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Technical Specification

**Satellite Earth Stations and Systems (SES);
Broadband Satellite Multimedia (BSM)
services and architectures;
Functional architecture for IP interworking with BSM networks**



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Foreword

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

Introduction

Terrestrial Internet protocols, in particular for signalling, management and control, are often ill adapted to the specifics of satellite networks (TR 101 984). It has been the goal of the BSM work to investigate which protocols should be adapted to the BSM world and propose a number of specific technical specifications to achieve this goal. In order to link all those documents under a common framework, the present document defines a BSM functional architecture. The architecture is not satellite system specific and relies on client server architectures to perform the needed tasks without interference with IP protocol operations.

1 Scope

The present document presents the architecture that relates the work done in SES BSM TRs on standardization (see TR 101 984 and TR 101 985, Addressing and Routing (see TR 102 155), Multicasting (see TR 102 156) and Performance and QoS (see TR 102 157). The present document provides the introduction to the subsequent Technical Specifications (TSs). The focus of the BSM work is on IP version 4 (IPv4). Actual protocol specification is beyond the scope of the present document and will be issued in specific TSs.

2 Void

3 Definitions and abbreviations

3.1 Definitions

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

adaptation: process of adapting standard protocols for better performance over a satellite (or other) subnetwork

architecture: abstract representation of a communications system

function: any discrete element that forms a defined part of an architecture

scenario: predicted sequence of events

3.2 Abbreviations

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

3GPP	Third Generation Partnership Project
ATM	Asynchronous Transfer Mode
BGP	Border Gateway Protocol
BSM	Broadband Satellite Multimedia
CSF	Client Server Function
HTTP	Hyper Text Transfer Protocol
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
IP	Internet Protocol
IPv4/v6	Internet Protocol version 4/6
MPLS	MultiProtocol Label Switching
NAT	Network Address Translation
PEP	Performance Enhancing Proxy
PIM	Protocol Independent Multicast
QID	Queuing IDentifier
QoS	Quality of Service
SD	Satellite Dependent
SI	Satellite Independent
SI-C-SAP	Satellite Independent - Control plane - Service Access Point
SI-M-SAP	Satellite Independent - Management plane - Service Access Point
SI-SAP	Satellite Independent - Service Access Point
SI-U-SAP	Satellite Independent - User plane - Service Access Point
SLC	Satellite Link Control
SMAC	Satellite Medium Access Control
SPHY	Satellite PHYsical
ST	Satellite Terminal

USB Universal Serial Bus
WG Working Group

4 Architectural framework

4.1 Principles

The BSM architectural framework is based on the principle that the recommended Technical Specifications should be linked by a common thread. Obviously all BSM protocols can be classified in the OSI layered model: the protocols the BSM uses to transport IP traffic mostly belong to the layers 2, 3 and above as they deal with MAC layer adaptation to support IP services and address resolution, network protocols such as routing, and finally policy control and management protocols for quality of service and resource management TR 101 985. It has been a recommendation of the IP interworking over satellite TR 102 155, TR 102 156 and TR 102 157 that the "adaptation" of the IP protocol at the ingress and egress of the BSM be located in a "Protocol Manager". This entity is mainly a control path entity that intercepts the appropriate IP protocols and ensures that they are correctly supported over the BSM.

In the BSM protocol stack, the "manager" resides mostly above the SAP. Its major functions include:

- How IP protocols and packet markings are to be interpreted and transmitted through the BSM.
- Which Satellite Independent (SI) protocols are used.
- And how they in turn trigger the Satellite Dependent (SD) functions.

4.2 Basic concepts

In addition to the definitions provided in clause 3.1 some concepts that are basic the BSM architecture are further explained below:

- **Adaptation:** as defined in clause 3.1 adaptation refers to the process of adapting standard protocols for better performance over, in the present document, a BSM satellite subnetwork. Adaptation, which should be transparent to the general Internet, involves, for example, changing timers, filtering traffic and reducing the transmission of messages over the satellite link to the protocol servers.
- **Architecture:** the architecture is an abstract representation of a communications system. Three complementary types of architecture are defined:
 - **Protocol architecture:** the protocol stacks involved in the operation of the system and the associated peering relationships.
 - **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.
- **Scenario:** in the present document a scenario will describe a realistic worked example, showing how a defined set of functions operate and apply to a specific IP interworking situation (or situations). Scenarios demonstrate both "why" we need a given set of functional specifications and "how" the proposed functional decomposition works to provide the desired result. In general, a scenario will be described by reference to one or more architectures.

- **Function:** a function converts a set of inputs into a set of outputs. A function is formally defined by the sets of inputs and of outputs. The set of inputs can be a continuum (e.g. an analog signal) or discrete (e.g. a digital signal). It might be that some inputs produce no output e.g. silent discard in address resolution. Inputs and outputs can be assembled in blocks or vectors (datagrams, packets, frames, etc.). This is the most basic definition and it proves to be sufficient in some cases (black box diagram). At the opposite, a function is ultimately defined when it is possible to derive an output from any input. Between these two ends, all intermediate definitions are possible. In the BSM, a function can use any combination of the following:
 - a protocol element (e.g. a complete stack or an single protocol entity);
 - a logical element (e.g. a process or procedure); and
 - a physical element (e.g. a router or server).
- Network engineering:
 - 1) In [telephony](#), the discipline concerned with determining [internetworking](#) service requirements for switched networks, and developing and implementing [hardware](#) and [software](#) to meet them. In addition, network engineering includes the end-to-end provisioning of network resources to meet service needs.
 - 2) In [computer science](#), the discipline of hardware and [software engineering](#) to accomplish the design goals of a [computer network](#).
 - 3) In [radio communications](#), the discipline concerned with developing network topologies. Because the BSM is concerned with all three functions all of those definitions apply.
- **Traffic engineering:** the determination of the numbers and kinds of circuits and quantities of related terminating and [switching](#) equipment required to meet anticipated [traffic loads](#) throughout a [communications system](#). Traffic engineering also targets the reduction and suitable distribution of loads across the network.

5 Overview

Figure 1 presents the BSM protocol stack for unicast services and figure 2 the same stack with the added multicast protocols. An important feature of both figures is the Satellite InDependent Service Access Point interface or SI-SAP interface. This interface provides the BSM with a layer of abstraction for the lower layer functions and makes use of a BSM specific identifier, the BSM_ID, to address BSM points of attachment. It allows the BSM protocols developed in the Satellite InDependent layer to perform over any BSM family. Moreover, the SI-SAP also enables the use of standard Internet protocols for example address resolution or multicast group management, directly over the BSM or with minimal adaptation to BSM physical characteristics. Finally the SI-SAP even makes it possible to envisage switching from one satellite system to another and to even a non-satellite technology while preserving the BSM operator's investment in layer 3 software development.

Figure 1 shows that there are only a small number of generic functions that need to cross the SI-SAP and those are related to connection/session management, resource management or security. As seen in figures 1 and 2, the BSM protocols are based on the OSI layered protocol stack. For the IP services most of the work has concentrated on the network layers with links to the underlying data link and MAC layers. The reason for this is simple: the developed protocols for IP over BSM should primarily be located in the satellite independent part of the BSM stack to be applicable to a range of different satellite dependent lower layers such as for example, DVB-S and DVB-RCS.

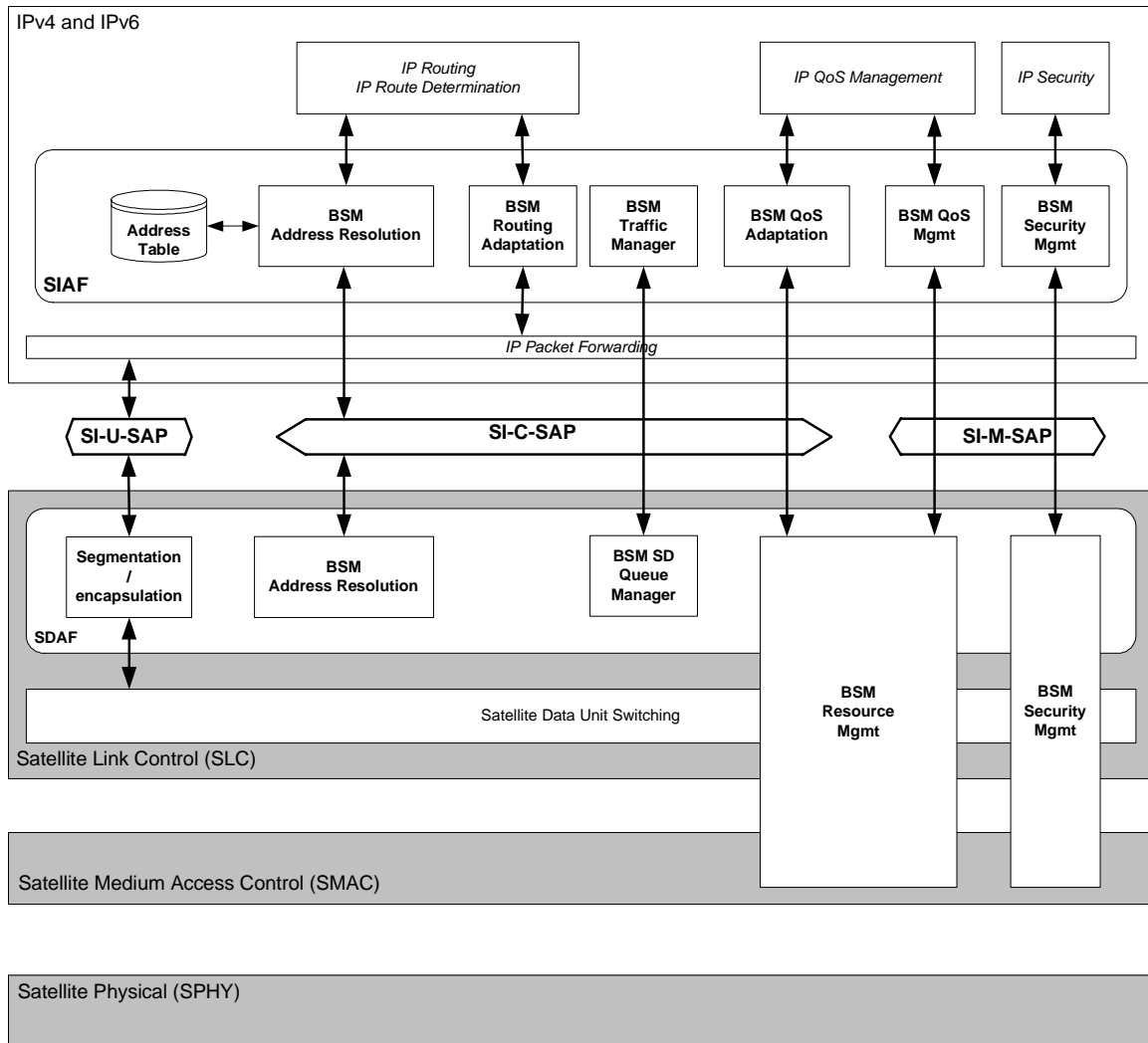


Figure 1: BSM protocol stack for unicast services

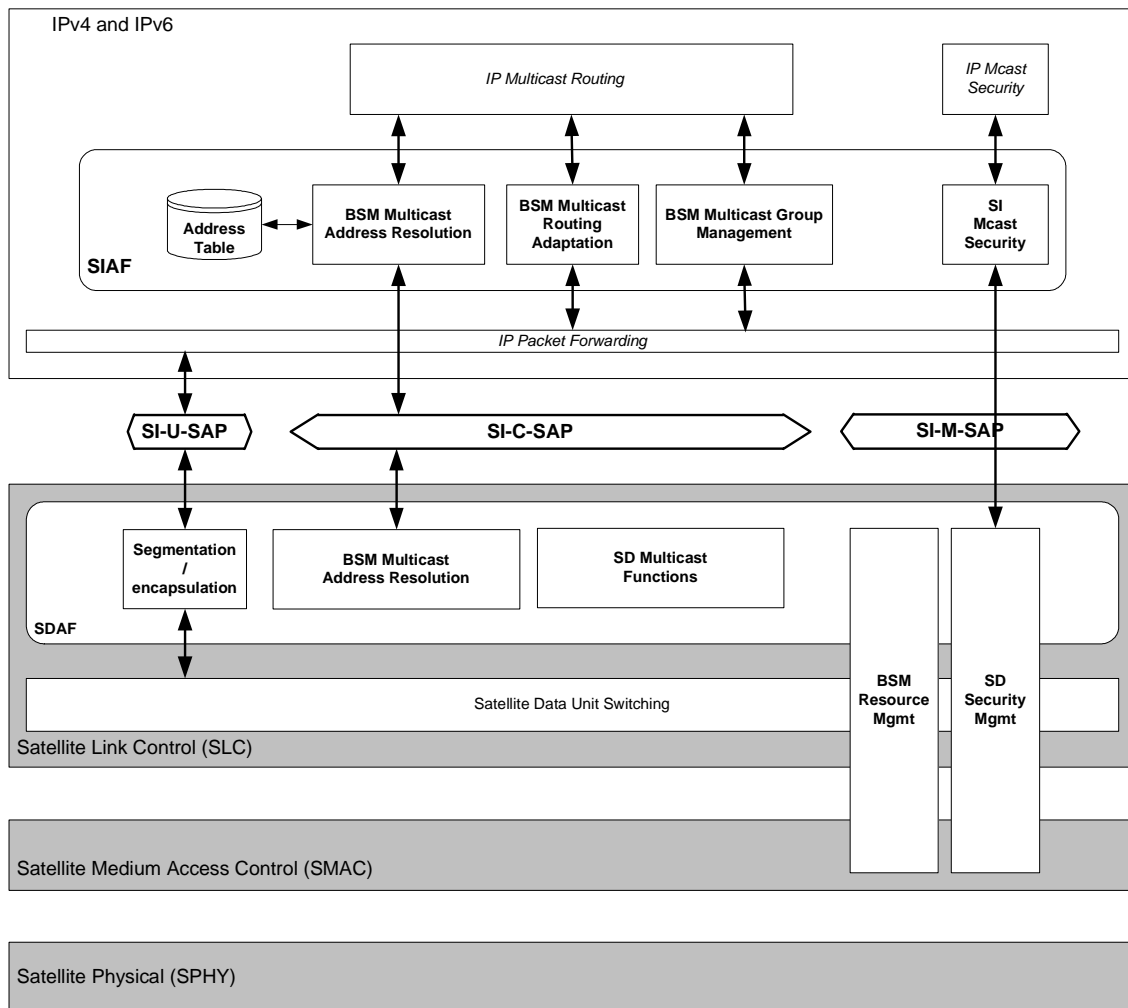


Figure 2: BSM protocol stack for multicast services

The major identified requirements for the BSM specific protocols at the satellite independent layer (above the SI-SAP) are:

- No BSM protocol should bring any changes to Internet protocols.
- And when specific BSM functions are required they should be done via proxies or managers.

As mentioned in clause 4, the recommendations the IP over BSM Technical Reports (see TR 102 155, TR 102 156 and TR 102 157) have proposed a number of specifications that are essential for the BSM to adequately handle current and future IP traffic. The specifications under development are identified within the OSI stack in figures 1 and 2. They cover advances in multicast, address resolution and routing/forwarding as well as resource management. The relationship between these functions is highlighted in clause 6.

6 SI-SAP architecture

The SI-SAP (Service - Access Point) provides an abstract interface allowing BSM protocols to be truly System Independent (SI) and to apply to all BSM families. The SI-SAP is the interface at which services from the lower layers are translated into system independent semantics.

For traffic handling the SI-SAP uses a BSM Identifier (BSM_ID) and a Queuing Identifier (QID):

- The BSM_ID uniquely identifies a BSM network point of attachment and allows IP layer address resolution protocols (equivalent to ARP for IPv4 and ND for IPv6) to be used over the BSM. The details of the BSM_ID in term of format and its usage will be specified in the TS on Address Resolution.
- The QID enables the BSM data transfer (IP packets) to be queued, policed and transmitted properly across the BSM.

The traffic classes are central to the concept of the Queue ID (QID). Traffic classes available at the SI-SAP enable QoS, performance management and resource allocation. They are defined in details in TS 102 295. The BSM queues can be defined by QoS specific parameters (flowspecs, path labels or Diffserv markings) and associated to lower layer transfer capabilities (e.g. to different capacity request categories in the DVB-RCS model). Some QID could be assigned permanently and others being dynamically created to satisfy as certain QoS. The QID however not limited to a capacity allocation class; it relates also to flow/behaviour with defined properties. This includes:

- buffer allocations for queuing;
- buffer management policies (e.g. RED / drop tail);
- priority in terms of transmission;
- capacity allocation class (as mentioned in the previous paragraph); and
- PID/channel ID mapping for segmentation/reassembly.

All of the BSM services such data transfer, address management, group advertisement etc. use SI-SAP primitives; these primitives are used to define the exchanged information between the satellite independent upper layers and the satellite dependent lower layers via the SI-SAP. The primitives are classified into functional groups within the User plane (U), Control plane (C) and Management plane (M). Figure 3 presents a detailed overview of the SI-SAP data transfer functions.

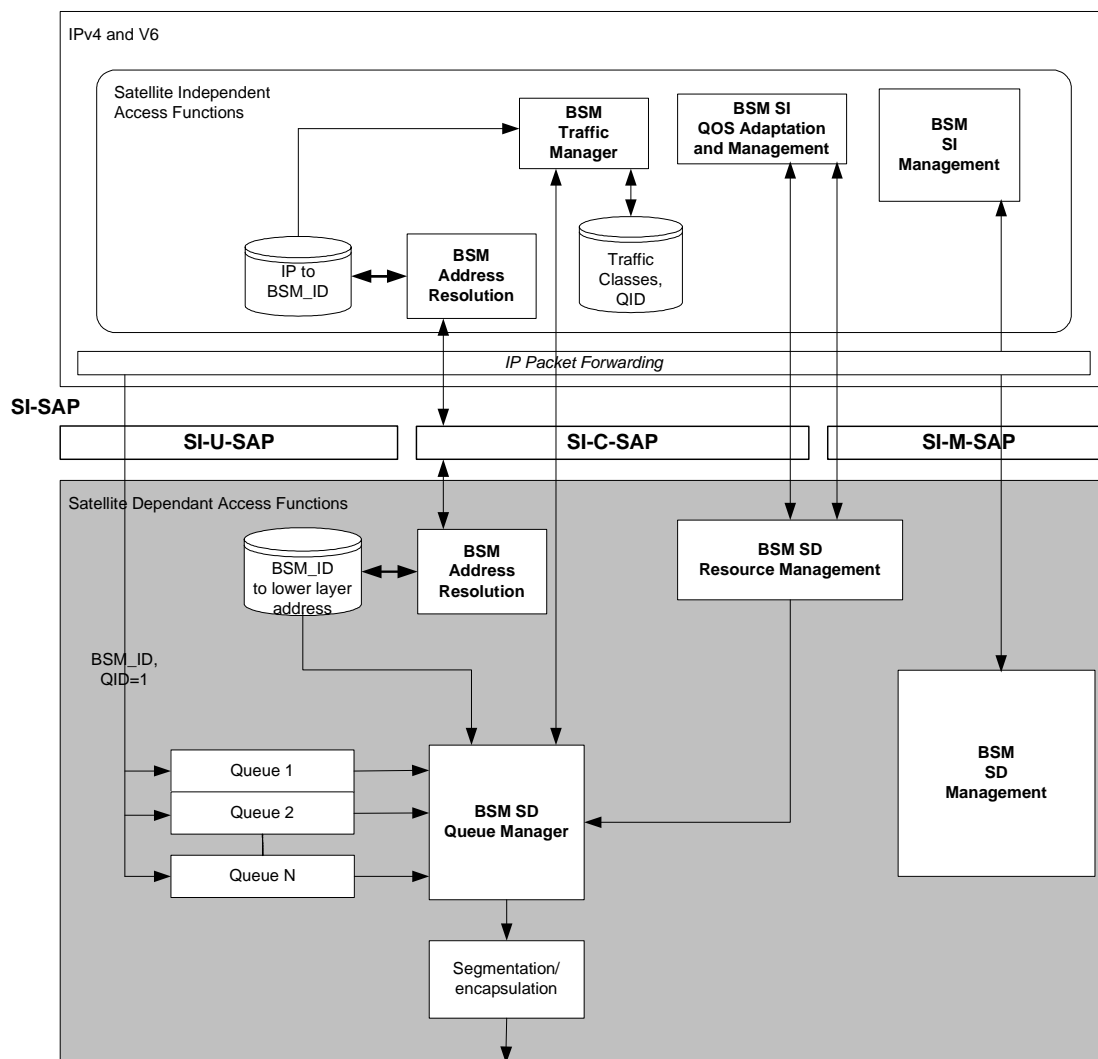


Figure 3: SI-SAP detailed overview

7 Network architecture

7.1 BSM network architecture

This clause reviews the major network architectures used for BSM networking. It also identifies the major interfaces that the BSM functional architecture will use. The network architectures are essential to define the specific client-server functions that will enable IP services over the BSM. For each of the recommended specifications (TS) a specific "manager" located in the appropriate server (in the appropriate domain) will be defined in relation with the appropriate BSM network configuration. Hence, the client server architecture relates to the specific network architectures and BSM hardware in the following way:

- protocol clients are located in all STs and in Gateways when appropriate; protocol clients should not be located in attached networks;
- protocol servers are located/distributed in the network or even across a network and are not strictly associated with gateways but with operators control and management networks; STs and/or Gateways communicate with the servers that are managed by its operator;

- all STs can be connected to multiple local hosts and can act as gateways to another subnetwork; and
- in any of the defined configurations an OBP payload can be involved on the control path especially as regards resource management.

The BSM network architectures are:

- *Access Network* (star configuration) using transparent or processing satellite system (see figure 4); in this configuration the Internet is accessible in one hop via a gateway. While a processing payload could be involved in the control path it is not a requisite. Figure 5 illustrates the protocol stack for the star network and a transparent payload.

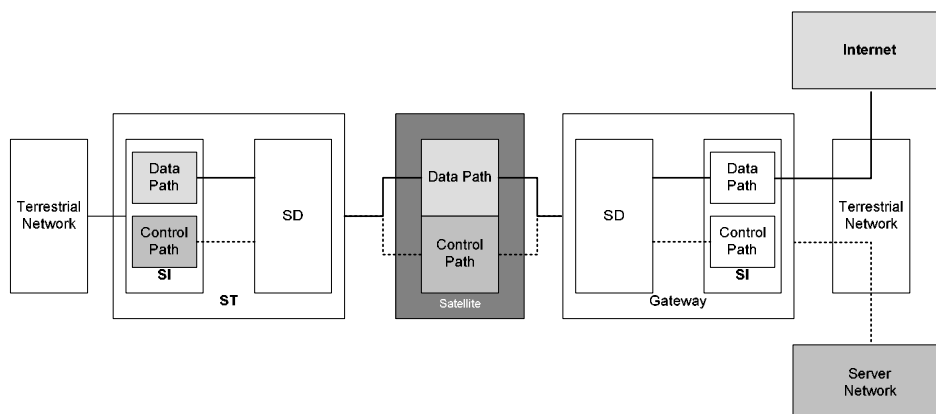


Figure 4: Star configuration access network

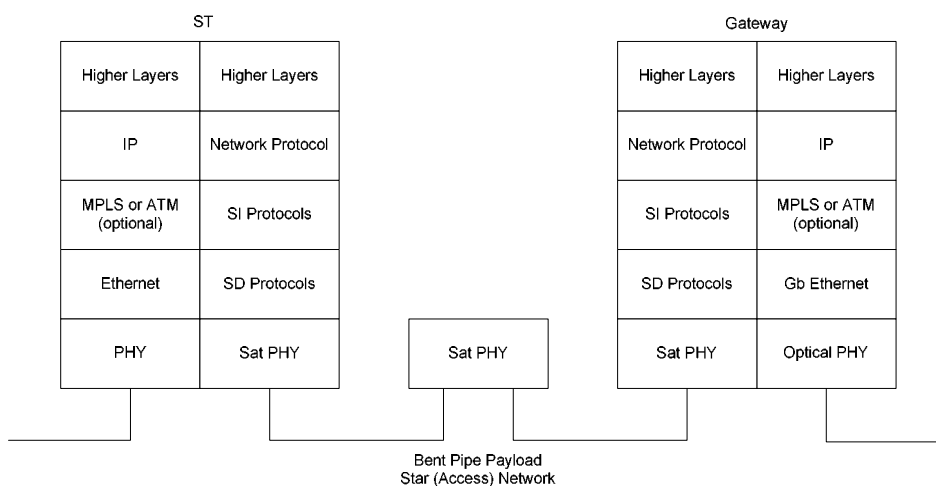


Figure 5: Star configuration example of a protocol stack

- *Mesh Network* using peer to peer communications between terminals/gateways (see figure 6). When the peer to peer connectivity is provided in one hop (ST to ST), this configuration uses an onboard processing device. This is the configuration most often associated with bridging or switching scenarios (see figure 7). The meshed configuration can also be supported over a transparent payload with double hop: data goes from the source ST to a Gateway and from the Gateway to the destination ST. A special case of the meshed scenario is when the BSM is used for interdomain connectivity, a likely scenario for both multicasting and bridging.

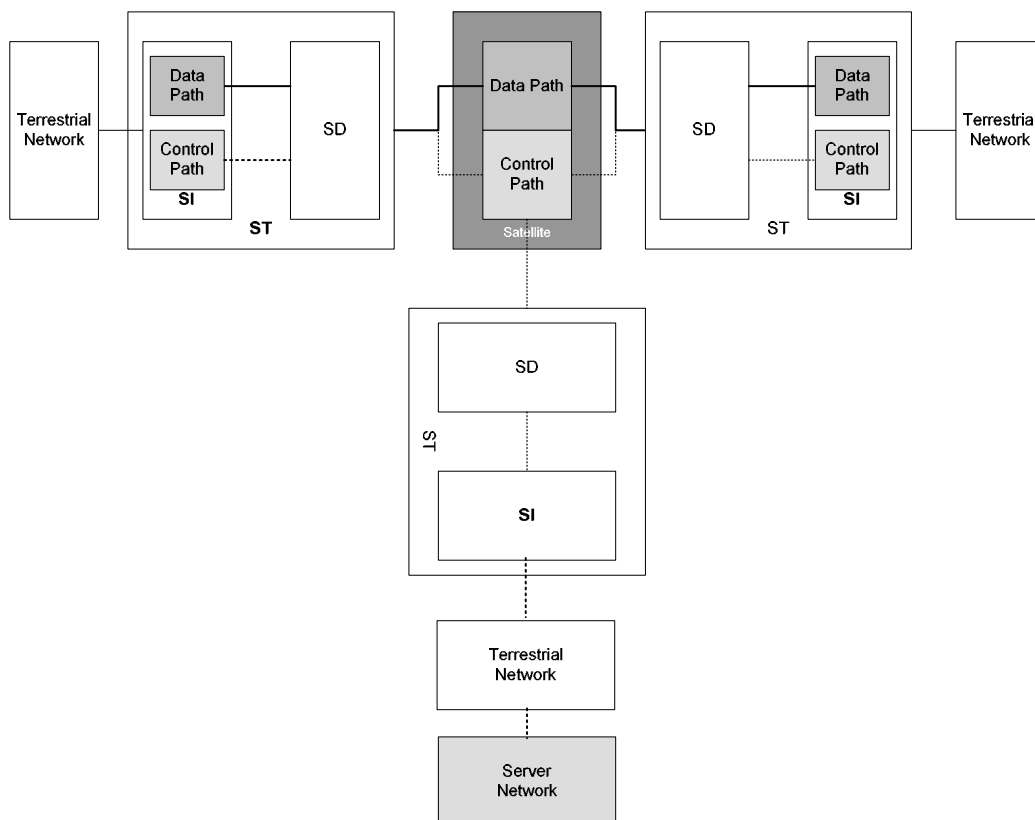


Figure 6: Meshed configuration

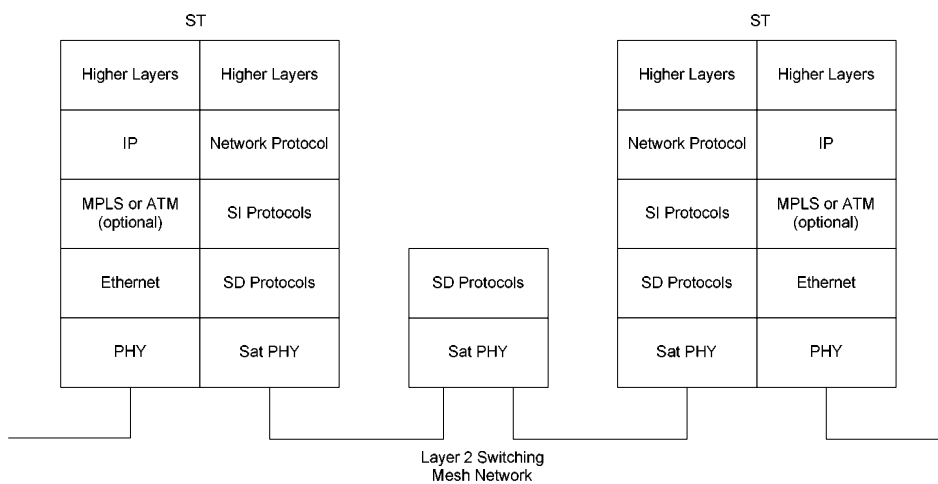


Figure 7: Meshed configuration: example of a protocol stack with Layer 2 switching in the satellite

7.2 BSM network interfaces

Figure 8 presents the major interfaces to the BSM. The architecture described in the present document as well as the TSs that will define specific BSM functionality and protocols that deal with interfaces I2, I3 and I4 on the ingress (access) side and I7, I8, I9 and I10 on the egress (gateway) side. Table 1 details all the named interfaces.

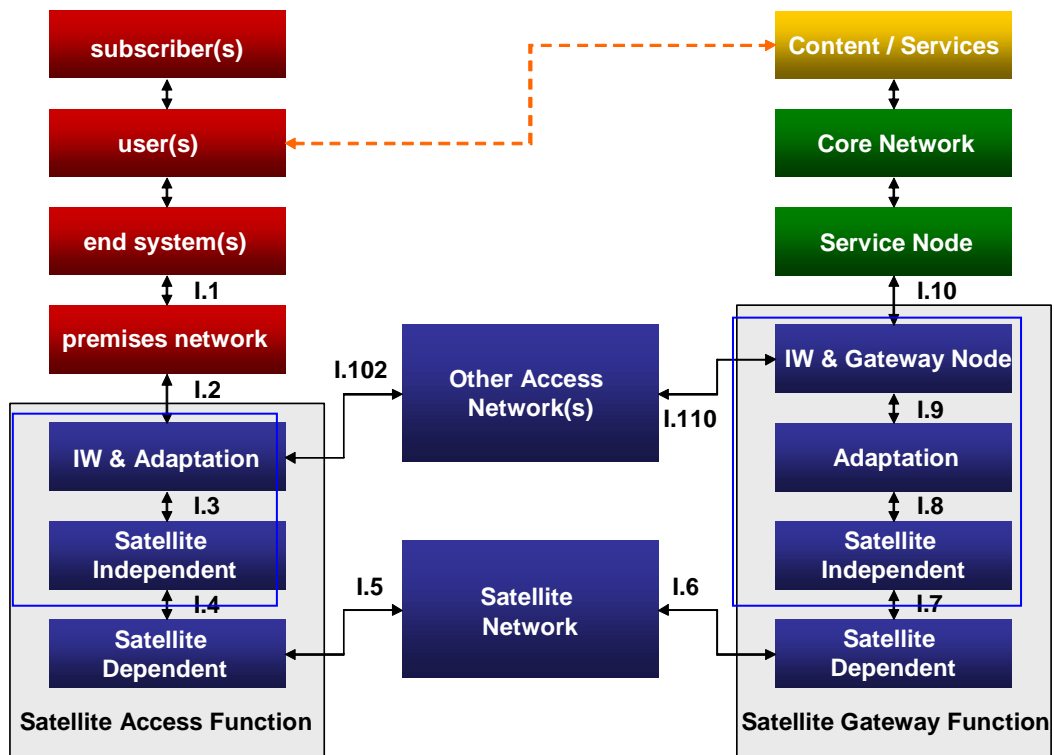


Figure 8: Reference model of BSM access from TR 101 984

Table 1: Interfaces for BSM access

Ref.	Interface name	Description of interface	Associated IP Interworking Architecture Role
I.1	External Network Interface	Interface between end system and customer premises network	Defines the QoS requirements
I.2	BSM Network Interface	External interface between satellite access function and customer premises network	Defines the QoS and framing requirements
I.3	BSM subnetwork service access point	Internal interface	May define the framing requirements
I.4	BSM Satellite Independent Service Access Point (SI-SAP)	Internal interface	Main interface for IP interworking; abstracts the SD functions to the higher layers; interprets the QoS and framing requirements
I.5	BSM Access Terminal Air Interface (see note)	Internal air interface	Not at layer 3
I.6	BSM Gateway Air Interface (see note)	Internal air interface	Not at layer 3
I.7	BSM Gateway Satellite Independent Service Access Point (SI-SAP)	Internal interface	Main interface for IP interworking; abstracts the SD functions to the higher layers; interprets the QoS and framing requirements
I.8	BSM gateway subnetwork service access point	Internal interface	May define the framing requirements
I.9	BSM gateway adaptation service access point	Internal interface	Defines the QoS and framing requirements
I.10	BSM Gateway Interface	External interface between satellite gateway function and terrestrial network	Defines the QoS requirements
I.102	Alternative return channel Interface	External interface to return channel (may be bi-directional)	Defines the QoS and framing requirements
I.110	Alternative return channel gateway Interface	External interface for return channel (may be bi-directional)	Defines the QoS and framing requirements

NOTE: The Access Terminal air interface may be identical to the Gateway air interface.

8 Logical architecture

8.1 Client server networking

The client/server software architecture is a versatile, message-based and modular infrastructure that is intended to improve usability, flexibility, interoperability, and scalability as compared to centralized management.

A client is defined as a requester of services and a server is defined as the provider of services. One widely used client server model is the Hyper Text Transfer Protocol (HTTP) at the basis of the transactions in the World Wide Web. HTTP uses "get" and "push" commands to request entities and provide responses. In the BSM, the client requests IP services from the BSM and the BSM server provides the adaptation protocols and other services to fulfil the request. The details of these transactions are beyond the scope of this note. A single ST can support both client and server software or provide the transit link to a server depending on the software, the targeted protocol and BSM network configuration.

8.2 Decomposition

The BSM functionality can be separated into 3 logical segments (see figure 9) that follows the BSM stack and will clarify the functional architecture:

- The *User Services Segment* is where the users services enter the BSM; its management functions are mostly real time and relate to packet handling and some packet level control; the applications located in the User Service Segment supply QoS requirements, Internet addressing and routing to the other segments; the User Services Segment is mainly located in the user (data) plane.
- The *Communication Segment* provides the connectivity between BSM segments and the Internet; while the communication segment is not intrinsically linked to any management function it can (especially in the case of processing satellites) provide support to resource management functions.
- The *Communication Services Segment* is where the specific non real time BSM services are provided and constitutes the main focus of the Technical Specifications; it contains all the servers that will enable communication to and from the BSM and the Internet; this is where the BSM protocols are adapted to the outside world. The communication services segment is mainly located in the control plane with some functions being in the Management Plane. In figure 9, the Communication Service Segment is illustrated as potentially being hosted by a number of providers.

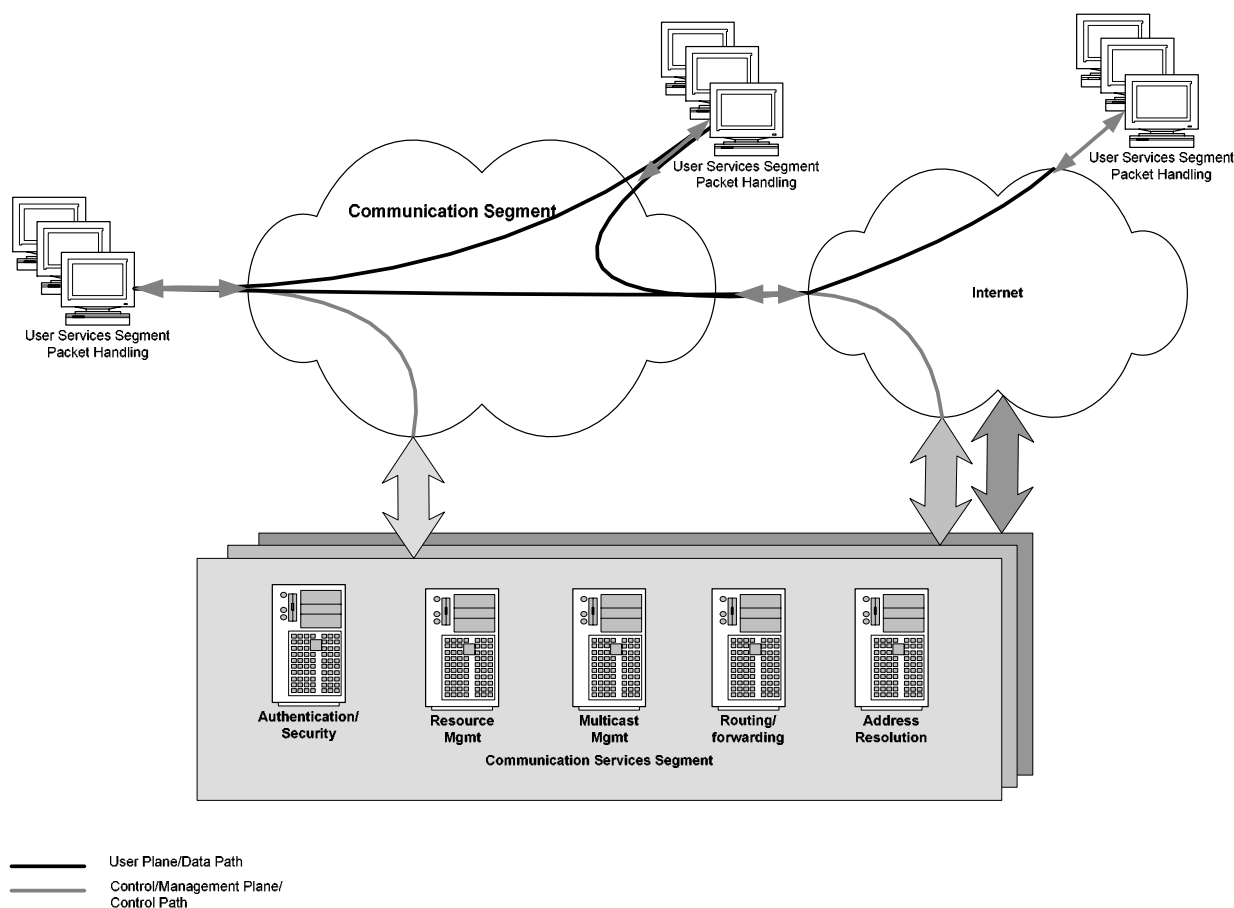


Figure 9: Logical decomposition

As mentioned in the previous clause a client - server architecture where servers are distributed amongst the operating entities (satellite, network and internet service providers) and the clients are located in terminals and gateways is favoured for its scalability, flexibility and ease of use with existing management and control systems.

8.3 Logical interfaces

For the client-server model that we are adopting, a generic interface called Client Server Function (CSF) interface is defined and then a series of subdivisions of this interface - one for each TS functions can be introduced, namely:

- CSF-1: The interface between the IETF protocols and the Client [interworking] function (internal to the IP layer) this is similar to the interfaces I.3/ I.8 (see figures 8 and 10).
- CSF-2: The interface between the peer IETF Client [interworking] functions (shown as user plane data path in figure 10);
- CSF-3: The interface between the Client function and the Server function(s) (shown as control plane path in figure 10).

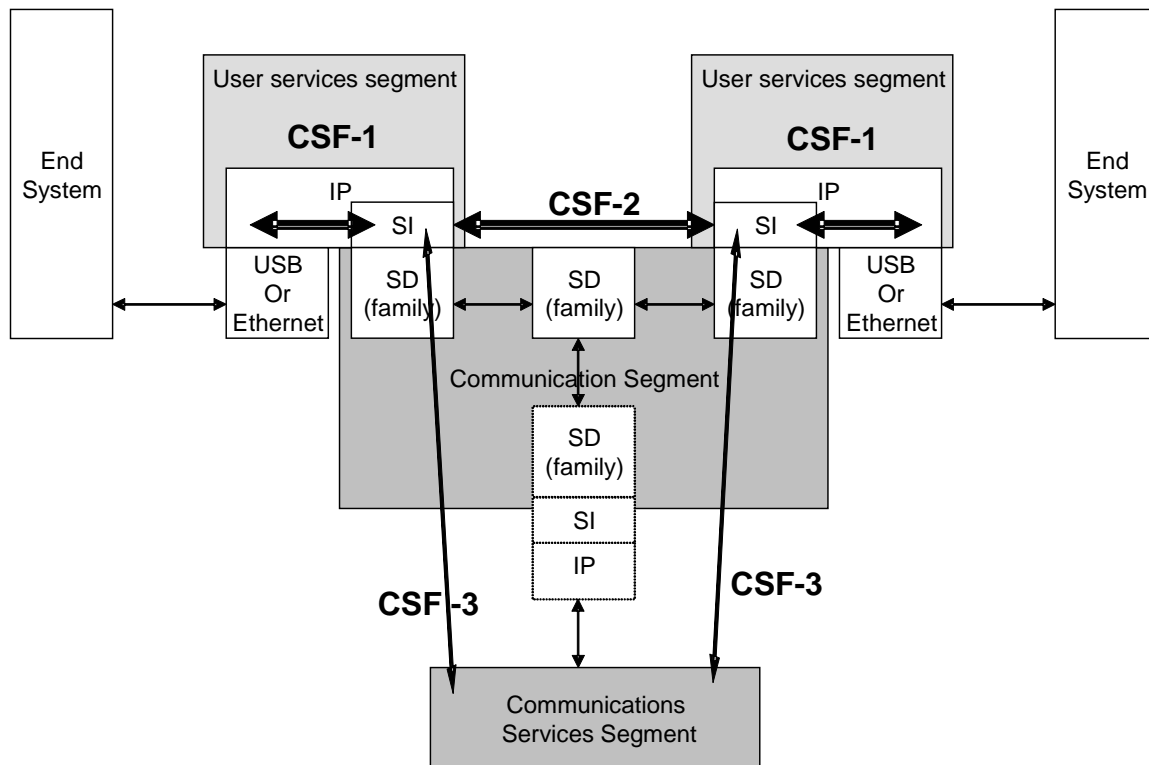


Figure 10: Protocol interfaces

9 Scenarios

9.1 Summary

This clause describes how a packet transits in the BSM and highlights how the TRs and proposed TSs interact in order to provide the BSM IP services. The BSM can act at Layer 2 on an Ethernet, at Layer 3 on a routed network and Layer 4, doing UDP or TCP port mapping and/or Network Address Translation (NAT). The BSM can also act above layer 4 by including a Performance Enhancing Proxy (PEP) or a transport relay functionality, or including an application layer proxy like a Web cache. This is all included in the concept of the "protocol" manager. For each of these functions the processing of a packet will change slightly but the "life" of a packet in the BSM follows the following steps:

- the protocol data unit is extracted at the ingress to the BSM from the ingress network interface;
- address processing (verification, resolution) is performed and the address of the egress BSM ST (and port on the ST) is found; in the case of multicasting there can be multiple egress STs, addresses can point to content not STs and group management will be necessary;
- other header processing is performed including QoS to priority mapping and queuing rules;
- the IP packet is segmented into SDU(s) (when appropriate); and
- the SDU is forwarded based on routing rules or network engineered paths.

A summary of the services offered by the BSM and how packets are processed is available in table 2.

Table 2: Summary of BSM packet processing

Packet Encapsulation	Services	Summary
IP		IP-layer address lookup is performed. Any-to-any connectivity is supported over the BSM among a closed group of logical ports.
IP over AAL5/ATM	BGP/MPLS VPNs	The IP Packet is extracted and IP-layer address lookup is performed. Any-to-any connectivity is supported over the BSM among a closed group of logical ports. From the standpoint of the user network, the BSM is a standard BGP-capable router.
IP over MPLS		The IP over MPLS Packet is extracted. Point-to-point connectivity is supported over MPLS between logical ports at the two ends of the BSM. Same applies to Ethernet and ATM over MPLS.
IP over DVB		Could be a transparent function; if not the IP packet is extracted. IP packet is encapsulated by MPE over a DVB transport stream; the MPE encapsulation could be part of the SI convergence protocols.
Ethernet	VLAN	The IP packet is extracted. Ethernet framing information could be used (out of scope). Point-to-point connectivity is supported over logical ports at the two ends of the BSM.

9.2 Network engineering functions

In order for the packet to be processed efficiently and forwarded effectively to its destination, a number of preliminary operations must have had taken place in advance. While network engineering (as a end to end function) is beyond the scope of the relevant TS it is important to highlight its essential functions as they relate to BSM packet transfer properties. Table 3 presents how the BSM protocols provide the network engineering services necessary for IP packet transfer over the BSM.

Table 3: BSM protocols and network engineering

BSM Technical Specification	User plane processing
IGMP/PIM	The definition of IGMP/PIM adaptation, proxies and snooping for gateways and terminals in order to manage how multicast packets will be forwarded in the BSM and how multicast services will be managed.
Multicast Address Resolution	Address Resolution to provide the services to map BSM multicast addresses to IP addresses.
Multicast Session Control (QoS)	Defines how multicast packets in the IP layer will be handled in the BSM.
BSM Address Resolution	Address Resolution to provide the services to map BSM unicast addresses to IP addresses.
BSM Routing	BSM Routing services to compute and distribute routing information.
RVSP/MPLS Framework	RVSP/MPLS framework that discovers paths, defines flow mapping information and path access rules and reserves resources.
Diffserv Framework	Ensure that the BSM and its attached networks agree on how to process Diffserv marked packets including the definition of traffic classes and performance goals (and Service Level Agreements).
Security	Ensure that the BSM ensure link security and content protection while integrating in the end to end security architectures of the Internet.

The "preliminary" operations ensure that the packets are well formed, that the BSM is ready to process packets, that the right settings have been made, that the right information exist about specific operators, that the BSM resources are available and have been reserved, that RSVP or MPLS paths have been established and verified, etc. They form the essential of the "Communication Management Services".

Traffic engineering can be associated to different categories, mostly non real-time such as:

- Information framing standards to create the packet and address resolution services.
- Initialization that ensures the availability of the BSM.
- Network management functions and subscriber specifics that set service agreements between operators and their customers; these are the parameters that allow packets to be forwarded according to macro-level service rules and generate the revenues of the service provider.
- Traffic engineering that sets up paths and rules to access them and enable the traffic to be effectively transmitted from ingress to egress.

As can be seen in table 3 the proposed TSs allow the full engineering of an IP services within the BSM.

9.3 Packet processing

A packet entering the BSM can be:

- an IPv4/v6 packet;
- an MPLS packet;
- ar an Ethernet frame or other layer 2 frame (or ATM cell).

The SI has all the functions necessary to adapt and de-encapsulate (and re-encapsulate) the incoming and outgoing packets to their appropriate protocols and interfaces. It also ensures that the packets are authorized to be transported over the BSM.

The flow of the IP packet will follow a well defined suite of functions as will be described in clauses 9.3.1 and 9.3.2. In this example, the processing onboard is excluded. In the case of an Ethernet frame the processing would be slightly different but the main steps would remain the same.

9.3.1 Ingress processing

The ingress processing, how the packet is treated when it enters the BSM, can be summarized as follows:

- verify the ingress IP header is valid (reverse address lookup) to avoid denial of service attacks;
- determine if the packet is MPLS; if so process as a MPLS marked packet and forward on the pre-determined path;
- determine from the IP address (if possible; if IPSEC is used this step is not possible) if this is:
 - a unicast traffic packet;
 - a multicast packet;
 - a signalling/maintenance packet.
- find the egress BSM address from the ingress IP address; if no address resolution has been performed either perform address resolution or forward to the default gateway;
- ensure connectivity is established through the BSM;
- authenticate the packet if necessary;
- find the BSM priority/traffic class from the DSCP markings or from the destination; if not marked and not a signalling packet mark as best effort;
- create the BSM header and pre-pend the header before or after packet segmentation into BSM data units (encapsulation); and
- send the segmented traffic to the appropriate queue to await bandwidth on demand, scheduling and transmission over the BSM.

9.3.2 Egress processing

At the egress (the exit of the BSM), the processing is reversed:

- verify the received BSM header is valid (reverse address lookup) to avoid rogue terminal transmissions;
- determine if the packet is MPLS; if so process as a MPLS marked packet and forward on the pre-determined path;
- determine from the BSM address if this is:
 - a unicast traffic packet;
 - a multicast packet;
 - a signalling/maintenance packet.
- find the egress IP address from the egress BSM address; if no address resolution has been performed either perform address resolution;
- re-assemble the IP packet and packet header from the BSM; and
- send the IP packet to the appropriate queue to await routing to the destination address and port.

Table 4 illustrates how the BSM protocols allow the full processing of an IP packet within the BSM.

Table 4: BSM protocols and packet processing

Technical Specification	User plane processing
IGMP/PIM	Forward the BSM multicast packets with the appropriate rules.
Multicast Address Resolution	Maps IP multicast addresses to BSM destinations.
Multicast Session control (QoS)	To ensure that multicast packets are processed according to the right rules inside the BSM.
BSM Address resolution	Maps IP addresses of ingress packets to a BSM destination.
BSM Routing Tables	Define the forwarding rules of the IP packets.
RVSP/MPLS framework	Recognizes which packet is part of which flow/path and forwards it accordingly.
Diffserv framework	Mapping Diffserv markings to BSM priorities.
Security	Ensure the BSM segment security (link and content).

Annex A (informative): Bibliography

- ETSI TR 101 984: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; Services and Architectures".
- ETSI TR 101 985: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; IP over Satellite".
- ETSI TR 102 155: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; IP interworking over satellite; Addressing and routing".
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- ETSI TR 102 157: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; IP Interworking over satellite; Performance, Availability and Quality of Service".
- ETSI TS 102 295: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM) services and architectures; BSM Traffic Classes".

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History

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