages over the radio interface.

As discussed in the LAPD section of this chapter, different layer 2 links are used for traffic management messages (RSL, SAPI= 0) and network management messages (OML, SAPI=62).

## RSL MESSAGES, TRAFFIC MANAGEMENT

For traffic management, there are two types of signaling messages:

- Transparent messages - which are forwarded by BTS without changes or interpretations
- Non-transparent messages - these messages makes the BTS perform specific actions or they are the result of BTS actions.

In addition, the messages sent over the RSL link are divided into four groups (after each message the GSM TS paragraph is found):

- Radio link layer management messages (08.58) 8.3
- Dedicated channel management messages (08.58) 8.4
- Common channel management messages (08.58) 8.5
- TRX management messages (08.58) 8.6

All messages basically have the same structure, as shown in Figure 7-26. They all have a message discriminator field and a message type field. All messages except those belonging to the TRX management group also have the channel number included. The radio link layer management messages have, in addition, the link identifier field.

The **message discriminator** determines which group the message belongs to. The four groups are listed above. In addition, this field contains a transparency flag (T bit) indicating whether or not the message is to be sent transparently through the BTS.

The **message type** points out the explicit message within the group.

The **channel number** indicates the time slot and the time slot configuration. For example, traffic channel + associated control channels. Note that the radio frequency is not included in the channel number. This information is instead given by the TEI value in the layer 2 part of the LAPD frame.

The **link identifier** tells the BTS how the message is to be sent on the radio path. It provides the SAPI (LAPDm SAPI, 3 bits only) value and type of signaling channel. The signaling channel can be either the SACCH or the main signaling channel which refers to SDCCH or FACCH.

| | |
|---|---|
| Radio link layer management | Message Discriminator |
| | Message Type |
| | Channel Number |
| | Link Identifier |
| | Additional Information |

| | |
|---|---|
| Dedicated channel + Common channel management | Message Discriminator |
| | Message Type |
| | Channel Number |
| | Additional Information |

| | |
|---|---|
| TRX management | Message Discriminator |
| | Message Type |
| | Additional Information |

*Figure 7-26 L3 message format on Abis (info field from Figure 7-24).*

Each information element consists of at least 2 octets. The first octet contains the name of the element and the element identifier. The remaining octets carry specific information. Figure 7-27 illustrates the channel number element. (The element identifier for this element has the value 00000001.)

| Element identifier | | | | | |
|---|---|---|---|---|---|
| c5 | c4 | c3 | c2 | c1 | TN |

TN is the time slot number, 3 bits coded in binary.
The coding of c5 - c1 is given below:

| c5 | c4 | c3 | c2 | c1 | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 | Bm + ACCH's (traffic channel) |
| 0 | 0 | 0 | 1 | T | Lm + ACCH's (half rate) |
| 0 | 1 | T | T | T | SDCCH/8 + SACCH/8 |
| 0 | 0 | 1 | T | T | SDCCH/4 + SACCH/4 |
| 1 | 0 | 0 | 0 | 0 | BCCH |
| 1 | 0 | 0 | 0 | 1 | Uplink CCCH (RACH) |
| 1 | 0 | 0 | 1 | 0 | Downlink CCCH (PCH + AGCH) |

T indicates sub-channel number

*Figure 7-27 Channel number information element.*

## Radio Link Layer Management Messages

This group of messages tells the BSC about the status of a signaling channel between the BTS and the MS. For example, whether the logical channel uses acknowledged mode or not.

Transparent messages such as RR, MM and CM are handled in both directions.

The following message types are used:

- **Data Request -** This message is sent from the BSC to the BTS to request the sending of a message (I-frames containing Layer 3 information) in transparently acknowledged mode on a radio link layer connection to the MS.
- **Data Indication -** This message is sent from the BTS to the BSC to indicate the reception of a message from the MS (I frames containing Layer 3 information) in acknowledged mode on a radio link layer connection. Layer 3 information, shown in Figure 7-26 as additional information, is conveyed transparently by the BTS.
- **Error Indication -** This procedure is used by the BTS to indicate an abnormal case such as link layer failure caused for example, by time-out. The additional information contains the relevant cause information.
- **Establish Request -** This procedure is used by the BSC to request establishment of a link layer connection in multiframe mode on the radio path. The BTS establishes the link with the MS by sending an SABM frame to the MS. There is no additional information in this message.
- **Establish Confirm -** This procedure is used by the BTS to confirm establishment of a link layer connection in multiframe mode with the MS. Upon reception of the acknowledgment (UA frame) from the MS, the BTS sends an establish confirm message to the BSC. There is no additional information in this message.
- **Establish Indication -** This procedure is used by the BTS to indicate to the BSC that a Layer 2 link on the radio path has been established in multiframe mode at the request of an MS. The BSC can use this indication to set up an SCCP connection to the MSC. Upon reception of a SABM frame from the MS on an active channel, the BTS sends an establish indication message to the BSC. The message contains the additional information (complete Layer 3 information) corresponding to the information field of the SABM frame if present.
- **Release Request -** This procedure is used by the BSC to request the release of a link layer connection on the radio path which also implies the release of the multiframe mode. The procedure is started by the BSC sending a Release

Request message to the BTS. The BTS then sends a DISC frame to the MS. When it has received the acknowledgment (UA or DM frame) from the MS, BTS sends a Release Confirm message to the BSC. At present there is no additional information in this message.

- **Release Confirm -** This message is sent from the BTS to the BSC to confirm the release of multiframe mode of a radio link connection. There is no additional information in the message.
- **Release Indication -** This procedure is used by the BTS to indicate to the BSC that a link layer connection on the radio path has been released at the request of an MS. When receiving a DISC frame on a link layer connection in multiframe mode from the MS, the BTS sends a Release Indication message to the BSC. (If the link layer is in idle mode, the BTS sends a DM frame to MS but does not notify BSC.)
- **Unit Data Request -** This message is sent from the BSC to the BTS to request the sending of a message (UI-frame containing Layer 3 information ) in unacknowledged mode on a radio link layer connection to the MS. Layer 3 information, shown in Figure 7-26 as additional information, is conveyed transparently by BTS.
- **Unit Data Indication -** This message is sent from the BTS to the BSC to indicate the reception of a message from the MS (UI-frame containing Layer 3 information) in unacknowledged mode on a radio link layer connection. Layer 3 information, shown in Figure 7-26 as additional information, is conveyed transparently by BTS.

## Dedicated Channel Management Messages

The dedicated channel management messages all deal with BSC commands to BTS and BTS messages received at the BSC concerning dedicated channels on the radio path. This is the largest group of messages on Abis interface.

Examples of dedicated channel management messages are channel activation to activate a radio channel, encryption command to request start of ciphering mode operation and handover detection sent from BTS to BSC when the BTS receives the handover access burst. Messages include:

- Channel Activation
- Channel Activation Acknowledge

- Channel Activation Negative Ack
- Connection Failure
- Deactivate Sacch
- Encryption Command
- Handover Detection
- Measurement Result
- Mode Modify Request
- Mode Modify Acknowledge
- Mode Modify Negative Acknowledge
- Rf Channel Release
- Ms Power Control
- Bs Power Control
- Rf Channel Release Acknowledge

## Common Channel Management Messages

This group of messages deals with BSC commands to the BTS and common radio channel messages from the BTS to the BSC.

Examples of common channel management messages are BCCH information to indicate new information to be broadcast on BCCH, and paging command to request paging of a MS. These messages include:

- BCCH Information
- CCH Load Indication
- Channel Required
- Delete Indication
- Paging Command
- Immediate Assign Command
- SMS Broadcast Request
- SMS Broadcast Command

## TRX Management Messages

These messages are related to TRX management procedures.

One example is SACCH filling, which is used by the BSC to indicate to each TRXC the new system information to be used as filling information on downlink SACCH. Another example is overload which is sent from the BTS to the BSC to indicate an overload situation. A third example is RF Resource Indication which is sent from the BTS to the BSC to indicate the interference level on idle channels of a TRX.

- RF Resource Indication
- SACCH Filling
- Overload
- Error Report

## OML MESSAGES, NETWORK MANAGEMENT

OML messages are used for testing, error reporting, and BTS start-up. OML messages use the same type of layer 2 protocol as RSL, that is, the LAPD protocol.

Examples of OML messages are:

- Reset Command, to reset a TRXC
- File Segment Transfer, to transfer files from BSC to BTS
- Define TGC TEI, to define a certain transceiver as TGC