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# OsmoBTS Abis Protocol Specification

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DRAFT

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The Asciidoc source code of this manual can be found at http://git.osmocom.org/osmo-gsm-manuals/

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# 1 Introduction

This document describes the A-bis interface of **OsmoBTS**. Based on 3GPP TS 12.21 and 08.58, this document indicates which of the 3GPP specified A-bis messages and IEs are implemented according to 3GPP specifications, which of these are not or not fully implemented, as well as OsmoBTS-specific extensions to the A-bis interface not specified by 3GPP.

Extensions to the A-bis interface specific to OsmoBTS are detailed in this document. For details on the messages and IEs that comply with above mentioned 3GPP specifications, please refer to those documents.

Table 2: 3GPP document versions referred to by this document

| | |
|---|---|
| 3GPP TS 08.56 | version 8.0.1 Release 1999 |
| 3GPP TS 08.58 | version 8.6.0 Release 1999 |
| 3GPP TS 08.60 | version 8.2.1 Release 1999 |
| 3GPP TS 12.21 | version 8.0.0 Release 1999 |

Table 3: IETF documents referred to by his document

| | |
|---|---|
| IETF RFC 768 | User Datagram Protocol |
| IETF RFC 791 | Internet Protocol |
| IETF RFC 793 | Transmission Control Protocol |
| IETF RFC 1889 | RTP: A Transport Protocol for Real-Time Applications |
| IETF RFC 3551 | RTP Profle for Audio and Video Conferences with Minimal Control |
| IETF RFC 4867 | RTP Payload Format and Files Storage Format for the Adaptive Multi-Rate (AMR) and Adaptive Multi-Rate Wideband (AMR-WB) Audio Codecs |
| IETF RFC 5993 | RTP Payload Format for Global Systems for Mobile Communications Half Rate (GSM-HR) |

# 2 Overview

The OsmoBTS A-bis interface consists of traffic management messages (RSL, Radio Signalling Link) and network management messages (OML, Operation & Maintenance Link), encapsulated in an IPA multiplex.

OML and RSL each use a separate TCP connection.

Table 4: TCP port numbers used by OsmoBTS Abis/IP

| **TCP Port Number** | **Usage** |
|---|---|
| 3002 | A-bis OML (inside IPA multiplex) |
| 3003 | A-bis RSL (inside IPA multiplex) |

Both TCP connections for OML and RSL are established in the BTS → BSC direction, i.e. the BTS is running as a TCP client, while the BSC is running as a TCP server.

The BTS first establishes the TCP connection for OML. Via OML, the BSC instructs the BTS to which IP address the RSL connection shall be established.

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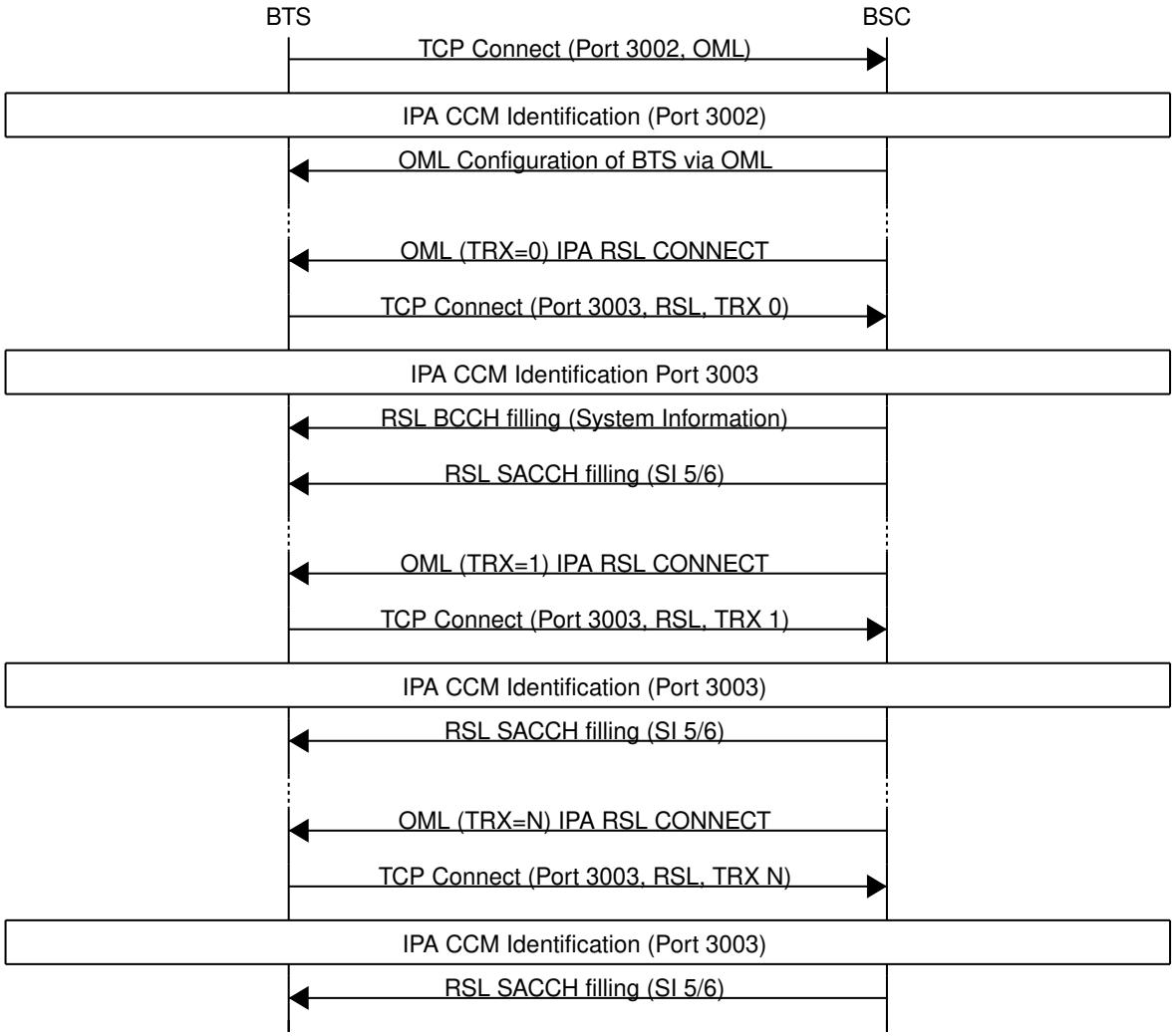



Figure 1: Overview of A-bis connection establishment

### 2.1 Identities

The BTS is locally configured (via administrative means, out of band of this specification) to have a Unit ID. The Unit ID consists of three parts:

- The Site Number
- The BTS number at the site
- The TRX number within the BTS

## 3 IPA Multiplex

The ETSI/3GPP specifications for A-bis transport (ETSI/3GPP TS 08.56) specify the transmission of RSL and OML messages over a LAPD based framing on top of 64kBit/s signalling times slots (B-channels) on E1 lines.

OsmoBTS does not implement this LAPD based transport, but instead implements A-bis over IP in a flavor first observed by ip.access nanoBTS products. The OsmoBTS implementation is a clean-room re-implementation based on the observation and dissection of protocol traces.

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LAPD as used in E1 signalling channels provides in-order transmission and reliable delivery. This is why TCP was chosen as Layer 4 transport protocol on top of IP. TCP however, is a stream based transport protocol, which doesn't preserve the boundaries of messages.

To work around this shortcoming, an additional framing layer called the IPA multiplex was introduced between TCP and the RSL and OML messages.

Table 5: Protocol Stacking

| RSL + OML (this document) |
|---|
| IPA (this document) |
| TCP (IETF RFC 793) |
| IP (IETF RFC 791) |
| Ethernet (IEEE 802.3) |

## 3.1 IPA Header

Each higher-layer PDU is encapsulated by a three-byte IPA header with the following structure:

Table 6: IPA Header Structure

| **Offset (Octets)** | **Length** | **Name** | **Description** |
|---|---|---|---|
| 0 | 2 | Length | Length of the variable-length payload section in network byte order (excluding the length of the IPA Header) |
| 2 | 1 | Stream Identifier | Identifies the stream of the payload |
| 3 | Variable | Payload | higher-layer PDU (i.e. RSL or OML message) |

## 3.2 IPA Stream Identifiers

The IPA Stream Identifier serves to differentiate different streams within the multiplex. In the context of A-bis, it can be seen as analogous to the LAPD TEI on classic A-bis over E1.

The following IPA stream identifiers are being used in A-bis/IP:

Table 7: IPA Stream Identifiers

| **Value (Hex)** | **Name** | **Description** |
|---|---|---|
| 0x00 | RSL | A-bis RSL according to this document, TRX 0 |
| 0x01 | RSL | A-bis RSL according to this document, TRX 1 |
| 0x0n | RSL | A-bis RSL according to this document, TRX n |
| 0xfe | CCM | IPA Connection Management |
| 0xff | OML | A-bis OML according to this document |

## 3.3 IPA Connection Management (CCM)

The IPA Connection Management is a sub-layer underneath the IPA multiplex which is used to manage the connection itself. It supports functions like Identity Management and Keep-Alive.

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#### 3.3.1 Identity Management

When a BTS connects to the BSC, the BSC must identify the connected BTS somehow. In ETSI/3GPP A-bis, the E1 multiplex + signalling timeslot number is used for this. In IP, there is no similar usable identity. Hence, the Unit ID is used for this purpose.

Table 8: Procedure for IPA peer identification is as follows

| Direction | Operation |
|---|---|
| BTS → BSC | BTS connects the TCP connection to be used with IPA |
| BTS ← BSC | BSC requests BTS identity with ID_GET |
| BTS → BSC | BTS responds BTS Unit ID with ID_RESP |
| BTS ← BSC | BSC responds with ID_ACK, if the Unit ID is known to the BSC |

Following the above peer identification procedure, transfer of higher-level messages such as OML or RSL commences.

#### 3.3.2 IPA CCM Messages

IPA CCM supports the following messages

Table 9: IPA CCM Messages

| Value | Name | Purpose |
|---|---|---|
| 0x00 | PING | Request a PONG from the peer |
| 0x01 | PONG | Response to a PING |
| 0x04 | ID_GET | Request Identity from peer |
| 0x05 | ID_RESP | Response to ID_GET |
| 0x06 | ID_ACK | Identity Acknowledged |

# 4 Organization & Maintenance Link (OML)

## 4.1 List of Messages

The following tables list the OML messages used by OsmoBTS, grouped by their level of compliance with 3GPP TS 52.021 (previously 3GPP TS 12.21).

#### 4.1.1 Messages Compliant With TS 52.021

Specific limitations apply, see the linked sections.

Table 10: Messages compliant with TS 52.021

| TS 52.021 § | type code (hex) | This document § | Message | ←/→ | Received/Sent by OsmoBTS |
|---|---|---|---|---|---|
| **SW Download Management Messages:** | | | | | |
| 8.3.7 | 0x10 | Section 4.2.1 | SW Activated Report | → | Sent |
| **Air Interface Management Messages:** | | | | | |

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Table 10: (continued)

| TS 52.021 § | type code (hex) | This document § | Message | ←/→ | Received/Sent by OsmoBTS |
|---|---|---|---|---|---|
| 8.6.1 | 0x41 | Section 4.2.2 | Set BTS Attributes | ← | Received |
| | 0x42 | | Set BTS Attributes Ack | → | Sent |
| | 0x43 | | Set BTS Attributes Nack | → | Sent |
| 8.6.2 | 0x44 | Section 4.2.3 | Set Radio Carrier Attributes | ← | Received |
| | 0x45 | | Set Radio Carrier Attributes Ack | → | Sent |
| | 0x46 | | Set Radio Carrier Attributes Nack | → | Sent |
| 8.6.3 | 0x47 | Section 4.2.4 | Set Channel Attributes | ← | Received |
| | 0x48 | | Set Channel Attributes Ack | → | Sent |
| | 0x49 | | Set Channel Attributes Nack | → | Sent |
| **State Management and Event Report Messages:** | | | | | |
| 8.8.1 | 0x61 | Section 4.2.5 | State Changed Event Report | → | Sent |
| 8.8.5 | 0x69 | Section 4.2.6 | Change Administrative State | ← | Received |
| | 0x6A | | Change Administrative State Ack | → | Sent |
| | 0x6B | | Change Administrative State Nack | → | Sent |
| **Equipment Management Messages:** | | | | | |
| 8.9.2 | 0x74 | Section 4.2.7 | Opstart | ← | Received |
| | 0x75 | | Opstart Ack | → | Sent |
| | 0x76 | | Opstart Nack | → | Sent |
| **Other Messages:** | | | | | |
| 8.11.1 | 0x81 | Section 4.2.8 | Get Attributes | ← | Received |
| | 8.11.3 | 0x82 | Section 4.2.9 | Get Attribute Response | → |
| | Sent | 8.11.1 | 0x83 | | Get Attributes Nack |

### 4.1.2 Messages Specific to OsmoBTS

Table 11: Messages specific to OsmoBTS, not found in 3GPP TS 52.021

| This document § | Message | ←/→ | Received/Sent by OsmoBTS |
|---|---|---|---|
| Section 4.3.1 | Set Attribute | ← | Received |

### 4.1.3 Messages Not Implemented by OsmoBTS

Table 12: 3GPP TS 52.021 messages not implemented by OsmoBTS

| TS 52.021 § | type code (hex) | Message |
|---|---|---|
| **SW Download Management Messages:** | | |
| 8.3.1 | 0x01 | Load Data Initiate |
| | 0x02 | Load Data Initiate Ack |
| | 0x03 | Load Data Initiate Nack |

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Table 12: (continued)

| TS 52.021 § | type code (hex) | Message |
|---|---|---|
| 8.3.2 | 0x04 | Load Data Segment |
| | 0x05 | Load Data Segment Ack |
| 8.3.3 | 0x06 | Load Data Abort |
| 8.3.4 | 0x07 | Load Data End |
| | 0x08 | Load Data End Ack |
| | 0x09 | Load Data End Nack |
| 8.3.5 | 0x0A | SW Activate Request |
| | 0x0B | SW Activate Request Ack |
| | 0x0C | SW Activate Request Nack |
| 8.3.6 | 0x0D | Activate SW |
| | 0x0E | Activate SW Ack |
| | 0x0F | Activate SW Nack |
| **A-bis Interface Management Messages:** | | |
| 8.4.1 | 0x21 | Establish TEI |
| | 0x22 | Establish TEI Ack |
| | 0x23 | Establish TEI Nack |
| 8.4.2 | 0x24 | Connect Terrestrial Signalling |
| | 0x25 | Connect Terrestrial Signalling Ack |
| | 0x26 | Connect Terrestrial Signalling Nack |
| 8.4.3 | 0x27 | Disconnect Terrestrial Signalling |
| | 0x28 | Disconnect Terrestrial Signalling Ack |
| | 0x29 | Disconnect Terrestrial Signalling Nack |
| 8.4.4 | 0x2A | Connect Terrestrial Traffic |
| | 0x2B | Connect Terrestrial Traffic Ack |
| | 0x2C | Connect Terrestrial Traffic Nack |
| 8.4.5 | 0x2D | Disconnect Terrestrial Traffic |
| | 0x2E | Disconnect Terrestrial Traffic Ack |
| | 0x2F | Disconnect Terrestrial Traffic Nack |
| **Transmission Management Messages:** | | |
| 8.5.1 | 0x31 | Connect Multi-Drop Link |
| | 0x32 | Connect Multi-Drop Link Ack |
| | 0x33 | Connect Multi-Drop Link Nack |
| 8.5.2 | 0x34 | Disconnect Multi-Drop Link |
| | 0x35 | Disconnect Multi-Drop Link Ack |
| | 0x36 | Disconnect Multi-Drop Link Nack |
| **Test Management Messages:** | | |
| 8.7.1 | 0x51 | Perform Test |
| | 0x52 | Perform Test Ack |
| | 0x53 | Perform Test Nack |
| 8.7.2 | 0x54 | Test Report |
| | 0x55 | Send Test Report |
| | 0x56 | Send Test Report Ack |
| 8.7.3 | 0x57 | Send Test Report Nack |
| 8.7.4 | 0x58 | Stop Test |
| | 0x59 | Stop Test Ack |
| | 0x5A | Stop Test Nack |
| **State Management and Event Report Messages:** | | |
| 8.8.2 | 0x62 | Failure Event Report |
| 8.8.3 | 0x63 | Stop Sending Event Reports |
| | 0x64 | Stop Sending Event Reports Ack |
| | 0x65 | Stop Sending Event Reports Nack |
| 8.8.4 | 0x66 | Restart Sending Event Reports |
| | 0x67 | Restart Sending Event Reports Ack |

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Table 12: (continued)

| TS 52.021 § | type code (hex) | Message |
|---|---|---|
| | 0x68 | Restart Sending Event Reports Nack |
| 8.8.6 | 0x6C | Change Administrative State Request |
| | 0x6D | Change Administrative State Request Ack |
| | 0x6E | Change Administrative State Request Nack |
| 8.8.7 | 0x93 | Report Outstanding Alarms |
| | 0x94 | Report Outstanding Alarms Ack |
| | 0x95 | Report Outstanding Alarms Nack |
| **Equipment Management Messages:** | | |
| 8.9.1 | 0x71 | Changeover |
| | 0x72 | Changeover Ack |
| | 0x73 | Changeover Nack |
| 8.9.3 | 0x87 | Reinitialize |
| | 0x88 | Reinitialize Ack |
| | 0x89 | Reinitialize Nack |
| 8.9.4 | 0x77 | Set Site Outputs |
| | 0x78 | Set Site Outputs Ack |
| | 0x79 | Set Site Outputs Nack |
| 8.9.5 | 0x90 | Change HW Configuration |
| | 0x91 | Change HW Configuration Ack |
| | 0x92 | Change HW Configuration Nack |
| **Measurement Management Messages:** | | |
| 8.10.1 | 0x8A | Measurement Result Request |
| 8.10.2 | 0x8B | Measurement Result Response |
| 8.10.3 | 0x8C | Stop Measurement |
| 8.10.4 | 0x8D | Start Measurement |
| **Other Messages:** | | |
| 8.11.2 | 0x84 | Set Alarm Threshold |
| | 0x85 | Set Alarm Threshold Ack |
| | 0x86 | Set Alarm Threshold Nack |

## 4.2 Details on Compliant OML Messages

### 4.2.1 SW Activated Report

OsmoBTS will send an *SW Activated Report* when RF has been activated successfully. The message is compliant with 3GPP TS 52.021 § 8.3.7.

Upon RF activation, two *SW Activated Report* messages will be sent, for the Object Classes

- Radio Carrier (0x02)
- Baseband Transceiver (0x04)

### 4.2.2 Set BTS Attributes

OsmoBTS will receive a *Set BTS Attributes* message and reply with a corresponding ACK message on success. IE handling is fully compliant to TS 52.021, except that a change of BCCH ARFCN or BSIC while in operation is not supported, and hence the *Starting Time* IE is rejected.

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Table 13: *Set BTS Attributes* IEs not handled by OsmoBTS

| TS 52.021 § | IE Name | Handling |
|---|---|---|
| 9.4.52 | Starting Time | not supported (provokes NACK cause 0x10) |

#### 4.2.3 Set Radio Carrier Attributes

This message conforms to 3GPP TS 52.021, with the following limitation, as frequency hopping is not supported by OsmoBTS:

Table 14: *Set Radio Carrier Attributes* IE limitations

| TS 52.021 § | IE Name | Handling |
|---|---|---|
| 9.4.5 | ARFCN List | ignored |

#### 4.2.4 Set Channel Attributes

This message conforms to 3GPP TS 52.021, with the following limitation: the following 3GPP TS 52.021 IEs provoke a NACK response when sent to OsmoBTS, as frequency hopping is not supported:

Table 15: *Set Channel Attributes* IE limitations

| TS 52.021 § | IE Name | Handling |
|---|---|---|
| 9.4.21 | HSN | not supported (provokes NACK cause 0x10) |
| 9.4.27 | MAIO | not supported (provokes NACK cause 0x10) |
| 9.4.52 | Starting Time | not supported (provokes NACK cause 0x10) |

#### 4.2.5 State Changed Event Report

This message is compliant with 3GPP TS 52.021. Exactly these IEs are sent by OsmoBTS:

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message Type (0xf5) | 3GPP TS 52.021 9.1 | M | V | 1 |
| Object Class | 3GPP TS 52.021 9.2 | M | V | 1 |
| Object Instance | 3GPP TS 52.021 9.3 | M | V | 3 |
| Operational State | 3GPP TS 52.021 9.4.38 | O | TV | 2 |
| Availability Status | 3GPP TS 52.021 9.4.7 | O | TL16V (with length of 1) | 3 |

#### 4.2.6 Change Administrative State

This message is compliant with 3GPP TS 52.021 § 8.8.5. It applies to all of the Object Classes defined in 3GPP TS 52.021 § 9.2 as well as Section 4.4.

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#### 4.2.7 Opstart

This message is compliant with 3GPP TS 52.021 § 8.9.2. It applies to all of the Object Classes defined in 3GPP TS 52.021 § 9.2 as well as Section 4.4.

#### 4.2.8 Get Attributes

This message is compliant with 3GPP TS 52.021 § 8.11.1.

For a list of supported attributes, see Section 4.2.9.

#### 4.2.9 Get Attribute Response

This message is compliant with 3GPP TS 52.021 § 8.11.3.

The following attributes are provided by OsmoBTS:

| 3GPP TS 52.021 chapter | description | see |
|---|---|---|
| 9.4.61 | SW Configuration | Section 4.6.21 |
| 9.4.30 | Manufacturer Id | Section 4.6.22 |

### 4.3 Details on OsmoBTS Specific Messages

#### 4.3.1 Set Attribute

The message type is 0xf5. This message is sent to OsmoBTS to set attributes on instances of managed objects of the non-standard additional Object Classes (see Section 4.4).

The message specifics depend on the Object Class and are detailed in Section 4.4.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message Type (0xf5) | 3GPP TS 52.021 9.1 | M | V | 1 |
| Object Class | 3GPP TS 52.021 9.2 | M | V | 1 |
| Object Instance | 3GPP TS 52.021 9.3 | M | V | 3 |
| *Object Class specific IEs follow, see Section 4.4...* | | | | |

### 4.4 Additional Object Classes

In addition to 3GPP TS 52.021 Chapter 9.2, the following managed objects are supported:

Table 19: Additional Managed Object Classes

| Value | Name | Description |
|---|---|---|
| 0xf0 | GPRS NSE | GPRS-NS Entity |
| 0xf1 | GPRS CELL | GPRS Cell Entity |
| 0xf2 | GPRS NSVC | GPRS NS Virtual Circuit |

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#### 4.4.1 GPRS-NSE Managed Object

There is one NS Entity per BTS. It supports the **Set Attribute** message with the following Information Elements:

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message Type | 3GPP TS 52.021 9.1 | M | V | 1 |
| Object Class | 3GPP TS 52.021 9.2 | M | V | 1 |
| Object Instance | 3GPP TS 52.021 9.3 | M | V | 3 |
| GPRS NSEI | Section 4.6.11 | O | TL16V | >= 5 |
| GPRS NS Configuration | Section 4.6.16 | O | TL16V | >= 10 |
| GPRS BSSGP Configuration | Section 4.6.15 | O | TL16V | >= 14 |

#### 4.4.2 GPRS Cell Managed Object

There is one GPRS Cell entity per BTS. It supports the **Set Attribute** message with the following Information Elements:

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message Type | 3GPP TS 52.021 9.1 | M | V | 1 |
| Object Class | 3GPP TS 52.021 9.2 | M | V | 1 |
| Object Instance | 3GPP TS 52.021 9.3 | M | V | 3 |
| GPRS Routing Area Code | Section 4.6.9 | O | TL16V | >= 4 |
| GPRS Paging Configuration | Section 4.6.10 | O | TL16V | >= 5 |
| GPRS RLC Configuration | Section 4.6.17 | O | TL16V | >= 12 |
| GPRS Coding Schemes | Section 4.6.18 | O | TL16V | >= 5 |
| GPRS RLC Configuration 2 | Section 4.6.19 | O | TL16V | >= 8 |
| GPRS RLC Configuration 3 | Section 4.6.20 | O | TL16V | >= 4 |

#### 4.4.3 GPRS NS-VC Managed Object

There are two GPRS NS-VC instances per BTS. It supports the **Set Attribute** message with the following Information Elements:

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message Type | 3GPP TS 52.021 9.1 | M | V | 1 |
| Object Class | 3GPP TS 52.021 9.2 | M | V | 1 |
| Object Instance | 3GPP TS 52.021 9.3 | M | V | 3 |
| GPRS NSVCI | Section 4.6.13 | O | TL16V | >= 5 |
| GPRS NS Link Configuration | Section 4.6.16 | O | TL16V | >= 11 |

### 4.5 Information Elements Overview

All of the IEs handled by OsmoBTS are listed below, with limitations and additions to TS 52.021 specified in more detail.

#### 4.5.1 IEs Conforming to TS 52.021

The following Information Elements are accepted by OsmoBTS.

IEs marked *ignored* may be sent to OsmoBTS without causing error conditions. These IEs are skipped during message parsing and are never evaluated.

IEs marked *ignored* and additionally marked as being received by OsmoBTS (←) are in fact parsed and their values are stored by OsmoBTS, but these stored items are currently not used in the OsmoBTS code base.

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Table 23: IEs conforming to TS 52.021

| tag (hex) | TS 52.021 § | IE name | ←/→ | Received/Sent by OsmoBTS |
|---|---|---|---|---|
| 0x00 | 9.4.1 | Abis Channel | | *ignored* |
| 0x01 | 9.4.2 | Additional Info | | *ignored* |
| 0x02 | 9.4.3 | Additional Text | | *ignored* |
| 0x03 | 9.4.4 | Administrative State | ← → | Received & Sent |
| 0x04 | 9.4.5 | ARFCN List | ← | Received, with exactly 1 ARFCN: see Section 4.6.2; ignored by *Set Radio Attribute* message (Section 4.2.3) |
| 0x05 | 9.4.6 | Autonomously Report | | *ignored* |
| 0x06 | 9.4.7 | Availability Status | → | Sent |
| 0x07 | 9.4.8 | BCCH ARFCN | ← | Received |
| 0x08 | 9.4.9 | BSIC | ← | Received |
| 0x09 | 9.4.10 | BTS Air Timer | ← | Received |
| 0x0a | 9.4.11 | CCCH Load Indication Period | ← | Received |
| 0x0b | 9.4.12 | CCCH Load Threshold | ← | Received |
| 0x0c | 9.4.13 | Channel Combination | ← | Received, with additional channel combinations: see Section 4.6.3 |
| 0x0d | 9.4.14 | Connection Failure Criterion | ← | Received, with limitations see Section 4.6.4 |
| 0x0e | 9.4.15 | Destination | | *ignored* |
| 0x0f | 9.4.16 | Event Type | | *ignored* |
| 0x11 | 9.4.17 | File Data | | *ignored* |
| 0x12 | 9.4.18 | File Id | | *ignored* |
| 0x13 | 9.4.19 | File Version | | *ignored* |
| 0x14 | 9.4.20 | GSM Time | | *ignored* |
| 0x16 | 9.4.22 | HW Configuration | | *ignored* |
| 0x18 | 9.4.24 | Intave Parameter | ← | |
| 0x19 | 9.4.25 | Interference level Boundaries | ← | |
| 0x1a | 9.4.26 | List of Required Attributes | | *ignored* |
| 0x1c | 9.4.28 | Manufacturer Dependent State | | *ignored* |
| 0x1d | 9.4.29 | Manufacturer Dependent Thresholds | | *ignored* |
| 0x1e | 9.4.30 | Manufacturer Id | | *ignored* |
| 0x1f | 9.4.31 | Max Timing Advance | ← | Received |
| 0x20 | 9.4.34 | Multi-drop BSC Link | | *ignored* |
| 0x21 | 9.4.35 | Multi-drop next BTS Link | | *ignored* |
| 0x22 | 9.4.36 | Nack Causes | → | Sent |
| 0x23 | 9.4.37 | Ny1 | ← | Received |
| 0x24 | 9.4.38 | Operational State | → | Sent |
| 0x25 | 9.4.39 | Overload Period | ← | *ignored* |
| 0x26 | 9.4.40 | Physical Config | | *ignored* |
| 0x27 | 9.4.41 | Power Class | | *ignored* |
| 0x28 | 9.4.42 | Power Output Thresholds | | *ignored* |
| 0x29 | 9.4.43 | Probable Cause | | *ignored* |
| 0x2a | 9.4.44 | RACH Busy Threshold | ← | Received |
| 0x2b | 9.4.45 | RACH Load Averaging Slots | ← | *ignored* |
| 0x2c | 9.4.46 | Radio Sub Channel | | *ignored* |
| 0x2d | 9.4.47 | RF Max Power Reduction | ← | Received |
| 0x2e | 9.4.48 | Site Inputs | | *ignored* |
| 0x2f | 9.4.49 | Site Outputs | | *ignored* |
| 0x30 | 9.4.50 | Source | | *ignored* |
| 0x31 | 9.4.51 | Specific Problems | | *ignored* |
| 0x33 | 9.4.53 | T200 | ← | *ignored* (1s on DCCH, 2s on ACCH) |
| 0x34 | 9.4.54 | TEI | | *ignored* |
| 0x35 | 9.4.55 | Test Duration | | *ignored* |

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Table 23: (continued)

| tag (hex) | TS 52.021 § | IE name | ←/→ | Received/Sent by OsmoBTS |
|---|---|---|---|---|
| 0x36 | 9.4.56 | Test No | | *ignored* |
| 0x37 | 9.4.57 | Test Report Info | | *ignored* |
| 0x38 | 9.4.58 | VSWR Thresholds | | *ignored* |
| 0x39 | 9.4.59 | Window Size | | *ignored* |
| 0x40 | 9.4.60 | TSC | ← | Received, with limitations: see Section 4.6.5 |
| 0x41 | 9.4.61 | SW Configuration | → | Sent, see Section 4.6.21 |
| 0x43 | 9.4.63 | Perceived Severity | | *ignored* |
| 0x44 | 9.4.64 | Get Attribute Response Info | → | Sent, see Section 4.6.22 |
| 0x45 | 9.4.65 | Outstanding Alarm Sequence | | *ignored* |
| 0x46 | 9.4.66 | HW Conf Change Info | | *ignored* |
| 0x47 | 9.4.32 | Measurement Result | | *ignored* |

### 4.5.2 IEs Not Conforming to TS 52.021

Table 24: IEs not conforming to TS 52.021

| tag (hex) | TS 52.021 § | IE name | Description |
|---|---|---|---|
| 0x15 | 9.4.21 | HSN | presence causes NACK response |
| 0x17 | 9.4.23 | HW Description | *ignored* by OsmoBTS, but coding may differ, see Section 4.6.1 |
| 0x1b | 9.4.27 | MAIO | presence causes NACK response |
| 0x32 | 9.4.52 | Starting Time | presence causes NACK response |
| 0x42 | 9.4.62 | SW Description | not supported |
| 0x48 | 9.4.33 | Measurement Type | not supported |

### 4.5.3 Additional Attributes and Parameters

The following Information Elements are defined in addition to those specified in 3GPP TS 52.021 Chapter 9.4.

All of these additional IEs are *received* by OsmoBTS.

These attributes are not used by OsmoBTS, but simply passed to OsmoPCU connected to the PCU socket.

Table 25: Additional IEs handled by OsmoBTS but not defined in TS 52.021

| tag (hex) | IE name | Description |
|---|---|---|
| 0x80 | RSL Destination IP Address | Section 4.6.6 |
| 0x81 | RSL Destination TCP Port | Section 4.6.7 |
| 0x85 | RSL IPA Stream ID | Section 4.6.8 |
| 0x9a | GPRS Routing Area Code | Section 4.6.9 |
| 0x9c | GPRS Paging Configuration | Section 4.6.10 |
| 0x9d | GPRS NSEI | Section 4.6.11 |

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Table 25: (continued)

| tag (hex) | IE name | Description |
|---|---|---|
| 0x9e | GPRS BVCI | Section 4.6.12 |
| 0x9f | GPRS NSVCI | Section 4.6.13 |
| 0xa0 | GPRS NS Configuration | Section 4.6.14 |
| 0xa1 | GPRS BSSGP Configuration | Section 4.6.15 |
| 0xa2 | GPRS NS Link Configuration | Section 4.6.16 |
| 0xa3 | GPRS RLC Configuration | Section 4.6.17 |
| 0xa8 | GPRS Coding Schemes | Section 4.6.18 |
| 0xa9 | GPRS RLC Configuration 2 | Section 4.6.19 |
| 0xac | GPRS RLC Configuration 3 | Section 4.6.20 |

## 4.6 Details on IEs

### 4.6.1 HW Description

TS 52.021 suggests a series of 5 length-value pairs for the *HW Description* IE. Instead, OsmoBTS interprets it as a single TL16V. The value of this IE is ignored by OsmoBTS, yet the coding may affect message parsing.

| | |
|---|---|
| Attribute Identifier (0x17) | 1 |
| Length | 2-3 |
| Ignored | N |

### 4.6.2 ARFCN List

Since OsmoBTS does not support frequency hopping, the *ARFCN List* must contain exactly one ARFCN.

### 4.6.3 Additional Channel Combinations

In addition to 3GPP TS 52.021 Chapter 9.4.13, the following channel combinations are supported:

Table 27: Additional Channel Combinations

| Value | Description |
|---|---|
| 0x0b | Reserved for PBCCH + PCCCH + PDTCH/F + PACCH/F + PTCCH/F |
| 0x0c | Reserved for PBCCH + PDTCH/F + PACCH/F + PTCCH/F |
| 0x0d | PDTCH/F + PACCH/F + PTCCH/F |
| 0x80 | ip.access style Dynamic TCH/F / PDCH |
| 0x81 | Reserved for Dynamic TCH/F / TCH/H |
| 0x90 | Osmocom style Dynamic TCH/F / TCH/H / PDCH |

The *Reserved* combinations are not actually supported/implemented yet, but merely reserved for such functionality, if it is eventually implemented.

For more information on how the different dynamic channel combinations work, please see the Section 5.4.

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#### 4.6.4 Connection Failure Criterion

3GPP TS 52.021 Chapter 9.4.14 specifies two different options for the *Connection Failure Criterion*. OsmoBTS only implements the option coded as 0x01, i.e. based upon uplink SACCH error rate (RADIO_LINK_TIMEOUT).

#### 4.6.5 TSC

Due to limitations in the currently supported PHY implementations, OsmoBTS supports only one global TSC for all channels on one TRX, rather than a separate TSC for each timeslot, as expected by 3GPP TS 52.021.

#### 4.6.6 RSL Destination IP Address

The value part of this attribute has a length of 4 octets and is encoded as IPv4 address in network byte order.

| | |
|---|---|
| Attribute Identifier (0x80) | 1 |
| IPv4 Address (MSB first) | 2-5 |

#### 4.6.7 RSL Destination TCP Port

The value part of this attribute has a length of 2 octets and contains the TCP destination port for the RSL connection, encoded in network byte order.

| | |
|---|---|
| Attribute Identifier (0x81) | 1 |
| Port number (MSB first) | 2-3 |

#### 4.6.8 RSL IPA Stream ID

The value part of this attribute has a length of one octet and specifies the IPA stream ID to be used for the RSL connection of this TRX.

| | |
|---|---|
| Attribute Identifier (0x85) | 1 |
| Stream ID | 2 |

#### 4.6.9 GPRS Routing Area Code

The value part of the GPRS Routing Area code consists of a single octet encoding the GPRS Routing Area Code.

This attribute is not used by OsmoBTS, but simply passed to OsmoPCU connected to the PCU socket.

#### 4.6.10 GPRS Paging Configuration

The value part of this attribute consists of two octets encoded as follows:

| Offset | Description |
|---|---|
| 0 | GPRS Paging repeat time in units of 50ms intervals |
| 1 | GPRS Paging repeat count |

#### 4.6.11 GPRS NSEI

The value part of the GPRS NSEI is encoded as 16bit integer value in network byte order.

This attribute is not used by OsmoBTS, but simply passed to OsmoPCU connected to the PCU socket.

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#### 4.6.12 GPRS BVCI

The value part of this attribute consists of two octets encoding the BSSGP Virtual Circuit Identifier (BVCI) as unsigned 16 bit integer in network byte order.

#### 4.6.13 GPRS NSVCI

The value part of the GPRS NSVCI attribute is a 16bit unsigned integer in network byte order, encoding the GPRS NSVCI as specified in 3GPP TS 08.16.

This attribute is not used by OsmoBTS, but simply passed to OsmoPCU connected to the PCU socket.

#### 4.6.14 GPRS NS Configuration

The value part of the GPRS NS Configuration consists of an array of 7 octets, each describing one GPRS NS related timer:

This attribute is not used by OsmoBTS, but simply passed to OsmoPCU connected to the PCU socket.

#### 4.6.15 GPRS BSSGP Configuration

The value part of the GPRS BSSGP configuration consists of an array of 11 octets, each describing one GPRS BSSGP related timer:

| Offset | Description |
|---|---|
| 0 | Blocking Timer (T1) |
| 1 | Blocking Retries |
| 2 | Unblocking Retries |
| 3 | Reset Timer (T2) |
| 4 | Reset Retries |
| 5 | Suspend Timer (T3) in units of 100ms |
| 6 | Suspend Retries |
| 7 | Resume Timer (T4) in units of 100ms |
| 8 | Resume Retries |
| 9 | Capability Update Timer (T5) |
| 10 | Capability Update Retries |

The detailed description of the meaning of those timers is given in the GPRS BSSGP specification 3GPP TS 08.18.

This attribute is not used by OsmoBTS, but simply passed to OsmoPCU connected to the PCU socket.

#### 4.6.16 GPRS NS Link Configuration

This attribute is 8 octets long and encoded as follows:

| Offset | Length | Description |
|---|---|---|
| 0 | 2 | GPRS-NS Remote UDP Port Number (SGSN side) |
| 2 | 4 | GPRS-NS Remote IPv4 Address (SGSN side) |
| 6 | 2 | GPRS-NS Local UDP Port Number (BTS side) |

All values are encoded in network byte order.

This attribute is not used by OsmoBTS, but simply passed to OsmoPCU connected to the PCU socket.

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#### 4.6.17 GPRS RLC Configuration

The value part of the GPRS RLC Configuration consists of an array of 9 octets, each describing a RLC timer:

| Offset | Description | Unit |
|---|---|---|
| 0 | GPRS RLC Timer T3142 | s |
| 1 | GPRS RLC Timer T3169 | s |
| 2 | GPRS RLC Timer T3191 | s |
| 3 | GPRS RLC Timer T3193 | 10ms |
| 4 | GPRS RLC Timer T3195 | s |
| 5 | GPRS RLC Timer T3101 | s |
| 6 | GPRS RLC Timer T3103 | s |
| 7 | GPRS RLC Timer T3105 | s |
| 8 | GPRS RLC CV Countdown | - |

The meaning of the RLC timers are specified in 3GPP TS 04.60.

The countdown value specifies the RLC CV value from which the countdown procedure is started.

This attribute is not used by OsmoBTS, but simply passed to OsmoPCU connected to the PCU socket.

#### 4.6.18 GPRS Coding Schemes

The value part of the GPRS Coding Schemes consists of two octets encoding the available GPRS and EDGE coding schemes.

| bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| byte at offset 0 | MCS9 | x | x | x | CS4 | CS3 | CS2 | CS1 |
| byte at offset 1 | MCS8 | MCS7 | MCS6 | MCS5 | MCS4 | MCS3 | MCS2 | MCS1 |

This attribute is not used by OsmoBTS, but simply passed to OsmoPCU connected to the PCU socket.

#### 4.6.19 GPRS RLC Configuration 2

The value part of this attribute is 8 octets long and encoded as follows:

| Offset | Length | Description | Unit |
|---|---|---|---|
| 0 | 2 | Downlink TBF Extension Timer | 10ms |
| 2 | 2 | Uplink TBF Extension Timer | 10ms |
| 4 | 2 | Initial GPRS Coding Scheme | - |

The Initial GPRS Coding Scheme is encoded as follows:

| Value | Description |
|---|---|
| 1 | CS 1 |
| 2 | CS 2 |
| 3 | CS 3 |
| 4 | CS 4 |

This attribute is not used by OsmoBTS, but simply passed to OsmoPCU connected to the PCU socket.

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#### 4.6.20 GPRS RLC Configuration 3

This attribute contains information about the initial MCS used for new EDGE TBFs.

It is encoded as follows:

| Value | Description |
|---|---|
| 1 | MCS 1 |
| 2 | MCS 2 |
| 3 | MCS 3 |
| 4 | MCS 4 |
| 5 | MCS 5 |
| 6 | MCS 6 |
| 7 | MCS 7 |
| 8 | MCS 8 |
| 9 | MCS 9 |

This attribute is not used by OsmoBTS, but simply passed to OsmoPCU connected to the PCU socket.

#### 4.6.21 SW Configuration

The SW Configuration IE is compliant with 3GPP TS 52.021 9.4.61: it contains a number of SW Description IEs (9.4.62).

Table 39: Coding of SW Configuration IE

| octet | value |
|---|---|
| 1 | NM_ATT_SW_CONFIG IEI (0x41) |
| 2-3 | length of value part |
| 4 | NM_ATT_SW_DESCR IEI (0x42) |
| 5 | NM_ATT_FILE_ID IEI (0x12) |
| 6-7 | length of file name |
| 8-N | ASCII coded file name (without terminating nul) |
| N+1 | NM_ATT_FILE_VERSION IEI (0x13) |
| N+2 - N+3 | length of file content |
| N+4 - M | file content |
| M+1 | NM_ATT_SW_DESCR IEI (0x42) |
| M+2 | NM_ATT_FILE_ID IEI (0x12) |
| ... | |

Table 40: File names and content sent in the SW Configuration IE

| file name | content |
|---|---|
| *osmobts* | ASCII coded OsmoBTS version number like "1.2.3" or "1.2.3.4-abcd" |
| *BTS_TYPE_VARIANT* | one of "osmo-bts-lc15", "osmo-bts-oc2g", "osmo-bts-octphy", "osmo-bts-omldummy", "osmo-bts-sysmo", "osmo-bts-trx", "osmo-bts-virtual" |
| *BTS_SUB_MODEL* | This file may be omitted; if present, may contain an ASCII coded model number like "sysmoBTS 1002" |

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#### 4.6.22 Manufacturer Id

The coding of the Manufacturer Id attribute is a sequence of bit flags (a bit vector), where a zero flag indicates absence and a set flag indicates presence of a specific BTS feature.

The number of flags transmitted depends on the software version of OsmoBTS and the BTS backend in use. More flags may be added in the future. The flag bits transmitted are followed by zero bits up to the next full octet boundary.

These features are currently defined:

Table 41: coding of BTS feature flags sent in the Manufacturer Id attribute

| octet | bit | feature name | description |
|---|---|---|---|
| 0 | 7 | HSCSD | High-Speed Circuit-Switched Data |
| | 6 | GPRS | General Packet Radio Service |
| | 5 | EGPRS | Enhanced GPRS (EDGE) |
| | 4 | ECSD | Enhanced Circuit-Switched Data |
| | 3 | HOPPING | Frequency Hopping |
| | 2 | MULTI_TSC | Multi-TSC |
| | 1 | OML_ALERTS | OML Alerts |
| | 0 | AGCH_PCH_PROP | AGCH/PCH proportional allocation |
| 1 | 7 | CBCH | Cell Broadcast Channel |
| | 6 | SPEECH_F_V1 | Fullrate speech V1 |
| | 5 | SPEECH_H_V1 | Halfrate speech V1 |
| | 4 | SPEECH_F_EFR | Fullrate speech EFR |
| | 3 | SPEECH_F_AMR | Fullrate speech AMR |
| | 2 | SPEECH_H_AMR | Halfrate speech AMR |
| | 1 | ETWS_PN | ETWS Primary Notification via PCH |
| | 0 | PAGING_COORDINATION | BSS Paging Coordination |
| 2 | 7 | IPV6_NSVC | NSVC IPv6 |
| | 6 | ACCH_REP | FACCH/SACCH Repetition |
| | 5 | CCN | Cell Change Notification |
| | 4 | VAMOS | Voice services over Adaptive Multi-user channels on One Slot |
| | 3 | reserved for future use, sent as zero | |
| | 2 | | |
| | 1 | | |
| | 0 | | |

## 4.7 A-bis OML Initialization / BTS bring-up

At the time an Abis/IP BTS connects to via OML to the BSC, it is initialized according to the procedures described in 3GPP TS 52.021 as amended by this document.

Each Managed Object (MO) is separately initialized. The initialization sequence and parameters differ slightly depending on the MO involved.

Some parts of the sequences described below are optional, such as the Software activation. In the OsmoBTS case, the software is not modular and thus all MOs start with the software fully activated. In effect, no *Software Activate Request* is being sent by the MO to the BSC, nor does the BSC need to initialize the *Activate Software* procedure.

Still, the full sequences are shown in order to explain the Abis/IP protocol.

Also, the initial state of the MOs at time of OML connection initialization is not always guaranteed to be *Disabled/Notinstalled*. Rather, the BSC implementation has to deal with the initial state as reported by the MOs at time of re-connection.

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#### 4.7.1 Site Manager MO Initialization

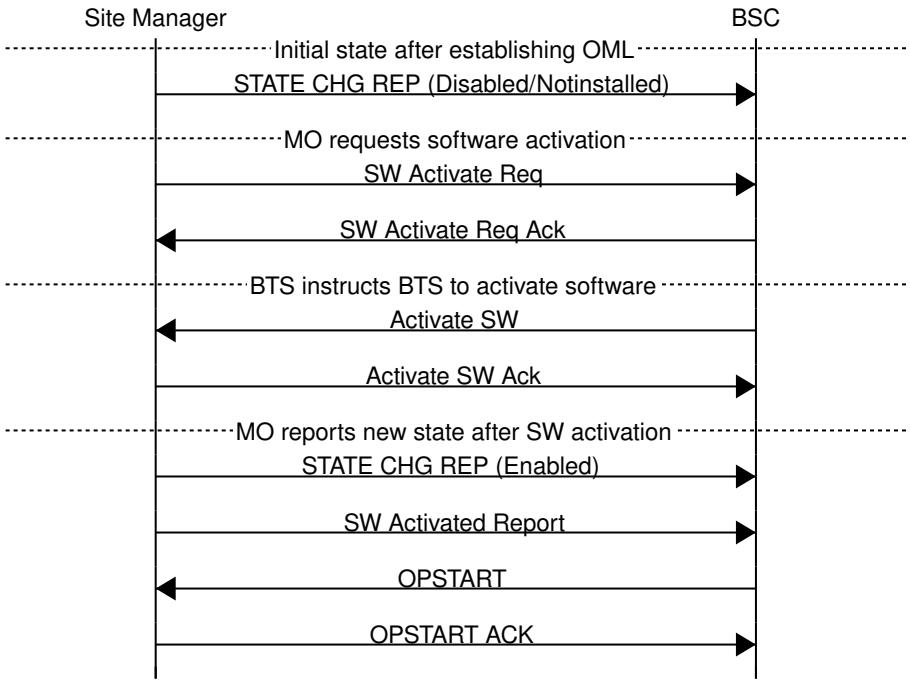



Figure 2: A-bis OML Initialization of Site Manager MO

The Site Manager MO does not depend on other MOs, nor does it have an Administrative state (*Locked/Unlocked*), thus it immediately commences in the *Enabled* state.

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#### 4.7.2 BTS MO Initialization

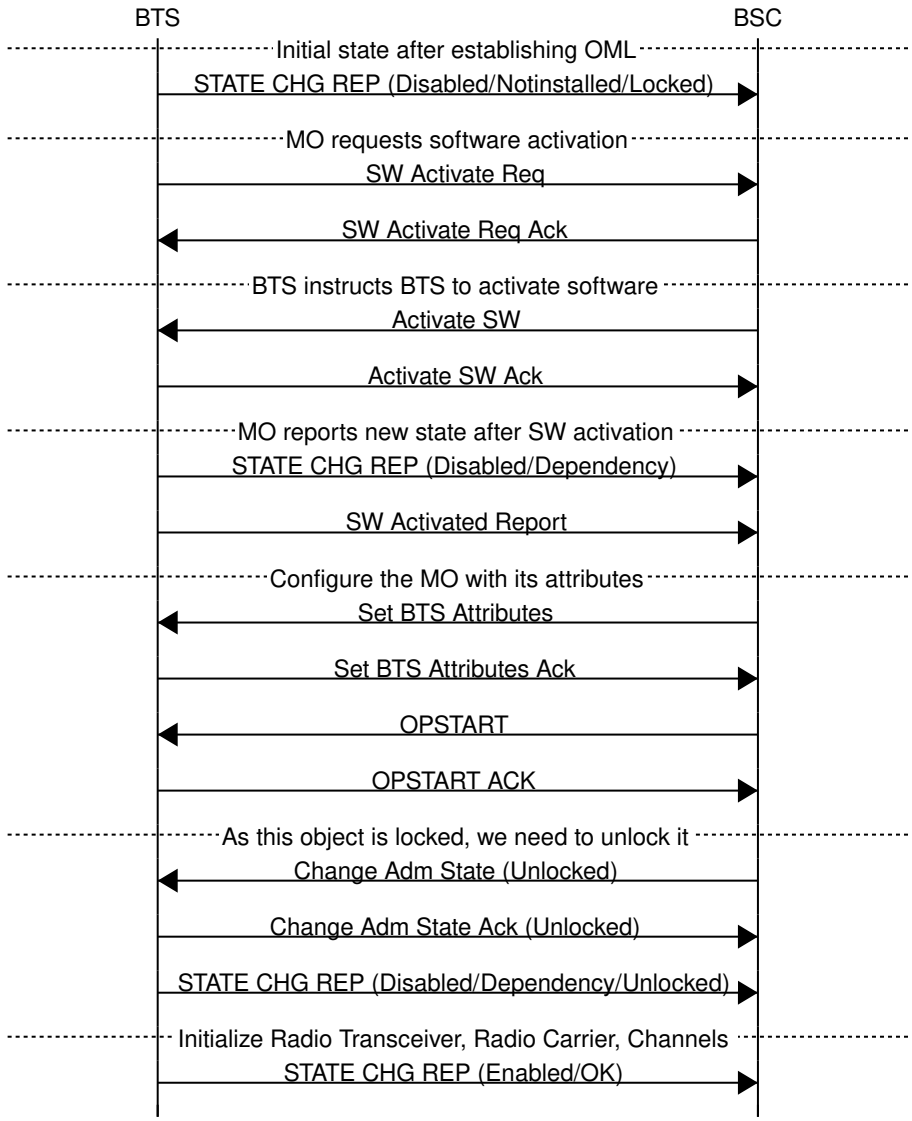



Figure 3: A-bis OML Initialization of BTS MO

As shown in the BTS MO, its state is

- Availability state *Dependency*, meaning it depends on other MOs to be initialized before becoming enabled.
- Administrative state *Locked*, as the object is first waiting to receive attributes in the *Locked* state, before the *Change Administrative State (Unlocked)* procedure is used to request transitioning into Unlocked state.

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#### 4.7.3 Baseband Transceiver MO Initialization

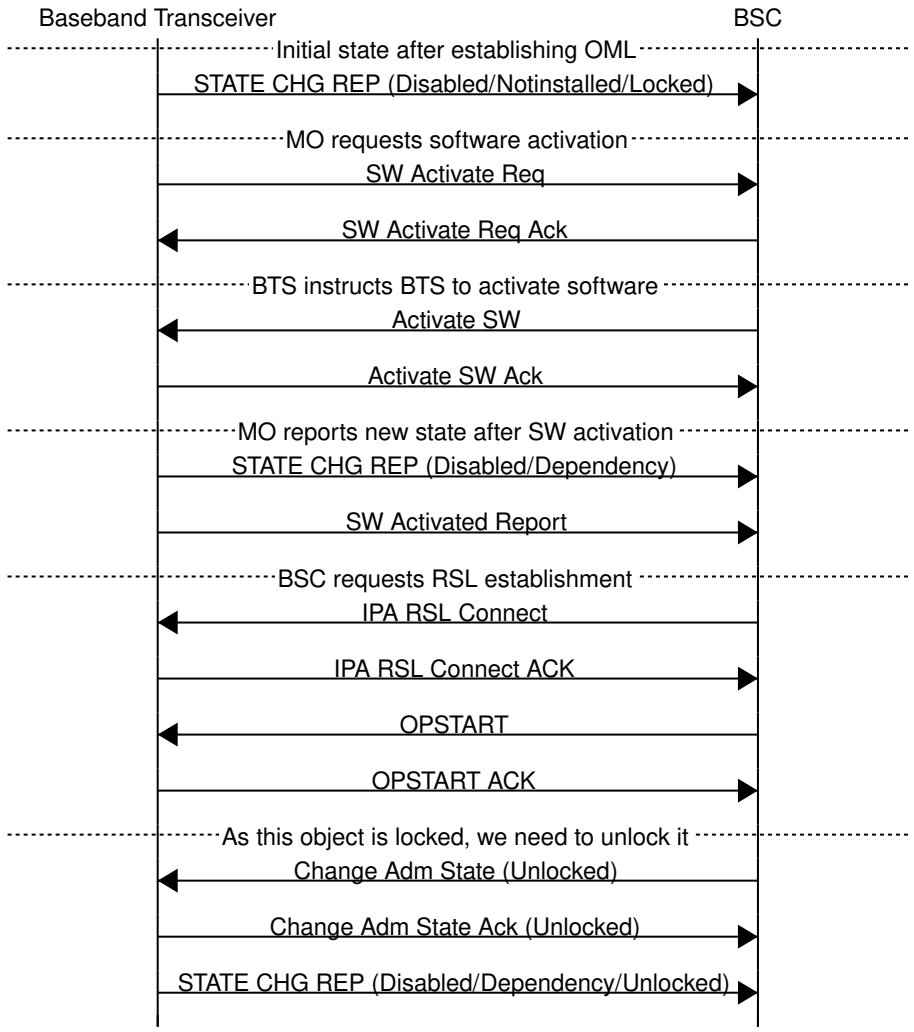



Figure 4: A-bis OML Initialization of Baseband Transceiver MO

There is one Baseband Transceiver MO per TRX in the BTS. For a multi-TRX BTS, the above procedure must be repeated for each TRX.

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#### 4.7.4 Radio Carrier MO Initialization

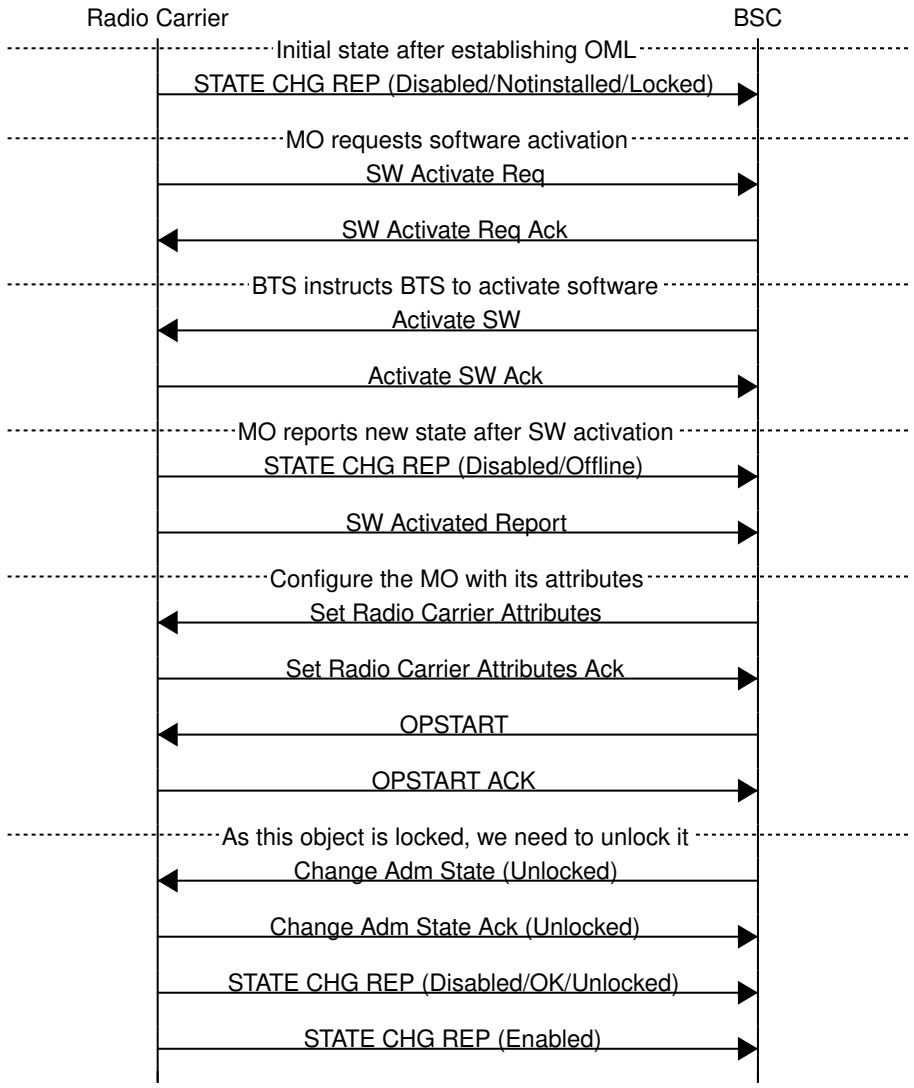



Figure 5: A-bis OML Initialization of Radio Carrier MO

There is one Radio Carrier MO per TRX in the BTS. For a multi-TRX BTS, the above procedure must be repeated for each TRX.

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#### 4.7.5 Channel MO Initialization

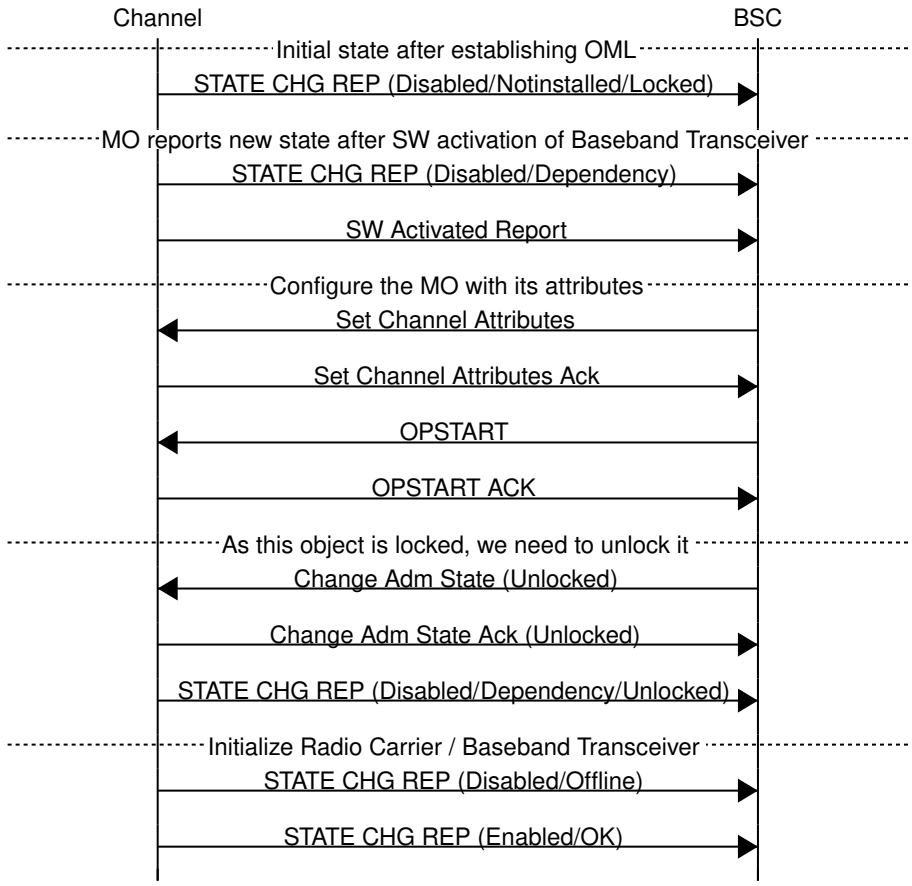



Figure 6: A-bis OML Initialization of Radio Carrier MO

There are 8 timeslots in each TRX, and correspondingly 8 Channel MOs in every TRX. The above procedure must thus be repeated for each timeslot in each transceiver of the BTS.

#### 4.7.6 Complete BTS Initialization Procedure

Some of below steps are optional, as is their detailed ordering. In practice, the procedures for different MOs may overlap. The message sequence charts in this document have been hand-crafted to avoid such overlap for the sake of clarity.

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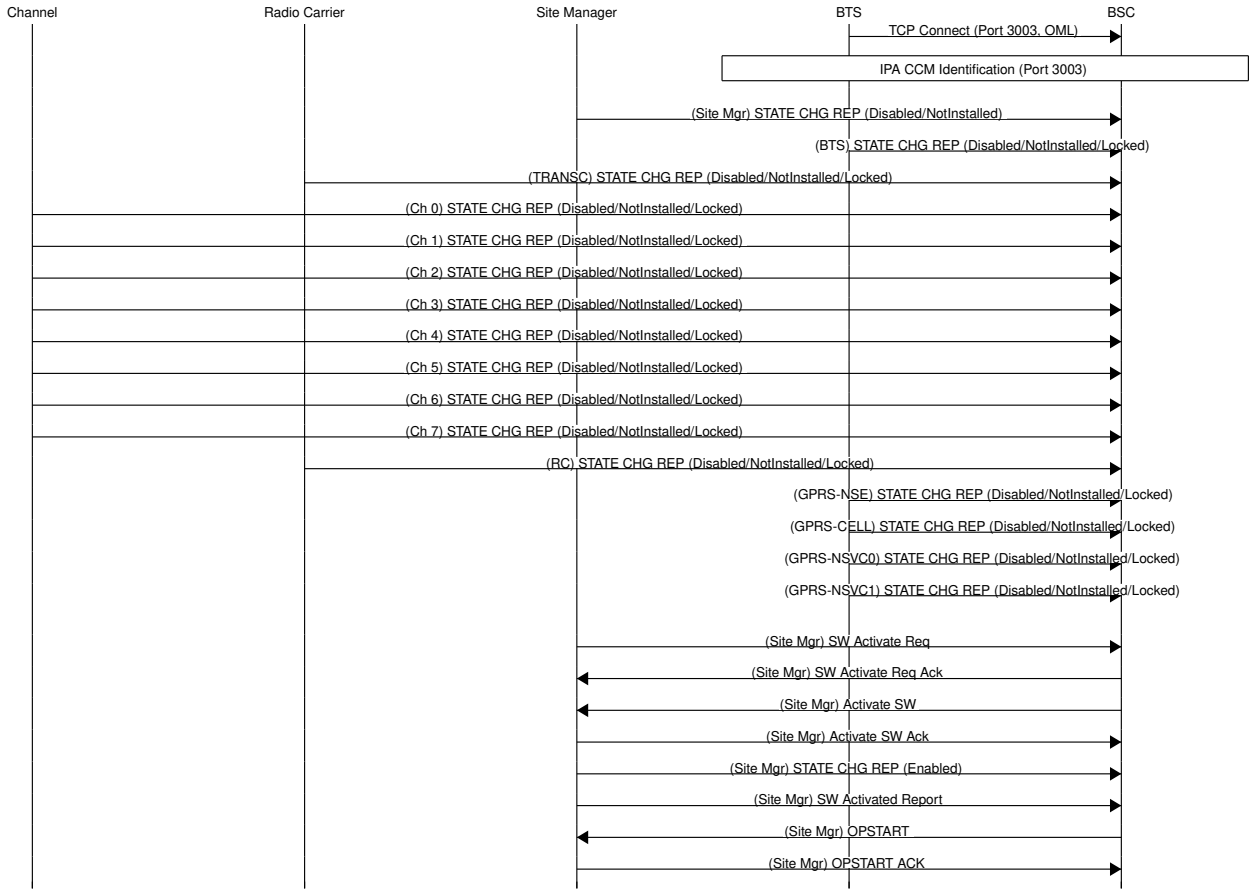



Figure 7: A-bis OML BTS bring-up (1/3)

As shown in Figure 7, after the OML TCP connection is established,

1. the identity is exchanged via IPA CCM,
2. the BTS sends an *OML EVENT STATE CHANGED REPORT* for every Managed Object, and
3. the BTS subsequently requests the activation of its *Site Manager* Object which the BSC performs by the *Activate SW* command.
4. After successful activation of the software in the Site Manager,
    a. the state changes to *Enabled*, and an event report is generated accordingly, and
    b. the BSC is notified about the SW activation in an associated report.
5. Finally, the BSC requests the start of the Site Manager
    a. using the *OPSTART* command,
    b. which is subsequently acknowledged by the Site Manager.

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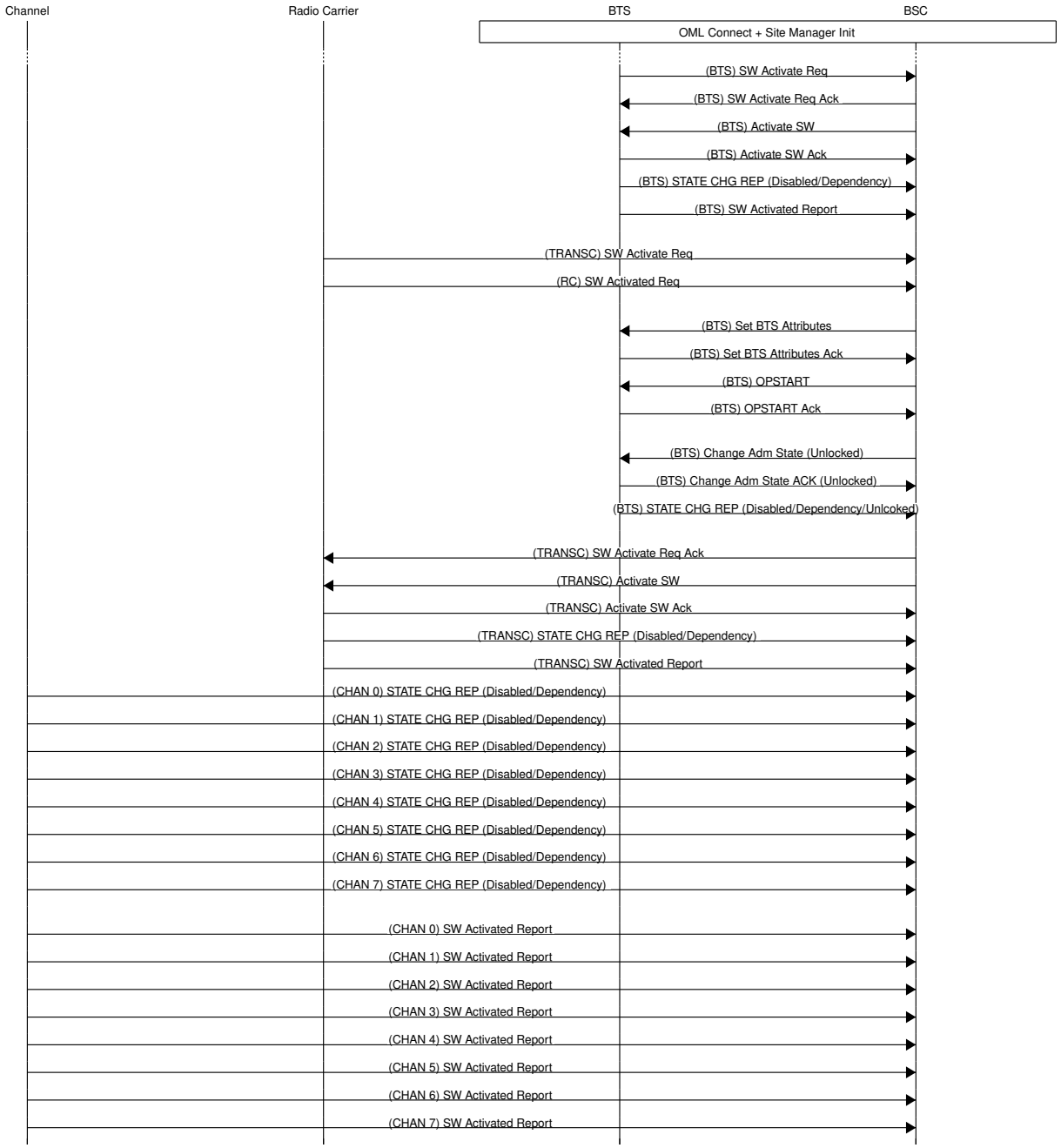



Figure 8: A-bis OML BTS bring-up (2/3)

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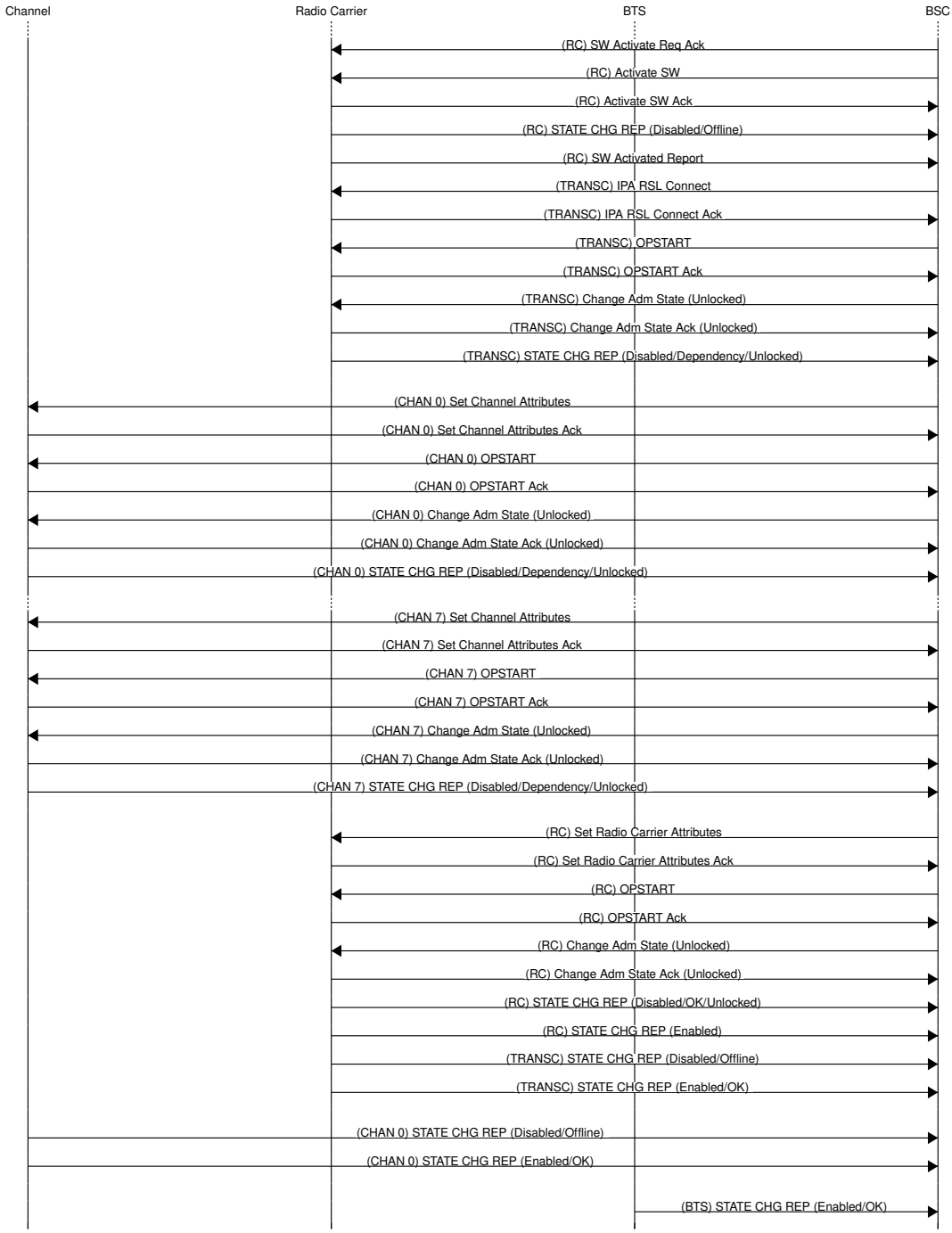



Figure 9: A-bis OML BTS bring-up (3/3)

Figure 8 shows:

1. Software Activation and associated state transitions of the BTS MO;
2. Setting of the BTS Attributes followed by OPSTART;
3. Software Activation and associated state transitions of the *Baseband Transceiver* MO;
4. Software Activation and associated state transitions of the *Radio Carrier* MO;

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5. Once the *Baseband Transceiver* MO has its software activated, the *Channel* MOs (one for each timeslot) indicate their state change as well as software activation.

Figure 9 shows:

1. The *Radio Carrier* MO Software Activation;
2. The Request to the *Baseband Transceiver* MO to establish the RSL signalling connection to the BSC;
3. Subsequent OPSTART and Change of Administrative State on the *Baseband Transceiver* MO;
4. The following procedure takes place for each of the *Channel* MOs:
    a. Set the Channel Attributes (such as channel combination),
    b. OPSTART,
    c. change the Administrative State to Unlocked,
    d. followed by a State Change Event Report with the new state.
5. After all *Channel* MOs are initialized, the Radio Carrier goes through a similar procedure:
    a. Set attributes,
    b. OPSTART,
    c. change Administrative State to Unlocked,
    d. followed by a State Change Event Report with the new State (Enabled/OK)
6. All *Channel* MOs now also report their state as Enabled/OK.
7. Finally, the BTS reports its state as Enabled/OK.

# 5 Radio Signalling Link (RSL)

## 5.1 List of Messages

The following tables list the RSL messages used by OsmoBTS A-bis/IP, grouped by their level of compliance with 3GPP TS 48.058.

### 5.1.1 Messages Compliant With TS 48.058

Specific additions and limitations apply, see the linked sections.

Table 42: Messages compliant with TS 48.058

| TS 48.058 § | This document § | Message | ←/→ | Received/Sent by OsmoBTS |
|---|---|---|---|---|
| **Radio link layer management messages** | | | | |
| 8.3.1 | - | DATA REQUEST | ← | Received |
| 8.3.2 | - | DATA INDICATION | → | Sent |
| 8.3.3 | - | ERROR INDICATION | → | Sent |
| 8.3.4 | - | ESTABLISH REQUEST | ← | Received |
| 8.3.5 | - | ESTABLISH CONFIRM | → | Sent |
| 8.3.6 | - | ESTABLISH INDICATION | → | Sent |
| 8.3.7 | - | RELEASE REQUEST | ← | Received |
| 8.3.8 | - | RELEASE CONFIRM | → | Sent |

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Table 42: (continued)

| TS 48.058 § | This document § | Message | ←/→ | Received/Sent by OsmoBTS |
|---|---|---|---|---|
| 8.3.9 | - | RELEASE INDICATION | → | Sent |
| 8.3.10 | - | UNIT DATA REQUEST | ← | Received |
| 8.3.11 | - | UNIT DATA INDICATION | → | Sent |
| **DEDICATED CHANNEL MANAGEMENT MESSAGES** | | | | |
| 8.4.1 | Section 5.2.1 | CHANNEL ACTIVATION | ← | Received |
| 8.4.2 | Section 5.2.1 | CHANNEL ACTIVATION ACKNOWLEDGE | → | Sent |
| 8.4.3 | Section 5.2.1 | CHANNEL ACTIVATION NEGATIVE ACKNOWLEDGE | → | Sent |
| 8.4.4 | - | CONNECTION FAILURE INDICATION | → | Sent |
| 8.4.5 | - | DEACTIVATE SACCH | ← | Received |
| 8.4.6 | - | ENCRYPTION COMMAND | ← | Received |
| 8.4.7 | - | HANDOVER DETECTION | → | Sent |
| 8.4.8 | Section 5.2.2 | MEASUREMENT RESULT | → | Sent |
| 8.4.9 | Section 5.2.3 | MODE MODIFY | ← | Received |
| 8.4.10 | - | MODE MODIFY ACKNOWLEDGE | → | Sent |
| 8.4.11 | - | MODE MODIFY NEGATIVE ACKNOWLEDGE | → | Sent |
| 8.4.14 | - | RF CHANNEL RELEASE | ← | Received |
| 8.4.15 | Section 5.2.4 | MS POWER CONTROL | ← | Received |
| 8.4.16 | - | BS POWER CONTROL | ← | Received |
| 8.4.19 | - | RF CHANNEL RELEASE ACKNOWLEDGE | → | Sent |
| 8.4.20 | Section 5.2.5 | SACCH INFO MODIFY | ← | Received |
| **COMMON CHANNEL MANAGEMENT MESSAGES** | | | | |
| 8.5.1 | Section 5.2.6 | BCCH INFORMATION | ← | Received |
| 8.5.2 | - | CCCH LOAD INDICATION | → | Sent |
| 8.5.3 | Section 5.2.7 | CHANNEL REQUIRED | → | Sent |
| 8.5.4 | - | DELETE INDICATION | → | Sent |
| 8.5.5 | Section 5.2.8 | PAGING COMMAND | ← | Received |
| 8.5.6 | - | IMMEDIATE ASSIGN COMMAND | ← | Received |
| 8.5.8 | - | SMS BROADCAST COMMAND | ← | Received |
| 8.5.9 | - | CBCH LOAD INDICATION | → | Sent |
| **TRX MANAGEMENT MESSAGES** | | | | |
| 8.6.1 | Section 5.2.9 | RF RESOURCE INDICATION | → | Sent |
| 8.6.2 | Section 5.2.10 | SACCH FILLING | ← | Received |
| 8.6.4 | - | ERROR REPORT | → | Sent |

### 5.1.2 Messages Specific to OsmoBTS

Table 43: Messages specific to OsmoBTS, not found in 3GPP TS 48.058

| This document § | | Message | ←/→ | Received/Sent by OsmoBTS |
|---|---|---|---|---|
| **User Plane Transport Management** (Section 5.3) | | | | |
| Section 5.3.1 | Section 5.7.1 | RSL Create Connection (CRCX) | ← | Received |
| | Section 5.7.2 | RSL Create Connection (CRCX) ACK | → | Sent |
| | Section 5.7.3 | RSL Create Connection (CRCX) NACK | → | Sent |
| Section 5.3.2 | Section 5.7.4 | RSL Modify Connection (MDCX) | ← | Received |
| | Section 5.7.5 | RSL Modify Connection (MDCX) ACK | → | Sent |
| | Section 5.7.6 | RSL Modify Connection (MDCX) NACK | → | Sent |

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Table 43: (continued)

| This document § | | Message | ←/→ | Received/Sent by OsmoBTS |
|---|---|---|---|---|
| Section 5.3.3 | Section 5.7.8 | RSL Delete Connection (DLCX) | ← | Received |
| | Section 5.7.9 | RSL Delete Connection (DLCX) ACK | → | Sent |
| | Section 5.7.10 | RSL Delete Connection (DLCX) NACK | → | Sent |
| Section 5.3.4 | Section 5.7.7 | RSL Delete Connection (DLCX) Indication | → | Sent |
| **IPA style PDCH Management** (Section 5.4.1) | | | | |
| Section 5.4.1.1 | Section 5.7.11 | RSL PDCH Activation | ← | Received |
| | Section 5.7.12 | RSL PDCH Activation ACK | → | Sent |
| | Section 5.7.13 | RSL PDCH Activation NACK | → | Sent |
| Section 5.4.1.2 | Section 5.7.14 | RSL PDCH Deactivation | ← | Received |
| | Section 5.7.15 | RSL PDCH Deactivation ACK | → | Sent |
| | Section 5.7.16 | RSL PDCH Deactivation NACK | → | Sent |
| **COMMON CHANNEL MANAGEMENT MESSAGES** | | | | |
| Section 5.5 | Section 5.7.17 | Osmocom ETWS Command | ← | Received |

### 5.1.3 Messages Not Implemented by OsmoBTS

Table 44: 3GPP TS 48.058 messages not implemented by OsmoBTS

| TS 48.058 § | Message |
|---|---|
| **DEDICATED CHANNEL MANAGEMENT MESSAGES** | |
| 8.4.12 | PHYSICAL CONTEXT REQUEST |
| 8.4.13 | PHYSICAL CONTEXT CONFIRM |
| 8.4.17 | PREPROCESS CONFIGURE |
| 8.4.18 | PREPROCESSED MEASUREMENT RESULT |
| 8.4.21 | TALKER DETECTION |
| 8.4.22 | LISTENER DETECTION |
| 8.4.23 | REMOTE CODEC CONFIGURATION REPORT |
| 8.4.24 | ROUND TRIP DELAY REPORT |
| 8.4.25 | PRE-HANDOVER NOTIFICATION |
| 8.4.26 | MULTIRATE CODEC MODIFICATION REQUEST |
| 8.4.27 | MULTIRATE CODEC MODIFICATION ACKNOWLEDGE |
| 8.4.28 | MULTIRATE CODEC MODIFICATION NEGATIVE ACKNOWLEDGE |
| 8.4.29 | MULTIRATE CODEC MODIFICATION PERFORMED |
| 8.4.30 | TFO REPORT |
| 8.4.31 | TFO MODIFICATION REQUEST |
| **COMMON CHANNEL MANAGEMENT MESSAGES** | |
| 8.5.7 | SMS BROADCAST REQUEST |
| 8.5.10 | NOTIFICATION COMMAND |
| **TRX MANAGEMENT MESSAGES** | |
| 8.6.3 | OVERLOAD |
| **LOCATION SERVICES MESSAGES** | |
| 8.7.1 | LOCATION INFORMATION |

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## 5.2 Message Limitation Details

### 5.2.1 Channel Activation

When used on a timeslot using the non-standard channel combination *NM_CHANC_OSMO_DYN* as configured by OML, the regular RSL channel activation procedures can not only be used for activation of circuit-switched channels, but also for activation of a PDCH.

See Section 5.4.2.

**NOTE**
Do not confuse this with the IPA style *PDCH ACT* type dynamic PDCH protocol employed by nanoBTS devices (Section 5.4.1).

### 5.2.2 Measurement Result

Conforms to 3GPP TS 48.058 § 8.4.8 with this limitation:

Table 45: *Measurement Result* IE limitations

| **TS 48.058 §** | **IE Name** | **Handling** |
|---|---|---|
| 9.3.37 | MS Timing Offset | never sent by OsmoBTS |

### 5.2.3 Mode Modify

Conforms to 3GPP TS 48.058 § 8.4.9 with these limitations:

Table 46: *Mode Modify* IE limitations

| **TS 48.058 §** | **IE Name** | **Handling** |
|---|---|---|
| 9.3.45 | Main channel reference | *ignored* |
| 9.3.53 | MultiRate Control | *ignored* |
| 9.3.54 | Supported Codec Types | *ignored* |

### 5.2.4 MS Power Control

Conforms to 3GPP TS 48.058 § 8.4.15 with these limitations:

Table 47: *MS Power Control* IE limitations

| **TS 48.058 §** | **IE Name** | **Handling** |
|---|---|---|
| 9.3.31 | MS Power Parameters | *ignored* |

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### 5.2.5 SACCH Info Modify

Conforms to 3GPP TS 48.058 § 8.4.20, with these exceptions:

Table 48: *SACCH Info Modify* IE limitations

| TS 48.058 § | IE Name | Handling |
|---|---|---|
| 9.3.30 | System Info Type | See below for available types |
| 9.3.23 | Starting Time | not supported, provokes an *Error Report* response |

Table 49: *System Info Type* values that can occur on the SACCH

| Value | Name |
|---|---|
| 0x05 | RSL_SYSTEM_INFO_5 |
| 0x06 | RSL_SYSTEM_INFO_6 |
| 0x0d | RSL_SYSTEM_INFO_5bis |
| 0x0e | RSL_SYSTEM_INFO_5ter |
| 0x0f | RSL_SYSTEM_INFO_10 |
| 0x47 | RSL_EXT_MEAS_ORDER |
| 0x48 | RSL_MEAS_INFO |

### 5.2.6 BCCH Information

Conforms to 3GPP TS 48.058 § 8.5.1, with these limitations and extensions:

Table 50: *BCCH Information* IE details

| TS 48.058 § | IE Name | Handling |
|---|---|---|
| 9.3.30 | System Info Type | See Section 5.2.5 for available types |
| 9.3.11 | L3 Info | This IE may be included instead of a 9.3.39 *Full BCCH Info* IE. The *Full BCCH Info* takes precedence over *L3 Info*. To stop SI transmission, both of these IEs must be omitted. |

### 5.2.7 Channel Required

Conforms to 3GPP TS 48.058 § 8.5.3, with these limitations:

Table 51: *Channel Required* message IE details

| TS 48.058 § | IE Name | Handling |
|---|---|---|
| 9.3.16 | Physical Context | never sent by OsmoBTS |

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#### 5.2.8 Paging Command

Conforms to 3GPP TS 48.058 § 8.5.5, with these limitations:

Table 52: *Paging Command* message IE details

| TS 48.058 § | IE Name | Handling |
|---|---|---|
| 9.3.49 | eMLPP Priority | *ignored* |

**Note**
If adding the identity to the paging queue fails, the BSC is not notified in any way.

#### 5.2.9 RF Resource Indication

For all osmo-bts variants, except osmo-bts-trx, this message does not conform to 3GPP TS 48.058 § 8.6.1, in that it omits the *Resource Information* IE that would contain the actual payload data, which renders this message void.

Table 53: *RF Resource Indication* message IE exceptions

| TS 48.058 § | IE Name | Handling |
|---|---|---|
| 9.3.21 | Resource Information | DSP based osmo-bts variants omit this IE, though TS 48.058 specifies it as mandatory. |

#### 5.2.10 SACCH Filling

Conforms to 3GPP TS 48.058 § 8.6.2, with these limitations:

Table 54: *SACCH Filling* message IE limitations

| TS 48.058 § | IE Name | Handling |
|---|---|---|
| 9.3.30 | System Info Type | See Section 5.2.5 for available types |
| 9.3.23 | Starting Time | *ignored* |

### 5.3 User Plane Transport Management

This chapter defines the A-bis/IP specific RSL procedures that are introduced in addition to the 3GPP TS 48.058 standard procedures.

In classic A-bis over E1, user plane traffic is carried over 16kBps sub-slots of 64kBps E1 time-slots according to ETSI/3GPP TS 08.60. As the E1 line is a dedicated line between BTS and BSC, no further addressing information is required.

In A-bis/IP as described by the present document, new RSL procedures have been introduced to deal with the different properties of the underlying IP based transport medium.

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#### 5.3.1 RSL Create Connection (CRCX)

This procedure is used by the BSC to request the BTS to allocate + bind to a BTS-local UDP port for the subsequent transmission of user-plane data via RTP.

To do so, the BSC sends the **Create Connection (CRCX)** message. In case of successful outcome, the BTS responds with **Create Connection (CRCX) ACK**. In case of any error, the BTS responds with **Create Connection (CRCX) NACK**.

See Section 5.7.1, Section 5.7.2, Section 5.7.3

#### 5.3.2 RSL Modify Connection (MDCX)

This procedure is used by the BSC to request the BTS to modify an already-bound BTS-local UDP port for user-plane RTP. It is used in particular to configure the remote IP address and UDP port to which the BTS shall send user-plane RTP traffic. This remote address is normally either a Media Gateway (MGW) of some sort, but could also be the RTP socket of the corresponding other leg of a mobile-to-mobile call.

To modify a user-plane connection, the BSC sends the **Modify Connection** message. In case of successful outcome, the BTS responds with **Modify Connection (MDCX) ACK**. In case of any error, the BTS responds with **Modify Connection (MDCX) NACK**.

See Section 5.7.4, Section 5.7.5, Section 5.7.6

#### 5.3.3 RSL Delete Connection (DLCX)

This procedure is used by the BSC to request the BTS to delete an already-existing BTS-local UDP port for user-plane RTP.

To delete a user-plane connection, the BSC sends the **Delete Connection (DLCX)** message. In case of successful outcome, the BTS responds with **Delete Connection (DLCX) ACK**. In case of any error, the BTS responds with **Delete Connection (DLCX) NACK**.

See Section 5.7.8, Section 5.7.9, Section 5.7.10

#### 5.3.4 RSL Delete Connection (DLCX) Indication

When a BTS-local UDP connection for user-plane RTP is automatically released at the time of RF CHANNEL RELEASE, the BTS sends a unilateral, non-acknowledged **RSL Delete Connection (DLCX) Indication** to the BSC.

See Section 5.7.7

### 5.4 Dynamic Channel Combinations

In the classic data model established by ETSI/3GPP for A-bis, each timeslot (channel) is configured using a static channel combination by means of A-bis OML. Particularly in presence of GPRS services, this is very inflexible and leads to inefficient use of air interface resources.

As such, several methods have been implemented to overcome this limitation. The fundamental operation can be outlined like this:

- Configuration of a particular *dynamic* channel combination via OML
- activation of TCH works like on a classic TCH channel combination
- activation of PDCH requires some specific PDCH activation procedure

There are two variants implemented in the OsmoBTS A-bis dialect:

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### 5.4.1 IPA Style Dynamic Channels

This method is used when OML uses *NM_CHANC_IPAC_TCHFull_PDCH* (0x80) as channel combination for the given timeslot.

*IPA style* refers to *ip.access* compatible PDCH activation and deactivation.

When the IPA style dynamic channel combination *TCH/F or PDCH* is set, the non-standard *PDCH ACTIVATE* (Section 5.4.1.1) and *PDCH DEACTIVATE* (Section 5.4.1.2) procedures are used for switching an idle channel into PDCH mode and back into idle mode.

When the channel is used as TCH/F, regular circuit-switched activation is performed, like on any traditional TCH/F. However, the BSC must make sure to first disable the PDCH on the timeslot, before activating it as TCH/F. Likewise, any circuit-switched TCH/F on the channel must be deactivated using standard RSL signalling, before the specific PDCH related procedures are used to enable the PDCH.

#### 5.4.1.1 PDCH Activate

This procedure is used by the BSC to request the BTS to activate an IPA style dynamic TCH/F+PDCH channel in PDCH mode.

The operation is not supported on any other physical channel type.

See Section 5.7.11, Section 5.7.12, Section 5.7.13

#### 5.4.1.2 PDCH Deactivate

This procedure is used by the BSC to request the BTS to deactivate an active PDCH on any an IPA style dynamic TCH/F+PDCH channel.

The operation is not supported on any other physical channel type.

See Section 5.7.14, Section 5.7.15, Section 5.7.16

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#### 5.4.1.3 IPA Style Dynamic Switchover Example

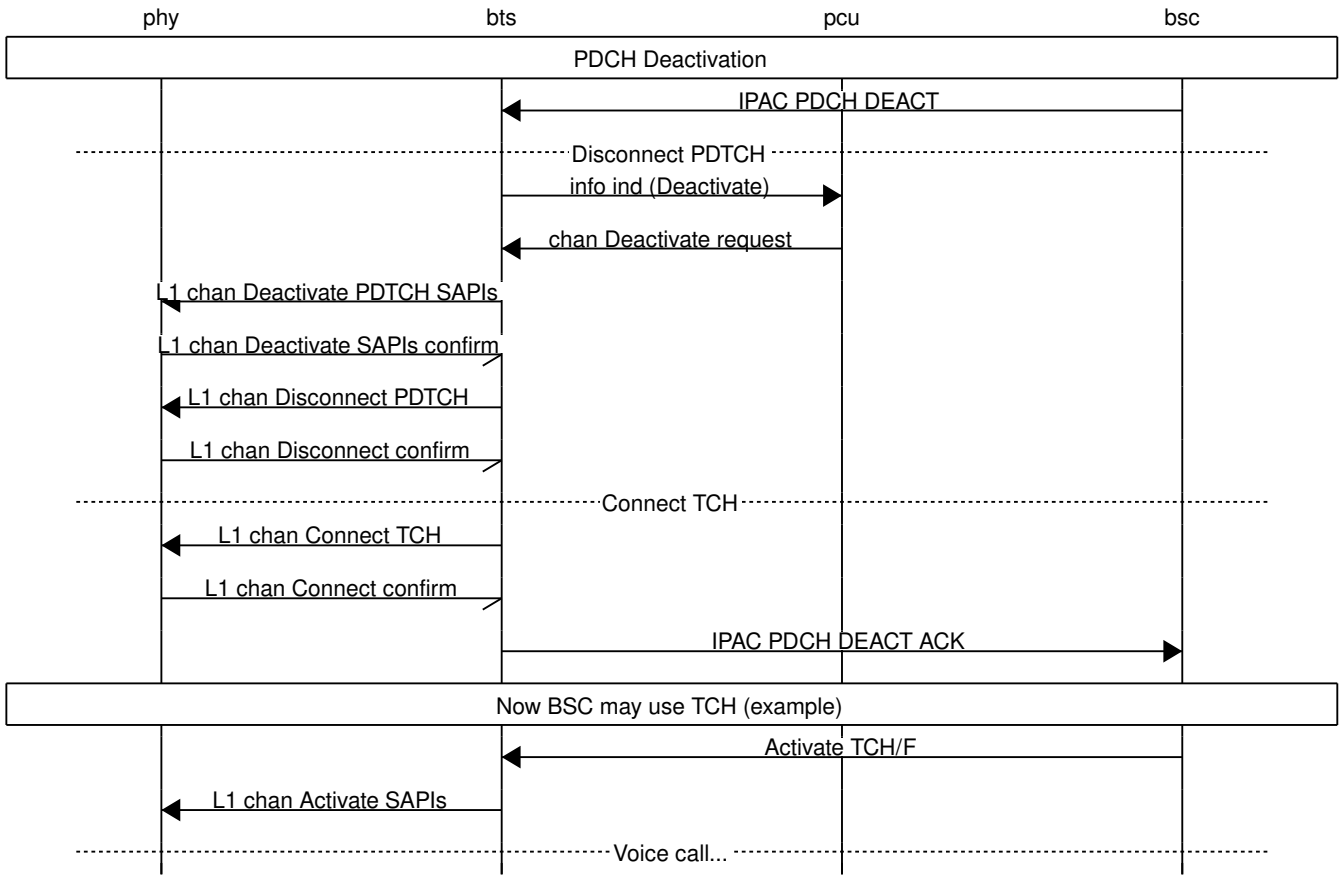



Figure 10: Part 1: example for dynamic channel switchover, for IPA style dynamic timeslots

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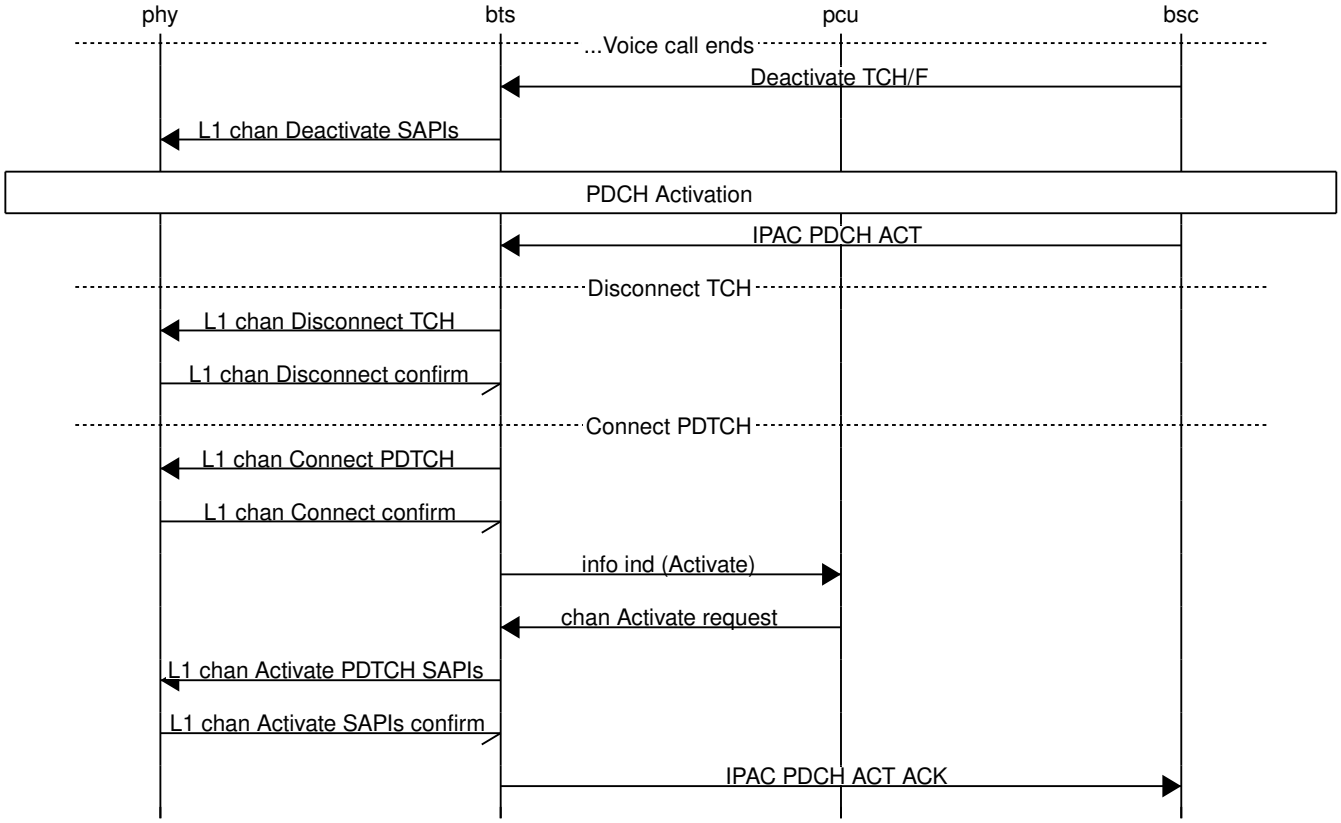



Figure 11: Part 2: example for dynamic channel switchover, for IPA style dynamic timeslots

### 5.4.2 Osmocom Style Dynamic Channels

This method is in use when OML uses *NM_CHANC_OSMO_DYN* (0x90) for the given time-slot.

The activation of PDCH is performed by using the regular *RSL CHANNEL ACTIVATE* procedure according to Section 5.2.1, with these modifications:

- The *C-bits* part of the *Channel Number* IE take the non-standard binary value 11000 (C5 through C1 as seen in 3GPP TS 48.058 § 9.3.1).
- The *A-bits* part of the *Activation Type* IE take the non-standard binary value 1111, with an additional fourth bit (add A4 to A3 through A1 as seen in 3GPP TS 48.058 § 9.3.3; all remaining reserved bits as well as the *R* bit are coded as zero).
- The normally mandatory *Channel Mode* IE is omitted; none of the optional IEs are included.

Hence the message consists of exactly these IEs:

Table 55: PDCH type *Channel Activation* message IEs

| **TS 48.058 §** | **IE Name** | **Handling** |
|---|---|---|
| 9.1 | Message discriminator | Dedicated Channel Management |
| 9.2 | Message type | CHANnel ACTIVation |
| 9.3.1 | Channel number | *C-bits* 11000, plus TS bits as usual |
| 9.3.3 | Activation type | *A-bits* 1111 |

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#### 5.4.2.1 Osmocom Style Dynamic Switchover Example

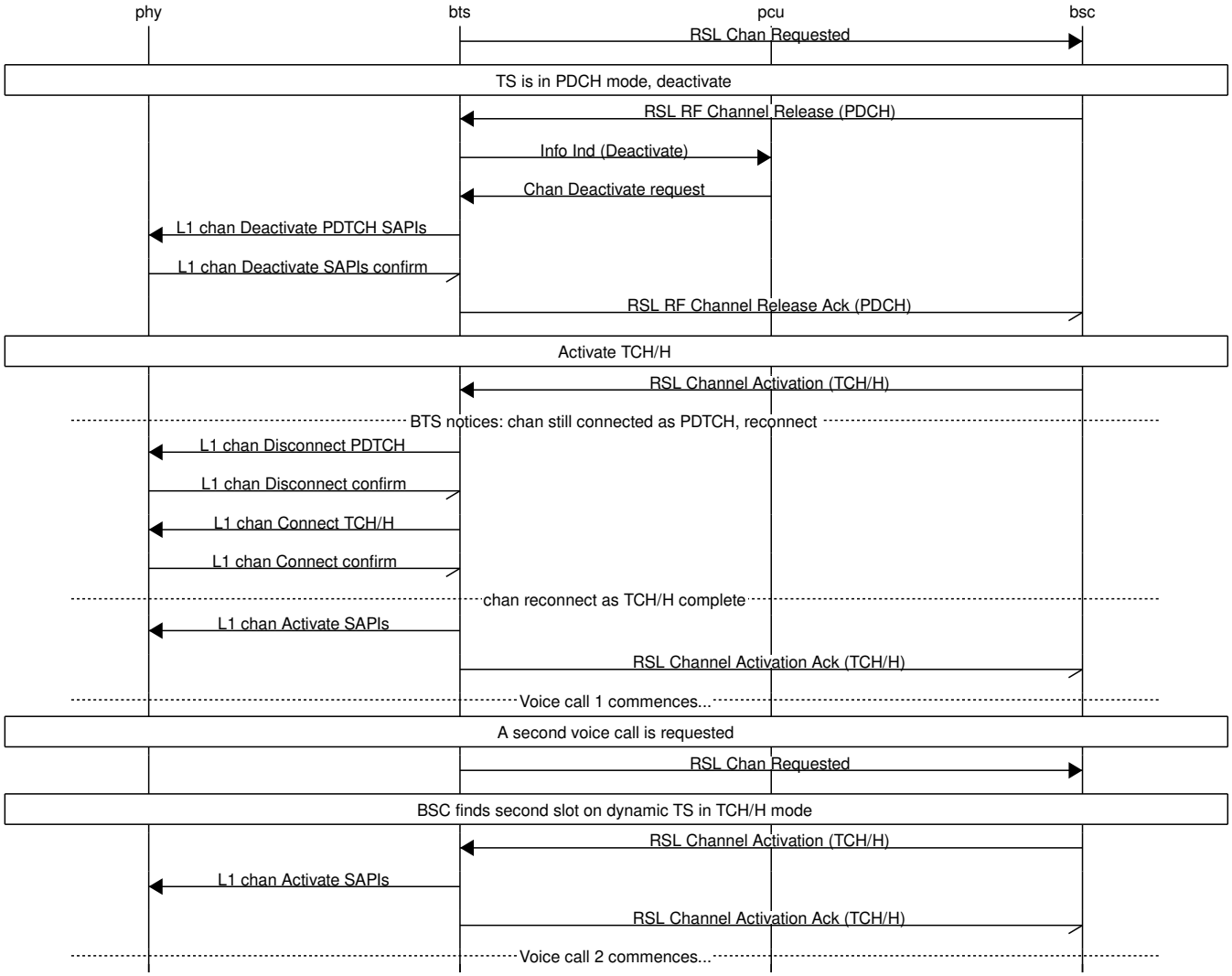



Figure 12: Part 1: example for dynamic channel switchover, for Osmocom style dynamic timeslots

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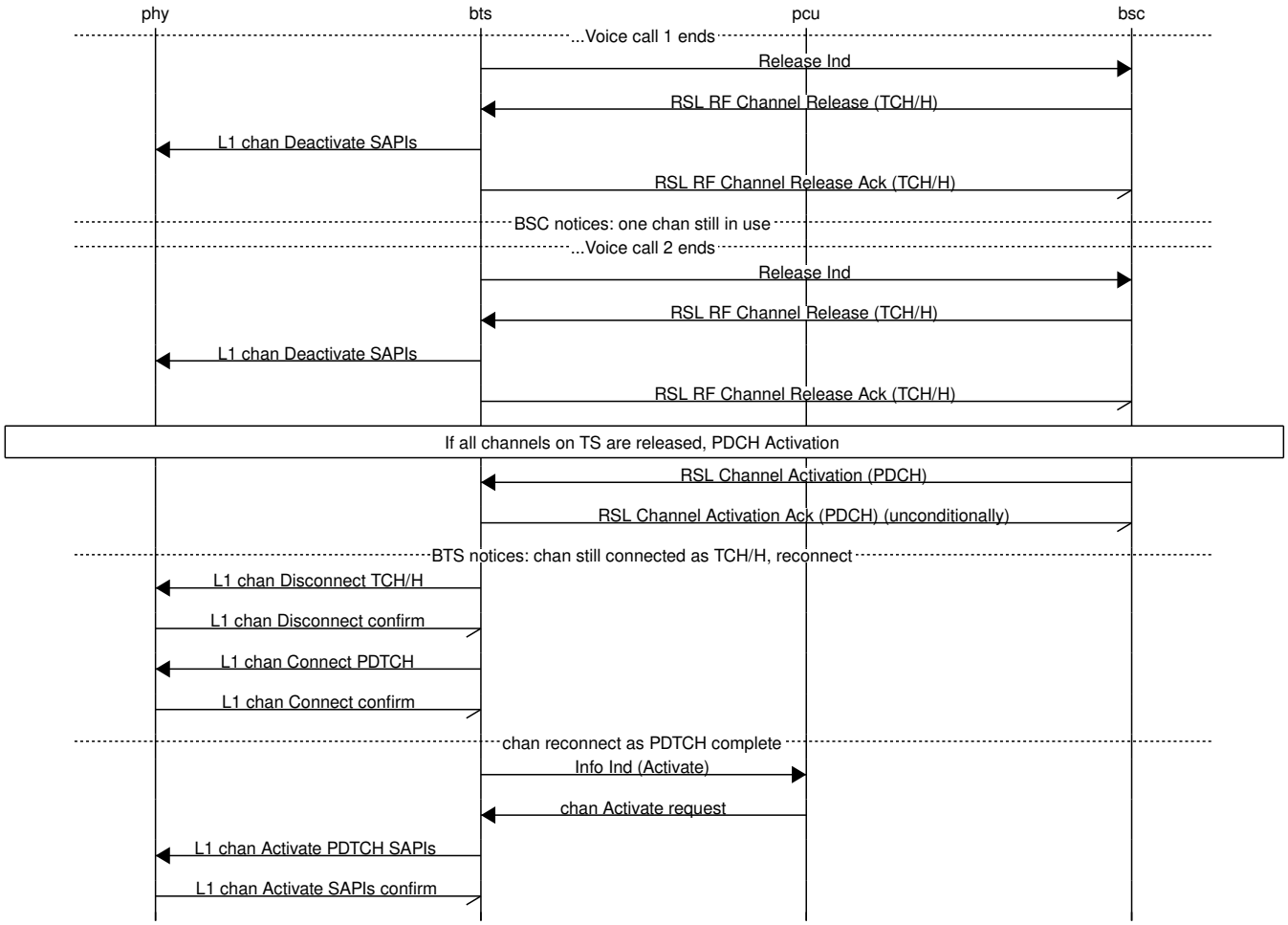



Figure 13: Part 2: example for dynamic channel switchover, for Osmocom style dynamic timeslots

## 5.5 ETWS (Earthquake and Tsunami Warning System)

ETWS as specified in 3GPP TS 23.041 includes not only notification via SMSCB, but also so-called Primary Notifications (PN). The ETWS PN are transmitted

- by the BSC to all subscribers with active dedicated channels
- by the BTS on the PCH to all subscribers in idle mode
- by the PCU on the PACCH to all subscribers with active TBF

Unfortunately, 3GPP forgot to update their specifications with any information as to how the ETWS PN is transmitted from BSC to BTS in a portable way, and Osmocom had to invent their own non-standard signaling for it.

See Section 5.7.17 for the Osmocom implementation.

## 5.6 BCCH carrier power reduction operation

According to 3GPP TS 45.008, section 7.1, the BCCH carrier (sometimes called C0) of a BTS shall maintain discontinuous Downlink transmission at full power in order to stay "visible" to the mobile stations. Because of that, early versions of this 3GPP document prohibited BS power reduction on C0. However, a new feature was introduced version 13.0.0 (2015-11) - "BCCH carrier power reduction operation".

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This is a special mode of operation, in which the variation of RF power level for some timeslots is relaxed for the purpose of energy saving. In other words, the output power on some timeslots, except the timeslot(s) carrying BCCH/CCCH, can be lower than the full power. In this case the maximum allowed difference is 6 dB.

Unfortunately, 3GPP did not specify in which way the BTS is instructed to activate and deactivate the BCCH carrier power reduction mode. Osmocom had to invent their own non-standard approach: the BSC needs to send *BS POWER CONTROL* message with the *Channel Number* IE set to 0x80 (BCCH) and the *Message Discriminator* set to 0x06 (Common Channel Management messages).

## 5.7 Message Formats and Contents

### 5.7.1 Create Connection (CRCX)

This message is sent by the BSC to the BTS to request the creation of a user-plane RTP connection for the specified **Channel number**.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Destination IP Address | Section 5.8.4 | O | TV | 5 |
| Destination IP Port | Section 5.8.5 | O | TV | 3 |
| IP Speech Mode | Section 5.8.7 | O | TV | 2 |
| RTP Payload Type 2 | Section 5.8.11 | O | TV | 2 |
| RTP CSD Format | Section 5.8.16 | O | TV | 2 |

### 5.7.2 Create Connection (CRCX) ACK

This message is sent by the BTS to the BSC to acknowledge the successful outcome of creating a user-plane RTP connection. It is sent in response to the **Create Connection (CRCX)**.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Connection Id | Section 5.8.10 | M | TV | 3 |
| Source IP Address | Section 5.8.8 | O | TV | 5 |
| Source IP Port | Section 5.8.6 | O | TV | 3 |
| RTP Payload Type 2 | Section 5.8.11 | O | TV | 2 |

### 5.7.3 Create Connection (CRCX) NACK

This message is sent by the BTS to the BSC to signal the unsuccessful outcome of creating a user-plane RTP connection. It is sent in response to the **Create Connection (CRCX)**.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Destination IP Address | Section 5.8.4 | O | TV | 5 |
| Destination IP Port | Section 5.8.5 | O | TV | 3 |
| Cause | 48.058 9.3.26 | O | TLV | >= 3 |

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#### 5.7.4 Modify Connection (MDCX)

This message is sent by the BSC to the BTS to modify the properties of a user-plane RTP connection.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Connection Id | Section 5.8.10 | O | TV | 3 |
| Destination IP Address | Section 5.8.4 | O | TV | 5 |
| Destination IP Port | Section 5.8.5 | O | TV | 3 |
| IP Speech Mode | Section 5.8.7 | O | TV | 2 |
| RTP Payload Type 2 | Section 5.8.11 | O | TV | 2 |
| RTP CSD Format | Section 5.8.16 | O | TV | 2 |

#### 5.7.5 Modify Connection (MDCX) ACK

This message is sent by the BTS to the BSC to acknowledge the successful modification of a user-plane RTP connection. It is sent in response to a **Modify Connection (MDCX)**

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Connection Id | Section 5.8.10 | O | TV | 3 |
| Source IP Address | Section 5.8.8 | C | TV | 5 |
| Source IP Port | Section 5.8.6 | C | TV | 3 |
| RTP Payload Type 2 | Section 5.8.11 | O | TV | 2 |

#### 5.7.6 Modify Connection (MDCX) NACK

This message is sent by the BTS to the BSC to signal the unsuccessful outcome of modifying the user-plane RTP connection for the specified Channel number. It is sent in response to the **Modify Connection (MDCX)**.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Cause | 48.058 9.3.26 | M | TLV | >= 3 |

#### 5.7.7 Delete Connection (DLCX) Indication

This message is sent by the BTS to indicate the automatic deletion of a BTS-local UDP connection for user-plane RTP traffic at the time of RF Channel release.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Connection Id | Section 5.8.10 | M | TV | 3 |
| Connection Id | Section 5.8.9 | M | TV | 3 |
| Cause | 48.058 9.3.26 | M | TLV | >= 3 |

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### 5.7.8 Delete Connection (DLCX)

This message is sent by the BSC to the BTS to request the disconnection of a user-plane RTP connection for the specified Channel number.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Connection Id | Section 5.8.10 | O | TV | 3 |

### 5.7.9 Delete Connection (DLCX) ACK

This message is sent by the BTS to signal the successful outcome of deleting the user-plane RTP connection for the specified Channel number. It is sent in response to the **Delete Connection (DLCX)**.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Connection Id | Section 5.8.10 | O | TV | 3 |
| Connection Statistics | Section 5.8.9 | C | TV | 29 |

### 5.7.10 Delete Connection (DLCX) NACK

This message is sent by the BTS to signal the unsuccessful outcome of deleting the user-plane RTP connection for the specified Channel number. It is sent in response to the **Delete Connection (DLCX)**.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Connection Id | Section 5.8.10 | O | TV | 3 |
| Cause | 48.058 9.3.26 | M | TLV | >= 3 |

### 5.7.11 PDCH Activate

This message is sent by the BSC to request the activation of a PDCH on a IPA style dynamic TCH/F+PDCH channel.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |

**NOTE**
This message is **not** used by Osmocom style dynamic channels

### 5.7.12 PDCH Activate ACK

This message is sent by the BTS to confirm the successful activation of a PDCH on a IPA style dynamic TCH/F+PDCH channel.

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| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Frame Number | 48.058 9.3.8 | O | TV | 3 |

**NOTE**
This message is **not** used by Osmocom style dynamic channels

#### 5.7.13 PDCH Activate NACK

This message is sent by the BTS to reject the successful activation of a PDCH on a IPA style dynamic TCH/F+PDCH channel.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Cause | 48.058 9.3.26 | M | TLV | >= 3 |

**NOTE**
This message is **not** used by Osmocom style dynamic channels

#### 5.7.14 PDCH Deactivate

This message is sent by the BSC to request the deactivation of a PDCH on a IPA style dynamic TCH/F+PDCH channel.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |

**NOTE**
This message is **not** used by Osmocom style dynamic channels

#### 5.7.15 PDCH Deactivate ACK

This message is sent by the BTS to confirm the successful deactivation of a PDCH on a IPA style dynamic TCH/F+PDCH channel.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |

**NOTE**
This message is **not** used by Osmocom style dynamic channels

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#### 5.7.16 PDCH Deactivate NACK

This message is sent by the BTS to reject the deactivation of a PDCH on a IPA style dynamic TCH/F+PDCH channel.

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| Cause | 48.058 9.3.26 | M | TLV | >= 3 |

**NOTE**
This message is **not** used by Osmocom style dynamic channels

#### 5.7.17 Osmocom ETWS Command

This message is sent by the BSC to transfer the ETWS Primary Notification (PN) from BSC to BTS and enable/disable transmission of ETWS PN by the BTS. For more information about ETWS, see 3GPP TS 23.041.

If the ETWS PN length is > 0, the BTS will immediately start transmission of the received ETWS PN on the PCH using P1 Rest Octets. It will also forward he ETWS PN to the PCU to enable the PCU to transmit it via PACCH on active TBF.

If the ETWS PN length is 0, the BTS will stop any ETWS PN broadcast via the PCH.

The Channel Number IE is set to the Downlink CCCH (PCH).

| INFORMATION ELEMENT | REFERENCE | PRESENCE | FORMAT | LENGTH |
|---|---|---|---|---|
| Message discriminator | 48.058 9.1 | M | V | 1 |
| Message type | Section 5.8.1 | M | V | 1 |
| Channel number | 48.058 9.3.1 | M | TV | 2 |
| SMSCB Message | 48.058 9.3.42 | M | TLV | 2-58 |

### 5.8 Information Element Codings

#### 5.8.1 A-bis/IP specific RSL Message discriminators

The following message discriminators are used in addition to those indicated in 3GPP TS 48.058 Section 9.1:

Table 73: OsmoBTS specific new message discriminators

| Message Type | Message | This document § |
|---|---|---|
| 0x70 | Create Connection (CRCX) | Section 5.7.1 |
| 0x71 | Create Connection (CRCX) ACK | Section 5.7.2 |
| 0x72 | Create Connection (CRCX) NACK | Section 5.7.3 |
| 0x73 | Modify Connection (MDCX) | Section 5.7.4 |
| 0x74 | Modify Connection (MDCX) ACK | Section 5.7.5 |
| 0x75 | Modify Connection (MDCX) NACK | Section 5.7.6 |
| 0x76 | Delete Connection (DLCX) Indication | Section 5.7.7 |
| 0x77 | Delete Connection (DLCX) | Section 5.7.8 |
| 0x78 | Delete Connection (DLCX) ACK | Section 5.7.9 |
| 0x79 | Delete Connection (DLCX) NACK | Section 5.7.10 |
| 0x7f | Osmocom ETWS Command | Section 5.7.17 |
| 0x48 | PDCH Activate | Section 5.7.11 |
| 0x49 | PDCH Activate ACK | Section 5.7.12 |

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Table 73: (continued)

| Message Type | Message | This document § |
|---|---|---|
| 0x4a | PDCH Activate NACK | Section 5.7.13 |
| 0x4b | PDCH Deactivate | Section 5.7.14 |
| 0x4c | PDCH Deactivate ACK | Section 5.7.15 |
| 0x4d | PDCH Deactivate NACK | Section 5.7.16 |

### 5.8.2 A-bis/IP specific RSL IEIs

The following Information Element Identifiers (IEIs) are used in addition to those indicated in 3GPP TS 48.058 Section 9.3:

Table 74: A-bis/IP specific information elements

| IEI | Name | This document § |
|---|---|---|
| 0x01 | RSL_IE_CHAN_NR | Section 5.8.3 |
| 0x60 | RSL_IE_OSMO_REP_ACCH_CAP | Section 5.8.12 |
| 0x61 | RSL_IE_OSMO_TRAINING_SEQUENCE | Section 5.8.13 |
| 0x62 | RSL_IE_OSMO_TEMP_OVP_ACCH_CAP | Section 5.8.14 |
| 0x63 | RSL_IE_OSMO_OSMUX_CID | Section 5.8.15 |
| 0xf0 | RSL_IE_IPAC_REMOTE_IP | Section 5.8.4 |
| 0xf1 | RSL_IE_IPAC_REMOTE_PORT | Section 5.8.5 |
| 0xf3 | RSL_IE_IPAC_LOCAL_PORT | Section 5.8.6 |
| 0xf4 | RSL_IE_IPAC_SPEECH_MODE | Section 5.8.7 |
| 0xf5 | RSL_IE_IPAC_LOCAL_IP | Section 5.8.8 |
| 0xf6 | RSL_IE_IPAC_CONN_STAT | Section 5.8.9 |
| 0xf8 | RSL_IE_IPAC_CONN_ID | Section 5.8.10 |
| 0xf9 | RSL_IE_IPAC_RTP_CSD_FORMAT | Section 5.8.16 |
| 0xfc | RSL_IE_IPAC_RTP_PAYLOAD2 | Section 5.8.11 |

### 5.8.3 RSL_IE_CHAN_NR

This information element is coded as described in 3GPP TS 48.058 Section 9.3.1, but in addition supports the following vendor specific values:

Table 75: RSL Channel Number extensions

| C5 | C4 | C3 | C2 | C1 | Description |
|---|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 0 | PDCH <1> |
| 1 | 1 | 0 | 0 | 1 | CBCH on SDCCH4 |
| 1 | 1 | 0 | 1 | 0 | CBCH on SDCCH8 |
| 1 | 1 | 1 | 0 | 1 | VAMOS TCH/F <2> |
| 1 | 1 | 1 | 1 | T | VAMOS TCH/H <2> |

<1> This extension is only valid on an Osmocom-style dynamic channel, having configured the *NM_CHANC_IPAC_TCHFull_PDCH* channel combination by OML. <2> These Osmocom specific values are used by osmo-bsc to address logical channels on the shadow timeslots in VAMOS mode, iff the BTS is an osmo-bts and VAMOS capable.

The TN-Bits are not re-defined in this case but use the same encoding as specified in TS 48.058 Section 9.3.1.

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#### 5.8.4 RSL_IE_IPAC_REMOTE_IP

This information element contains the remote (MGW side) IPv4 address in network byte order. It is encoded as fixed-size element with one byte IEI followed by four bytes IPv4 address.

#### 5.8.5 RSL_IE_IPAC_REMOTE_PORT

This information element contains the remote (MGW side) UDP port in network byte order. It is encoded as fixed-size element with one byte IEI followed by two bytes UDP port number.

#### 5.8.6 RSL_IE_IPAC_LOCAL_PORT

This information element contains the local (BTS side) IPv4 address in network byte order. It is encoded as fixed-size element with one byte IEI followed by two bytes UDP port number.

#### 5.8.7 RSL_IE_IPAC_SPEECH_MODE

This information element encodes the speech mode. It is set according to the voice codec used on the connection. It is encoded as a fixed-size element of two bytes, with one byte IEI followed by one byte Speech mode indicator.

Table 76: A-bis/IP Speech Mode Indicator Values

| Value | Description |
|---|---|
| 0x00 | TCH/F with FR codec |
| 0x01 | TCH/F with EFR codec |
| 0x02 | TCH/F with AMR codec |
| 0x03 | TCH/H with HR codec |
| 0x05 | TCH/H with AMR codec |

#### 5.8.8 RSL_IE_IPAC_LOCAL_IP

This information element contains the local (BTS side) IPv4 address in network byte order. It is encoded as fixed-size element with one byte IEI followed by four bytes IPv4 address.

#### 5.8.9 RSL_IE_IPAC_CONN_STAT

This information element contains statistics about the RTP connection.

It is encoded as 30 bytes, with the first byte as IEI, the second byte as length (=28), and 28 bytes fixed-length payload encoded as follows:

Table 77: A-bis/IP Connection Statistics

| Offset | Size | Description |
|---|---|---|
| 0 | 4 | Total number of RTP packets sent |
| 4 | 4 | Total number of octets sent |
| 8 | 4 | Total number of RTP packets received |
| 12 | 4 | Total number of octets received |
| 16 | 4 | Total number of lost packets in Rx direction |
| 20 | 4 | Inter-arrival Jitter |

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Table 77: (continued)

| Offset | Size | Description |
|---|---|---|
| 24 | 4 | Average transmission delay |

All the above values are encoded in network byte order.

A detailed definition of the individual values is given in RFC 1889.

#### 5.8.10 RSL_IE_IPAC_CONN_ID

This IE is a TV with a value length of two bytes. The value is a 16 bit connection ID in network byte order.

#### 5.8.11 RSL_IE_IPAC_RTP_PAYLOAD2

This information element contains the RTP payload identifier, which is used in the PT (Payload Type) field of the RTP header in subsequent transmissions of the RTP flow.

#### 5.8.12 RSL_IE_OSMO_REP_ACCH_CAP

This is a one byte length TLV IE that is used to enable or disable repeated ACCH capabilities on the BTS side during Channel Activation and Mode Modify.

The IE contains a bitfield in the lower nibble in order to set the ACCH repetition policy for each of the two channel types individually. Depending on the state of the bits (see table below) the ACCH repetition mode is either enabled or disabled completely.

The lower 3 bit of the higher nibble are used to signal an RXQUAL threshold to set the BER on which UL-SACCH or DL-FACCH repetition shall be turned on. If the field is set to 0, then UL-SACCH and DL-FACCH will be always on. DL-FACCH will also be turned on automatically as soon as the MS requests a DL-SACCH repetition.

If the IE is not present, then ACCH repetition completely is disabled.

| bit | 7 | 6 - 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|
| byte at offset 0 | 0 | RXQUAL | UL-SACCH | DL-SACCH | DL-FACCH/ALL | DL-FACCH/CMD |

(Bits 7 is reserved for future use and must be set to zero.)

#### 5.8.13 RSL_IE_OSMO_TRAINING_SEQUENCE

This TLV IE instructs the BTS to use a specific training sequence set and training sequence code for a given lchan. It is sent by OsmoBSC in RSL CHANNEL ACTIVATION and MODE MODIFY messages to the BTS, iff the BTS is VAMOS-capable, i.e. if an Abis-over-IP connected BTS indicated BTS_FEAT_VAMOS in the OML BTS features (Manufacturer Id information element, see Section 4.6.22).

If this information element is present, the receiver shall ignore any other training sequence set and training sequence code bits from other information elements of the same RSL message.

This is an Osmocom-specific extension of the RSL layer, which was added to express more than two TSC sets. For VAMOS operation, OsmoBSC selects from one of four separate training sequence codings per modulation scheme, while usual RSL IEs are only able to express a single-bit TSC set number. For clarity, this IE contains both the TSC set and the TSC in one IE, and is defined as overruling any other IEs containing TSC or TSC set numbers.

The first value octet indicates the training sequence set, and the second octet indicates the training sequence code to be used. Receiving values from a reserved value range should be considered an error condition.

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Table 79: RSL_IE_OSMO_TRAINING_SEQUENCE

| IE octet | value |
|---|---|
| octet 1 | RSL_IE_OSMO_TRAINING_SEQUENCE IEI (0x61) |
| octet 2 | length of the value part (2) |
| octet 3 | TSC set |
| octet 4 | TSC |

The training sequence set (TSC set) is coded like the *CS Domain TSC Set* bits, as defined in the *Extended TSC Set* IE in 3GPP TS 44.018 10.5.2.82 [3gpp-ts-44-018], and corresponds to the *TSC Set* as defined in 3GPP TS 45.002 [3gpp-ts-45-002]. The encoded training sequence set number ranges from 0 to 3, any other values are reserved for future use. The encoded 0 corresponds to TSC Set 1, see Table 80.

Table 80: TSC set (octet 3) coding

| octet 3 value | interpretation |
|---|---|
| 0 | *TSC Set 1* as in 3GPP TS 45.002 |
| 1 | *TSC Set 2* |
| 2 | *TSC Set 3* |
| 3 | *TSC Set 4* |
| 4..255 | reserved values |

The training sequence code (TSC) corresponds to the *TSC* bits as defined in the *Channel Description 2* IE in 3GPP TS 44.018 10.5.2.5a [3gpp-ts-44-018]. The training sequence code ranges from 0 to 7, any other values are reserved for future use.

Table 81: TSC (octet 4) coding

| octet 4 value | interpretation |
|---|---|
| 0 | *Training Sequence Code (TSC) 0* as in 3GPP TS 45.002 |
| 1 | *Training Sequence Code (TSC) 1* |
| 2 | *Training Sequence Code (TSC) 2* |
| 3 | *Training Sequence Code (TSC) 3* |
| 4 | *Training Sequence Code (TSC) 4* |
| 5 | *Training Sequence Code (TSC) 5* |
| 6 | *Training Sequence Code (TSC) 6* |
| 7 | *Training Sequence Code (TSC) 7* |
| 8..255 | reserved values |

#### 5.8.14 RSL_IE_OSMO_TEMP_OVP_ACCH_CAP

FIXME: this IE has been defined, but remains to be documented.

#### 5.8.15 RSL_IE_OSMO_OSMUX_CID

FIXME: this IE has been defined, but remains to be documented.

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#### 5.8.16 RSL_IE_IPAC_RTP_CSD_FORMAT

This information element contains the RTP Circuit Switched Data format.

Table 82: A-bis/IP RTP CSD Format

| Offset | Size | Description |
|---|---|---|
| 0 | 4 | RTP CSD Format D |
| 4 | 4 | RTP CSD Format IR |

Table 83: A-bis/IP RTP CSD Format D Values

| Value | Description |
|---|---|
| 0 | External TRAU format |
| 1 | Non-TRAU Packed format |
| 2 | TRAU within the BTS |
| 3 | IWF-Free BTS-BTS Data |

Table 84: A-bis/IP RTP CSD Format IR Values

| Value | Description |
|---|---|
| 0 | 8 kb/s |
| 1 | 16 kb/s |
| 2 | 32 kb/s |
| 3 | 48 kb/s |

## 5.9 A-bis RSL Initialization / BTS bring-up

Upon receiving the *IPA RSL CONNECT* OML message by the respective *Baseband Transceiver* MO, the BTS proceeds with establishing a separate TCP connection for the given TRX.

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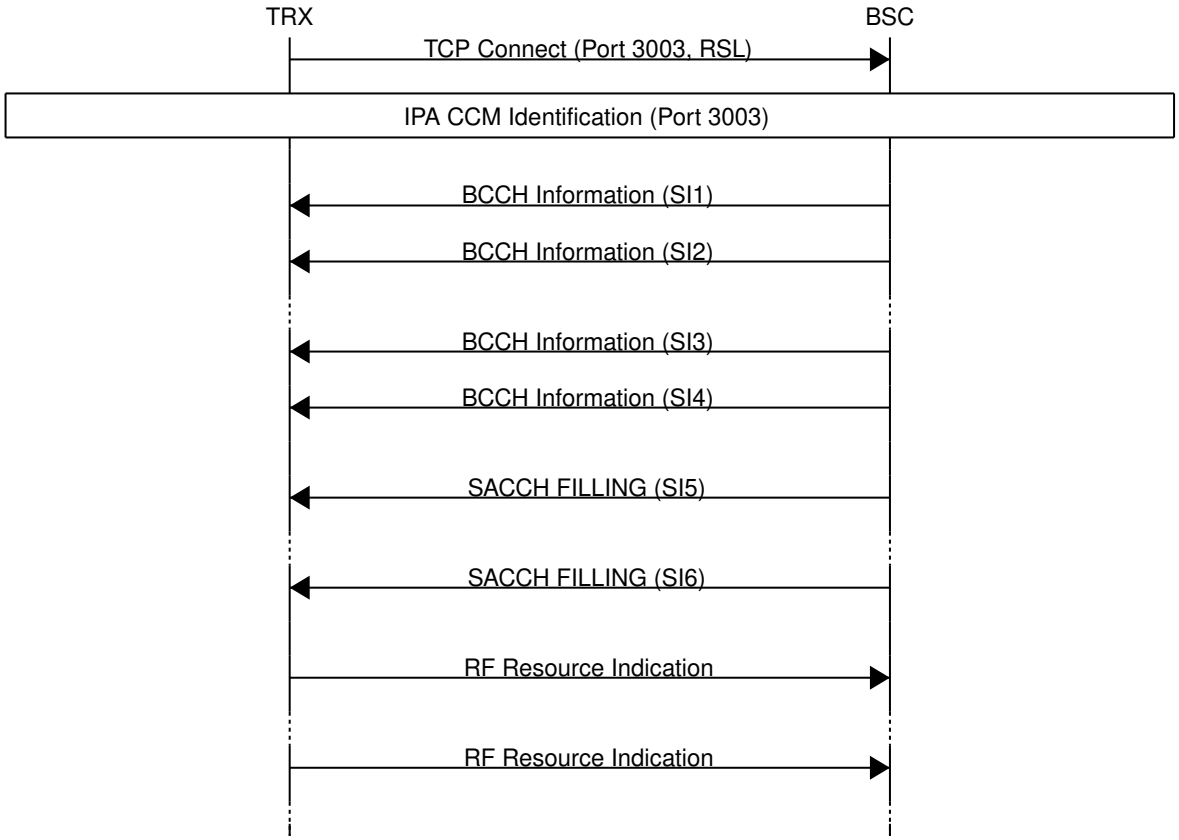



Figure 14: A-bis RSL BTS bring-up for primary TRX

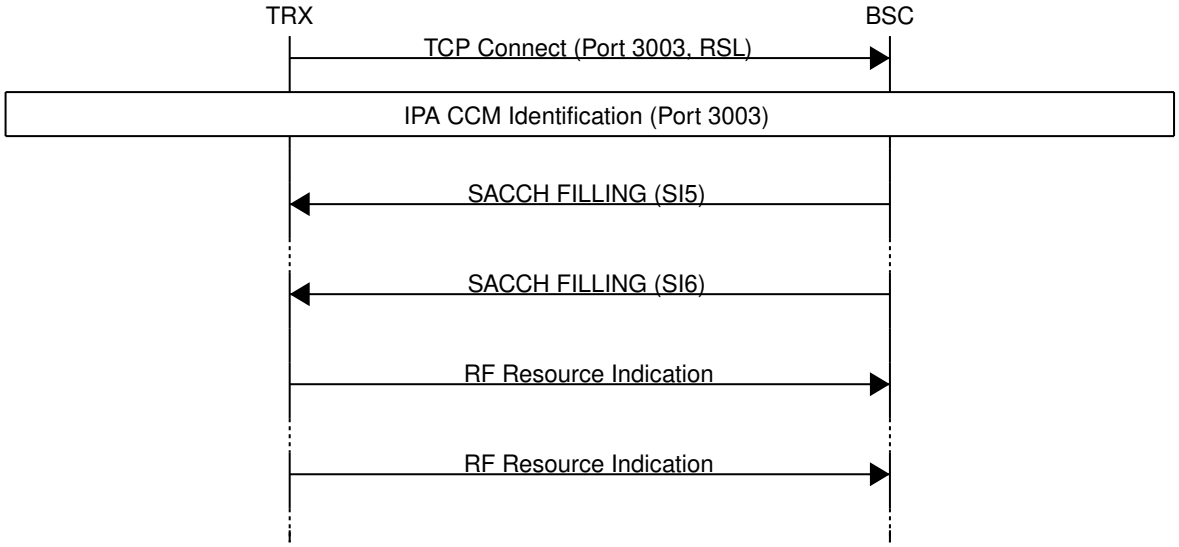



Figure 15: A-bis RSL BTS bring-up for secondary TRXs

The initialization of the primary and secondary TRX slightly differ, as illustrated by the differences of Figure 14 and Figure 15. Since the secondary TRX has no BCCH, it does not (need to) receive any *RSL BCCH INFORMATION* messages from the BSC.

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# 6 User-Plane Traffic via RTP

RTP (Realtime Transfer Protocol) is a protocol for streaming audio and video data. It is specified by IETF RFC 1889.

OsmoBTS A-bis/IP implements RTP as transport medium for circuit-switched user-plane traffic, contrary to the E1 sub-slot based transport specified in 3GPP TS 08.60.

The RTP transport endpoint parameters are configured using the RSL User Plane Transport Management procedures described in Section 5.3.

RTCP is implemented in addition to RTP, on a UDP port number of the RTP port incremented by one.

## 6.1 RTP Payload Formats

The RTP payload format depends on the voice codec used on the radio channel. The OsmoBTS is simply passing the GSM speech frames between the Um radio interface channels and the RTP payload (and vice-versa).

No transcoding function is implemented in the BTS!

Table 85: RTP Payload formats

| TCH | Codec | RTP payload format specification |
|---|---|---|
| TCH/F | FR | IETF RFC 3551 Section 4.5.8 |
| TCH/F | EFR | IETF RFC 3551 Section 4.5.9 |
| TCH/F | AMR | IETF RFC 4867 |
| TCH/H | HR | IETF RFC 5993 |
| TCH/H | AMR | IETF RFC 4867 |

# 7 Glossary

**2FF**
2nd Generation Form Factor; the so-called plug-in SIM form factor

**3FF**
3rd Generation Form Factor; the so-called microSIM form factor

**3GPP**
3rd Generation Partnership Project

**4FF**
4th Generation Form Factor; the so-called nanoSIM form factor

**A Interface**
Interface between BTS and BSC, traditionally over E1 (*3GPP TS 48.008* [3gpp-ts-48-008])

**A3/A8**
Algorithm 3 and 8; Authentication and key generation algorithm in GSM and GPRS, typically COMP128v1/v2/v3 or MILENAGE are typically used

**A5**
Algorithm 5; Air-interface encryption of GSM; currently only A5/0 (no encryption), A5/1 and A5/3 are in use

**Abis Interface**
Interface between BTS and BSC, traditionally over E1 (*3GPP TS 48.058* [3gpp-ts-48-058] and *3GPP TS 52.021* [3gpp-ts-52-021])

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**ACC**
Access Control Class; every BTS broadcasts a bit-mask of permitted ACC, and only subscribers with a SIM of matching ACC are permitted to use that BTS

**AGCH**
Access Grant Channel on Um interface; used to assign a dedicated channel in response to RACH request

**AGPL**
GNU Affero General Public License, a copyleft-style Free Software License

**AQPSK**
Adaptive QPSK, a modulation scheme used by VAMOS channels on Downlink

**ARFCN**
Absolute Radio Frequency Channel Number; specifies a tuple of uplink and downlink frequencies

**AUC**
Authentication Center; central database of authentication key material for each subscriber

**BCCH**
Broadcast Control Channel on Um interface; used to broadcast information about Cell and its neighbors

**BCC**
Base Station Color Code; short identifier of BTS, lower part of BSIC

**BTS**
Base Transceiver Station

**BSC**
Base Station Controller

**BSIC**
Base Station Identity Code; 16bit identifier of BTS within location area

**BSSGP**
Base Station Subsystem Gateway Protocol (*3GPP TS 48.018* [3gpp-ts-48-018])

**BVCI**
BSSGP Virtual Circuit Identifier

**CBC**
Cell Broadcast Centre; central entity of Cell Broadcast service

**CBCH**
Cell Broadcast Channel; used to transmit Cell Broadcast SMS (SMS-CB)

**CBS**
Cell Broadcast Service

**CBSP**
Cell Broadcast Service Protocol (*3GPP TS 48.049* [3gpp-ts-48-049])

**CC**
Call Control; Part of the GSM Layer 3 Protocol

**CCCH**
Common Control Channel on Um interface; consists of RACH (uplink), BCCH, PCH, AGCH (all downlink)

**Cell**
A cell in a cellular network, served by a BTS

**CEPT**
Conférence européenne des administrations des postes et des télécommunications; European Conference of Postal and Telecommunications Administrations.

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**CGI**
Cell Global Identifier comprised of MCC, MNC, LAC and BSIC

**CSFB**
Circiut-Switched Fall Back; Mechanism for switching from LTE/EUTRAN to UTRAN/GERAN when circuit-switched services such as voice telephony are required.

**dB**
deci-Bel; relative logarithmic unit

**dBm**
deci-Bel (milliwatt); unit of measurement for signal strength of radio signals

**DHCP**
Dynamic Host Configuration Protocol (*IETF RFC 2131* [ietf-rfc2131])

**downlink**
Direction of messages / signals from the network core towards the mobile phone

**DSCP**
Differentiated Services Code Point (*IETF RFC 2474* [ietf-rfc2474])

**DSP**
Digital Signal Processor

**dvnixload**
Tool to program UBL and the Bootloader on a sysmoBTS

**EDGE**
Enhanced Data rates for GPRS Evolution; Higher-speed improvement of GPRS; introduces 8PSK

**EGPRS**
Enhanced GPRS; the part of EDGE relating to GPRS services

**EIR**
Equipment Identity Register; core network element that stores and manages IMEI numbers

**ESME**
External SMS Entity; an external application interfacing with a SMSC over SMPP

**ETSI**
European Telecommunications Standardization Institute

**FPGA**
Field Programmable Gate Array; programmable digital logic hardware

**Gb**
Interface between PCU and SGSN in GPRS/EDGE network; uses NS, BSSGP, LLC

**GERAN**
GPRS/EDGE Radio Access Network

**GFDL**
GNU Free Documentation License; a copyleft-style Documentation License

**GGSN**
GPRS Gateway Support Node; gateway between GPRS and external (IP) network

**GMSK**
Gaussian Minimum Shift Keying; modulation used for GSM and GPRS

**GPL**
GNU General Public License, a copyleft-style Free Software License

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**Gp**
Gp interface between SGSN and GGSN; uses GTP protocol

**GPRS**
General Packet Radio Service; the packet switched 2G technology

**GPS**
Global Positioning System; provides a highly accurate clock reference besides the global position

**GSM**
Global System for Mobile Communications. ETSI/3GPP Standard of a 2G digital cellular network

**GSMTAP**
GSM tap; pseudo standard for encapsulating GSM protocol layers over UDP/IP for analysis

**GSUP**
Generic Subscriber Update Protocol. Osmocom-specific alternative to TCAP/MAP

**GT**
Global Title; an address in SCCP

**GTP**
GPRS Tunnel Protocol; used between SGSN and GGSN

**HLR**
Home Location Register; central subscriber database of a GSM network

**HNB-GW**
Home NodeB Gateway. Entity between femtocells (Home NodeB) and CN in 3G/UMTS.

**HPLMN**
Home PLMN; the network that has issued the subscriber SIM and has his record in HLR

**IE**
Information Element

**IMEI**
International Mobile Equipment Identity; unique 14-digit decimal number to globally identify a mobile device, optionally with a 15th checksum digit

**IMEISV**
IMEI software version; unique 14-digit decimal number to globally identify a mobile device (same as IMEI) plus two software version digits (total digits: 16)

**IMSI**
International Mobile Subscriber Identity; 15-digit unique identifier for the subscriber/SIM; starts with MCC/MNC of issuing operator

**IP**
Internet Protocol (*IETF RFC 791* [ietf-rfc791])

**IPA**
*ip.access GSM over IP* protocol; used to multiplex a single TCP connection

**Iu**
Interface in 3G/UMTS between RAN and CN

**IuCS**
Iu interface for circuit-switched domain. Used in 3G/UMTS between RAN and MSC

**IuPS**
Iu interface for packet-switched domain. Used in 3G/UMTS between RAN and SGSN

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**LAC**
Location Area Code; 16bit identifier of Location Area within network

**LAPD**
Link Access Protocol, D-Channel (*ITU-T Q.921* [itu-t-q921])

**LAPDm**
Link Access Protocol Mobile (*3GPP TS 44.006* [3gpp-ts-44-006])

**LLC**
Logical Link Control; GPRS protocol between MS and SGSN (*3GPP TS 44.064* [3gpp-ts-44-064])

**Location Area**
Location Area; a geographic area containing multiple BTS

**LU**
Location Updating; can be of type IMSI-Attach or Periodic. Procedure that indicates a subscriber's physical presence in a given radio cell.

**M2PA**
MTP2 Peer-to-Peer Adaptation; a SIGTRAN Variant (*RFC 4165* [ietf-rfc4165])

**M2UA**
MTP2 User Adaptation; a SIGTRAN Variant (*RFC 3331* [ietf-rfc3331])

**M3UA**
MTP3 User Adaptation; a SIGTRAN Variant (*RFC 4666* [ietf-rfc4666])

**MCC**
Mobile Country Code; unique identifier of a country, e.g. 262 for Germany

**MFF**
Machine-to-Machine Form Factor; a SIM chip package that is soldered permanently onto M2M device circuit boards.

**MGW**
Media Gateway

**MM**
Mobility Management; part of the GSM Layer 3 Protocol

**MNC**
Mobile Network Code; identifies network within a country; assigned by national regulator

**MNCC**
Mobile Network Call Control; Unix domain socket based Interface between MSC and external call control entity like osmo-sip-connector

**MNO**
Mobile Network Operator; operator with physical radio network under his MCC/MNC

**MO**
Mobile Originated. Direction from Mobile (MS/UE) to Network

**MS**
Mobile Station; a mobile phone / GSM Modem

**MSC**
Mobile Switching Center; network element in the circuit-switched core network

**MSC pool**
A number of redundant MSCs serving the same core network, which a BSC / RNC distributes load across; see also the "MSC Pooling" chapter in OsmoBSC's user manual [userman-osmobsc] and *3GPP TS 23.236* [3gpp-ts-23-236]

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**MSISDN**
Mobile Subscriber ISDN Number; telephone number of the subscriber

**MT**
Mobile Terminated. Direction from Network to Mobile (MS/UE)

**MTP**
Message Transfer Part; SS7 signaling protocol (*ITU-T Q.701* [itu-t-q701])

**MVNO**
Mobile Virtual Network Operator; Operator without physical radio network

**NCC**
Network Color Code; assigned by national regulator

**NITB**
Network In The Box; combines functionality traditionally provided by BSC, MSC, VLR, HLR, SMSC functions; see OsmoNITB

**NRI**
Network Resource Indicator, typically 10 bits of a TMSI indicating which MSC of an MSC pool attached the subscriber; see also the "MSC Pooling" chapter in OsmoBSC's user manual [userman-osmobsc] and *3GPP TS 23.236* [3gpp-ts-23-236]

**NSEI**
NS Entity Identifier

**NVCI**
NS Virtual Circuit Identifier

**NWL**
Network Listen; ability of some BTS to receive downlink from other BTSs

**NS**
Network Service; protocol on Gb interface (*3GPP TS 48.016* [3gpp-ts-48-016])

**OCXO**
Oven Controlled Crystal Oscillator; very high precision oscillator, superior to a VCTCXO

**OML**
Operation & Maintenance Link (ETSI/*3GPP TS 52.021* [3gpp-ts-52-021])

**OpenBSC**
Open Source implementation of GSM network elements, specifically OsmoBSC, OsmoNITB, OsmoSGSN

**OpenGGSN**
Open Source implementation of a GPRS Packet Control Unit

**OpenVPN**
Open-Source Virtual Private Network; software employed to establish encrypted private networks over untrusted public networks

**Osmocom**
Open Source MObile COMmunications; collaborative community for implementing communications protocols and systems, including GSM, GPRS, TETRA, DECT, GMR and others

**OsmoBSC**
Open Source implementation of a GSM Base Station Controller

**OsmoNITB**
Open Source implementation of a GSM Network In The Box, combines functionality traditionally provided by BSC, MSC, VLR, HLR, AUC, SMSC

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**OsmoSGSN**
Open Source implementation of a Serving GPRS Support Node

**OsmoPCU**
Open Source implementation of a GPRS Packet Control Unit

**OTA**
Over-The-Air; Capability of operators to remotely reconfigure/reprogram ISM/USIM cards

**PC**
Point Code; an address in MTP

**PCH**
Paging Channel on downlink Um interface; used by network to page an MS

**PCP**
Priority Code Point (*IEEE 802.1Q* [?])

**PCU**
Packet Control Unit; used to manage Layer 2 of the GPRS radio interface

**PDCH**
Packet Data Channel on Um interface; used for GPRS/EDGE signalling + user data

**PIN**
Personal Identification Number; a number by which the user authenticates to a SIM/USIM or other smart card

**PLMN**
Public Land Mobile Network; specification language for a single GSM network

**PUK**
PIN Unblocking Code; used to unblock a blocked PIN (after too many wrong PIN attempts)

**RAC**
Routing Area Code; 16bit identifier for a Routing Area within a Location Area

**RACH**
Random Access Channel on uplink Um interface; used by MS to request establishment of a dedicated channel

**RAM**
Remote Application Management; Ability to remotely manage (install, remove) Java Applications on SIM/USIM Card

**RF**
Radio Frequency

**RFM**
Remote File Management; Ability to remotely manage (write, read) files on a SIM/USIM card

**Roaming**
Procedure in which a subscriber of one network is using the radio network of another network, often in different countries; in some countries national roaming exists

**Routing Area**
Routing Area; GPRS specific sub-division of Location Area

**RR**
Radio Resources; Part of the GSM Layer 3 Protocol

**RSL**
Radio Signalling Link (*3GPP TS 48.058* [3gpp-ts-48-058])

**RTP**
Real-Time Transport Protocol (*IETF RFC 3550* [ietf-rfc3550]); Used to transport audio/video streams over UDP/IP

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**SACCH**
Slow Associate Control Channel on Um interface; bundled to a TCH or SDCCH, used for signalling in parallel to active dedicated channel

**SCCP**
Signaling Connection Control Part; SS7 signaling protocol (*ITU-T Q.711* [itu-t-q711])

**SDCCH**
Slow Dedicated Control Channel on Um interface; used for signalling and SMS transport in GSM

**SDK**
Software Development Kit

**SGs**
Interface between MSC (GSM/UMTS) and MME (LTE/EPC) to facilitate CSFB and SMS.

**SGSN**
Serving GPRS Support Node; Core network element for packet-switched services in GSM and UMTS.

**SIGTRAN**
Signaling Transport over IP (*IETF RFC 2719* [ietf-rfc2719])

**SIM**
Subscriber Identity Module; small chip card storing subscriber identity

**Site**
A site is a location where one or more BTSs are installed, typically three BTSs for three sectors

**SMPP**
Short Message Peer-to-Peer; TCP based protocol to interface external entities with an SMSC

**SMSC**
Short Message Service Center; store-and-forward relay for short messages

**SS7**
Signaling System No. 7; Classic digital telephony signaling system

**SS**
Supplementary Services; query and set various service parameters between subscriber and core network (e.g. USSD, 3rd-party calls, hold/retrieve, advice-of-charge, call deflection)

**SSH**
Secure Shell; *IETF RFC 4250* [ietf-rfc4251] to 4254

**SSN**
Sub-System Number; identifies a given SCCP Service such as MSC, HLR

**STP**
Signaling Transfer Point; A Router in SS7 Networks

**SUA**
SCCP User Adaptation; a SIGTRAN Variant (*RFC 3868* [ietf-rfc3868])

**syslog**
System logging service of UNIX-like operating systems

**System Information**
A set of downlink messages on the BCCH and SACCH of the Um interface describing properties of the cell and network

**TCH**
Traffic Channel; used for circuit-switched user traffic (mostly voice) in GSM

**TCP**
Transmission Control Protocol; (*IETF RFC 793* [ietf-rfc793])

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**TFTP**
Trivial File Transfer Protocol; (*IETF RFC 1350* [ietf-rfc1350])

**TOS**
Type Of Service; bit-field in IPv4 header, now re-used as DSCP (*IETF RFC 791* [ietf-rfc791])

**TRX**
Transceiver; element of a BTS serving a single carrier

**TS**
Technical Specification

**u-Boot**
Boot loader used in various embedded systems

**UBI**
An MTD wear leveling system to deal with NAND flash in Linux

**UBL**
Initial bootloader loaded by the TI Davinci SoC

**UDP**
User Datagram Protocol (*IETF RFC 768* [ietf-rfc768])

**UICC**
Universal Integrated Chip Card; A smart card according to *ETSI TR 102 216* [etsi-tr102216]

**Um interface**
U mobile; Radio interface between MS and BTS

**uplink**
Direction of messages: Signals from the mobile phone towards the network

**USIM**
Universal Subscriber Identity Module; application running on a UICC to provide subscriber identity for UMTS and GSM networks

**USSD**
Unstructured Supplementary Service Data; textual dialog between subscriber and core network, e.g. **100 → Your extension is 1234*

**VAMOS**
Voice services over Adaptive Multi-user channels on One Slot; an optional extension for GSM specified in Release 9 of 3GPP GERAN specifications (*3GPP TS 48.018* [3gpp-ts-48-018]) allowing two independent UEs to transmit and receive simultaneously on traffic channels

**VCTCXO**
Voltage Controlled, Temperature Compensated Crystal Oscillator; a precision oscillator, superior to a classic crystal oscillator, but inferior to an OCXO

**VLAN**
Virtual LAN in the context of Ethernet (*IEEE 802.1Q* [ieee-802.1q])

**VLR**
Visitor Location Register; volatile storage of attached subscribers in the MSC

**VPLMN**
Visited PLMN; the network in which the subscriber is currently registered; may differ from HPLMN when on roaming

**VTY**
Virtual TeletYpe; a textual command-line interface for configuration and introspection, e.g. the OsmoBSC configuration file as well as its telnet link on port 4242

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# A Osmocom TCP/UDP Port Numbers

The Osmocom GSM system utilizes a variety of TCP/IP based protocols. The table below provides a reference as to which port numbers are used by which protocol / interface.

Table 86: TCP/UDP port numbers

| L4 Protocol | Port Number | Purpose | Software |
|---|---|---|---|
| UDP | 1984 | Osmux | osmo-mgw, osmo-bts |
| UDP | 2427 | MGCP GW | osmo-bsc_mgcp, osmo-mgw |
| TCP | 2775 | SMPP (SMS interface for external programs) | osmo-nitb |
| TCP | 3002 | A-bis/IP OML | osmo-bts, osmo-bsc, osmo-nitb |
| TCP | 3003 | A-bis/IP RSL | osmo-bts, osmo-bsc, osmo-nitb |
| TCP | 4227 | telnet (VTY) | osmo-pcap-client |
| TCP | 4228 | telnet (VTY) | osmo-pcap-server |
| TCP | 4236 | Control Interface | osmo-trx |
| TCP | 4237 | telnet (VTY) | osmo-trx |
| TCP | 4238 | Control Interface | osmo-bts |
| TCP | 4239 | telnet (VTY) | osmo-stp |
| TCP | 4240 | telnet (VTY) | osmo-pcu |
| TCP | 4241 | telnet (VTY) | osmo-bts |
| TCP | 4242 | telnet (VTY) | osmo-nitb, osmo-bsc, cellmgr-ng |
| TCP | 4243 | telnet (VTY) | osmo-bsc_mgcp, osmo-mgw |
| TCP | 4244 | telnet (VTY) | osmo-bsc_nat |
| TCP | 4245 | telnet (VTY) | osmo-sgsn |
| TCP | 4246 | telnet (VTY) | osmo-gbproxy |
| TCP | 4247 | telnet (VTY) | OsmocomBB |
| TCP | 4249 | Control Interface | osmo-nitb, osmo-bsc |
| TCP | 4250 | Control Interface | osmo-bsc_nat |
| TCP | 4251 | Control Interface | osmo-sgsn |
| TCP | 4252 | telnet (VTY) | sysmobts-mgr |
| TCP | 4253 | telnet (VTY) | osmo-gtphub |
| TCP | 4254 | telnet (VTY) | osmo-msc |
| TCP | 4255 | Control Interface | osmo-msc |
| TCP | 4256 | telnet (VTY) | osmo-sip-connector |
| TCP | 4257 | Control Interface | osmo-ggsn, ggsn (OpenGGSN) |
| TCP | 4258 | telnet (VTY) | osmo-hlr |
| TCP | 4259 | Control Interface | osmo-hlr |
| TCP | 4260 | telnet (VTY) | osmo-ggsn |
| TCP | 4261 | telnet (VTY) | osmo-hnbgw |
| TCP | 4262 | Control Interface | osmo-hnbgw |
| TCP | 4263 | Control Interface | osmo-gbproxy |
| TCP | 4264 | telnet (VTY) | osmo-cbc |
| TCP | 4265 | Control Interface | osmo-cbc |
| TCP | 4266 | D-GSM MS Lookup: mDNS serve | osmo-hlr |
| TCP | 4267 | Control Interface | osmo-mgw |
| TCP | 4268 | telnet (VTY) | osmo-uecups |
| SCTP | 4268 | UECUPS | osmo-uecups |
| TCP | 4269 | telnet (VTY) | osmo-e1d |
| TCP | 4270 | telnet (VTY) | osmo-isdntap |
| TCP | 4271 | telnet (VTY) | osmo-smlc |
| TCP | 4272 | Control Interface | osmo-smlc |
| TCP | 4273 | telnet (VTY) | osmo-hnodeb |
| TCP | 4274 | Control Interface | osmo-hnodeb |

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Table 86: (continued)

| L4 Protocol | Port Number | Purpose | Software |
|---|---|---|---|
| TCP | 4275 | telnet (VTY) | osmo-upf |
| TCP | 4276 | Control Interface | osmo-upf |
| TCP | 4277 | telnet (VTY) | osmo-pfcp-tool |
| TCP | 4278 | Control Interface | osmo-pfcp-tool |
| UDP | 4729 | GSMTAP | Almost every osmocom project |
| TCP | 5000 | A/IP | osmo-bsc, osmo-bsc_nat |
| UDP | 23000 | GPRS-NS over IP default port | osmo-pcu, osmo-sgsn, osmo-gbproxy |
| TCP | 48049 | BSC-CBC (CBSP) default port | osmo-bsc, osmo-cbc |

# B Bibliography / References

#### B.0.0.0.1 References


[1] [userman-ice1usb] Osmocom Project: icE1usb User Manual.

[2] [userman-ogt] Pau Espin: osmo-gsm-tester User Manual.

[3] [userman-remsim] Harald Welte: osmo-remsim User Manual.

[4] [osmobts-abis-spec] Neels Hofmeyr & Harald Welte. OsmoBTS Abis Protocol Specification. https://ftp.osmocom.org/docs/latest/osmobts-abis.pdf

[5] [userman-osmobsc] Osmocom Project: OsmoBSC User Manual. https://ftp.osmocom.org/docs/latest/osmobsc-usermanual.pdf

[6] [vty-ref-osmobsc] Osmocom Project: OsmoBSC VTY Reference Manual. https://ftp.osmocom.org/docs/-latest/osmobsc-vty-reference.pdf

[7] [userman-osmobts] Osmocom Project: OsmoBTS User Manual. https://ftp.osmocom.org/docs/latest/osmobts-usermanual.pdf

[8] [vty-ref-osmobts] Osmocom Project: OsmoBTS VTY Reference Manual. https://ftp.osmocom.org/docs/-latest/osmobts-trx-vty-reference.pdf https://ftp.osmocom.org/docs/latest/osmobts-sysmo-vty-reference.pdf https://ftp.osmocom.org/docs/latest/osmobts-lc15-vty-reference.pdf https://ftp.osmocom.org/docs/latest/-osmobts-oc2g-vty-reference.pdf https://ftp.osmocom.org/docs/latest/osmobts-octphy-vty-reference.pdf https://ftp.osmocom.org/docs/latest/osmobts-virtual-vty-reference.pdf

[9] [userman-osmocbc] Osmocom Project: OsmoCBC User Manual. https://ftp.osmocom.org/docs/latest/-osmocbc-usermanual.pdf

[10] [vty-ref-osmocbc] Osmocom Project: OsmoCBC VTY Reference Manual. https://ftp.osmocom.org/docs/-latest/osmocbc-vty-reference.pdf

[11] [userman-osmogbproxy] Osmocom Project: OsmoGBProxy User Manual. https://ftp.osmocom.org/docs/-latest/osmogbproxy-usermanual.pdf

[12] [vty-ref-osmogbproxy] Osmocom Project: OsmoGBPRoxy VTY Reference Manual. https://ftp.osmocom.org/-docs/latest/osmogbproxy-vty-reference.pdf

[13] [userman-osmoggsn] Osmocom Project: OpenGGSN User Manual. https://ftp.osmocom.org/docs/latest/-osmoggsn-usermanual.pdf

[14] [vty-ref-osmoggsn] Osmocom Project: OsmoGGSN VTY Reference Manual. https://ftp.osmocom.org/docs/-latest/osmoggsn-vty-reference.pdf


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[15] [userman-osmohlr] Osmocom Project: OsmoHLR User Manual. https://ftp.osmocom.org/docs/latest/osmohlr-usermanual.pdf

[16] [vty-ref-osmohlr] Osmocom Project: OsmoHLR VTY Reference Manual. https://ftp.osmocom.org/docs/latest/-osmohlr-vty-reference.pdf

[17] [userman-osmohnbgw] Osmocom Project: OsmoHNBGW User Manual. https://ftp.osmocom.org/docs/latest/-osmohnbgw-usermanual.pdf

[18] [vty-ref-osmohnbgw] Osmocom Project: OsmoHNBGW VTY Reference Manual. https://ftp.osmocom.org/-docs/latest/osmohnbgw-vty-reference.pdf

[19] [userman-osmomgw] Osmocom Project: OsmoMGW User Manual. https://ftp.osmocom.org/docs/latest/-osmomgw-usermanual.pdf

[20] [vty-ref-osmomgw] Osmocom Project: OsmoMGW VTY Reference Manual. https://ftp.osmocom.org/docs/-latest/osmomgw-vty-reference.pdf

[21] [userman-osmomsc] Osmocom Project: OsmoMSC User Manual. https://ftp.osmocom.org/docs/latest/-osmomsc-usermanual.pdf

[22] [vty-ref-osmomsc] Osmocom Project: OsmoMSC VTY Reference Manual. https://ftp.osmocom.org/docs/-latest/osmomsc-vty-reference.pdf

[23] [userman-osmonitb] Osmocom Project: OsmoNITB User Manual. https://ftp.osmocom.org/docs/latest/-osmonitb-usermanual.pdf

[24] [vty-ref-osmonitb] Osmocom Project: OsmoNITB VTY Reference Manual. https://ftp.osmocom.org/docs/-latest/osmonitb-vty-reference.pdf

[25] [userman-osmopcu] Osmocom Project: OsmoPCU User Manual. https://ftp.osmocom.org/docs/latest/-osmopcu-usermanual.pdf

[26] [vty-ref-osmopcu] Osmocom Project: OsmoPCU VTY Reference Manual. https://ftp.osmocom.org/docs/-latest/osmopcu-vty-reference.pdf

[27] [userman-osmosgsn] Osmocom Project: OsmoSGSN User Manual. https://ftp.osmocom.org/docs/latest/-osmosgsn-usermanual.pdf

[28] [vty-ref-osmosgsn] Osmocom Project: OsmoSGSN VTY Reference Manual. https://ftp.osmocom.org/docs/-latest/osmosgsn-vty-reference.pdf

[29] [userman-osmosipconnector] Osmocom Project: OsmoSIPconnector User Manual. https://ftp.osmocom.org/-docs/latest/osmosipconnector-usermanual.pdf

[30] [vty-ref-osmosipconnector] Osmocom Project: OsmoSIPconnector VTY Reference Manual. https://ftp.osmocom.org/docs/latest/osmosipconnector-vty-reference.pdf

[31] [userman-osmosmlc] Osmocom Project: OsmoSMLC User Manual. https://ftp.osmocom.org/docs/latest/-osmosmlc-usermanual.pdf

[32] [vty-ref-osmosmlc] Osmocom Project: OsmoSMLC VTY Reference Manual. https://ftp.osmocom.org/docs/-latest/osmosmlc-vty-reference.pdf

[33] [userman-osmostp] Osmocom Project: OsmoSTP User Manual. https://ftp.osmocom.org/docs/latest/osmostp-usermanual.pdf

[34] [vty-ref-osmostp] Osmocom Project: OsmoSTP VTY Reference Manual. https://ftp.osmocom.org/docs/latest/-osmostp-vty-reference.pdf

[35] [userman-osmotrx] Osmocom Project: OsmoTRX User Manual. https://ftp.osmocom.org/docs/latest/osmotrx-usermanual.pdf

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[36] [vty-ref-osmotrx] Osmocom Project: OsmoTRX VTY Reference Manual. https://ftp.osmocom.org/docs/-latest/osmotrx-uhd-vty-reference.pdf https://ftp.osmocom.org/docs/latest/osmotrx-lms-vty-reference.pdf https://ftp.osmocom.org/docs/latest/osmotrx-ipc-vty-reference.pdf https://ftp.osmocom.org/docs/latest/-osmotrx-usrp1-vty-reference.pdf

[37] [3gpp-ts-23-041] 3GPP TS 23.041: Technical realization of Cell Broadcast Service (CBS)

[38] [3gpp-ts-23-048] 3GPP TS 23.048: Security mechanisms for the (U)SIM application toolkit; Stage 2 https://www.3gpp.org/DynaReport/23048.htm

[39] [3gpp-ts-23-236] 3GPP TS 23.236: Intra-domain connection of Radio Access Network (RAN) nodes to multiple Core Network (CN) nodes https://www.3gpp.org/DynaReport/23236.htm

[40] [3gpp-ts-24-007] 3GPP TS 24.007: Mobile radio interface signalling layer 3; General Aspects https://www.3gpp.org/DynaReport/24007.htm

[41] [3gpp-ts-24-008] 3GPP TS 24.008: Mobile radio interface Layer 3 specification; Core network protocols; Stage 3. https://www.3gpp.org/dynareport/24008.htm

[42] [3gpp-ts-31-101] 3GPP TS 31.101: UICC-terminal interface; Physical and logical characteristics https://www.3gpp.org/DynaReport/31101.htm

[43] [3gpp-ts-31-102] 3GPP TS 31.102: Characteristics of the Universal Subscriber Identity Module (USIM) application https://www.3gpp.org/DynaReport/31102.htm

[44] [3gpp-ts-31-103] 3GPP TS 31.103: Characteristics of the IMS Subscriber Identity Module (ISIM) application https://www.3gpp.org/DynaReport/31103.htm

[45] [3gpp-ts-31-111] 3GPP TS 31.111: Universal Subscriber Identity Module (USIM) Application Toolkit (USAT) https://www.3gpp.org/DynaReport/31111.htm

[46] [3gpp-ts-31-115] 3GPP TS 31.115: Secured packet structure for (Universal) Subscriber Identity Module (U)SIM Toolkit applications https://www.3gpp.org/DynaReport/31115.htm

[47] [3gpp-ts-31-116] 3GPP TS 31.116: Remote APDU Structure for (U)SIM Toolkit applications https://www.3gpp.org/DynaReport/31116.htm

[48] [3gpp-ts-35-205] 3GPP TS 35.205: 3G Security; Specification of the MILENAGE algorithm set: General

[49] [3gpp-ts-35-206] 3GPP TS 35.206: 3G Security; Specification of the MILENAGE algorithm set: Algorithm specification https://www.3gpp.org/DynaReport/35206.htm

[50] [3gpp-ts-44-006] 3GPP TS 44.006: Mobile Station - Base Station System (MS - BSS) interface; Data Link (DL) layer specification https://www.3gpp.org/DynaReport/44006.htm

[51] [3gpp-ts-44-018] 3GPP TS 44.018: Mobile radio interface layer 3 specification; Radio Resource Control (RRC) protocol https://www.3gpp.org/DynaReport/44018.htm

[52] [3gpp-ts-44-064] 3GPP TS 44.064: Mobile Station - Serving GPRS Support Node (MS-SGSN); Logical Link Control (LLC) Layer Specification https://www.3gpp.org/DynaReport/44064.htm

[53] [3gpp-ts-45-002] 3GPP TS 45.002: Digital cellular telecommunications system (Phase 2+) (GSM); GSM/EDGE Multiplexing and multiple access on the radio path https://www.3gpp.org/DynaReport/45002.htm

[54] [3gpp-ts-48-008] 3GPP TS 48.008: Mobile Switching Centre - Base Station system (MSC-BSS) interface; Layer 3 specification https://www.3gpp.org/DynaReport/48008.htm

[55] [3gpp-ts-48-016] 3GPP TS 48.016: General Packet Radio Service (GPRS); Base Station System (BSS) - Serving GPRS Support Node (SGSN) interface; Network service https://www.3gpp.org/DynaReport/48016.htm

[56] [3gpp-ts-48-018] 3GPP TS 48.018: General Packet Radio Service (GPRS); Base Station System (BSS) - Serving GPRS Support Node (SGSN); BSS GPRS protocol (BSSGP) https://www.3gpp.org/DynaReport/48018.htm

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[57] [3gpp-ts-48-049] 3GPP TS 48.049: Digital cellular communications system; Base Station Controller - Cell Broadcast Centre (BSC-CBC) interface specification; Cell Broadcast Service Protocol (CBSP) https://www.3gpp.org/DynaReport/48049.htm

[58] [3gpp-ts-48-056] 3GPP TS 48.056: Base Station Controller - Base Transceiver Station (BSC - BTS) interface; Layer 2 specification https://www.3gpp.org/DynaReport/48056.htm

[59] [3gpp-ts-48-058] 3GPP TS 48.058: Base Station Controller - Base Transceiver Station (BSC - BTS) Interface; Layer 3 specification https://www.3gpp.org/DynaReport/48058.htm

[60] [3gpp-ts-51-011] 3GPP TS 51.011: Specification of the Subscriber Identity Module - Mobile Equipment (SIM-ME) interface

[61] [3gpp-ts-51-014] 3GPP TS 51.014: Specification of the SIM Application Toolkit for the Subscriber Identity Module - Mobile Equipment (SIM - ME) interface https://www.3gpp.org/DynaReport/51014.htm

[62] [3gpp-ts-52-021] 3GPP TS 52.021: Network Management (NM) procedures and messages on the A-bis interface https://www.3gpp.org/DynaReport/52021.htm

[63] [etsi-tr102216] ETSI TR 102 216: Smart cards https://www.etsi.org/deliver/etsi_tr/102200_102299/102216/03.00.00_60/tr_102216v030000p.pdf

[64] [etsi-ts102221] ETSI TS 102 221: Smart Cards; UICC-Terminal interface; Physical and logical characteristics https://www.etsi.org/deliver/etsi_ts/102200_102299/102221/13.01.00_60/ts_102221v130100p.pdf

[65] [etsi-ts101220] ETSI TS 101 220: Smart Cards; ETSI numbering system for telecommunication application providers https://www.etsi.org/deliver/etsi_ts/101200_101299/101220/12.00.00_60/ts_101220v120000p.pdf

[66] [etsi-ts102671] ETSI TS 102 671: Smart Cards; Machine to Machine UICC; Physical and logical characteristics https://www.etsi.org/deliver/etsi_ts/102600_102699/102671/18.01.00_60/ts_102671v180100p.pdf

[67] [ieee-802.1q] IEEE 802.1Q: Bridges and Bridged Networks https://ieeexplore.ieee.org/document/6991462

[68] [ietf-rfc768] IETF RFC 768: User Datagram Protocol https://tools.ietf.org/html/rfc768

[69] [ietf-rfc791] IETF RFC 791: Internet Protocol https://tools.ietf.org/html/rfc791

[70] [ietf-rfc793] IETF RFC 793: Transmission Control Protocol https://tools.ietf.org/html/rfc793

[71] [ietf-rfc1035] IETF RFC 1035: Domain Names - Implementation and Specification https://tools.ietf.org/html/rfc1035

[72] [ietf-rfc1350] IETF RFC 1350: Trivial File Transfer Protocol https://tools.ietf.org/html/rfc1350

[73] [ietf-rfc2131] IETF RFC 2131: Dynamic Host Configuration Protocol https://tools.ietf.org/html/rfc2131

[74] [ietf-rfc2474] IETF RFC 2474: Definition of the Differentiated Services Field (DS Field) in the IPv44 and IPv6 Headers https://tools.ietf.org/html/rfc2474

[75] [ietf-rfc2719] IETF RFC 2719: Signal Transport over IP https://tools.ietf.org/html/rfc2719

[76] [ietf-rfc3331] IETF RFC 3331: Message Transfer Part 2 User Adaptation Layer https://tools.ietf.org/html/rfc3331

[77] [ietf-rfc3550] IETF RFC 3550: RTP: A Transport protocol for Real-Time Applications https://tools.ietf.org/html/rfc3550

[78] [ietf-rfc3596] IETF RFC 3596: DNS Extensions to Support IP Version 6 https://tools.ietf.org/html/rfc3596

[79] [ietf-rfc3868] IETF RFC 3868: SCCP User Adaptation Layer https://tools.ietf.org/html/rfc3868

[80] [ietf-rfc4165] IETF RFC 4165: Message Transfer Part 2 Peer-to-Peer Adaptation Layer https://tools.ietf.org/html/rfc4165

[81] [ietf-rfc4251] IETF RFC 4251: The Secure Shell (SSH) Protocol Architecture https://tools.ietf.org/html/rfc4251

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[82] [ietf-rfc4666] IETF RFC 4666: Message Transfer Part 3 User Adaptation Layer https://tools.ietf.org/html/-rfc4666

[83] [ietf-rfc5771] IETF RFC 5771: IANA Guidelines for IPv4 Multicast Address Assignments https://tools.ietf.org/html/rfc5771

[84] [itu-t-q701] ITU-T Q.701: Functional Description of the Message Transfer Part (MTP) https://www.itu.int/rec/-T-REC-Q.701/en/

[85] [itu-t-q711] ITU-T Q.711: Functional Description of the Signalling Connection Control Part https://www.itu.int/rec/T-REC-Q.711/en/

[86] [itu-t-q713] ITU-T Q.713: Signalling connection control part formats and codes https://www.itu.int/rec/T-REC-Q.713/en/

[87] [itu-t-q714] ITU-T Q.714: Signalling connection control part procedures https://www.itu.int/rec/T-REC-Q.714/en/

[88] [itu-t-q921] ITU-T Q.921: ISDN user-network interface - Data link layer specification https://www.itu.int/rec/-T-REC-Q.921/en

[89] [smpp-34] SMPP Develoepers Forum. Short Message Peer-to-Peer Protocol Specification v3.4 https://docs.nimta.com/SMPP_v3_4_Issue1_2.pdf

[90] [gnu-agplv3] Free Software Foundation. GNU Affero General Public License. https://www.gnu.org/licenses/-agpl-3.0.en.html

[91] [freeswitch_pbx] FreeSWITCH SIP PBX https://freeswitch.org

[92] [tw-ts-001] TW-TS-001: Enhanced RTP transport of FR and EFR codec frames in an IP-based GSM RAN https://www.freecalypso.org/specs/tw-ts-001-v010100.txt

[93] [tw-ts-002] TW-TS-002: Enhanced RTP transport of HRv1 codec frames in an IP-based GSM RAN https://www.freecalypso.org/specs/tw-ts-002-v010100.txt

[94] [tw-ts-003] TW-TS-003: BSSMAP extension for selection of enhanced RTP transport formats https://www.freecalypso.org/specs/tw-ts-003-v010002.txt

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