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TECHNICAL SPECIFICATION

Satellite Earth Stations and Systems (SES);
Broadband Satellite Multimedia (BSM);
Common air interface specification;
Satellite Independent Service Access Point (SI-SAP) interface: Services

Reference

DTS/SES-00351

Keywords

BSS, interface, MSS, protocol, satellite

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Contents

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

Modal verbs terminology

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Introduction

The SI-SAP interface implements the concept of hardware abstraction layer, aimed at logically separating Satellite Independent (SI) from Satellite Dependent (SD) layers of the protocol stack. In particular, it enables address resolution, multicast management, resource reservation and data transfer services so as to keep the implementation of the involved functionalities at SI and SD layer independent. To this regard, the present document identifies the functional areas for which SI-SAP interface service primitives are actually missing and provides guidance to the use and the implementation of the complete set of SI-SAP interface service primitives.

It can be noted that the definition of SI-SAP interface services and the technical specification of inherent primitives complements and completes the material already available in the existing ETSI documents relating to SI-SAP interface ETSI TS 102 292 [1] to ETSI TS 102 461 [9]. Hence, the present document along with technical specifications ETSI TS 102 292 [1] to ETSI TS 102 461 [9] should be considered as the reference documentation for SI-SAP interface services' definition and primitives' specification.

1 Scope

The present document specifies the SI-SAP interface service and related primitives preliminarily defined in [1] and [7].

The scope of the document is twofold. On the one hand, revision of existing service specifications is carried out in order to reflect services' update demanded by current satellite systems. On the other hand, new services are defined in order to bridge the gaps in the following functional areas:

- Logon/logoff.
- Satellite Independent (SI) layer configuration.
- Group transmit.

Accordingly, the specification of new primitives for the aforementioned services is also provided in the present document.

Final notes about the use and the implementation of SI-SAP interface service primitives are provided as two independent annexes at the end of the present document. In more detail, illustration of SI-SAP interface and primitives' implementation in specific use-cases is given in the annex A. Details about the implementation of a SI-SAP interface in real satellite system are provided in the annex B, where the focus is on the SI-SAP interface implementation as i) local interface (mandatory) or ii) external interface to a BSM subsystem (optional).

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 102 292 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM) services and architectures; Functional architecture for IP interworking with BSM networks".

[2] ETSI TS 102 464 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Interworking with DiffServ QoS".

[3] ETSI TS 102 463 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Interworking with IntServ QoS".

[4] ETSI TS 102 462 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); QoS Functional Architecture".

[5] ETSI TS 102 460 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Address Management at the SI-SAP".

[6] ETSI TS 102 856-2 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Multi-Protocol Label Switching (MPLS) interworking over satellite; Part 2: Negotiation and management of MPLS labels and MPLS signalling with attached networks".

[7] ETSI TS 102 357 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Common Air interface specification; Satellite Independent Service Access Point SI-SAP".

[8] ETSI TS 102 294 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM) services and architectures; IP interworking via satellite; Multicast functional architecture".

[9] ETSI TS 102 461 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Multicast Source Management".

[10] IETF RFC 4601: "Protocol Independent Multicast - Sparse Mode (PIM-SM): Protocol Specification (Revised)".

[11] IETF RFC 3376: "Internet Group Management Protocol, Version 3".

[12] IETF RFC 5342: "IANA Considerations and IETF Protocol Usage for IEEE 802 Parameters".

[13] ISO/IEC 7498-1: "Information Technology-Open Systems Interconnection-Basic Reference Model: The Basic Model. International Standard".

[14] ISO/IEC 10731: "Information Technology-Open Systems Interconnection-Basic Reference Model-Conventions for the Definition of OSI Services. International Standard".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TS 102 295 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM) services and architectures; BSM Traffic Classes".

[i.2] ETSI TS 102 855 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Interworking and Integration of BSM in Next Generation Networks (NGNs)".

[i.3] ETSI TS 102 675-2 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Part 2: Performance Management Information Base".

[i.4] ETSI TS 102 674 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); PIM-SM Adaptation".

[i.5] ETSI TS 102 673 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Performance Parameters".

[i.6] ETSI TS 102 672 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Management Functional Architecture".

[i.7] ETSI TS 102 466 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Multicast Security Architecture".

[i.8] ETSI TS 102 465 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); General Security Architecture".

[i.9] ETSI TS 102 856-1 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Multi-Protocol Label Switching (MPLS) interworking over satellite Part 1: MPLS-based Functional Architecture".

[i.10] ETSI TS 102 675-1 (V1.1.1: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Part 1: Performance Management at the SI-SAP".

[i.11] ETSI TS 102 293 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM) services and architectures; IP Interworking over satellite; Multicast group management; IGMP adaptation".

[i.12] ETSI TR 102 676 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Performance Enhancing Proxies (PEPs)".

[i.13] ETSI TR 102 467 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Transition to IPv06".

[i.14] ETSI TR 102 187 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; Overview of BSM families".

[i.15] ETSI TR 101 984 (V1.2.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Services and architectures".

[i.16] ETSI TR 102 353 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Guidelines for the Satellite Independent Service Access Point (SI-SAP)".

[i.17] ETSI TR 102 287 (V1.1.1): "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); IP Interworking over satellite; Security aspects".

[i.18] IETF RFC 4815: "RObust Header Compression (ROHC): Corrections and Clarifications to RFC 3095".

[i.19] IETF RFC 3261: "SIP: Session Initiation Protocol".

[i.20] IETF RFC 753: "Internet Message Protocol".

[i.21] IETF RFC 793: "Transmission Control Protocol".

[i.22] IETF RFC 768: "User Datagram Protocol".

[i.23] IETF RFC 1661: "The Point-to-Point Protocol (PPP)".

[i.24] IETF RFC 3135: "Performance Enhancing Proxies Intended to Mitigate Link-Related Degradations".

[i.25] IETF RFC 2516: "A Method for Transmitting PPP Over Ethernet (PPPoE)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

architecture: abstract representation of a communications system

NOTE: Three complementary types of architecture are defined:

- Functional Architecture: the discrete functional elements of the system and the associated logical interfaces.
- Network Architecture: the discrete physical (network) elements of the system and the associated physical interfaces.
- Protocol Architecture: the protocol stacks involved in the operation of the system and the associated peering relationships.

BSM Network: BSM subnetwork together with the BSM interworking and adaptation functions that are required to provide IP interfaces (i.e. layer 3 and below) to attached networks

BSM Subnetwork: all the BSM network elements below the Satellite Independent Service Access Point (SI-SAP)

BSM System (BSMS): system comprising a BSM Network together with a Network Management Centre (NMC) and Network Control Centre (NCC)

NOTE: The BSM System also includes any additional elements that are required to provide the network services to the subscribers and their users.

control plane: the plane that provides the control functions

NOTE: The control plane has a layered structure and performs the call control and connection control functions; it deals with the signalling necessary to set up, supervise and release calls and connections.

flow (of IP packets): traffic associated with a given connection-oriented, or connectionless, packet sequence having the same 5-tuple of source address, destination address, Source Port, Destination Port, and Protocol type

forwarding: process of relaying a packet from source to destination through intermediate network segments and nodes

NOTE: The forwarding decision is based on information that is already available in the routing table. The decision on how to construct that routing table is the routing decision.

management plane: plane that provides the management functions

NOTE: The management plane provides two types of functions, namely layer management and plane management functions:

- Plane management functions are functions related to a system as a whole and provides coordination between all the planes. Plane management has no layered structure.
- Layer management functions are functions relating to resources and parameters residing in its protocol entities. Layer management handles the operation and maintenance (OAM) of information flows specific to the layer concerned.

network control centre: equipment at OSI layer 2 that controls the access of terminals to a satellite network, including element management and resource management functionality

user plane: plane that has a layered structure and provides user information transfer, along with associated controls (e.g. flow control, recovery from errors, etc.)

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

bslbf	bit string, left bit first
BSM	Broadband Satellite Multimedia
BSM_GID	BSM Group Identity
BSM_ID	BSM Identity
BSMS	BSM System
DiffServ	Differentiated services (IETF)
FL	Forward Link
GIF	Gateway Interworking Functions
IETF	Internet Engineering Task Force
IGMP	Internet Group Multicast Protocol
IP	Internet Protocol
ISO	International Organization for Standardization
LAN	Local Area Network
MAC	Medium Access Control
MPEG	Moving Picture Experts Group
MPLS	Multi-Protocol Label Switching
MTU	Maximum Transfer Unit
NCC	Network Control Centre
NMC	Network Management Centre
OSI	Open Systems Interconnection
PDU	Protocol Data Unit
PEP	Performance Enhancing Proxy
PIM-SM	Protocol Independent Multicast - Sparse Mode
PPP	Point to Point Protocol
PPPoE	Point to Point Protocol over Ethernet
QID	Queue Identifier
QIDSPEC	QID Specification
QoS	Quality of Service
RES	Response

RFC	Request for Comments
RL	Return Link
ROHC	Robust Header Compression
SD	Satellite Dependent
SDAF	Satellite Dependent Adaptation Functions
SDU	Service Data Unit
SI	Satellite Independent
SIAF	Satellite Independent Adaptation Functions
SIP	Session Initiation Protocol
SI-SAP	Satellite Independent Service Access Point
SLC	Satellite Link Control
SMAC	Satellite Medium Access Control
SPHY	Satellite Physical
ST	Satellite Terminal
TCP	Transmission Control Protocol
TS	Technical Specification
UDP	User Datagram Protocol
UIF	User Interworking Functions
uimsbf	unsigned integer most significant bit first
Wi-Fi	Wireless Fidelity

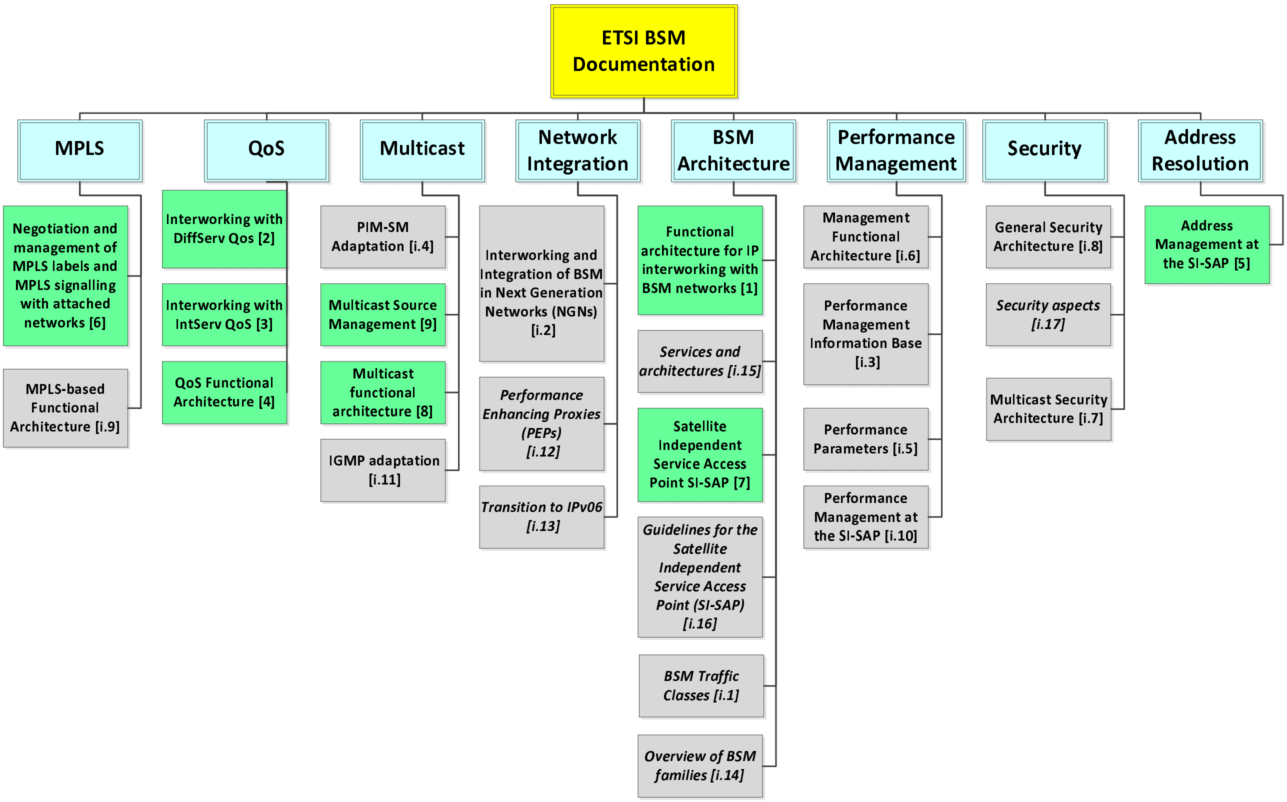
4 Document overview

4.1 Relations with other ETSI documents

The available ETSI BSM document (technical specification and reports) provide accurate specifications of the SI-SAP interface service primitives and informative material about the ETSI BSM architecture. In general, it is possible to identify eight main functional areas, which are addressed in the ETSI BSM architecture framework:

- MPLS, ETSI TS 102 856-2 [6] and ETSI TS 102 856-1 [i.9]. It deals with the implementation of the MPLS protocol in the ETSI BSM architecture, with the related implications from SI-SAP interface concept viewpoint.
- QoS, ETSI TS 102 464 [2] to ETSI TS 102 462 [4]. It deals with the design of the functional QoS-enabled architecture and the related SI-SAP interface service primitives.
- Multicast ETSI TS 102 294 [8], ETSI TS 102 461 [9], ETSI TS 102 674 [i.4] and ETSI TS 102 293 [i.11]. It deals with the design of the functional multicast-enables architecture and the related SI-SAP interface service primitives.
- Network Integration ETSI TS 102 855 [i.2], ETSI TR 102 676 [i.12] and ETSI TR 102 467 [i.13]. It deals with the integration of the ETSI BSM with other services and networks.
- BSM Architecture ETSI TS 102 292 [1], ETSI TS 102 357 [7], ETSI TS 102 295 [i.1], ETSI TR 102 187 [i.14], ETSI TR 101 984 [i.15] and ETSI TR 102 353 [i.16]. It deals with the overall ETSI BSM architecture definition and the specification of the SI-SAP interface.
- Performance management ETSI TS 102 675-2 [i.3], ETSI TS 102 673 [i.5], ETSI TS 102 672 [i.6] and ETSI TS 102 675-1 [i.10]. It deals with the architecture and parameters defined to support performance management.
- Security ETSI TS 102 466 [i.7], ETSI TS 102 465 [i.8] and ETSI TR 102 287 [i.17]. It deals with the security services and related definition, to be supported by the ETSI BSM architecture.
- Address Resolution ETSI TS 102 460 [5]. It deals with the address resolution services supported by the ETSI BSM architecture and the related SI-SAP interface service primitives.

Figure 4.1 reports the aforementioned functional areas, indicating the specific ETSI BSM documents (Technical specifications (TSs) and Technical Reports (TRs) comprised).



Legend: Green: documents containing SI-SAP interface definitions addressed by the present document
Grey: documents containing SI-SAP interface definitions not addressed in the present document
Document titles in italic: technical reports

Figure 4.1: Structure of the ETSI BSM documentation

The functional areas for which SI-SAP interface service primitives are defined or addressed are the following:

- MPLS.
- QoS.
- Multicast.
- BSM architecture.
- Address resolution.

The present document is aimed at consolidating the specification of the current SI-SAP interface service primitives and providing the specification to new ones, needed to bridge some functional gaps. As such, the overall technical definition and specification of SI-SAP services is contained in the present document for what regards the aforementioned changes and the existing ETSI documents ETSI TS 102 292 [1] to ETSI TS 102 461 [9] for the functions not addressed in the present document.

4.2 Structure of the present document

The remainder of the present document is structured as follows:

- Clause 5 gives the essentials of the BSM architecture along with the overview of the standardized SI-SAP interface service primitives. Missing services and update of current ones are identified, in order to properly update the set of the SI-SAP interface service primitives.
- Clause 6 defines the new primitives and updates the existing one, where applicable.
- Annex A illustrates the use of SI-SAP interface service primitives with reference to the tasks carried out during satellite communications.

- Annex B discusses the implementation of the SI-SAP interface as external. Implementation of all SI-SAP interface service primitives in terms of primitive message definition and protocol encapsulation is addressed.

5 ETSI BSM architecture

5.1 General

The aim of clause 5 is to briefly summarize the primitives that the SI-SAP interface implements towards the underlying protocol layers and the service that are therein supported. Finally, this clause outlines the services that the SI-SAP interface is actually not providing and those that are not properly defined. For these services, specification of the corresponding SI-SAP interface service primitives is provided in clause 6.

5.2 Architecture definition

The ETSI BSM architecture ETSI TS 102 292 [1] is superimposed to a general satellite network composed of satellite terminals, gateway, satellite, Network Management Centre (NMC) and Network Control Centre (NCC).

The architecture comprises three main elements (depicted in Figure 5.1):

- BSM Subnetwork. It is the set constituted by the satellite dependent (SD) layer (satellite network interfaces) and the satellite, with the related links, i.e. feeder up-/down-links and user up-/down-links.
- BSM Network. It is the set constituted by the BSM subnetwork and the rest of the satellite terminal and gateway protocol stack, including the SI-SAP interface along with the interworking functions provided by the satellite independent (SI) layers and the network interfaces towards the outside of the BSM network.
- BSM System (BSMS). It is the set constituted by the BSM network, NMC and NCC. The BSM system essentially provides control and management on the BSM network.

NOTE 1: Network premises and external network can be connected to the BSM network, according to the technology implemented at the physical layer.

NOTE 2: The gateway should implement interworking functions, whereas these may be implemented in the satellite terminal. In case the User Interworking Functions (UIF) functions are implemented, the satellite terminal acts as satellite router, otherwise as a bridge or layer 2 switch.

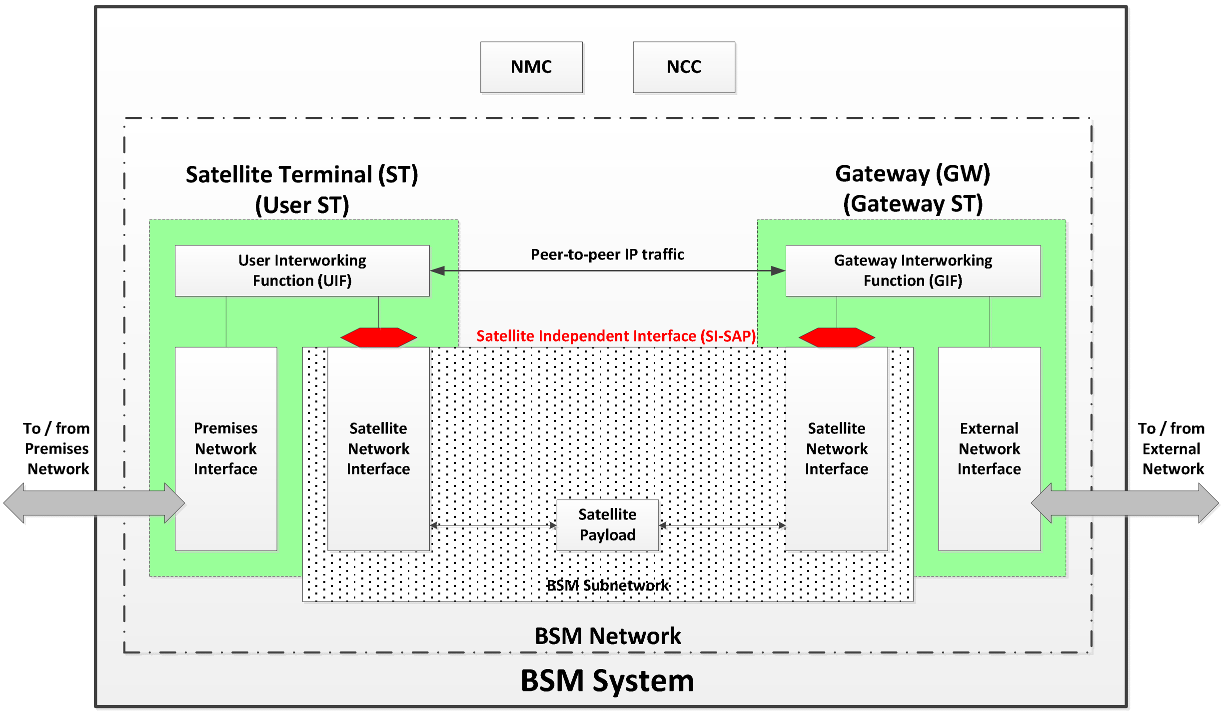


Figure 5.1: ETSI BSM Architecture Decomposition

The SI-SAP interface ETSI TS 102 357 [7] and ETSI TR 102 353 [i.16] is defined as part of the BSM network (outside the BSM subnetwork) and logically separates the satellite network interface from the higher layers, in order to provide a functional separation between satellite dependent (SD) and independent (SI) layers. As such, the SI-SAP interface can be regarded as a hardware abstraction layer.

The SI layer implements the higher layers of the protocol stack, namely the network layer. Broadly speaking the SI layer can be considered as implementing IPv4 or IPv6 protocols IETF RFC 753 [i.20]. In addition to this, it also implements the satellite independent adaptation functions (SIAF) module aimed at performing all necessary functions to allow SI interwork with SD layer.

The SD layer implements the lowers layer of the protocol stack, conveniently subdivided as follows, according to the ISO/OSI terminology:

- Satellite link control (SLC).
- Satellite medium access control (SMAC).
- Satellite physical (SPHY).

The SD layer also implements the satellite dependent adaptation functions (SDAF) module aimed at performing all necessary functions to allow SD to interwork with the SI layer.

The SI-SAP interface provides a set of service primitives, which are exchanged between the SIAF and SDAF modules. The implementation of the SI-SAP interface actually allows to keep the implementation of SI and SD layers separated and independent, while all adaptations functions are carried out by the dedicated SIAF and SDAF modules.

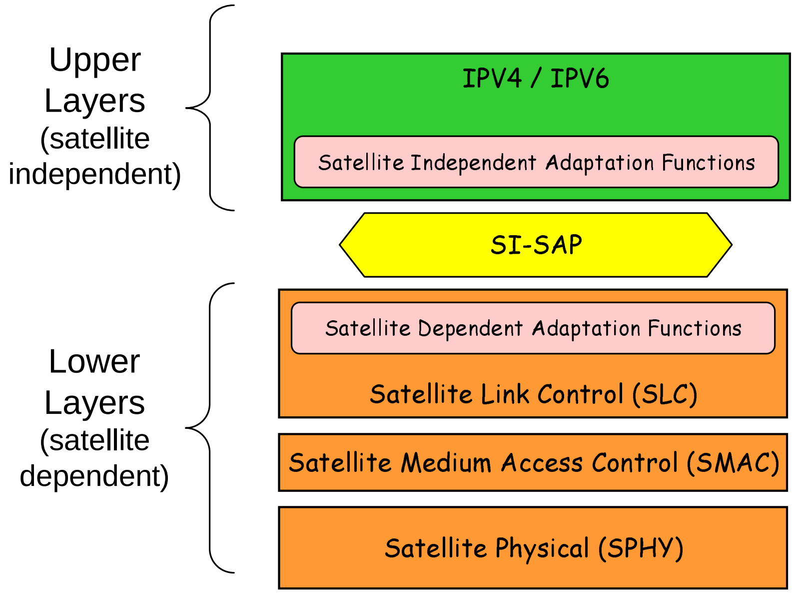


Figure 5.2: SI-SAP interface: separation between SI and SD layers

5.3 Services

The SI-SAP interface provides services pertaining to:

- User plane (U-plane).
- Control plane (C-plane).
- Management plane (M-plane).

Being the services defined in the three planes completely independent, it is actually possible to see the SI-SAP interface as decomposed in three independent interfaces:

- SI-U-SAP.
- SI-C-SAP.

- SI-M-SAP.

The SI-SAP interface provides the services primitives demanded to enable interworking between the SI and SD layers:

- Address Resolution ETSI TS 102 460 [5]. It is aimed at performing the mapping between SI and SD layer addresses, by means of the BSM Identity (BSM_ID) that defines the address of a specific SI-SAP interface instance.

- QoS management (SI-C-SAP and SI-M-SAP). It is aimed at performing the QoS mapping between the model (e.g. Intserv ETSI TS 102 463 [3], DiffServ ETSI TS 102 464 [2]) implemented at the SI layer, by means of the Queue Identifiers (QIDs) that points to the SD layer queues.

NOTE 1: The service primitives are referred to as *resource reservation*.

NOTE 2: The service primitives are defined only for the C-plane, since M-plane functions are performed without interaction between SI and SD layers.

NOTE 3: Interaction between SI layer and QoS-based routing protocols running on top of it can trigger the SIAF module to invoke the relevant primitives.

- Multicast management (SI-C-SAP and SI-M-SAP) ETSI TS 102 294 [8] and ETSI TS 102 461 [9]. It is aimed at performing the mapping functions between the multicast groups defined at SI and SD layers, along with the corresponding operations in creating, joining and leaving multicast groups respectively.

NOTE 4: The service primitives are referred to as *group receive* and *group transmit* (not defined).

NOTE 5: The service primitives are defined only for the C-plane, since M-plane functions are performed without interaction between SI and SD layers.

NOTE 6: Interaction between SI layer and multicast group membership and routing protocols can trigger the SIAF module to invoke the relevant primitives.

- Security management (SI-C-SAP and SI-M-SAP) ETSI TS 102 465 [i.8]. It is aimed at the performing the mapping functions between security functions performed at SI and SD layers and providing the necessary database for authentication and encryption keys.

NOTE 7: The study on security managements pointed out that no specific SI-SAP interface service primitives are needed as security is managed separately at SI and SD layers.

- Data transfer (SI-U-SAP) ETSI TS 102 357 [7]. It is aimed at transferring SI PDUs (e.g. IP datagrams) from the SI to SD layers, with the necessary adaptation (segmentation/reassembly) to be performed by the SDAF module.

Figure 5.3 depicts the functional architecture of the ETSI BSM architecture, highlighting the functions provided by the SIAF and SDAF module to enable unicast data transfer over the BSM system. The extension to the multicast case is straightforward and consists in the definition of multicast resolution address and group management functions. The corresponding architecture is not reported here, but the interested reader can refer to ETSI TS 102 292 [1] and ETSI TS 102 294 [8] for more details about it.

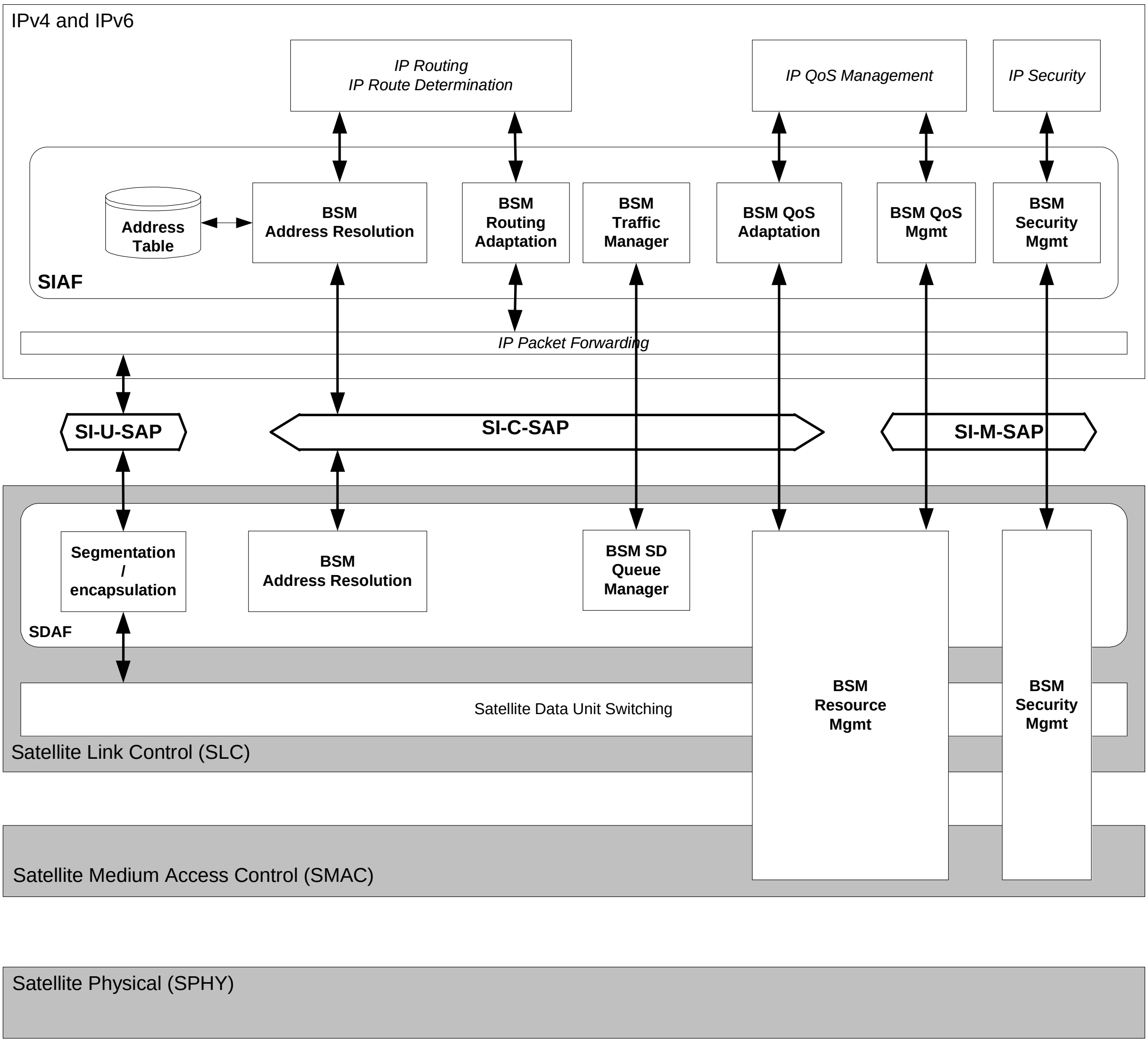


Figure 5.3: ETSI BSM functional architecture to enable unicast data traffic

5.4 SI-SAP interface

The SI-SAP interface defines primitives to be exchanged between the SI and SD layers, in order to support U- and C- plane functionalities. M-plane functionalities are no supported by specific SI-SAP interface service primitives, as management functions are segregated in specific protocol layers, with no interaction between SI and SD protocol layers.

According to ISO/OSI terminology ISO/IEC 10731 [14], primitives exchanged between layer N+1 and layer N are the implementation of services offered to layer N+1 by layer N and provided through the Service Access Point of layer N+1.

Four types of primitives are defined and also applied in the SI-SAP interface definition:

- Request. The request comes from the SAP of layer N+1 to request a given service to layer N. The request can be locally acknowledged or unacknowledged by layer N.
- Confirmation. The confirmation primitive is issued to acknowledge a request primitive received from layer N+1 and to confirm the service request. Hence, it is issued by layer N toward layer N+1.The confirmation can be local as acknowledgment of the request or after remote confirmation from the counterpart peer.
- Indication. The indication primitive is triggered upon unsolicited event or reception of a protocol message (data or control plane) at layer N. hence it is issued from layer N towards layer N+1. In reaction to this primitive, layer N+1 SAP can issue a response Primitive (see below).

- Response. The response primitive is triggered upon reception of protocol message or indication of unsolicited event. Hence, it is issued from layer N+1 towards layer N. The primitive may be used from a peer to signal the counterpart peer about the completion of a specific action requested by the former service indication.

The overall ISO/OSI primitive model ISO/IEC 7498-1 [13] is illustrated in the following, where reference to SI-SAP interface and ETSI BSM architecture is terms of SI and SD layers is given ETSI TS 102 292 [1].

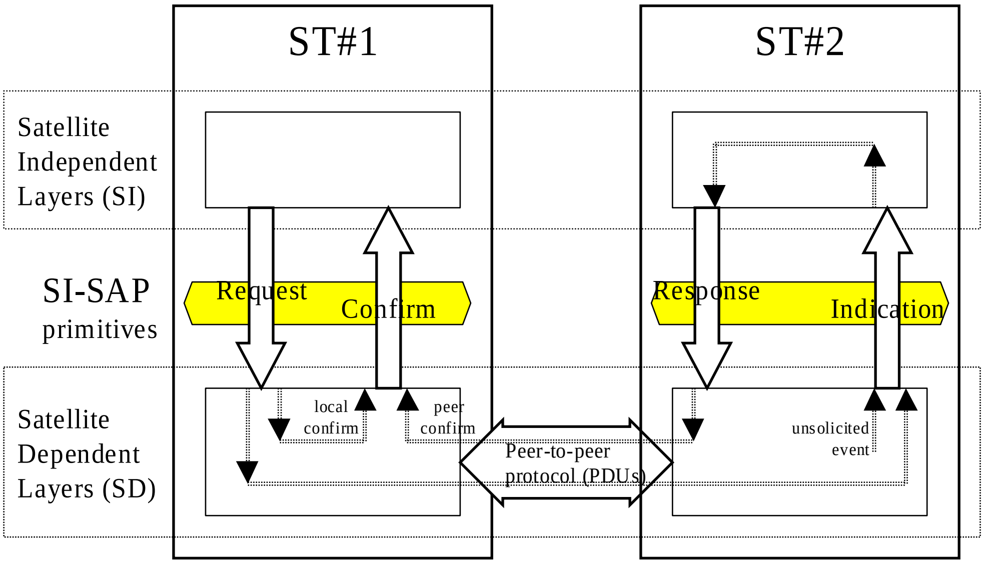


Figure 5.4: SI-SAP interface definition and service primitive exchange

To this regard, layer N+1 shall be considered as the SI layer, whereas layer N is the SD layer.

5.5 Defined SI-SAP interface service primitives

According to the services provided by the SD layer to the SI layer through the SI-SAP interfaces, the SI-SAP interface service primitives currently defined are as in Table 5.1, where each primitive is denoted as `Layer-Plane-PrimitiveName-PrimitiveSemantics`, where:

- `Layer`: It is the N+1 layer requesting a given service from layer N. In this case, the involved N+1 layer is the SI.
- `Plane`: It refers to the User (U), Control (C), or Management (M) plane.
- `PrimitiveName`: It defines the name of the primitive.
- `PrimitiveSemantics`: It defines the type of primitive according to the ISO/OSI terminology:
  - Request (req)
  - Confirmation (cfm).
  - Response (res).
  - Indication (ind).

Table 5.1: Summary of defined SI-SAP interface service primitives and related primitives

U-plane services		
Service	Aim	Primitives
Data transfer [1] and [7]	To transfer data from the SI to the SD layer for transmission to peer destination; To deliver data from the SD to the SI layer.	SI-U-UNITDATA-req SI-U-UNITDATA-ind
C-plane services		
Service	Aim	Primitives
Resource reservation [2], [3] and [4]	To open, modify and release SD layer resource reservations To query about the status of SD layer resource reservations	SI-C-QUEUE_OPEN-req, -cfm SI-C-QUEUE_MODIFY-req, -cfm SI-C-QUEUE_CLOSE-req, -cfm SI-C-QUEUE_MODIFY-ind, -res SI-C-QUEUE_CLOSE-ind, -res SI-C-QUEUE_STATUS-ind, -res
Group receive [8] and [9]	To enable SD layer to receive data belonging to a given multicast group multicast	SI-C-RGROUP_OPEN-req, -cfm SI-C-RGROUP_CLOSE-req, -cfm
Address resolution [5]	To perform resolution between SI and SD addresses	SI-C-AR_QUERY-req, -cfm SI-C-AR_INFO-ind, -res
M-plane services		
Service	Aim	Primitives
None	No M-plane services are defined	None

5.6 Update of SI-SAP interface service primitives

In addition to the services discussed in the former clause (i.e. data transfer, resource reservation, group receive and address resolution), three new services shall be also considered to complete the set of functions provided in satellite networks:

- Logon/logoff. These services are provided by the SD layer (lower layer of a satellite terminal protocol stack) and once accomplished, notifications could be sent to the SI layer to notify the corresponding events and trigger actions at the SI level.
- SI layer configuration. This service is started upon successful logon procedure and triggered by the SI layer in order to configure the addressing plan of the SI layer.
- Group transmit. This service (already foreseen in the ETSI BSM documents ETSI TS 102 357 [7] and ETSI TS 102 461 [9], not defined though) is requested by the SI layer in order to add a new multicast or, conversely, to remove an existing multicast group and signal the event to the affected satellite terminals.

Further to this, the definition of the user plane primitives (SI-U-UNITDATA) shall also be updated in order to reflect to need for including the BSM_ID of the source, when the BSM network implements MPLS protocol ETSI TS 102 856-2 [6] on top of the SD layer.

6 SI-SAP interface service primitives

6.1 General

Clause 6 addresses the specification of the new services (logon, logoff, SI layer configuration, and group transmit) along with the related primitives and the update of the primitives of the data transfer service.

6.2 Logon

6.2.1 Service definition

The logon service is carried out by the SD layer to notify the SI layer about the accomplished logon procedure.

The logon service is carried out in consequence of the following event:

- The ST enters the satellite network by exchanging the SD-dependent control message with the gateway, in order to log on and synchronize with the satellite and the gateway.

Being the logon procedure exclusively performed by the protocol entity implemented at the SD layer, no direct interaction with the SI layer occurs during this phase. On the other hand, the logon service notification is intended to trigger the SI layer to initiate, in turn, the SI layer configuration.

6.2.2 Primitives involved in the service

The logon service shall use a single primitive:

- SI-C-LOGON-IND.

6.2.3 Parameters

The service primitive calls the following parameters:

- BSM_ID. It is the BSM Identity of the local SI-SAP interface.
- Hardware Address. It is the hardware address (i.e. the 48-bit MAC address) of the ST that has initiated the service.

6.2.4 Service primitive: SI-C-LOGON

6.2.4.1 SI-C-LOGON primitive specification

Table 6.1: SI-C-LOGON primitive specification

PRIMITIVE NAME	SI-C-LOGON-***
FUNCTION	Successful logon notification

Primitive parameters:			**-ind**		**Comments**
BSM_ID			M		Specific values of BSM_ID are used to distinguish between unicast, broadcast and multicast data transfers
Hardware Address			M		The hardware address of the satellite terminal

6.2.4.2 SI-C-LOGON-IND

The logon message primitive is an unsolicited *indication* from the SD layer to the SI layer, to inform the SI layer about the completed logon procedures.

Upon primitive receipt, the SI layer shall request the SI layer configuration service from the SD layer.

6.3 Logoff

6.3.1 Service definition

The logoff service is provided by the SD layer to inform the SI layer that a logoff procedure has been initiated. The procedure can be triggered within the BSM network (ST or gateway) or in the BSM system (NCC or NMC) but outside the BSM network.

The logoff service is carried out in consequence of either of the following events:

- The satellite terminal disconnects from the satellite network.
- The gateway disconnects from the satellite.
- The NCC/NMC of the satellite network shutdown the satellite network and inform satellite terminals and the satellite network gateway about the logoff event.

As the logoff procedure is executed at the SD layer, no direct interaction with the SI layer occurs during this phase.

6.3.2 Primitives involved in the service

The logoff service shall use a single primitive:

- SI-C-LOGOFF-IND.

6.3.3 Parameters

The service primitive calls the following parameters:

- BSM_ID. It is the BSM Identity of the local SI-SAP interface.
- Logoff Source. It identifies the source that initiated the logoff procedure. The source is part of the BSM system but may also be external to the BSM network.

6.3.4 Service primitive: SI-C-LOGOFF

6.3.4.1 SI-C-LOGOFF primitive specification

Table 6.2: SI-C-LOGOFF primitive specification

PRIMITIVE NAME	SI-C-LOGOFF-***
FUNCTION	Successful logon notification

Primitive parameters:			**-ind**		**Comments**
BSM_ID			M		Specific values of BSM_ID are used to distinguish between unicast, broadcast and multicast data transfers
Logoff Source			M		To identify the source of the logoff event: satellite, terminal gateway, system (NCC/NMC)

6.3.4.2 SI-C-LOGOFF-IND

The logoff message primitive is an unsolicited *indication* from the SD layer to the SI layer.

Upon primitive receipt, the SDAF module shall reset all relevant traffic information related to address resolution, resource reservation, and multicast group membership, because the satellite air interface will be shut down.

6.4 SI layer configuration

6.4.1 Service definition

The SI layer configuration service is provided by the SD layer of a ST to the SI layer in order to receive the necessary parameters from the gateway to perform the SI layer configuration in terms of addressing plan. Where applicable, the gateway may also provide additional parameters, related to the configuration of other SI layer services, such as PEP ETSI TR 102 676 [i.12] and IETF RFC 3135 [i.24] and header compression (e.g. ROHC, IETF RFC 4815 [i.18])

6.4.2 Primitives involved in the service

The SI layer configuration service shall use the following primitives:

- SI-C-CONF-REQ.
- SI-C-CONF-CFM.
- SI-C-CONF-IND.
- SI-C-CONF-RES.

6.4.3 Parameters

The service primitives call the following parameters:

- SICONF_BlockNumber. It defines the number of configuration blocks contained in the primitive. The first block is mandatory and contains information about address plans. Following blocks are optional.
- Network_Address_Type. It defines the network protocol according to Ether Type (IETF RFC 5342 [12])
- Client_Network_Address. It defines the network address that the ST requests to configure. It is set to 0 by default.
- Client_Netmask. It defines the netmask of the network address that the St requests to configure. It is set to 0 by default.
- Gateway_Network_Address. It defines the network address of the gateway that the ST requests to receive.
- Hardware_Address. It defines the hardware address (48-bit MAC address) of the ST.
- BSM_ID. It defines the BSM Identity of the SI-SAP interface instance used by the ST to consume the service.
- Block_ID. It defines the specific configuration block.
- Block_Length. It defines the length of the configuration block.
- Information_Block. It contains specific information of the configuration block. Depending on the specific SI (or higher layers) service configuration, this field can be further structured in sub-fields.

6.4.4 Service primitive: SI-C-SICONF

6.4.4.1 SI-C-SICONF primitive specification

Table 6.3: SI-C-SICONF primitive specification

PRIMITIVE NAME	SI-C-SICONF-***
FUNCTION	SI layer configuration for network addressing

Primitive parameters:	**-req**	**-cfm**	**-ind**	**-res**	**Comments**
SICONF_BlockNumber	O	O	O	O	The number of information block for the SI configuration
Network_Address_Type	M	M	M	M	
Client_Network_Address	O	M	M	M	The network address the satellite terminal requests to acquire
Client_Netmask	O	M	M	M	The netmask the satellite terminal requests to acquire
Gateway_Network_Address	O	M	M	M	The network address of the gateway the satellite terminal requests to receive
Hardware_Address	-	-	M	-	The hardware address of the satellite terminal
BSM_ID	-	-	M	-	The BSM identifier of the satellite terminal. Specific values of BSM_ID are used to distinguish between unicast, broadcast and multicast data transfers
for (i=0, i< SICONF_BlockNumber-1, i++) {					
Block_ID	O	O	O	O	It identifies the specific block of information
Block_Length	O	O	O	O	The length of the information block coming next
Information_Block()	O	O	O	O	The actual information block
}					

6.4.4.2 SI-C-SICONF-REQ

The SI layer configuration primitive is a *request* from the SI layer to get the configuration parameters from the gateway.

Upon primitive receipt, the SD layer shall forward the request to the gateway.

6.4.4.3 SI-C-SICONF-CFM

The SI layer configuration primitive is a *confirmation* issued by the SD layer to notify the SI layer about the set of parameters provided by the gateway necessary to perform the SI layer configuration.

Upon primitive receipt, the SI layer shall implement the addressing plan and may implement the configuration of the other services, if provided in the service primitive.

6.4.4.4 SI-C-SICONF-IND

The SI layer configuration primitive is an unsolicited *indication* from the SD layer of the gateway containing the list of parameters provided by the ST to carry out the SI layer configuration.

Upon primitive receipt, the SI layer of the gateway processes the provided service parameters.

6.4.4.5 SI-C-SICONF-RES

The SI layer configuration primitive is a *response* from the SI layer of the gateway containing the list of parameters to be provided to the ST to carry out the SI layer configuration.

Upon primitive receipt, the SD layer shall forward the response to the ST.

6.5 Group transmit

6.5.1 Service definition

The group transmit service is carried out by the SI layer of a gateway to enable the SD layer to transmit a new multicast group and to record the satellite terminals that subscribed to a given multicast group. The service may be triggered by multicast group membership (e.g. IGMP IETF RFC 3376 [11]) and routing protocol (e.g. PIM-SM IETF RFC 4601 [10]) messages received by the gateway.

6.5.2 Primitives involved in the service

The group transmit service shall use the following primitives:

- SI-C-MCGROUP_ADD-REQ.
- SI-C-MCGROUP_ADD-CFM.
- SI-C-MCGROUP_REMOVE-REQ.
- SI-C-MCGROUP_REMOVE-CFM.

6.5.3 Parameters

The service primitives call the following parameters:

- BSM_ID. It defines the BSM Identity of the SI-SAP interface instance used by the ST during the multicast group transmit service. It is set to 0 by default during the activation of a new multicast group.
- BSM_GID. It defines the BSM Group Identity of the SI-SAP interface instance used by the gateway to manage the multicast groups.
- Cause Code. It is the return code generated after service primitive processing. It reports about the success (failure) of the requested service.

6.5.4 Service primitive: SI-C-MCGROUP_ADD

6.5.4.1 SI-C-MCGROUP_ADD primitive specification

Table 6.4: SI-C-MCGROUP_ADD primitive specification

PRIMITIVE NAME	SI-C-MCGROUP_ADD-***
FUNCTION	To generate a new multicast group upon multicast SI signalling

Primitive parameters:	**-req**	**-cfm**			**Comments**
BSM_ID	M	M			BSM Identifier of the satellite terminal belonging to the multicast group being added
BSM_GID	M	M			Identifier of the BSM Group to be added, to which the Destination BSM Identifier belongs to
Cause Code	-	M			Return code to signal the success or the error source

6.5.4.2 SI-C-MCGROUP_ADD-REQ

The group transmit primitive is a *request* from the SI layer to enable the SD layer to transmit a new multicast group or subscribe new ST to the list of receivers for a given multicast group.

Upon primitive receipt, the SD layer records the address of the new multicast group being activated and the addresses of the STs requesting to subscribe to the given multicast group. The SD layer also configures the multicast transmission frame accordingly.

6.5.4.3 SI-C-MCGROUP_ADD-CFM

The group transmit primitive is a *confirmation* from the SD layer about the completion of the multicast transmission configuration for the new group and the subscribers addresses.

Upon primitive receipt, no action is performed by the SI layer.

6.5.5 Service primitive: SI-C-MCGROUP_REMOVE

6.5.5.1 SI-C-MCGROUP_REMOVE primitive specification

Table 6.5: SI-C-MCGROUP_REMOVE primitive specification

PRIMITIVE NAME	SI-C-MCGROUP_REMOVE-***
FUNCTION	To remove an existing multicast group upon multicast SI signalling

Primitive parameters:	**-req**	**-cfm**			**Comments**
BSM_ID	M	M			BSM Identifier of the satellite terminal belonging to the multicast group being removed
BSM_GID	M	M			Identifier of the BSM Group to be removed, to which the Destination BSM Identifier belongs to
Cause Code	-	M			Return code to signal the success or the error source

6.5.5.2 SI-C-MCGROUP_REMOVE-REQ

The group transmit primitive is a *request* from the SI layer to remove the address of a given multicast group address or of satellite terminals that unsubscribe from the given multicast group.

Upon primitive receipt, the SD layer removes the address of the multicast group and the STs unsubscribing from the multicast group and reconfigure the multicast transmission frame accordingly.

6.5.5.3 SI-C-MCGROUP_REMOVE-CFM

The group transmit primitive is a *confirmation* from the SD layer about the completion of the multicast transmission removal for the new group and the subscribers addresses.

Upon primitive receipt, no action is performed by the SI layer.

6.6 Data transfer

6.6.1 Service definition

The data transfer service is carried out by the SI layer in conformance to the service definition given in ETSI TS 102 357 [7].

6.6.2 Primitives involved in the service

The data transfer service shall use the following primitives, as stated in ETSI TS 102 357 [7]:

- SI-U-UNITDATA-REQ.
- SI-U-UNITDATA-CFM.

6.6.3 Parameters

The service primitives call the following parameters:

- Destination BSM_ID. It defines the BSM Identity of the SI-SAP interface instance used by the other peer to receive user data.
- Source BSM_ID. It defines the BSM Identity of the SI-SAP interface instance used by the local peer to transmit user data. It shall be used in the case of MPLS running on top of the SD layers; it is optional in the other application scenarios.
- QID. It defines the queue identifier pointing at the SD queue. It is negotiated between SI and SD layers during the resource reservation operation. It conforms to the definition given in ETSI TS 102 357 [7].
- SDU_Type. It defines the protocol type of the SDU transported by the primitive. It conforms to the definition given in ETSI TS 102 357 [7] for 'SDU Type'.
- SDU_Data_Byte. It is the array of bytes composing the SDU being transported by the primitive. It conforms to the definition given in ETSI TS 102 357 [7] for 'SDU'.

6.6.4 Service primitive: SI-U-UNITDATA

6.6.4.1 SI-U-UNITDATA primitive specification

Table 6.6: SI-U-UNITDATA primitive specification

PRIMITIVE NAME	SI-C-UNITDATA -***
FUNCTION	To transfer user data through the BSM network.

Primitive parameters:	**-req**		**-ind**		**Comments**
Destination BSM_ID	M		M		Specific values of BSM_ID are used to distinguish between unicast, broadcast and multicast data transfers
Source BSM_ID	O		O		
QID	M		-		
SDU_Type	M		M=		IPv4; IPv6 etc.
SDU_Data_Byte	M		M=		

6.6.4.2 SI-U-UNITDATA-REQ

The data transfer primitive is a *request* from the SI layer to trigger the SD layer to transmit the transported SDU over the BSM subnetwork.

Upon primitive receipt, the SD layer forwards the SDU to the SD queues according to the signalled QID and eventually encapsulates the SDU in an SD frame according to the destination address (*Destination BSM_ID*).

6.6.4.3 SI-U-UNITDATA-IND

The data transfer primitive is an unsolicited *indication* from the SD layer to deliver a SDU to the SI layer.

Upon primitive receipt, the SI layer processes the SDU: the SI layer shall insert the SDU in the routing chain or forward it to the upper layer for further protocol processing operations depending on the destination address (*Destination BSM_ID*).

6.7 Summary of SI-SAP interface service primitives

According to the specification of new and updated services given in the previous clauses, the summary of overall SI-SAP interface service primitives is as follows (Table 6.7, where the services already defined in the ETSI BSM relevant documentation are shaded in grey).

Table 6.7: Summary of overall SI-SAP interface service primitives and related primitives

U-plane services		
Service	Aim	Primitives
Data transfer [1] and [7]	To transfer data from the SI to the SD layer for transmission to peer destination; To deliver data from the SD to the SI layer.	SI-U-UNITDATA-req SI-U-UNITDATA-ind
C-plane services		
Service	Aim	Primitives
Resource reservation [2], [3] and [4]	To open, modify and release SD layer resource reservations To query about the status of SD layer resource reservations	SI-C-QUEUE_OPEN-req, -cfm SI-C-QUEUE_MODIFY-req, -cfm SI-C-QUEUE_CLOSE-req, -cfm SI-C-QUEUE_MODIFY-ind, -res SI-C-QUEUE_CLOSE-ind, -res SI-C-QUEUE_STATUS-ind, -res
Group receive [8] and [9]	To enable (disable) SD layer to receive data belonging to a given multicast group multicast	SI-C-RGROUP_OPEN-req, -cfm SI-C-RGROUP_CLOSE-req, -cfm
Group transmit	To enable (disable) the SD layer to transmit data belonging to a new multicast group	SI-C-MCGROUP_ADD-req, -cfm SI-C-MCGROUP_REMOVE-req, -cfm
Address resolution [5]	To perform resolution between SI and SD addresses	SI-C-AR_QUERY-req, -cfm SI-C-AR_INFO-ind, -res
Logon/logoff	To notify the SI layer about completed logon/logon procedures	SI-C-LOGON-ind SI-C-LOGOFF-ind
SI layer configuration	To carry out the configuration of SI layer after the logon procedure	SI-C-SICONF-req, -cfm, -ind, -res
M-plane services		
Service	Aim	Primitives
None	No M-plane services are defined	

Annex A (informative): Use of the SI-SAP interface service primitives

A.1 General

The annex A illustrates the use of the SI-SAP interface service primitives in a bent-pipe star satellite network.

A.2 Use-Cases

SI-SAP interface service primitives are illustrated throughout the rest of this annex, according to the following application scenario (use-cases), subdivided for plane services:

- C-Plane SI-SAP interface service primitives:
  - Logon/logoff. It considers the cases where a satellite terminal log in and then log out of the reference satellite network.
  - SI layer configuration. It considers the case where a satellite terminal performs the SI layer configuration upon successful logon completion.
  - Address resolution. It considers the case where a satellite terminal determines the address of the communication destination point (the gateway in a star topology).
  - Multicast management. It considers the cases where a new multicast group is activated and a satellite terminal requests to join the group, receives the corresponding data, and finally leaves the group. Because of the implications with address resolution, this use-case also contains the Address Resolution use-case.
  - Resource reservation. It considers all cases related to QoS management, where request of new satellite resources, modification of allocated one, or release of a present resource allocation are performed by BSM nodes (satellite terminals and/or gateways).
- U-Plane SI-SAP interface service primitives:
  - Data Transfer. It considers the case where a unicast or a multicast data flow is distributed by a gateway to the satellite terminals of the reference BSM satellite network.

A.3 Use of SI-SAP interface service primitives

A.3.1 General

The clause A.3 illustrates how SI-SAP interface service primitives are invoked by the SI layer and the corresponding primitives exchanged between satellite terminals and gateway in a satellite network, considering separately each specific use-case, introduced before.

The description is supported by time-sequence diagrams, in order to exemplify and then visualize how service primitives are exchanged between the involved BSM nodes over time.

A.3.2 Logon/logoff

Logon/Logoff services are performed by the SD layer by means of specific functions implemented in the physical layer. Interaction between SD and SI layers is required to notify the higher layers (SI) about the completed configuration of SD layer (in case of logon) or the shutdown of the physical air interface (in case of logoff).

In the first case, the logon phase (as sketched in the following) consists of the following steps:

1. Exchange of control messages between the SD peers of satellite terminals and gateway. These messages are triggered by the SD peer in terms of specific SD primitives run between the peer and the air interface module (SD_logon_cfm, _ind, _ res, _cfm).

2. Once the logon is successfully completed (SD_logon_cfm is received by the satellite terminal SD peer), an internal control message (SD_logon_signalling) is delivered from the SD peer to the SDAF module.

3. The SDAF modules calls a SI-C-LOGON-IND primitive aimed at informing the SIAF module (within the SI layer) about the successful completion of the logon procedure.

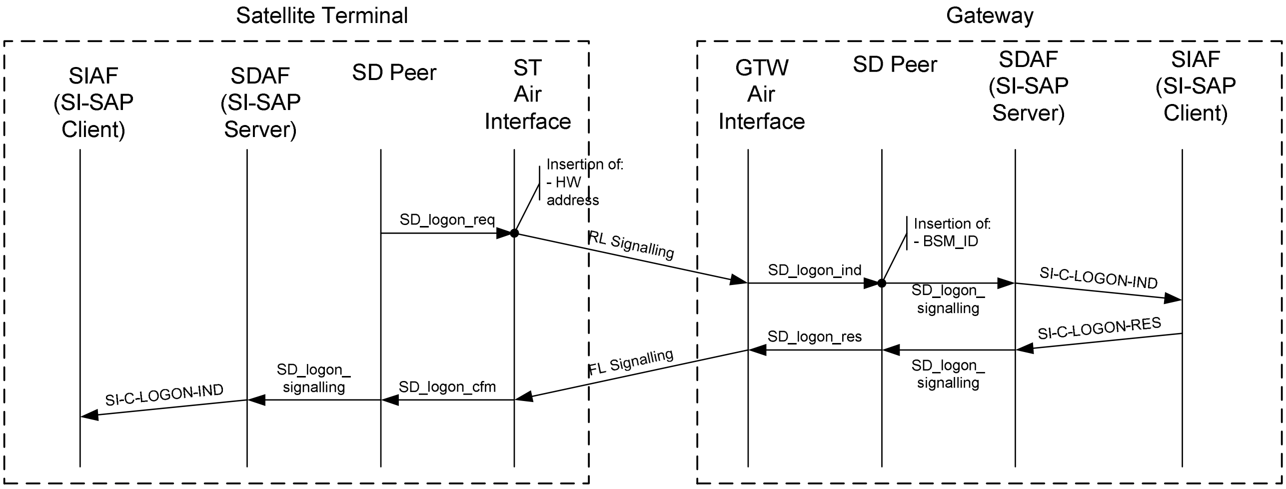


Figure A.1: Logon Procedure and Exchange of SI-SAP interface service primitives

A logoff event can be triggered by different entities:

- NCC/NMC (denoted as 'source: system' in figure A.2).
- Gateway.
- Satellite terminal.

In each case, the following steps are performed:

1. The logoff procedure is started by SD layer peers by means of dedicated primitives (SD_logoff_req, _ind, _res, _cfm) exchanged with the air interface module.

2. Control messages are transmitted over the return and forward links (FL and RL signalling).

3. Once the logoff procedure is successfully completed, internal control messages (SD_logoff_signalling) are exchanged between the SD peer and the SDAF module.

4. The SDAF module calls the SI-C-LOGOFF-IND primitive to notify the higher layer (SI) about the unavailability of the satellite air interface and the consequent suspension of any communication and networking activity.

NOTE: A logoff procedure started by a satellite terminal can be completed through two disjoint events:

1) The logoff request is followed by a logoff confirmation.

2) The logoff request is not followed by any logoff confirmation (a timer expires).

In either case, the logoff is considered completed at the satellite terminal side; the indication primitive will be eventually issued by the SDAF module towards the SI layer (SIAF), as previously introduced.

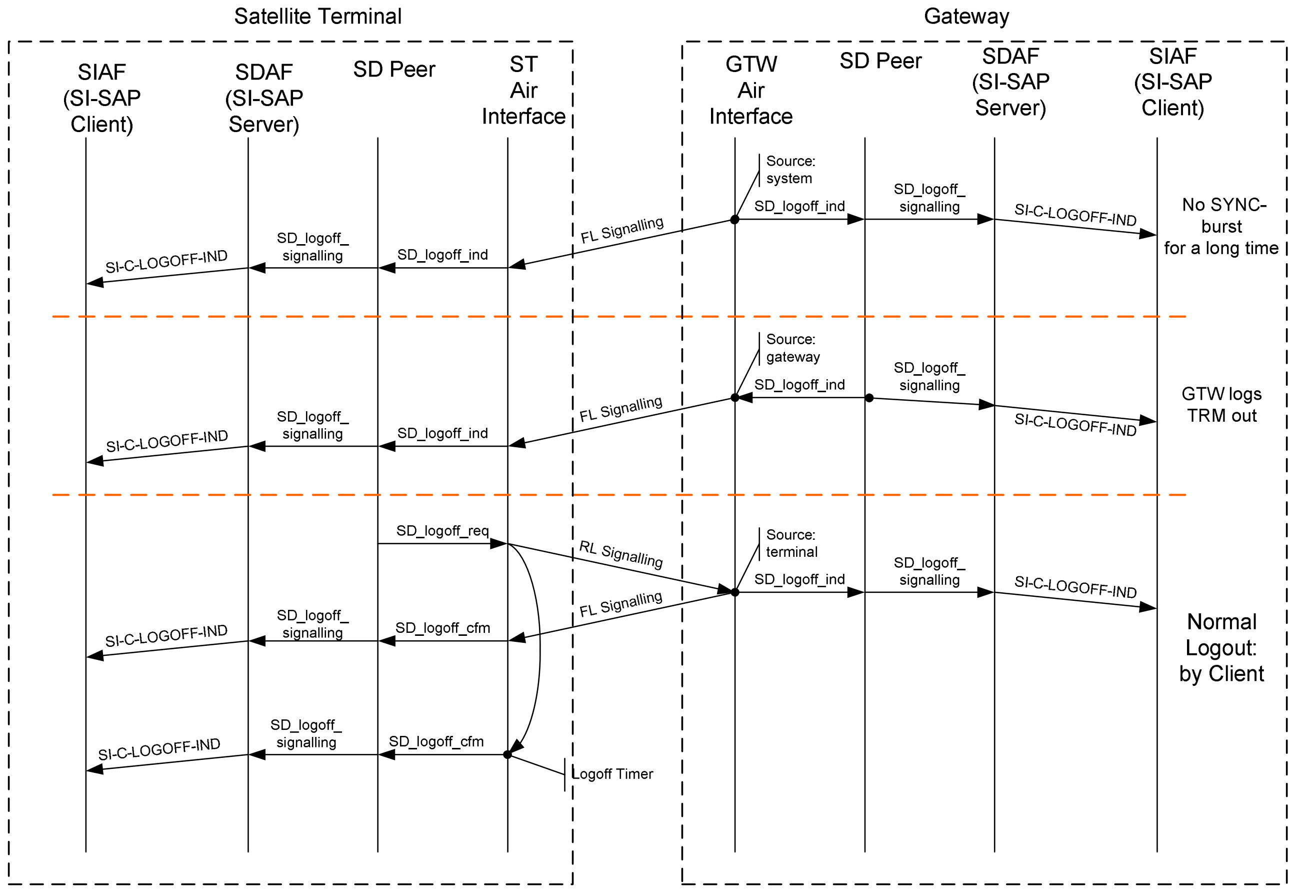


Figure A.2: Logoff Procedure and Exchange of SI-SAP interface service primitives

A.3.3 SI layer configuration

Upon successful logon procedure, the configuration of SI layer is performed. In more detail, the SIAF module issues a SI-C-SICONF-REQ primitive to be processed by the SDAF module, which will in turn generate an internal control message (SD-signalling) to inform the SD peer about the request.

SI layer configuration can actually proceed in two ways, depending on the availability of SI layer configuration data, possibly provided by the gateway to the satellite terminal during the logon phase.

In case no configuration data is available, the following steps are performed:

1. The SIAF module issues an SI-C-SICONF-REQ primitive.
2. The SDAF module processes the SI-C-SICONF-REQ primitive and generates a control message.
3. The control message is encapsulated in an SD frame and delivered to the gateway over the air interface.
4. The SDAF module implemented in the gateway issues an SI-C-SICONF-IND primitive to request the SI layer to provide the network configuration (network address) of the satellite terminal.
5. Upon network configuration retrieval, the SIAF module issues an SI-C-SICONF-RES SD primitive.
6. The SDAF module processes the primitive and generates a control message.
7. The control message is in an SD frame and then forwarded to the satellite terminal through the air interface over the FL.
8. As soon as the SD frame is received by the satellite terminal, it is finally delivered to the SD peer, which generates the control messages needed to activate the SDAF module.

9. The SDAF module issues an SI-C-SICONF-CFM primitive, whose reception from the SIAF is interpreted as positive notification of the successful configuration. Network configuration data are carried in the confirmation primitive.

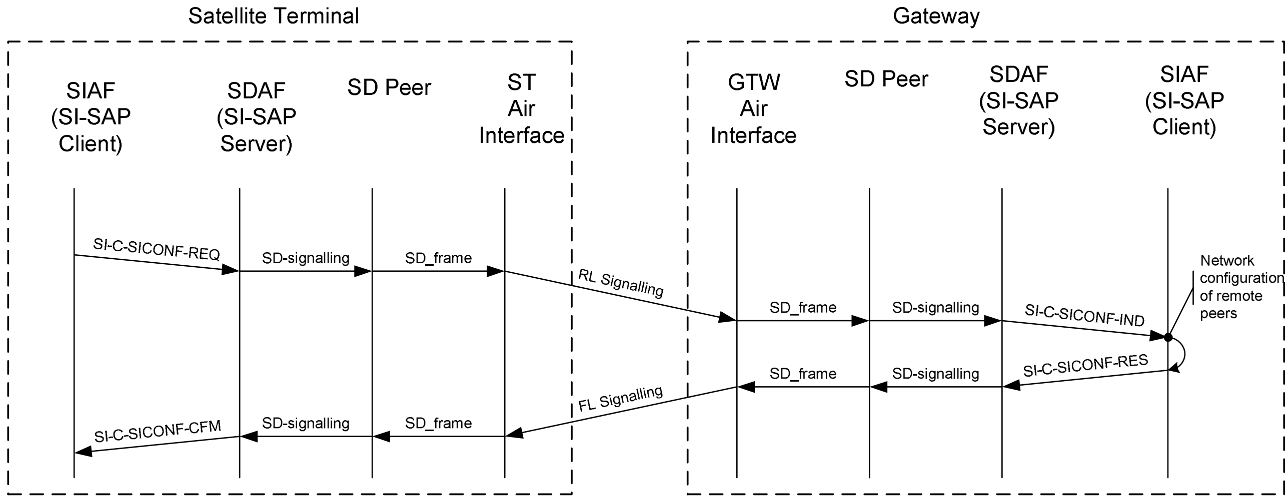


Figure A.3: Network Configuration in case no data are provided during the logon phase

In case network configuration information is already provided from the gateway to the to the satellite terminal SD layer directly during the logon phase, the resulting exchange of primitives occurring to perform the network configuration is simpler:

1. The SIAF module issues an SI-C-SICONF-REQ primitive.

2. The SDAF module processes the SI-C-SICONF-REQ primitive and generates a control message.

3. SD control messages are locally looped back by the SD peer to the SDAF module, because the SD peer has already received the network configuration data during the logon phase from the gateway and stored them accordingly.

4. The confirmation primitive is issued accordingly, thus saving a round trip time delay with respect to the previous case.

NOTE: The implementation of either case strictly depends on the information exchanged during the logon phase, which is strictly technology dependent.

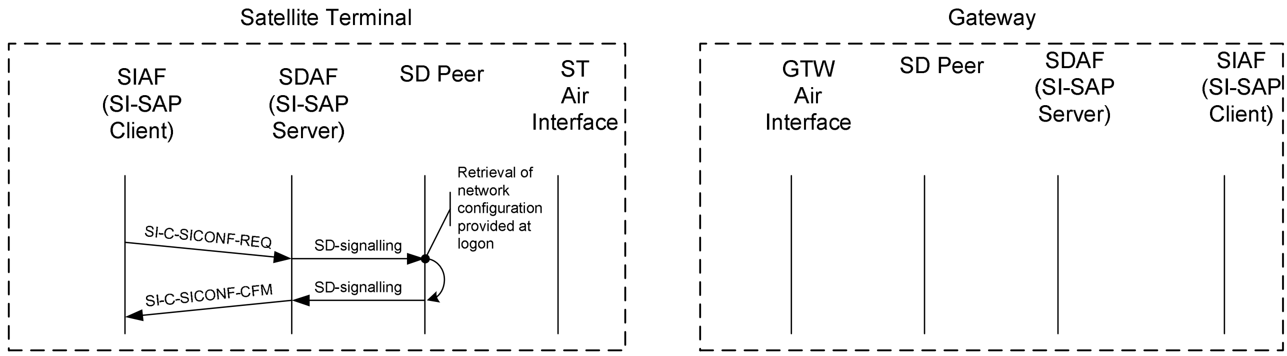


Figure A.4: Network configuration in the case data are provided during the logon phase

The network configuration data may contain information additional to the network address configurations, such as PEP activation, ROHC profile, just to cite a few. The exchanged primitives can therefore be used to configure different functionalities of the higher layer (also above the SI layer). This feature depends, however, on the specific technology being implemented; the corresponding information will be contained in the optional extension blocks of the SI-C-SICONF-CFM primitive.

A.3.4 Address resolution

The aim of addressing resolution services is to allow SI layer to resolve the BSM_ID address of the SI-SAP interface, which will be used by the C-plane or U-plane primitives during later satellite operations.

The address resolution request is performed according to the following steps:

1. The SIAF module issues the request primitive SI-C-AR_QUERY-REQ.
2. The SDAF module processes the primitive and generates internal control message.
3. The control message is encapsulated in an SD frame, which will be transmitted to the gateway through the air interface over RL.
4. The SD frame is received by the other end and the SD peer is triggered to create internal control messages.
5. The control message is processed by the SDAF module and an SI-C-AR_QUERY-IND primitive is issued and delivered to the SIAF module.
6. The SIAF retrieves the requested BSM_ID and issues a SI-C-AR_QUERY-RES primitive.
7. The SDAF module processes the primitive and translates the content into an SD frame for the transmission to the corresponding satellite terminal over FL.
8. On the satellite terminal side, as soon as the SD frame is received, SDAF functionalities will be activated by means of internal control messages.
9. The SDAF module creates an SD-C-AR_QUERY-CFM primitive, to be transferred to the SIAF module.
10. After the successful reception of the primitive, the SIAF module can finally extract and store the requested BSM_ID address, to be used later on satellite operations (for both U- and C-plane primitives).

NOTE 1: The BSM_ID of the destination SI-SAP interface depends on the network topology. In the case of star networks, the BSM_ID is actually that of the gateway, whereas in the case of mesh network it corresponds to satellite terminals'.

NOTE 2: The procedure does not differ in the case of unicast or multicast address resolution. The differentiation between the two is in that the confirmation primitive will set the multicast flag set to 1 in case of multicast address resolution. Accordingly, BSM_GID will be used instead of BSM_ID.

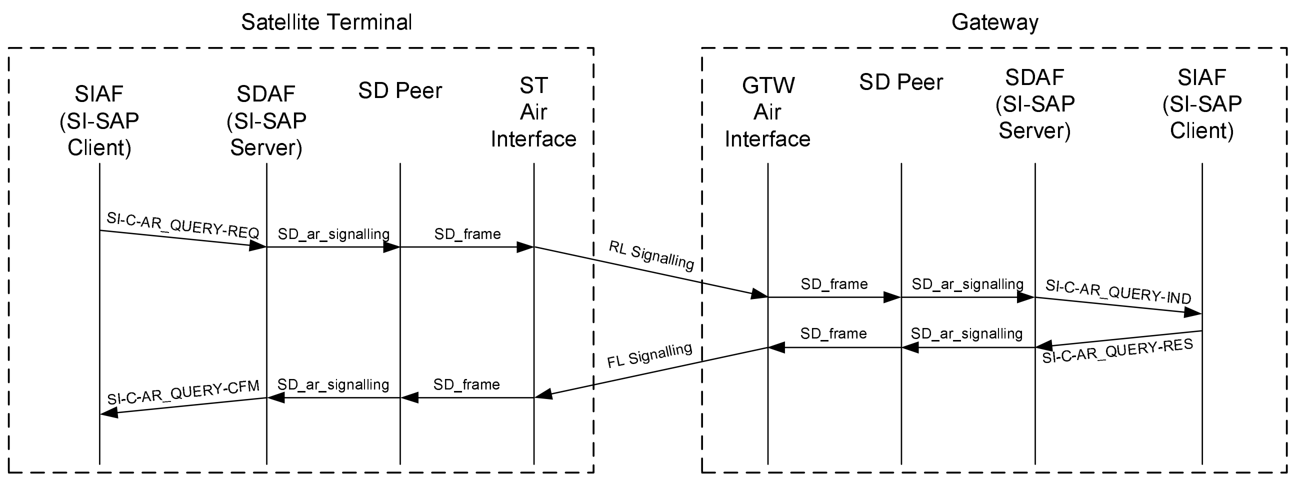


Figure A.5: Address Resolution phase with interaction between satellite terminal and gateway

Finally, it can be observed that in the case of star network the BSM_ID of the gateway is already available after the logon phase, because the logon primitives exchanged at SD layer also contain the hardware address (MAC address) of the gateway. Hence, the BSM_ID can be derived from this address.

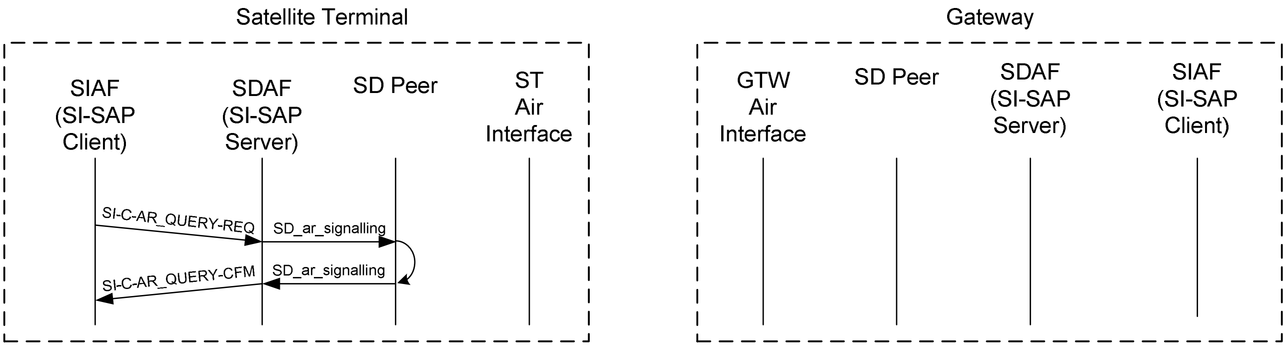


Figure A.6: Address Resolution phase performed locally in the satellite terminal

A.3.5 Multicast management

A.3.5.1 General

Multicast management entails the different phase of a dynamic multicast group membership (group creation, group listening, group removal) and the address resolution to allow the distribution of multicast data flows from the gateway to the satellite terminals subscribing to a given multicast group.

A.3.5.2 Group creation

The creation of a multicast group is usually carried out by a given application (e.g. video streaming, file sharing etc.) and the new group advertisement is performed by means of multicast routing (e.g. PIM-SM) and group membership protocols (IGMP). Upon group advertisement carried in group membership protocol, the following steps involving the SI-SAP interface are performed:

1. The SIAF module implemented in the gateway SI layer issues an SI-MCGROUP_ADD-REQ primitive and delivers it to the SDAF module.
2. The SDAF module processes the primitive and triggers the SD layer to generate the corresponding SD control messages.
3. A table of correspondences between the BSM_ID of the satellite terminals logged in the satellite network and the corresponding multicast group address of the SI-SAP interface (BSM_GID) is created by the SDAF module.
4. As soon as a group is created, only a correspondence between the BSM_GID (a default one is provided by the SIAF in the request primitive) and an empty set of BSM_ID is created.
5. Afterwards, when a satellite terminal joins the group through multicast routing protocol message exchange, the SIAF module of the gateway will update this correspondence by notifying the SDAF module.

A.3.5.3 Group join

The operation of joining a multicast group is initiated as soon as multicast routing protocol messages, announcing the multicast group, are received. The following steps involving the SI-SAP interface service primitives are performed:

1. The SIAF module issues an SI-C-AR_QUERY-REQ primitive in order to determine BSM_GID of a given multicast group.
2. Once the address resolution is completed by reception of the SI-C-AR_QUERY-CFM primitive, the BSM_GID is available to the SIAF module.
3. The SIAF module issues the SI-C-RGROUP_OPEN-REQ primitive in order to join the multicast group.
4. The SDAF module processes the primitive and triggers the SD layer peer configuration to enable the reception of the SD frames belonging to the requested multicast group.
5. Finally, the SI-C-RGROUP_OPEN-CFM confirmation primitive is sent back from the SDAF module to the SIAF module.

6. Contextually, the SI layer of the satellite layer notifies the counterpart at the gateway side about the join to the multicast group by means of a multicast routing protocol message.

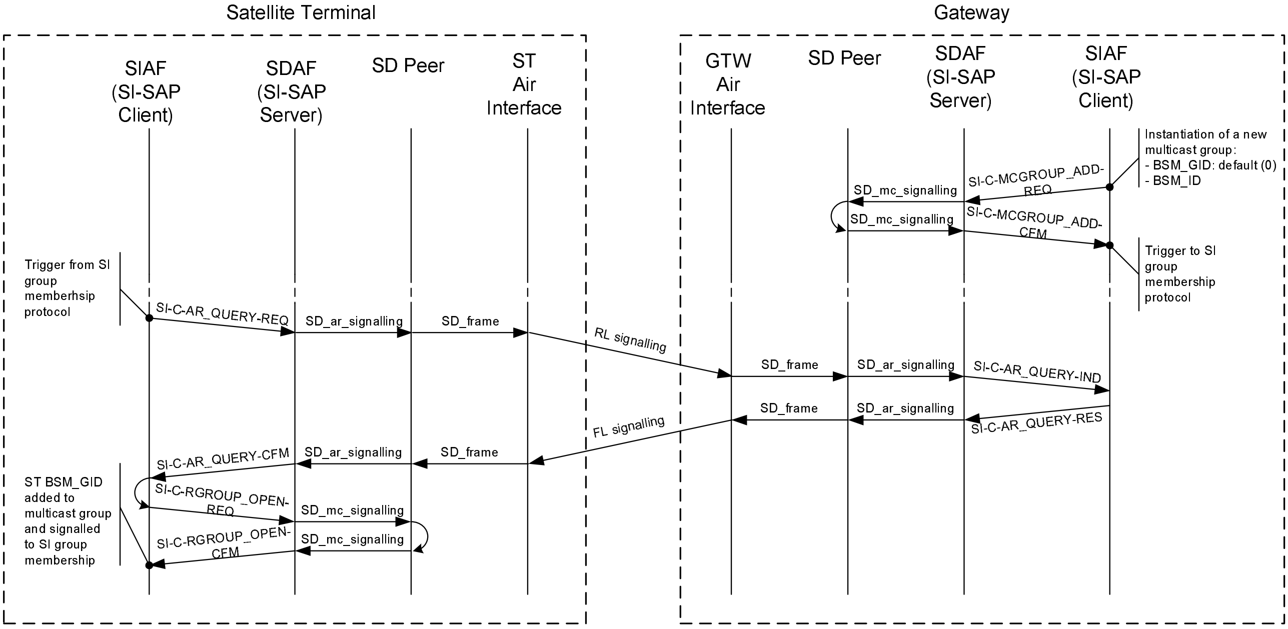


Figure A.7: Multicast management phase performed with interaction between satellite terminals and gateway

NOTE: As it has been already remarked in the description of address resolution phase, the procedure can be performed locally, provided that hardware addresses are available already after the logon phase. In this case, the overall multicast management procedure will be carried out by satellite terminals and gateway independently from an SI-SAP interface perspective. In any case, multicast routing protocol messages will be exchanged between the two parts to complete the configuration at the SI layer. This case is sketched below.

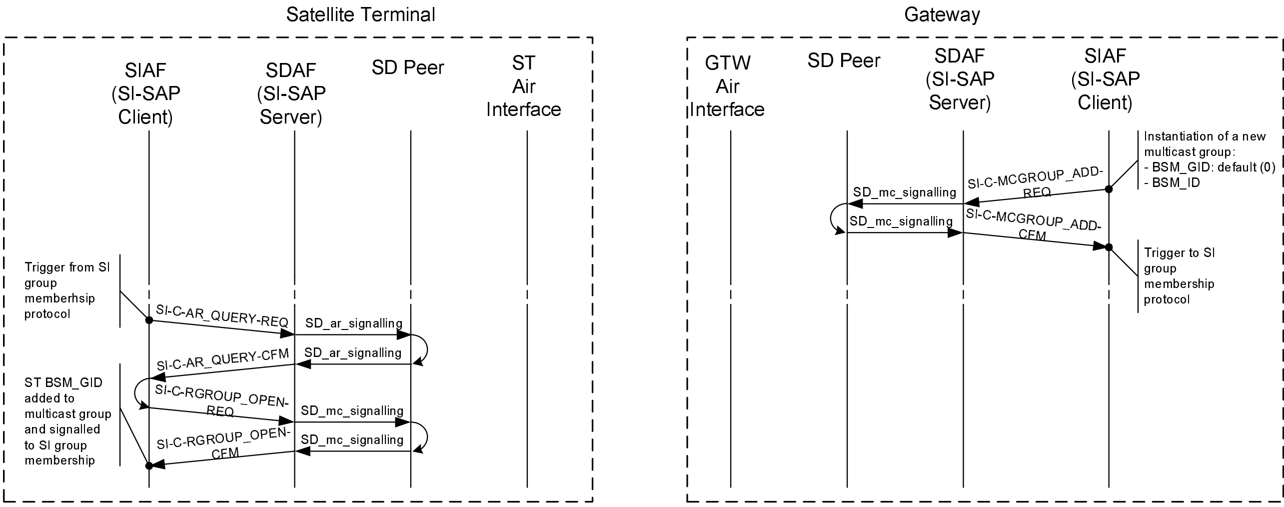


Figure A.8: "Join to" a multicast group without interaction between satellite terminals and gateway

A.3.5.4 Group leave

In the case a multicast group is removed from the initiating application or a user decides to unsubscribe from a given multicast group, this reflects into exchange of multicast routing protocol messages and of SI-SAP interface service primitives eventually. As soon as a user decides to leave the multicast group through the multicast application client, a leave multicast group membership protocol message is delivered to the SI layer of the corresponding satellite terminal. Afterwards, the following steps involving the SI-SAP interface service primitives are performed:

1. The SIAF module issues an SI-C-RGROUP_CLOSE-REQ primitive to inform the SD layer about the multicast group to be removed, in order to filter out all multicast streams associated to that BSM_GID.

2. A multicast 'leave' message will be sent from the SI layer of the satellite terminal to the gateway by means of multicast routing protocols.

3. On the gateway, upon reception of the leave message on the gateway, the SIAF module issues an SI-C-MCGROUP_REMOVE-REQ primitive.

4. The SDAF module processes the primitive and removes the interested BSM_ID from the multicast correspondence table.

NOTE 1: In case the initiating application decides to drop the multicast group, the procedure is started at the gateway and propagated to all satellite terminals affected by the multicast group removal. As such, the same primitives used in the other case are also invoked here. The only difference consists in the fact that the SDAF module implemented in the gateway will delete the entire correspondence for that specific BSM_GID.

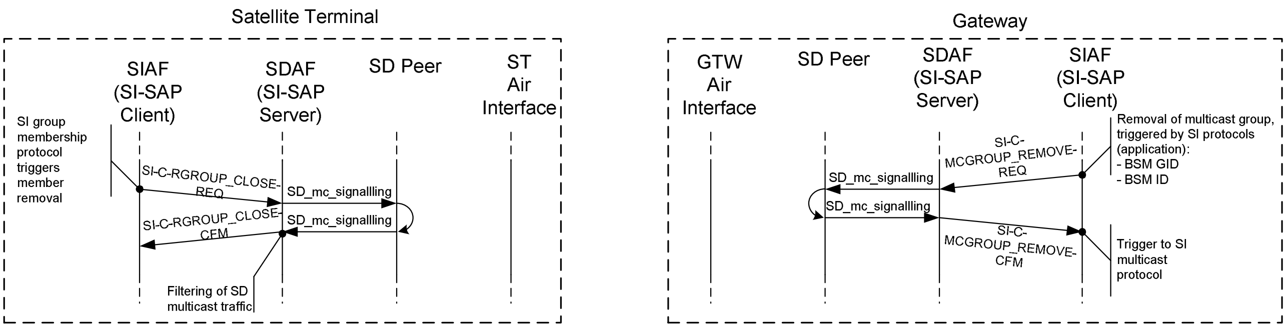


Figure A.9: Leave a multicast group at the satellite terminal level

NOTE 2: Finally, the status of a multicast group membership can be queried locally by the SIAF module implemented in a satellite terminal, by issuing a SI-C_RGROUP_STATUS-REQ primitive. The local SDAF module will respond to the received primitive with a SI-C-RGROUP_STATUS-CFM primitive, issued after the necessary interaction with the SD layer peer by means of dedicated control messages.

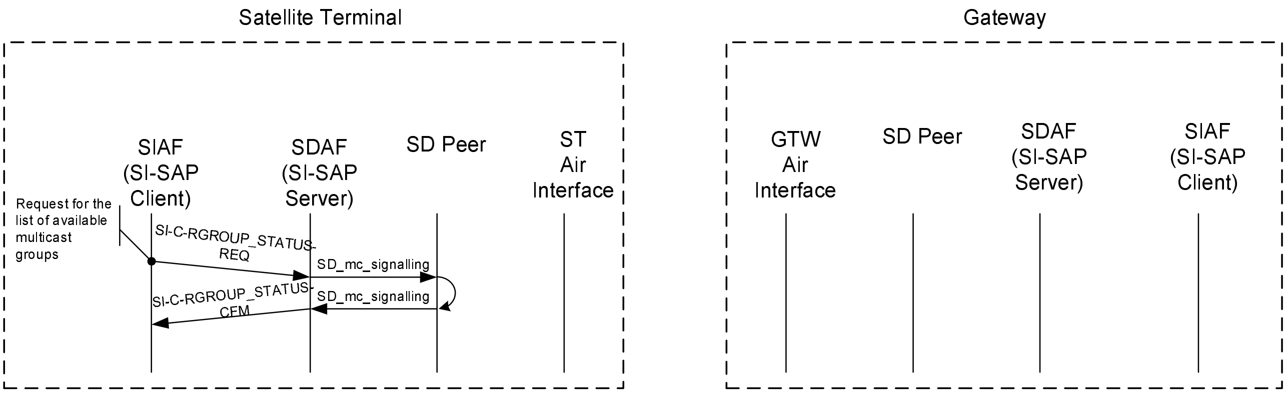


Figure A.10: Querying of the multicast group status

A.3.6 Resource reservation

A.3.6.1 General

The ETSI BSM architecture provides resource reservation functions in support to QoS management. The related SI-SAP interface service primitives deal with request, modification, cancel, and status of satellite capacity requests. They are invoked by the SIAF module when data traffic demand new or updated QoS requirements and existing capacity allocations should be cancelled instead.

A.3.6.2 Request of a new resource reservation

The request for new resources is performed according to the following steps:

1. The SIAF module issues the SI-C-QUEUE_OPEN-REQ primitive to request the necessary satellite capacity resources.

NOTE 1: The final objective of the request is the assignation of a given queue identifier (QID) at the SD layer, which will be used in the forthcoming data communication. The desired QoS requests demanded by the reference traffic flow (or aggregate) are transported in QID specification (QIDSPEC) in the service primitive.

2. The SDAF module processes the primitive and generates control messages to properly configure the scheduling policies applying on the queues implemented in the SD layer.

3. The SDAF module issues the confirmation primitive SI-C-QUEUE_OPEN_CFM with the status flag set to a positive value in case the request can be accommodated.

NOTE 2: In more detail, a specific QID is assigned to the requested QIDSPEC profile for the reference given traffic (or aggregate) flow.

4. If the reservation request cannot be satisfied, the SI-C-QUEUE_OPEN_CFM is issued with the status flag set to a negative value to notify the SI layer about the unavailability of the resources to accommodate the reservation request.

NOTE 3: It can be noted that resource reservation does not imply interaction between satellite terminals and gateway at SI-SAP interface. Interaction, instead, occurs by means of the control messages encapsulated in SD frames periodically exchanged between satellite terminal and gateway in order to properly allocate the satellite capacity.

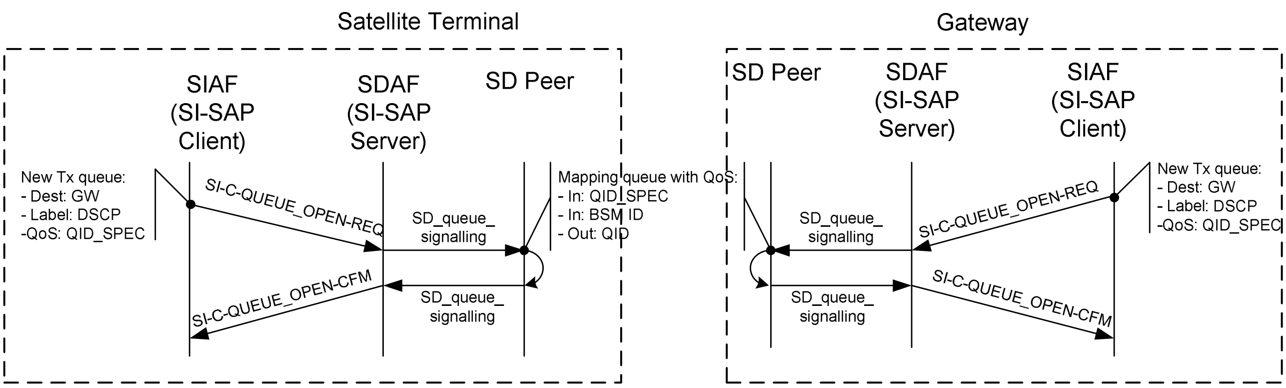


Figure A.11: Resource reservation: creation of a new QID in response to a new QIDSPEC

A.3.6.3 Modification of an existing resource reservation

In the case an existing QoS demand (encoded as QIDSPEC) is upgraded (or downgraded), a corresponding re-allocation of the satellite capacity resources is performed. To this end, the following steps are performed:

1. The SIAF module issues an SI-C-QUEUE_MODIFY-REQ primitive.

2. The SDAF module processes the primitive and triggers the SD layer to properly configure the scheduling policies if the satellite capacity can accommodate the updated QoS request.

3. The SDAF module issues an SI-C-QUEUE_MODIFY-CFM primitive, with the status flag set to positive or negative value to notify the SIAF module about the successful or failed resource reservation update.

The exchange of primitives is depicted in the following.

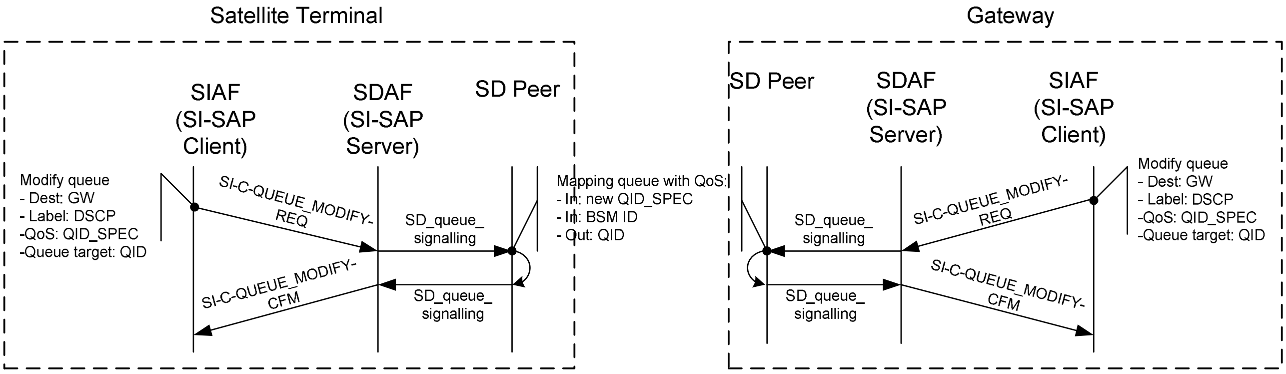


Figure A.12: Resource reservation: update of an existing QID based on a new QIDSPEC

The update of resource reservations can be unsolicited and triggered by the SD layer because of fluctuations of the satellite capacity, whereby current QoS demands cannot be any longer accommodated. In this case, the following steps are performed:

1. The SDAF module issues an SI-C-QUEUE_MODIFY-IND primitive.

2. The SIAF module processes the primitive and records the change about the satellite capacity availability.

NOTE: This event can trigger the SI layer to call QoS-based routing protocols (e.g. SIP, IETF RFC 3261 [i.19]) to inform end-users about the variation of the QoS capabilities offered by the satellite system. This possibility is however implementation specific and is beyond the scope of the present document.

3. The SIAF module optionally issues an SI-C-QUEUE_MODIFY-RES to inform the SDAF module about the received notification.

A.3.6.4 Release of an existing resource reservation

In the case a resource reservation is no longer valid (e.g. short-lived traffic flow, or QoS downgrade to Best Effort), the SI layer requests the SD layer to withdraw the satellite capacity reserved to a specific QID. To this end the following steps are performed:

1. The SIAF module issues an SI-C-QUEUE_CLOSE-REQ primitive.

2. The SDAF module processes the primitive and internal SD control messages are generated to properly re-configure the scheduling policies of the SD queues and to make the allocated satellite capacity available to other traffic flows (or aggregates).

3. Once this operation is accomplished, the SDAF module issues the SI-C-QUEUE_CLOSE-CFM primitive to notify the SIAF layer about the successful cancellation.

As also observed for the resource reservation, unsolicited notification can also be generated by the SD layer to inform the SI layer about the cancellation of a given resource reservation, assigned to a specific QID. In this case the following steps are performed:

1. The SDAF module issues the SI-C-QUEUE_CLOSE-IND primitive, as soon as the SD peer informs it through internal control message about the unavailability of the formerly assigned satellite capacity portion.

NOTE: The SI layer can react to this event by invoking QoS-based routing protocols (e.g. SIP, IETF RFC 3261 [i.19]) to inform end-users about unavailability of satellite capacity. This possibility is however implementation specific and is beyond the scope of the present document.

2. The SIAF module optionally issues an SI-C-QUEUE_MODIFY-RES to inform the SDAF module about the received notification.

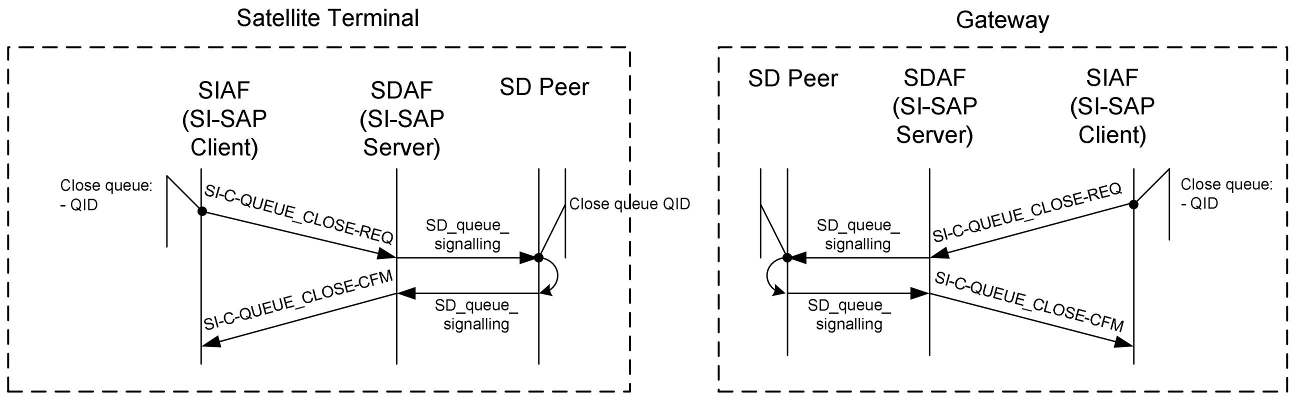


Figure A.13: Resource reservation: cancellation

A.3.6.5 Status of an existing resource reservation

The SI-SAP interface also provides primitives to infer the status of the satellite capacity reservations. To this end, the following steps are performed:

1. The SIAF module issues the SI-C-QUEUE_STATUS-REQ primitive to infer the status of the resource reservation for which a specific QID has been formerly assigned.
2. The SDAF module processes the primitive and generates internal control messages to infer the status of the satellite capacity allocated.
3. The SDAF module issues an SI-C-QUEUE_STATUS-CFM primitive to inform the SIAF module about the status of the reserved satellite capacity.

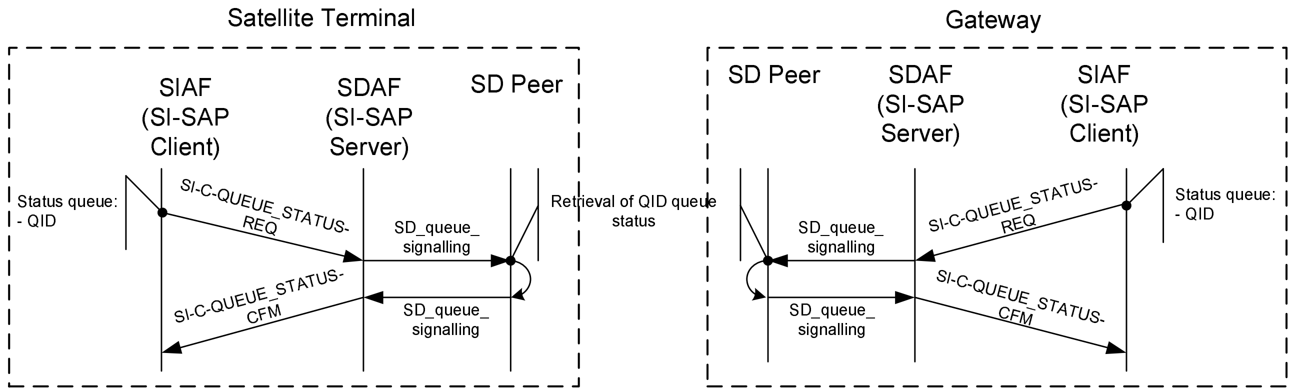


Figure A.14: Status querying of existing resource reservations

Unsolicited notification from the SD towards SI layer can also be provided in the case of resource reservation status. In this case the following steps are performed:

1. The SDAF module issues an SI-C-QUEUE_STATUS-IND primitive to inform the SIAF module about the status of the reserved satellite capacity.

NOTE: This notification can be issued on a periodic or an asynchronous base, upon trigger from the SD layer. The exact nature of the event occurrence is obviously specific of the reference SD technology being implemented.

A.3.7 Data transfer

Data transfer is started by the SIAF module as soon as an SI layer PDU (e.g. IP datagram) is transmitted through the satellite network. To this end, the following steps are performed:

1. The SIAF module issues an SI-U-UNITDATA-REQ primitive containing the SI layer PDU.

2. The SDAF module processes the primitive and generates control message so that the SD peer generates an SD_frame encapsulating the original SI layer PDU (or a fragment of it in case of size mismatch), which will be delivered to the other end over the satellite air interface.

3. At the other end, the SDAF module issues an SI-U-UNITDATA-IND primitive containing the native SI layer PDU (or a fragment of it), upon reception of the SD_frame.

4. The SIAF module processes the primitive, extracts the SI layer PDU (e.g. IP datagram) and forwards it to the SI layer for the other processing operations, such as routing or multiplexing to higher layers.

NOTE: Differentiation between unicast and multicast traffic is accounted by means the BSM_ID (BSM_GID for multicast flows) defined in the aforementioned U-plane primitives.

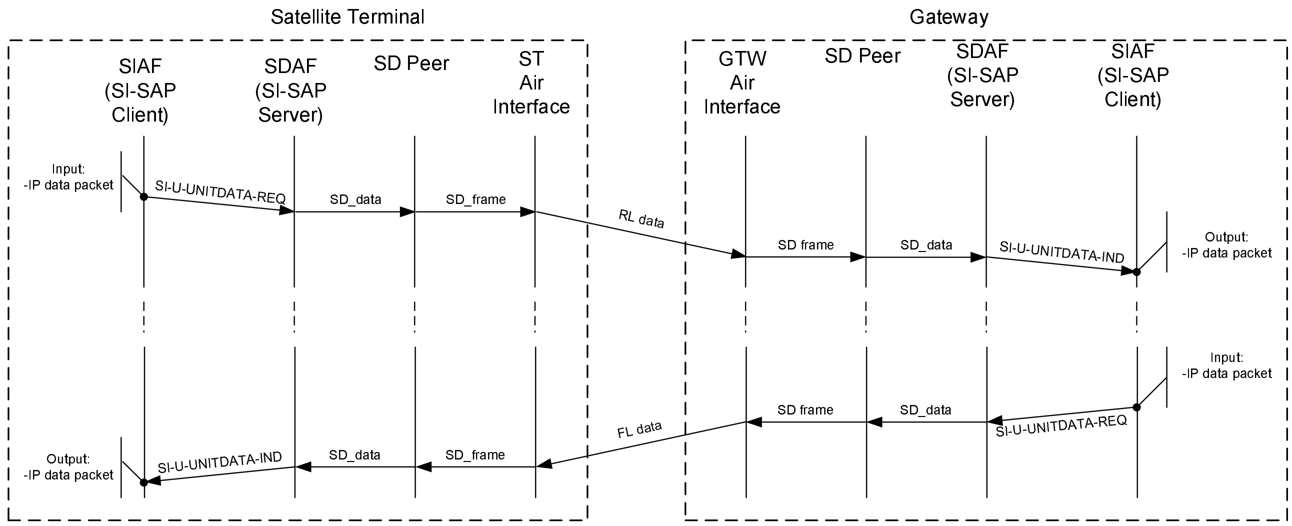


Figure A.15: Data transfer between satellite terminals and gateway

A.4 Interaction of SI-SAP interface service primitives

A.4.1 General

The clause 4 is devoted to the sequence of actions that take place during satellite communications, reflected into exchange of SI-SAP interface service primitives. To this regard, two main operative phases are illustrated:

- System Initialization. This phase corresponds to the start-up of a satellite terminal with the corresponding logon and overall protocol stack configuration.

- Data Communication. This phase corresponds to regular data communication where both unicast and multicast flows are injected in the BSM satellite network, with implications on QoS, multicast, and address resolution procedures.

A.4.2 System initialization

During the system initialization, a satellite terminal wants to "enter" the satellite network and therefore requests to log in the satellite system. Upon logon completion and signal carrier acquisition (along with the rest of SD layer configuration), the overall configuration of the SI layer is performed in order to set the functionalities, amongst which the network addressing plan is the most important. As such, the following operations are performed in order:

- Logon.

- SI layer Configuration.

The SI layer configuration is carried out according to the availability of network address information provided already during the logon phase, so that querying the SI layer peer running on the gateway is not necessary. On the other hand (unavailability of information), the SI configuration is carried out by interacting with the gateway SIAF module and hence taking an additional round trip time delay.

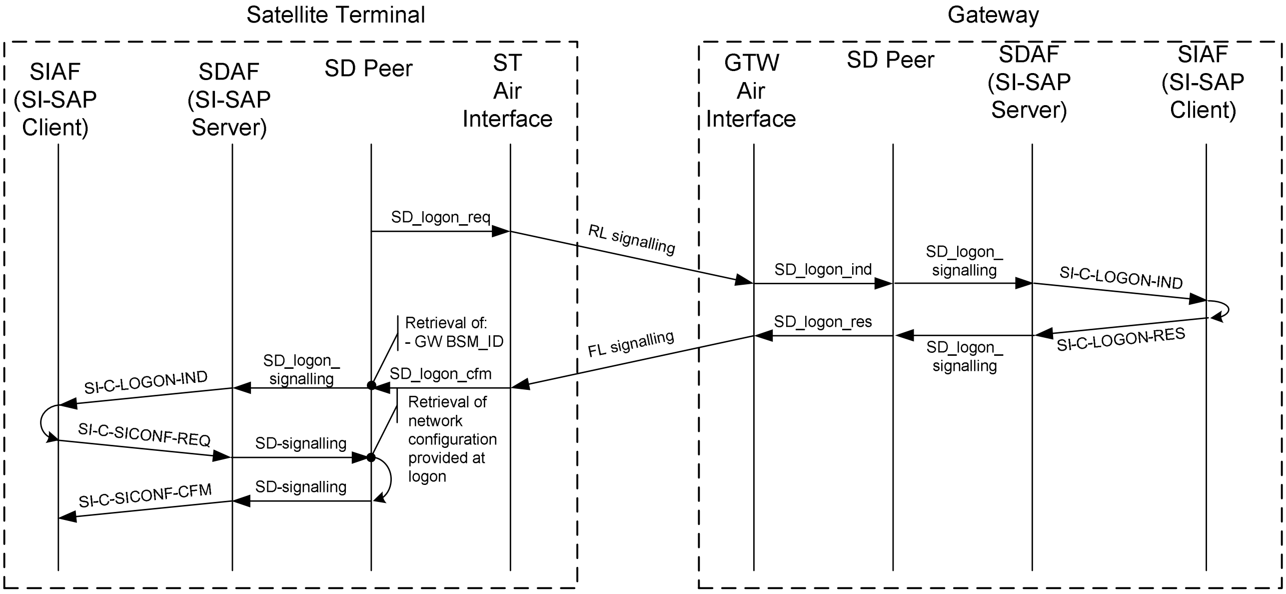


Figure A.16: System initialization with availability of logon information

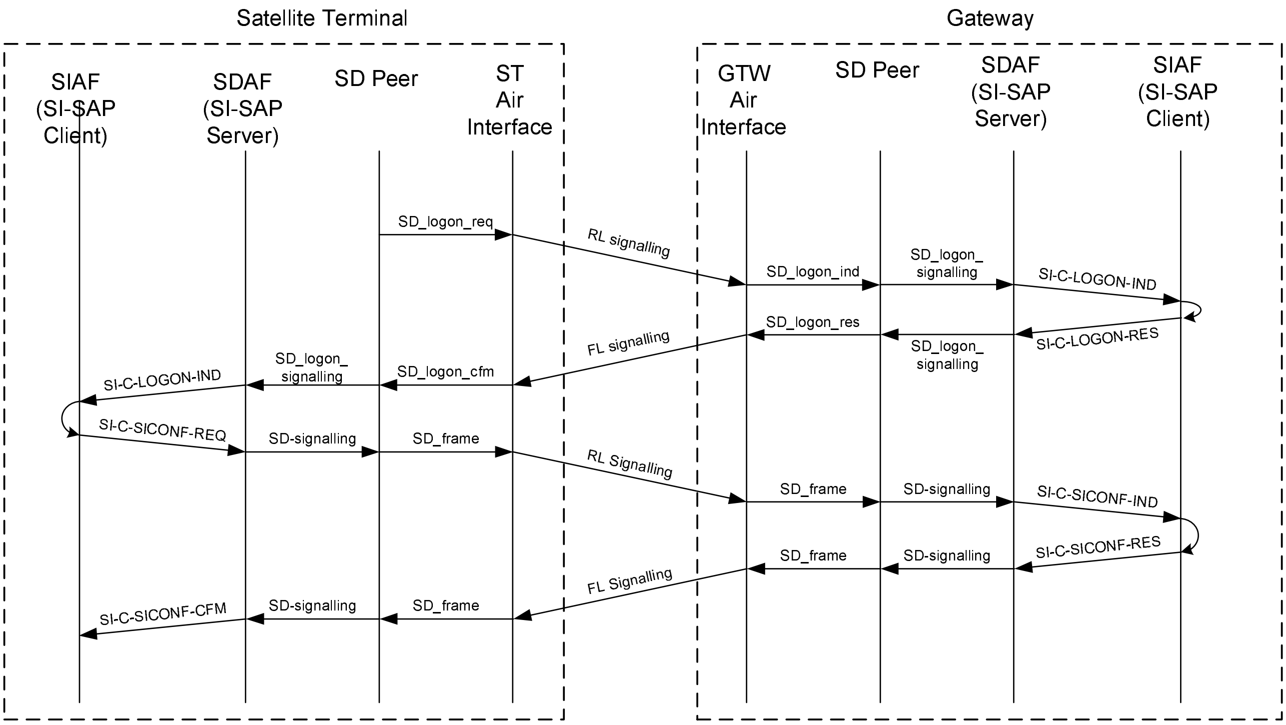


Figure A.17: System initialization without availability of logon information

A.4.3 Data communication

A.4.3.1 General

Data communication can be either unicast or multicast (broadcast traffic is directly generated by the SD layer, thus not requiring any exchange of SI-SAP interface service primitives), with the related implications from an address resolution and multicast management point of view.

A.4.3.2 Unicast

In the case of unicast data transfer, the following steps are performed:

1. Resolution of the unicast address (locally or remotely, depending on the availability of the hardware address of the gateway).
2. Resource reservation to allocate the portion of satellite capacity needed to accommodate the QoS demands of the traffic (or aggregate) flow.
3. Transfer of the data flow coming from the SI layers from one side to the other side of the satellite network.
4. Once received at the SI layer of the destination, the traffic flow can be re-routed or multiplexed to the higher layers (transport and application, in case of a proxy).

NOTE: It may also happen that the traffic flow is short-lived, whereby the resource reservation holds valid for a limited period of time. Once this time interval is expired, release of the satellite capacity portion is therefore performed.

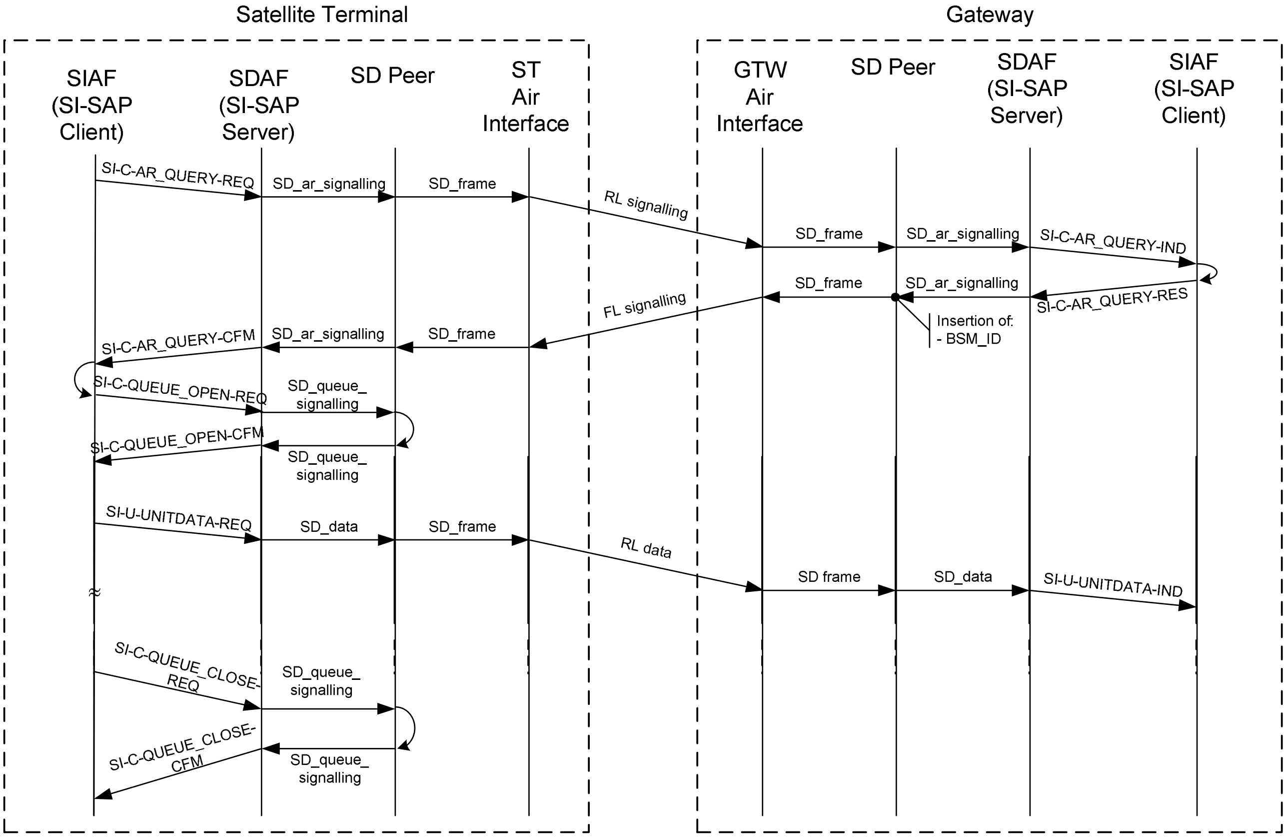


Figure A.18: Unicast data communication with address resolution performed without available logon information

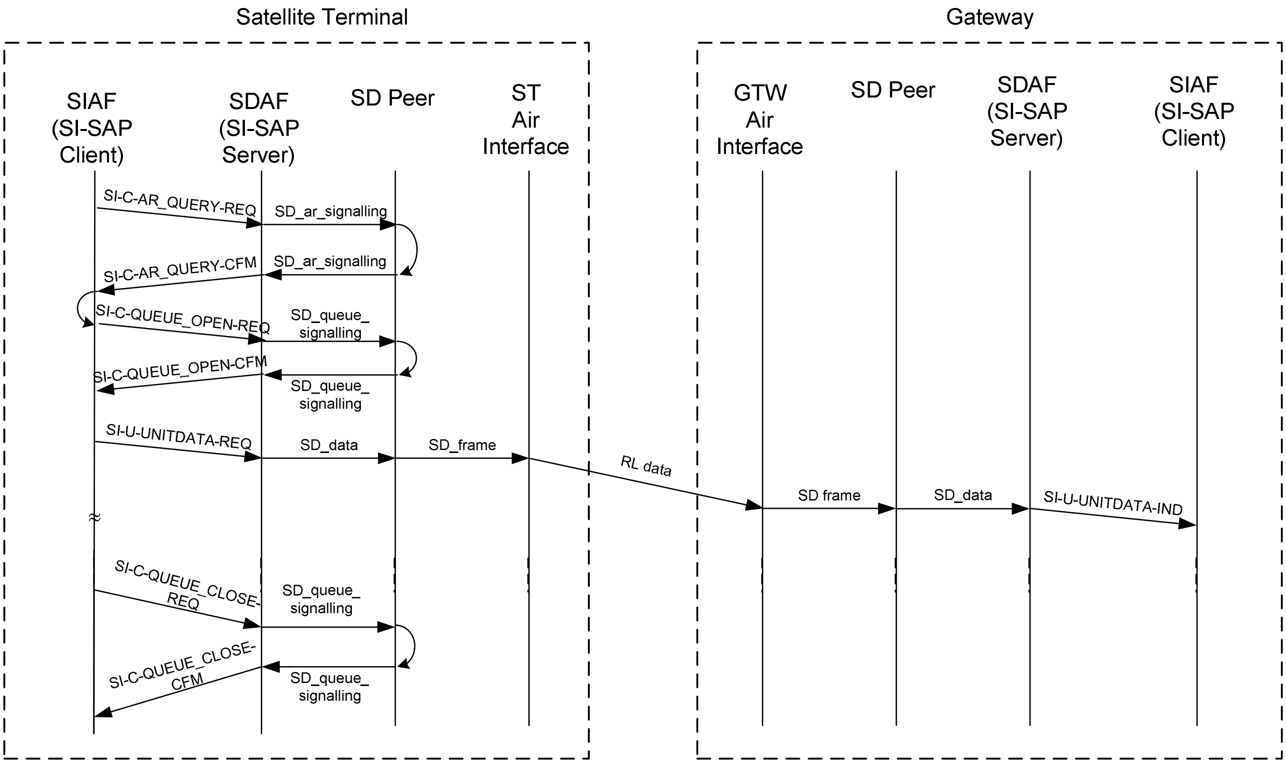


Figure A.19: Unicast data communication with address resolution performed with available logon information

A.4.3.3 Multicast

In addition to address resolution and data transfer, performing multicast data communication also involves the creation, participation and leave from a multicast group. First of all, a multicast application (e.g. multicast streaming) triggers multicast membership and routing protocols to advertise the presence of a new multicast group over the satellite network. Afterwards, the SI-SAP interface service primitives are invoked according to the following steps:

1. The SDAF module within the gateway creates a new BSM_GID and manages the membership of satellite terminals (BSM_IDs) upon service primitives' reception from the SIAF module.

2. As soon as a satellite terminal decides to join a given multicast group, BSM_GID address resolution is carried out through address resolution primitives (run locally or remotely, depending on the information already available at the SD layer).

3. At the same time, multicast routing and membership protocols inform the SI layer of the gateway about the group membership update.

4. The SIAF module informs the SDAF layer about the satellite terminal (BSM_ID) joining the multicast group (BSM_GID) so as to keep the membership association information updated.

5. Resource reservation procedures are started in order to properly allocate the required satellite capacity portion.

6. Multicast data are distributed from the gateway to the satellite terminals being part of the multicast tree.

On the other hand, when the satellite terminal leaves the multicast tree, it informs the gateway through the multicast routing protocol. From an SI-SAP interface perspective, the following operations are performed:

1. The SDAF module updates the list of BSM_GID upon primitives' reception from the SIAF module, by removing the multicast group from which the satellite terminal has decided to leave.

2. On the gateway side, the membership of satellite terminals to multicast group is also updated to reflect the multicast group leave.

3. Release of the resource previously allocated to the multicast data flow is carried out.

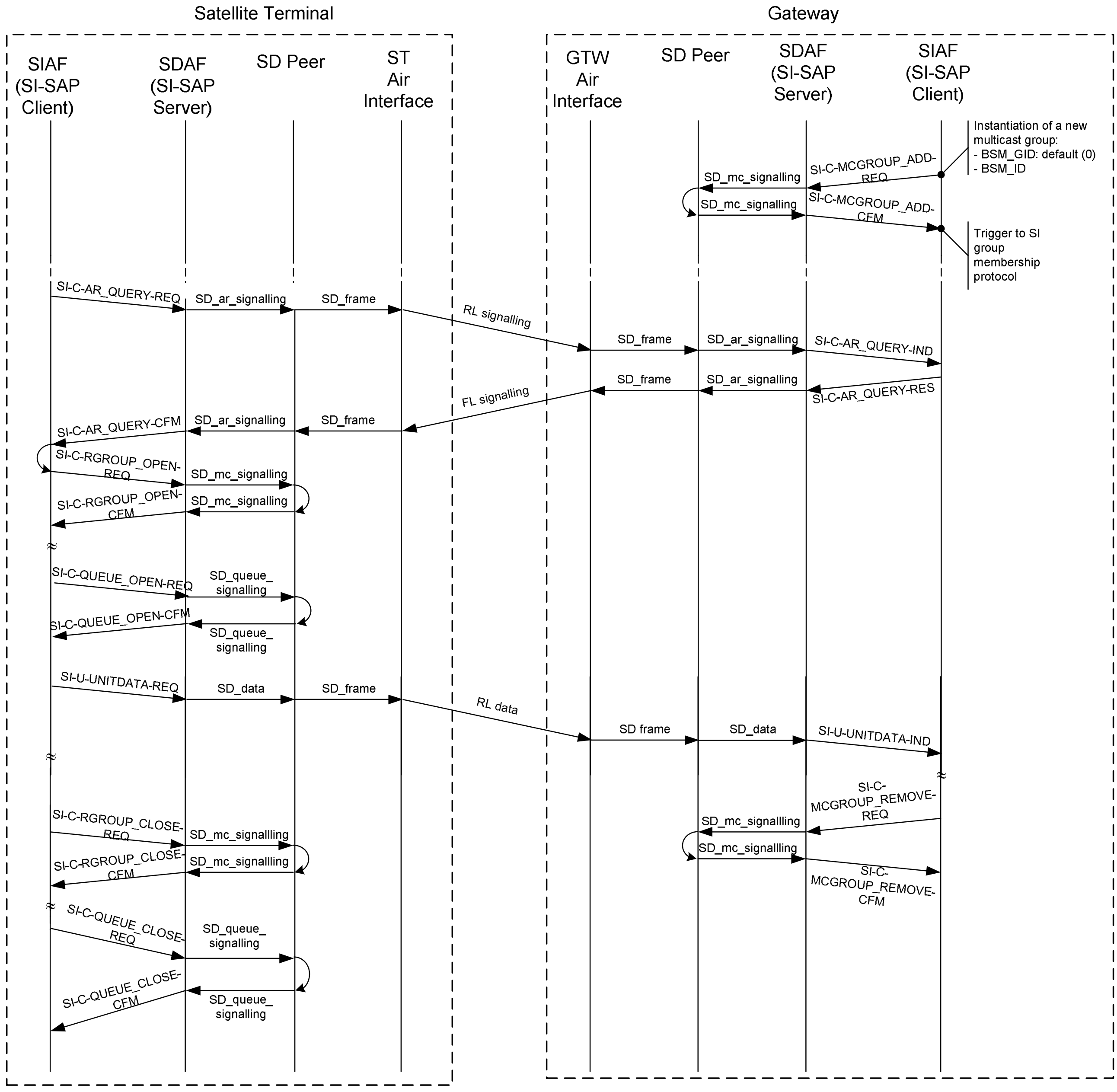


Figure A.20: Multicast data communication
(address resolution performed without available logon information)

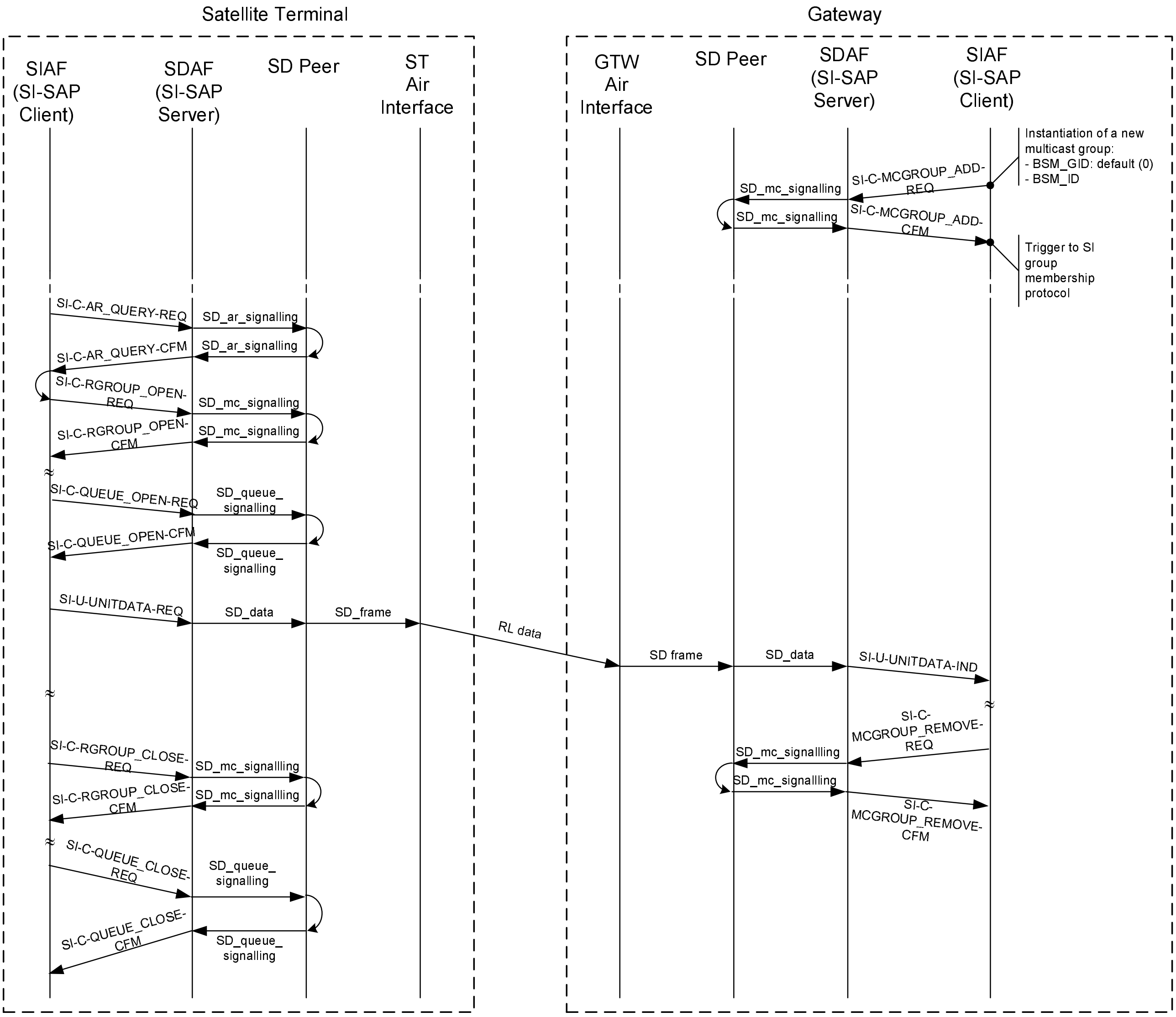


Figure A.21: Multicast data communication (address resolution performed with available logon information)

Annex B (informative): Implementation of the SI-SAP as external interface

B.1 Introduction

The implementation of the SI-SAP interface and related SI-SAP interface service primitives in a real satellite system can be done either locally or in a distributed way.

The former is the approach defined according to the ISO/OSI specifications, where protocol interfaces are logically instantiated between adjacent layers N+1 and N. The protocol entity of layer N+1 requests a service from the protocol entity of layer N by exchanging the primitives corresponding to that service.

The SI-SAP interface is implemented in the ETSI BSM architecture according to the same principles, by overriding the protocol interface natively defined between SI and SD layers, whose characteristics are dependent on the specific protocol technology being used at the SD layer. The overriding of interface functionalities is carried out by the implementation of the SIAF and SDAF modules, which can be implemented in software or hardware.

On the other hand, the definition of the SI-SAP interface in a distributed way implies its implementation as an *external interface*. The definition of SI-SAP as external interfaces should only addresses the case of the satellite terminal, although this definition can be in principle applicable to the gateway. This option stems from the fact that the satellite terminal needs not implement the SI layer and the related UIF functions, whereas the SI layer and the GIF functions are implemented by the gateway.

Hence, the SI-SAP interface is defined between:

1) SD layer of the satellite terminal.

2) SI layer implemented in the user equipment (or router) belonging to the premises' network.

The two elements can be interconnected by point-to-point protocol technology (e.g. Ethernet). In this case, the SI-SAP interface really defines an external logical interface, whereby the exchange of SI-SAP interface service primitives is actually performed over the physical interface of the two sub-elements. As such, the SI-SAP interface service primitives are defined as specific messages transported by the technology implemented by the point-to-point protocol.

The concept of external SI-SAP interface is depicted in the following picture, where the case of user equipment or router implementing the SIAF module is considered. The premises network is connected to the satellite terminal implementing only the SD layer via LAN.

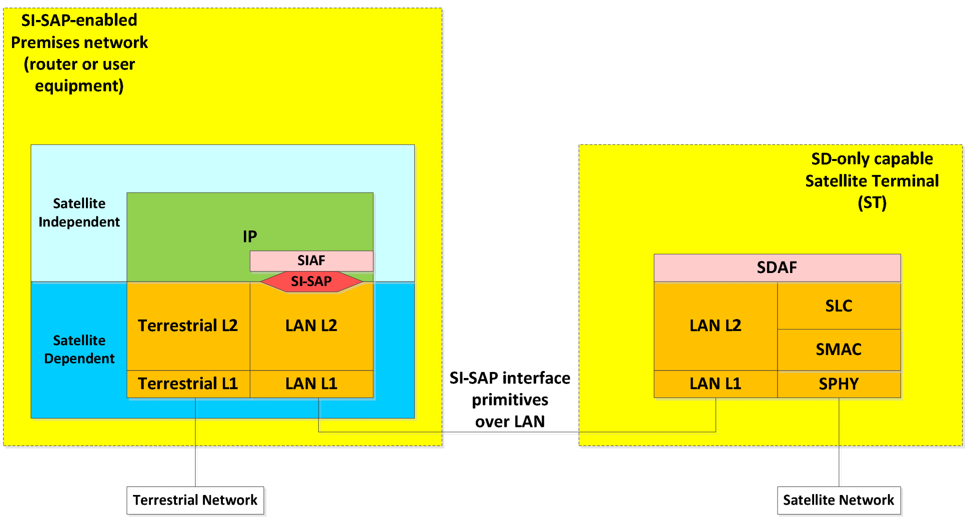


Figure B.1: External SI-SAP interface

For the sake of the overall SI-SAP interface and related service primitives' implementation, the following key points need to be addressed:

- Message format.
- Protocol encapsulation.

The former relates to how SI-SAP interface service primitives should be transcoded and the additional message information needed for processing on SIAF and SDAF modules.

The latter relates to the selection of the protocol, whose PDU will encapsulate the primitive message transmitted (received) by SIAF and SDAF modules.

Details about these two key points are provided in clauses B.2 and B.3.

B.2 Message format

B.2.1 General and syntax definition

The SI-SAP interface service primitives should be transcoded in corresponding messages to be transferred between SIAF and SDAF across the external SI-SAP interface.

Each SI-SAP interface primitive is mapped to a corresponding SI-SAP interface primitive message, which contains the information represented in the primitive. Furthermore, the message also implements a dedicated header to support the processing functions at the SIAF and SDAF modules' side.

In more detail, the SI-SAP header contains information (payload of the SI-SAP interface primitive message) about the successive block in order to dispatch the specific primitive information to the corresponding SIAF (SDAF) functionality. Further to this, integrity and sequencing functions should also be provided.

The SI-SAP header and the relative SI-SAP payload are specified in clauses B.2.1.1 and B.2.1.2. Where not explicitly stated, usual terminology (e.g. QID, BSM_ID) of the SI-SAP interface documents is used and therefore not further expanded. With respect to the primitives' specification provided in the relevant ETSI BSM documents, this annex contains instead more details (e.g. additional flags, padding) that should be properly taken into account while implementing the primitives.

Each SI-SAP interface primitive message is composed of a header and a payload. The overall specification is as follows:

Table B.1: SI-SAP interface primitive message syntax definition

Syntax	Number of bits	Mnemonic
SI-SAP_Header()		
SI-SAP_Payload()		According to MPEG-2 semantics

For the sake of the generality, the SI-SAP_Header() and the SI-SAP_Payload() can be composed of several blocks and fields.

Clause B.2.2 draws the details of the SI-SAP_Header and the SI-SAP_Payload. In particular, the SI-SAP_Header signals the specific primitive message that is then defined in the SI-SAP_Payload.

B.2.2 SI-SAP header

Table B.2: SI-SAP_Header syntax definition

Syntax	Number of bits	Mnemonic
SI-SAP_Header() {		
Message_Type	16	uimsbf
Length	16	uimsbf
Query_Handler	32	uimsbf
Checksum	32	uimsbf
}		

Message_Type. It indicates the SI-SAP interface primitive message type.

Length. Length of the SI-SAP message (header and payload).

Query_Handler. The query handler used to match request and confirm which identifies the query using a 32 bits integer (random number).

Checksum. Checksum performed on the header and the payload to verify its integrity once received.

B.2.3 SI-SAP interface primitive messages

B.2.3.1 Data transfer

Table B.3: SI-U-UNITDATA-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-U-UNITDATA-REQ() {		
SI-SAP_Header()	96	
Source_BSM_ID	48	uimsbf
Destination_BSM_ID	48	uimsbf
QID	24	uimsbf
Padding	8	uimsbf
SDU_Type	16	uimsbf
for (i = 0; i < N1; i++) {		
SDU_Data_Byte	8	bslbf
}		
}		
NOTE: *N1: size of the SDU in bytes.*		

Padding. Number of additional bits to align the primitive header length to a multiple of 32 bits.

SDU_Type. It identifies the protocol layer generating the SDU encapsulated in this message.

SDU_Data_Byte. The SDU which is N1 bytes long.

Source_BSM_ID. The BSM_ID of the source.

Destination_BSM_ID. The BSM_ID of the destination.

Please note that indication of source and destination BSM_ID occurs only in the U-plane primitives. In the C-Plane primitives, BSM_ID is indicated to uniquely denote the BSM_ID of the destination.

Table B.4: SI-U-UNITDATA-IND syntax definition

Syntax	Number of bits	Mnemonic
SI-U-UNITDATA-IND() {		
SI-SAP_Header()	96	
Source_BSM_ID	48	uimsbf
Destination_BSM_ID	48	uimsbf
SDU_Type	16	uimsbf
for (i = 0; i < N1; i++) {		
SDU_Data_Byte	8	bslbf
}		
}		
NOTE: *N1: size of the SDU in bytes.*		

B.2.3.2 Logon/logoff

Table B.5: SI-C-LOGON-IND syntax definition

Syntax	Number of bits	Mnemonic
SI-C-LOGON-IND() {		
SI-SAP_Header()	96	
Hardware_Address	48	uimsbf
BSM_ID	48	uimsbf
}		

Hardware_Address. It is the hardware address (48 bit MAC address) of the gateway.

Table B.6: SI-C-LOGOFF-IND syntax definition

Syntax	Number of bits	Mnemonic
SI-C-LOGOFF-IND() {		
SI-SAP_Header()	96	
BSM_ID	48	uimsbf
Source	2	uimsbf
Padding	14	uimsbf
}		

Source. It indicates the source of the logoff event: gateway, satellite terminal, or network-triggered (e.g. NCC).

B.2.3.3 SI layer configuration

Table B.7: SI-C-SICONF-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-C-SICONF-REQ() {		
SI-SAP_Header()	96	
Network_Address_Type	32	uimsbf
Client_Network_Address	32	uimsbf
Client_Netmask	32	uimsbf
Gateway_Network_Address	32	uimsbf
SICONF_BlockNumber	8	uimsbf
for (i=0, i< SICONF_BlockNumber-1, i++) {		
Block_ID	8	uimsbf
Block_Length	16	uimsbf
Information_Block()	variable	uimsbf
}		
Padding	variable	uimsbf
}		

Client_Network_Address. The network address requested by the satellite terminal. It is set to a standard value (0.0.0.0) in case no specific address is being requested.

Client_Netmask. The netmask related to the network address requested by the satellite terminal. It is set to 0.0.0.0 in case none is requested explicitly.

Gateway_Network_Address. The network address of the gateway that the satellite terminal requests to know.

SICONF_BlockNumber. Number of information blocks for the SI layer configuration.

Block_ID. Identifier to signal the type of block being transported. It can identify different features (e.g. PEP, ROHC) supported by the system, which can be configured automatically with this primitive. So far, no specific Block_IDs are defined.

Block_Length. Length of the information block.

Information_Block(). The actual SI layer configuration information, according to the type signalled in Block_ID.

Table B.8: SI-SICONF-IND syntax definition

Syntax	Number of bits	Mnemonic
SI-C-SICONF-IND() {		
SI-SAP_Header()	96	
Network_Address_Type	32	uimsbf
Client_Network_Address	32	uimsbf
Client_Netmask	32	uimsbf
Gateway_Network_Address	32	uimsbf
Hardware_Address	48	uimsbf
BSM_ID	48	uimsbf
SICONF_BlockNumber	8	uimsbf
for (i=0, i< SICONF_BlockNumber-1, i++) {		
Block_ID	8	uimsbf
Block_Length	16	uimsbf
Information_Block()	variable	uimsbf
}		
Padding	variable	uimsbf
}		

Client_Network_Address. The network address requested by the satellite terminal. It is set to a standard value (0.0.0.0) in case no specific address is being requested.

Client_Netmask. The netmask related to the network address requested by the satellite terminal. It is set to 0.0.0.0 in case none is requested explicitly.

Gateway_Network_Address. The network address of the gateway that the satellite terminal requests to know.

Hardware_Address. It indicates the hardware address (48 bit MAC address) of the gateway.

Table B.9: SI-C-SICONF-RES syntax definition

Syntax	Number of bits	Mnemonic
SI-C-SICONF-RES() {		
SI-SAP_Header()	96	
Network _Address_Type	32	uimsbf
Client_Network_Address	32	uimsbf
Client_Netmask	32	uimsbf
Gateway_Network_Address	32	uimsbf
SICONF_BlockNumber	8	uimsbf
for (i=0, i< SICONF_BlockNumber-1, i++) {		
Block_ID	8	uimsbf
Block_Length	16	uimsbf
Information_Block()	variable	uimsbf
}		
Padding	variable	uimsbf
}		

Client_Network_Address. The network address requested by the satellite terminal. It is assigned by the gateway in coordination with the NCC/NMC according to the used addressing plan.

Client_Netmask. The netmask related to the network address requested by the satellite terminal. It is assigned by the gateway in coordination with the NCC/NMC according to the used addressing plan.

Gateway_Network_Address. The network address of the gateway that the satellite terminal requests to know.

Table B.10: SI-C-SICONF-CFM syntax definition

Syntax	Number of bits	Mnemonic
SI-C-SICONF-CFM() {		
SI-SAP_Header()	96	
Network_Address_Type	32	uimsbf
Client_Network_Address	32	uimsbf
Client_Netmask	32	uimsbf
Gateway_Network_Address	32	uimsbf
SICONF_BlockNumber	8	uimsbf
for (i=0, i< SICONF_BlockNumber-1, i++) {		
Block_ID	8	uimsbf
Block_Length	16	uimsbf
Information_Block()	variable	uimsbf
}		
Padding	variable	uimsbf
}		

Client_Network_Address. The network address requested by the satellite terminal. It is assigned by the gateway in coordination with the NCC/NMC according to the used addressing plan. It is the same as defined in the -RES primitive.

Client_Netmask. The netmask related to the network address requested by the satellite terminal. It is assigned by the gateway in coordination with the NCC/NMC according to the used addressing plan. It is the same as defined in the -RES primitive.

Gateway_Network_Address. The network address of the gateway that the satellite terminal requests to know. It is the same as defined in the -RES primitive.

B.2.3.4 Address resolution

Table B.11: SI-C-AR_QUERY-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-C-AR_QUERY-REQ() {		
SI-SAP_Header()	96	
Status_Notifier	1	uimsbf
if (Status_Notifier == 1) {		
Status	1	bslbf
} else {		
Padding	1	uimsbf
}		
Padding	30	uimsbf
Network_Address_Type	32	uimsbf
Network_Address	32	uimsbf
}		

Status_Notifier. It signal whether the status indication is present or not.

Table B.12: SI-C-AR_QUERY-CFM syntax definition

Syntax	Number of bits	Mnemonic
SI-C-AR_QUERY-CFM() {		
SI-SAP_Header()	96	
Padding	1	uimsbf
Status	1	bslbf
BSM_Multicast_Flag	1	bslbf
Padding	1	uimsbf
Cause_Code	4	uimsbf
Padding	8	uimsbf
BSM_ID	48	uimsbf
Network_Address_Type	32	uimsbf
Network_Address	32	uimsbf
}		

Table B.13: SI-C-AR_QUERY-IND syntax definition

Syntax	Number of bits	Mnemonic
SI-C-AR_QUERY-IND() {		
SI-SAP_Header()	96	
Status_Notifier	1	uimsbf
if (Status_Notifier == 1) {		
Status	1	bslbf
} else {		
Padding	1	uimsbf
}		
Padding	30	uimsbf
Network_Address_Type	32	uimsbf
Network_Address	32	uimsbf
}		

Status_Notifier. It signal whether the status indication is present or not.

Table B.14: SI-C-AR_QUERY-RES syntax definition

Syntax	Number of bits	Mnemonic
SI-C-AR_QUERY-RES() {		
SI-SAP_Header()	96	
Padding	1	uimsbf
Status	1	bslbf
BSM_Multicast_Flag	1	bslbf
Padding	1	uimsbf
Cause_Code	4	uimsbf
Padding	8	uimsbf
BSM_ID	48	uimsbf
Network_Address_Type	32	uimsbf
Network_Address	32	uimsbf
}		

Table B.15: SI-C-AR_INFO-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-C-AR_INFO-REQ() {		
SI-SAP_Header()	96	
Padding	1	uimsbf
Status	1	bslbf
BSM_Multicast_Flag	1	bslbf
Padding	5	uimsbf
Info_Type	4	uimsbf
Padding	4	uimsbf
BSM_ID	48	uimsbf
Network_Address_Type	32	uimsbf
Network_Address	32	uimsbf
}		

Table B.16: SI-C-AR_INFO-IND syntax definition

Syntax	Number of bits	Mnemonic
SI-C-AR_INFO-IND() {		
SI-SAP_Header()	96	
Padding	1	uimsbf
Status	1	bslbf
BSM_Multicast_Flag	1	bslbf
Padding	5	uimsbf
Info_Type	4	uimsbf
Padding	4	uimsbf
BSM_ID	48	uimsbf
Network_Address_Type	32	uimsbf
Network_Address	32	uimsbf
}		

Table B.17: SI-C-AR_INFO-RES syntax definition

Syntax	Number of bits	Mnemonic
SI-C-AR_INFO-RES() {		
SISAP_Header()	96	
Info_Type	4	uimsbf
Padding	28	uimsbf
}		

B.2.3.5 Multicast management

Table B.18: SI-C-RGROUP_OPEN-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-C-RGROUP_OPEN-REQ() {		
SI-SAP_Header()	96	
BSM_GID	48	uimsbf
Padding	16	uimsbf
}		

Table B.19: SI-C-RGROUP_OPEN-CFM syntax definition

Syntax	Number of bits	Mnemonic
SI-C-RGROUP_OPEN-CFM() {		
SI-SAP_Header()	96	
BSM_GID	48	uimsbf
Cause_Code	8	uimsbf
Padding	8	uimsbf
}		

Table B.20: SI-C-RGROUP_CLOSE-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-C-RGROUP_CLOSE-REQ() {		
SI-SAP_Header()	96	
BSM_GID	48	uimsbf
Cause_Code	8	uimsbf
Padding	8	uimsbf
}		

Table B.21: SI-C-RGROUP_CLOSE-CFM syntax definition

Syntax	Number of bits	Mnemonic
SI-C-RGROUP_CLOSE-CFM() {		
SI-SAP_Header()	96	
BSM_GID	48	uimsbf
Cause_Code	8	uimsbf
Padding	8	uimsbf
}		

Table B.22: SI-C-RGROUP_STATUS-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-C-RGROUP_STATUS-REQ() {		
SI-SAP_Header()	96	
}		

Table B.23: SI-C-RGROUP_STATUS-CFM syntax definition

Syntax	Number of bits	Mnemonic
SI-C-RGROUP_STATUS-CFM() {		
SI-SAP_Header()	96	
for (i = 0; i < N3; i++) {		
BSM_GID	48	uimsbf
}		
Padding	0 or 16	uimsbf
}		

N3. The total number of GIDs in this primitive defined using 16 bits.

Table B.24: SI-C-MCGROUP_ADD-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-C-MCGROUP_ADD-REQ() {		
SI-SAP_Header()	96	
BSM_GID	48	uimsbf
BSM_ID	48	uimsbf
}		

Table B.25: SI-C-MCGROUP_ADD-CFM syntax definition

Syntax	Number of bits	Mnemonic
SI-C-MCGROUP_ADD-CFM() {		
SI-SAP_Header()	96	
BSM_GID	48	uimsbf
BSM_ID	48	uimsbf
Cause_Code	8	uimsbf
Padding	24	uimsbf
}		

Table B.26: SI-C-MCGROUP_REMOVE-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-C-MCGROUP_REMOVE-REQ() {		
SI-SAP_Header()	96	
BSM_GID	48	uimsbf
BSM_ID	48	uimsbf
}		

Table B.27: SI-C-MCGROUP_REMOVE-CFM syntax definition

Syntax	Number of bits	Mnemonic
SI-C-MCGROUP_REMOVE-CFM() {		
SI-SAP_Header()	16	
BSM_GID	48	uimsbf
BSM_ID	48	uimsbf
Cause_Code	8	uimsbf
Padding	24	uimsbf
}		

B.2.3.6 Resource reservation

Table B.28: QIDSPEC syntax definition

Syntax	Number of bits	Mnemonic
QIDSPEC() {		
Traffic_Classes	32	uimsbf
if (Traffic_Classes == 0) {		
Token_Bucket_Rate	32	uimsbf
Token_Bucket_Size	32	uimsbf
Peak_Data_Rate	32	uimsbf
Minimum_Policed_Unit	32	uimsbf
Maximum_Packet_Size	32	uimsbf
}		
Rate	32	uimsbf
if (Traffic_Classes == 0) {		
Slack_Term	32	uimsbf
}		
}		

Traffic_Classes. It indicates the current traffic classes type ("0" = IntServ, "1" = DiffServ).

When considering the DiffServ traffic classes type the final number of bits is 32. When considering the IntServ traffic classes type the final number of bits is 7 x 32 bits = 224 bits.

Table B.29: SI-C-QUEUE_OPEN-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-C-QUEUE_OPEN-REQ() {		
SI-SAP_Header()	96	
Lease_Time	4	uimsbf
Padding	12	uimsbf
BSM_ID	48	uimsbf
IP_Queue_Label	32	uimsbf
QIDSPEC()	N2	
}		
NOTE: *N2: 32 or 224 bits.*		

Table B.30: SI-C-QUEUE_OPEN-CFM syntax definition

Syntax	Number of bits	Mnemonic
SI-C-QUEUE_OPEN-CFM() {		
SI-SAP_Header()	96	
Lease_Time	4	uimsbf
Success_Flag	1	bslbf
Padding	11	uimsbf
BSM_ID	48	uimsbf
IP_Queue_Label	32	uimsbf
QIDSPEC()	N2	uimsbf
QID	24	uimsbf
Padding	8	uimsbf
}		
NOTE: *N2: 32 or 224 bits.*		

Table B.31: SI-C-QUEUE_MODIFY-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-C-QUEUE_MODIFY-REQ() {		
SI-SAP_Header()	96	
Lease_Time	4	uimsbf
Padding	1	uimsbf
QIDSPEC_Reminder	1	uimsbf
Padding	10	uimsbf
BSM_ID	48	uimsbf
IP_Queue_Label	32	uimsbf
if (QIDSPEC_Reminder == 1) {		
QIDSPEC()	N2	
}		
QID	24	uimsbf
Padding	8	uimsbf
}		
NOTE: *N2: 32 or 224 bits.*		

QIDSPEC_Reminder. It is a flag indicating whether the QIDSPEC is present or not.

Table B.32: SI-C-QUEUE_MODIFY-CFM syntax definition

Syntax	Number of bits	Mnemonic
SI-C-QUEUE_MODIFY-CFM() {		
SI-SAP_Header()	96	
Lease_Time	4	uimsbf
Success_Flag	1	bslbf
Padding	11	uimsbf
BSM_ID	48	uimsbf
IP_Queue_Label	32	uimsbf
QIDSPEC()	N2	uimsbf
QID	24	uimsbf
Padding	8	uimsbf
}		
NOTE: *N2: 32 or 224 bits.*		

Table B.33: SI-C-QUEUE_MODIFY-IND syntax definition

Syntax	Number of bits	Mnemonic
SI-C-QUEUE_MODIFY-IND() {		
SI-SAP_Header()	96	
Lease_Time	4	uimsbf
Padding	1	uimsbf
QIDSPEC_Reminder	1	uimsbf
IP_Queue_Label_Notifier	1	uimsbf
BSM_ID_Notifier	1	uimsbf
Padding	8	uimsbf
if (BSM_ID_Notifier) {		
BSM_ID	48	uimsbf
} else {		
Padding	16	uimsbf
}		
if (IP_Queue_Label_Notifier == 1) {		
IP_Queue_Label	32	uimsbf
}		
if (QIDPSEC_Reminder == 1) {		
QIDSPEC()	N2	
}		
QID	24	uimsbf
Padding	8	uimsbf
}		
NOTE: *N2: 32 or 224 bits.*		

BSM_ID_Notifier. It indicates whether the BSM_ID field is used by the primitive.

IP_Queue_Label_Notifier. It indicates whether the IP_Queue_Label field is used by the primitive.

QIDPSEC_Reminder. It indicates whether the QIDPSEC field is used by the primitive.

Table B.34: SI-C-QUEUE_MODIFY-RES syntax definition

Syntax	Number of bits	Mnemonic
SI-C-QUEUE_MODIFY-RES() {		
SI-SAP_Header()	96	
Lease_Time	4	uimsbf
Padding	28	uimsbf
QID	24	uimsbf
Padding	8	uimsbf
}		

Table B.35: SI-C-QUEUE_CLOSE-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-C-QUEUE_CLOSE-REQ() {		
SI-SAP_Header()	96	
Padding	5	uimsbf
QIDSPEC_Reminder	1	uimsbf
Padding	10	uimsbf
BSM_ID	48	uimsbf
IP_Queue_Label	32	uimsbf
if (QIDSPEC_Reminder == 1) {		
QIDSPEC()	N2	
}		
QID	24	uimsbf
Padding	8	uimsbf
}		
NOTE: *N2: 32 or 224 bits.*		

QIDPSEC_Reminder. It indicates whether the QIDPSEC field is used by the primitive.

Table B.36: SI-C-QUEUE_CLOSE-CFM syntax definition

Syntax	Number of bits	Mnemonic
SI-C-QUEUE_CLOSE-CFM() {		
SI-SAP_Header()	96	
Padding	16	uimsbf
BSM_ID	48	uimsbf
IP_Queue_Label	32	uimsbf
QID	24	uimsbf
Padding	8	uimsbf
}		

Table B.37: SI-C-QUEUE_CLOSE-IND syntax definition

Syntax	Number of bits	Mnemonic
SI-C-QUEUE_CLOSE-IND() {		
SI-SAP_Header()	96	
Padding	6	uimsbf
IP_Queue_Label_Notifier	1	uimsbf
BSM_ID_Notifier	1	uimsbf
Padding	8	uimsbf
if (BSM_ID_Notifier) {		
BSM_ID	48	uimsbf
} else {		
Padding	16	uimsbf
}		
if (IP_Queue_Label_Notifier == 1) {		
IP_Queue_Label	32	uimsbf
}		
QID	24	uimsbf
Padding	8	uimsbf
}		

BSM_ID_Notifier. It indicates whether the BSM_ID field is used by the primitive.

IP_Queue_Label_Notifier. It indicates whether the IP_Queue_Label field is used by the primitive.

Table B.38: SI-C-QUEUE_CLOSE-RES syntax definition

Syntax	Number of bits	Mnemonic
SI-C-QUEUE_CLOSE-RES() {		
SI-SAP_Header()	96	
Padding	16	uimsbf
BSM_ID	48	uimsbf
IP_Queue_Label	32	uimsbf
QID	24	uimsbf
Padding	8	uimsbf
}		

Table B.39: SI-C-QUEUE_STATUS-REQ syntax definition

Syntax	Number of bits	Mnemonic
SI-C-QUEUE_STATUS-REQ() {		
SI-SAP_Header()	96	
QID	24	uimsbf
Padding	8	uimsbf
}		

Table B.40: SI-C-QUEUE_STATUS-CFM syntax definition

Syntax	Number of bits	Mnemonic
SI-C-QUEUE_STATUS-CFM() {		
SI-SAP_Header()	96	
Available_Data_Rate	32	uimsbf
Min_Transmission_Delay	32	uimsbf
Max_Hardware_Delay	32	uimsbf
IP_Queue_Label	32	uimsbf
IP_Queue_Information	32	uimsbf
QID	24	uimsbf
Padding	8	uimsbf
}		

B.3 Protocol encapsulation

B.3.1 General

The transport of the SI-SAP interface primitive message, whose format has been defined in the previous clause, is carried out according to the point-to-point protocol implemented in the user equipment (within the premises network) and in the premises network interface implemented in the satellite terminal.

The user equipment can implement any point-to-point protocol, providing an interface towards the SI layer. The satellite terminal needs not to implement the SI layer, but should implement a protocol architecture supporting both SD layer and the point-to-point protocol employed by user equipment.

Depending on the satellite terminal architecture, two options can be considered:

- Option 1: The satellite terminal implements the SI layer.
- Option 2: The satellite terminal does not implement any SI layer.

B.3.2 Option 1

B.3.2.1 Datagram encapsulation

The SI-SAP interface service primitive messages are encapsulated according to the protocol defined in the SI layer. The SI layer PDUs will be therefore received and processed by the SI layer protocol entity on the other side. The SI-SAP interface primitive messages are processed by the SDAF (SIAF module). For the sake of the exemplification, it is reasonable to assume the SI layer to implement the TCP/IP protocol stack, so that a SI-SAP interface service primitive message can be encapsulated according to three possible alternatives:

a) UDP, IETF RFC 768 [i.22] datagram (then encapsulated in an IP datagram).

b) TCP, IETF RFC 793 [i.21] segment (then encapsulated an in IP datagram).

c) IP, IETF RFC 753 [i.20] datagram (directly).

B.3.2.2 UDP datagram encapsulation

In this case, the SI-SAP interface service primitive message is the payload of a UDP datagram. Specific destination UDP port should be used to signal the use of the corresponding SIAF (SDAF) module. It can be noted that UDP layer does not offer any segmentation service and therefore segmentation functions should be performed directly by the SIAF (SDAF) module in case the overall IP datagram size exceeds the MTU.

Alternatively, the IP layer can also perform segmentation and reassembling functions, if enabled.

It can be observed that in general the case of SI-SAP interface primitive message segmentation very much depends on the specific point-to-point technology being implemented. If Ethernet is taken as reference, the necessity of fragmentation can occur only in the case of U-plane primitives, whereas is not possible for C-plane primitives whose corresponding message size does not exceed 256 bytes. Finally, it can be observed that use of UDP as encapsulation protocol does not guarantee any reliability measure, which might be provided instead by the SIAF (SDAF) module.

It can also be noted that wired point-to-point link are very robust and link errors are unlikely to occur. If, instead, the underlying point-to-point technology is wireless (e.g. Wi-Fi), the occurrence of link errors cannot be considered negligible; therefore, proper reliability measures should be implemented in the SIAF (SDAF) module.

B.3.2.3 TCP segment encapsulation

In this case, the SI-SAP interface primitive message is the payload of a TCP segment. Specific destination TCP port should be used to signal the use of the corresponding SIAF (SDAF) module.

Differently from UDP, it can be observed that TCP implements a segmentation service; therefore no segmentation function needs to be implemented in the SIAF (SDAF) module. The same argument also holds for reliability, as TCP implements recovery functions.

Finally, it can be noted that TCP (unlike UDP) offers a stream-oriented service; therefore it might happen that two SI-SAP interface service primitives are encapsulated in the same TCP segment. To prevent processing problems at the destination, the Nagle algorithm for that specific TCP connection should be disabled. Alternatively, it is still possible to allow two SI-SAP interface primitive messages to be encapsulated in the same TCP segment: the information contained in the SI-SAP header of each message can help correctly reconstruct the native messages and separate them.

B.3.2.4 IP datagram encapsulation

In this case, the SI-SAP message is the payload of an IP datagram. The same notes considered for UDP encapsulation also apply here.

It can be however noted that transport of a message directly within an IP datagram is an obsolete practice and should be deprecated.

B.3.3 Option 2

On the contrary, if the satellite terminal does not implement the SI layer, the transport of the SI-SAP interface message is carried out directly by the link layer protocol technology or by a proper point-to-point protocol.

If Ethernet is assumed to be the link layer technology, the SI-SAP message can be directly encapsulated in the Ethernet frame payload, with the same indications raised for UDP encapsulation for what concerns segmentation and reliability. Further to this, a specific `EtherType` field IETF RFC 5342 [12] should be defined to point to the SI-SAP external interface application.

Alternatively, it is also possible to use a dedicated point-to-point protocol running on top of the link layer protocol, serving as encapsulation protocol. For instance, the PPP IETF RFC 1661 [i.23] protocol can be used, with the transport of a PPP frame in Ethernet regulated according to PPPoE IETF RFC 2516 [i.25]. Also in this case, the indications about segmentation and reliability noted above are still valid and should be properly applied.

History

Document history		
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