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Foreword

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

Introduction

IETF IP multicast protocols, in particular their signalling characteristics, are often not well suited to the specifics of BSMs, as discussed in TR 102 156. The present document defines the functional architecture that is going to be used to specify how and where IP multicast protocols need to be "adapted" to be better suited to the BSM environment. This architecture relies heavily on the generic BSM Architecture Technical Specification TS 102 292; it does not use satellite specifics, is based on client server architectures and does not interfere with standard IP protocols and Internet operations. It applies the BSM architecture to a specific application, multicast. Hence it provides both a test case for the architecture and a framework for the TSs that will specify the protocols ensuring multicast services can be provided efficiently over BSM networks.

1 Scope

The present document presents a functional multicast services architecture bringing together the previous BSM TRs on Standardisation (see TR 101 984 and TR 101 985) and Multicasting (see TR 102 156) and the TS on BSM Functional Architecture (see TS 102 292). It also links in a common framework the current Work Items on Multicast Protocols over the BSM. Finally, it provides a functional structure to the subsequent Multicast Technical Specifications (TSs) to be produced by the SES Technical Committee. The focus of the present document is on the IP version 4 (IPv4) protocols; this is consistent with the other protocol work performed in the BSM working group.

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

BSM multicast session: instance of a multicast session that originates and terminates within BSM elements (STs, gateways)

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

multicast group: multicast IP address to which hosts may subscribe

multicast session: specific instance of multicast communication

proxy: function that intervenes between a source and destination and performs that function as an intermediary for the remote devices in each direction

scenario: predicted sequence of events

snooping: function associated with a layer 2 switch or bridge that intervenes on a given layer 3 protocol between a source and destination

3.2 Abbreviations

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

3GPP	Third Generation Partnership Project
BSM	Broadband Satellite Multimedia
CBT	Core Based Trees
CSF	Client Server Function
DHCP	Dynamic Host Configuration Protocol
DRM	Digital Rights Management
IETF	Internet Engineering Task Force
IGMP	Internet Group Management Protocol
INT	Internet Notification Table
IP	Internet Protocol
IPv4/v6	Internet Protocol version 4/6
LAN	Local Area Network
MLD	Multicast Listener Discovery

MMT	Multicast Mapping Table (DVB-RCS)
PID	Packet IDentifier
PIM-SM	Protocol Independent Multicast - Sparse Mode
QoS	Quality of Service
RFC	Request For Comments
SD	Satellite Dependent
SDAF	Satellite Dependent Adaptation Functions
SI	Satellite Independent
SIAF	Satellite Independent Adaptation Function
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
SSM	Source Specific Multicast
ST	Satellite Terminal
USB	Universal Serial Bus
WG	Working Group

4 BSM multicast framework

The protocols that enable multicast over BSM are located in the satellite independent part of the BSM stack. The mapping of these functions to layer 2 protocols, while essential for the operation of the BSM in multicast mode are beyond the scope of this architecture but will be addressed under other Work Items of the BSM working group. This architecture resides within the *Communication Services, which* contains all the servers that will enable communication to and from the BSM and the Internet and where the BSM protocols are adapted to the outside world (see figure 1).

4.1 Basic concepts

In addition to the definitions provided in clause 3.1 and the basic concepts introduced in the Architecture TS 102 292 some concepts that are necessary to fully understand the BSM multicast services are further explained below:

- **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.

- **Multicast proxying:** refers to operations that are performed on behalf of other devices in order to improve performance or cost, for example. An IP layer proxy is a function that intervenes between a source and destination of IP packets that relate to a given IP protocol. For multicast group management an IGMP Proxy behaves as a single IGMP client on behalf of several downstream hosts, and in the opposite sense as a local IGMP querier to these hosts on behalf of a remote querier.

- **multicast session:** specific instance of multicast communication by a multicast group defined by its transmission parameters, participants, and time of existence. In this context:

  - Applications associate a specific source address with a multicast session; the same destination address but with a different set of source will be viewed as a different group.

  - A group address may need to be interpreted by its scope in the sense that the same address could be used in different part of the network independently an issue with BSM networks that cover access domains and multiple multicast offerings.

- **snooping:** function associated with a layer 2 switch or bridge that intervenes on a given layer 3 protocol between a source and destination. It learns about network behaviour from intercepted IP packets and without explicit configuration as a network function (with IP address, etc.).

4.2 Link to the generic BSM architecture

In the Architecture TS 102 292 the following interfaces are defined in figure 1:

- CSF-1: The interface between the IETF protocols and the Client function (internal to the IP layer).
- CSF-2: The interface between the peer IETF Client [interworking] functions.
- CSF-3: The interface between the Client function and the Server function(s).

The multicast group management protocol is directly linked to the CSF-3 across the BSM even when using snooping or proxying because the protocol architecture is mostly at layer 3. Layer 2 operations related to reverse address resolution and packet replication or higher layer network management function are only described here as they relate to architectural scenarios.

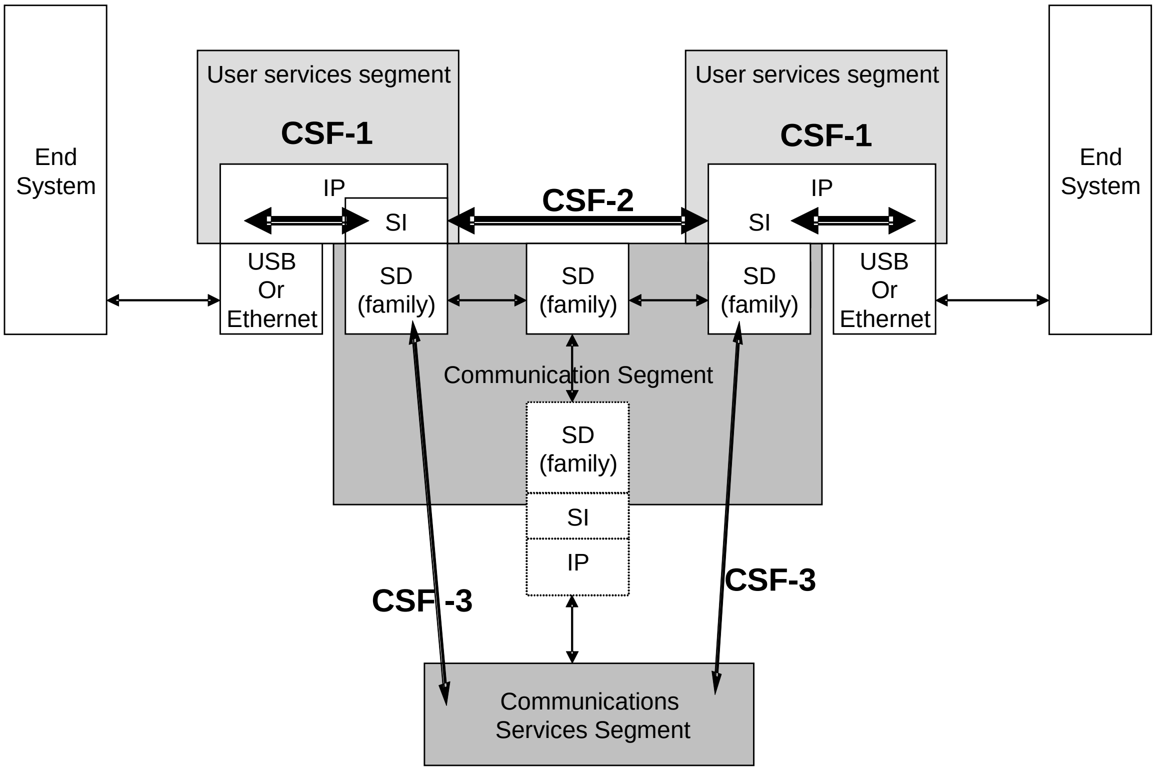

Figure 1: BSM architecture

In terms of multicasting the BSM architecture can be used to define main functions such as:

- multicast routing and group management;
- address resolution/translation; and
- security.

These run over the CSF-3 interface and are located mainly above the SI-SAP. The generic BSM multicast architecture is shown in figure 2.

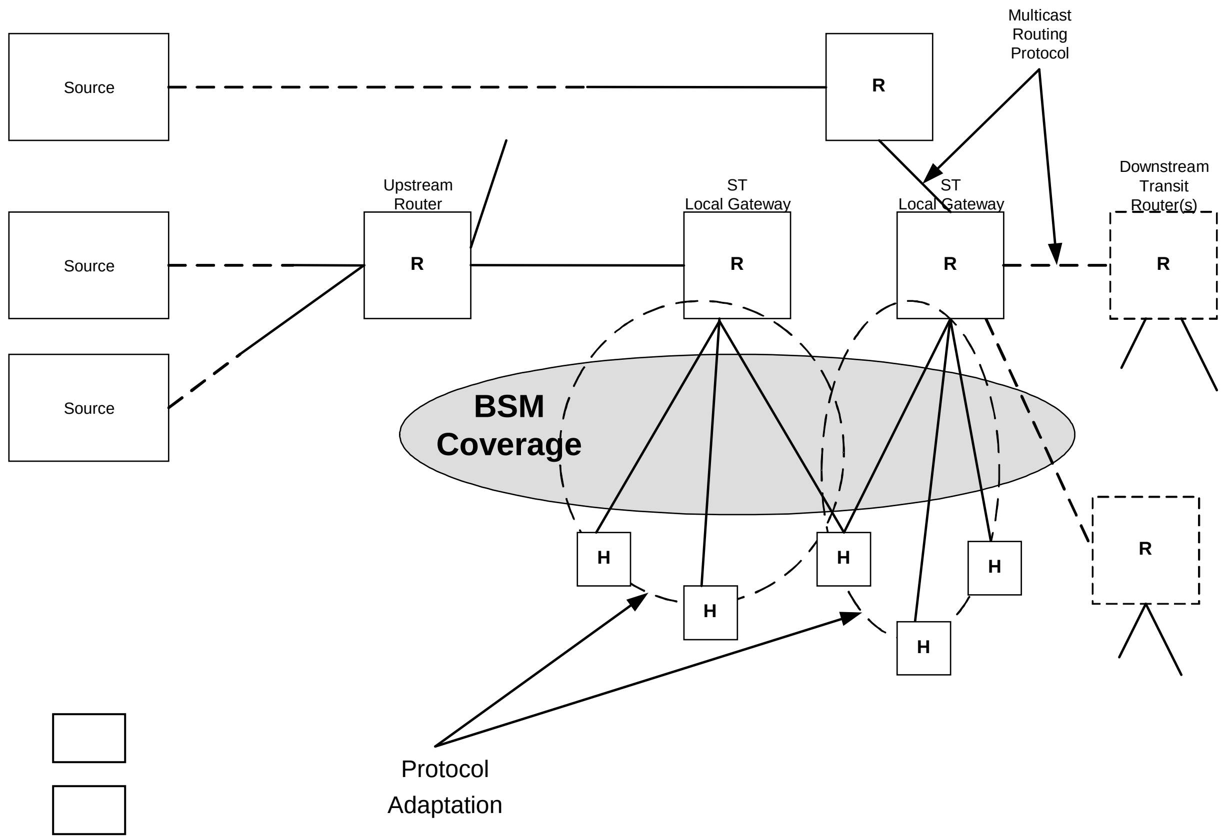

Figure 2: BSM generic multicast architecture

In clause 4, the multicast architectures that are going to be the basis of the proposed TSs are introduced. For each of the recommended protocol, a TS specifying the manager or the "adaptation" of the protocol and located in the appropriate server (in the appropriate domain) will be defined in relation with the BSM. Both BSM specific modules and IETF standard modules are illustrated for completeness.

4.2.1 Multicast over different BSM topologies

Multicast protocols over the BSM may operate differently over the different BSM families. The use of double hops for transmitting multicast information should be avoided where possible, for example by adding adaptation of protocols over meshed networks, but may be un-avoidable in some cases.

The main difference between the mesh network and star network topologies is with packet forwarding and replication: in a star network the hub becomes de facto the virtual source of all multicast traffic. In this configuration all external sources appear as sources at the hub and all clients first forward their packet to the hub for redistribution. In a mesh topology any ST can be the multicast source. Hence at the BSM level, two instances of multicast can happen:

- single source or origination multicast (via a gateway at the hub) - this is for star network topology where all BSM multicast sessions originate at the gateway (or a single ST); the actual "source" can be anywhere; and
- multiple source or origination: any ST can be the root node of the BSM multicast session given it is connected to the IP multicast source or rendezvous point; any such ST that can transmit data to a particular multicast session; a destination ST is a leaf node of the multicast session and is an ST that receives data from a particular multicast session; this will necessitate double hops on the data path (via the hub) in all BSMs that do not have onboard processing.

4.3 BSM multicast-specific protocol stack

Figure 3 presents the BSM protocol stack specific to multicast; it is taken directly from the BSM functional architecture (see TS 102 292). Figure 3 shows how the basic set of functions and SI-SAP primitives for unicast Internet connectivity is complemented by multicast specific functions. They correspond to the recommendation of the multicast TR 102 156 for future work in BSM multicast, namely in the Satellite Independent layers:

- BSM Multicast Group Management;
- BSM routing;
- BSM Multicast Address Resolution; and
- Multicast Security.

Because of the nature of the BSM, some of these functions, most notably for routing and group management, will necessitate adaptation for better performance with BSM delays and transmission/reception characteristics. Multicast, like unicast functions such as DHCP or web access, uses local proxies in the requesting hosts to reduce the control traffic load. In the BSM this reduction of traffic is important over the air interface and proxies will be used in addition to protocol adaptation. Proxies, essentially virtual devices, are not illustrated in figure 3, which shows protocols only. Adaptation and proxying use are defined and specified in clause 5.1. Figure 3 finally indicates some satellite dependent group management that is being performed in the BSM WG (SD multicast functions). This work defines how multicast groups can be mapped onto Satellite Dependant, for example DVB specifics using the DVB-RCS Multicast Mapping Tables (MMT) or DVB Internet Notification Tables (INT). Annex A gives a short overview of the lower layer mapping necessary to enable multicast over BSM networks.

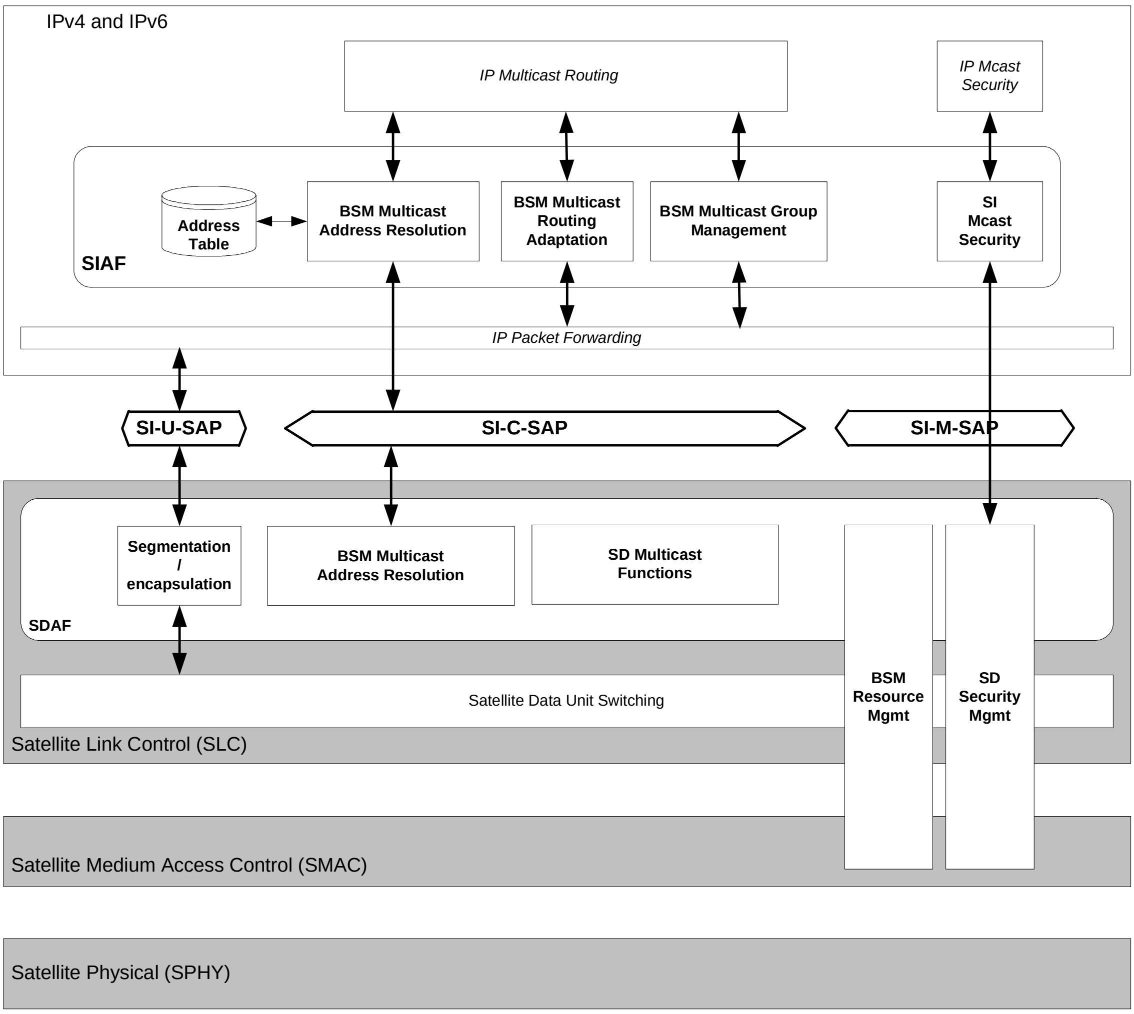

Figure 3: OSI protocol stack for BSM multicast services

4.4 Multicast services over the BSM

Multicast operations over the BSM can have multiple forms:

- Multicast session attributes:
  - on-demand: when a subnetwork wants to receive multicast data protocols allow to request the service over the BSM (pull model); and
  - scheduled: multicast data is sent to all registered users according to a schedule (push model).
- IP multicast group management attributes:
  - static: the ST statically forwards all received groups or a pre-configured set of groups; and
  - dynamic: the ST allows attached hosts to dynamically set which groups to forward.
- Multicast address resolution:
  - static: all multicast addresses are preconfigured and only refreshed unfrequently via tables or direct operator's intervention; and
  - dynamic: multicast addresses are mapped dynamically using an address resolution protocol.

Since scheduled and static operations do not necessitate any IP layer protocol operations beyond the usual connectivity, this architecture is focused on the dynamic multicast management at the IP layer where hosts join and leave multicast sessions "at any time". The essential aspects of the architecture cover:

1) **IP Multicast group management** via the Internet Group Management Protocol (IGMP) proxying or snooping and protocol adaptation that support dynamic join and leave operations this is based on IGMPv2 protocol that was successfully adapted to satellite operations.

2) **IP Multicast routing protocols** such as the PIM-SM and CBT that are recommended in the ETSI Multicast TR 102 156 as well as recent SSM work standardized by RFC 3569.

3) **Multicast address resolution** to resolve a IP multicast address to a BSM multicast address.

4) **Multicast Security** to define how security policies can be applied to multicast transmissions (e.g. only authorized users can receive the content and that the content is protected by the some form of Digital Rights Management or DRM).

IP multicast protocols and their signalling characteristics were originally developed on terrestrial wired LAN or WAN technologies.

EXAMPLE: On wired networks, hosts can listen to the multicast transmission from other hosts and will not re-transmit information that was already sent by another host; the amount of traffic to manage group membership can thus be reduced.

Alternatively these protocols can operate over high bandwidth networks where signalling overhead or information tunnelling is not an issue. Finally most protocols are tuned to the short delays of the terrestrial networks. None of these characteristics belong to the BSM:

- STs may not be aware of other STs;
- satellite uplink bandwidth is scarce and delays of the order of seconds common.

Hence for the BSM, intercepting IGMP, PIM-SM and other IP multicast control traffic at the ST is recommended to "adapt" the protocols to the BSM environment. In general the adaptation uses a client server architecture. Proxies will also be used when applicable.

5 Multicast protocols over the BSM

5.1 Adaptation

While the SI-SAP provides a layer of abstraction that separates layer 3 protocols from the lower layer functions, the BSM has specific characteristics as compared with a standard Ethernet such as:

- long(er) transmission delay;
- scarce spectrum resources especially on uplink;
- transmission channels may not be broadcast channels; hence all transmissions may not be heard by all terminals, especially uplink transmissions.

This requires that standard protocols for routing, group management or address resolution to be "adapted" for better performance. This adaptation, transparent to the general Internet, involves changing timers, filter and reduce traffic over the air messages to the multicast servers. An implementation of such adaptation is provided in TS 102 293 for the group management case.

5.2 Proxying

In the wired Internet, even with ample bandwidth in the core, the edge networks experience congestion and it is to the benefit of operators and users alike to keep the bandwidth for revenue generating traffic. Proxying is used to keep some function usually associated with a remote server local to the user by caching frequently requested information and acting as the server for a number of usual operations. The cache of information is refreshed periodically with fewer commands especially during periods of lower load. Proxying is currently used in the Internet for example for address resolution (DHCP proxies), web access (Web proxies) and multicast group management (IGMP proxies). Proxying provides the added feature of security (preventing access from an external device to the proxy) and address filtering (preventing access to some web sites for example).

It can be seen when comparing with clause 5.1, that adaptation and proxying are different types of functions:

- A proxy is not changing anything in the protocol (it is not adapting). A proxy is an agent (a virtual device) and has an address and will be directly involved in the communication; for example it is a well-known function of any network setup to specify the proxy addresses.
- The adaptation is not an agent (there is no virtual device). The adaptation function does not have an address: you cannot communicate with the adaptation; only with the server running the adapted protocol.

Layer 3-based multicast STs interfacing with downstream subnetworks can be implemented as either routers or proxies, The router version is applicable when multicast routing protocols (e.g. PIM-SM) are carried over the satellite. The proxy version is applicable when IGMP is carried over the satellite.

5.3 IGMP over BSM

IP Multicast Group management in the sense of management of a multicast tree determines whether a group is forwarded and where packet replication happens. Figures 4 and 5 show the operation of IGMP over the BSM with both layer 2 (snooping) and layer 3 (proxying) approaches. In both cases IGMP messages are intercepted before they enter the BSM. When a host requests to join or leave a multicast group via IGMP, the corresponding ST (the one the host is attached to) receives the IGMP message and if necessary makes a request to the querier. After processing of the request the receiving ST may start to receive or stop receiving multicast content. Both snooping and proxying are helpful in reducing traffic over the BSM. IGMP snooping, as implied by the name, is a feature that allows the ST to "listen in" on the IGMP conversation between hosts and routers and can tell the BSM network which groups need not be forwarded, hence the traffic reduction at the sender side. Details of the IGMP adaptation are available in TS 102 293.

As seen in the clause 5.2, the generic definition of a proxy is an entity performing a function for another device. Like many other IP functions, IGMP is often handled through proxy servers when a single interface from several hosts on a local subnetwork to the external network to is needed. The IGMP proxy offers a mechanism for multicast forwarding based on IGMP membership information. The proxy has to decide about forwarding packets on each of its interfaces based on the IGMP information and as such replaces the usual IGMP querier the proxy can be used together with IGMP adaptation to reduce traffic over the satellite link or to send traffic only outside peak hours. The proxy gets the multicast management messaging (join, leave, prune) and responds to the query locally without necessitating access to the remote server. When necessary the proxy will upgrade its information by querying the server but that could be only infrequently especially over semi-dynamic or static multicast architecture. While the adapted protocol and the proxy are independent and the use of one does not necessitate the other, when used together the performance of the combination is improved as it adds the fast response to the user offered by local functions, to the reduced traffic over the air interface required by the BSM and adds flexibility of the timing of those transmissions. Such IGMP proxies are commonly used and require no modification if they are used at the client side of the satellite (draft-ietf-magma-igmp-proxy-04 - see bibliography).

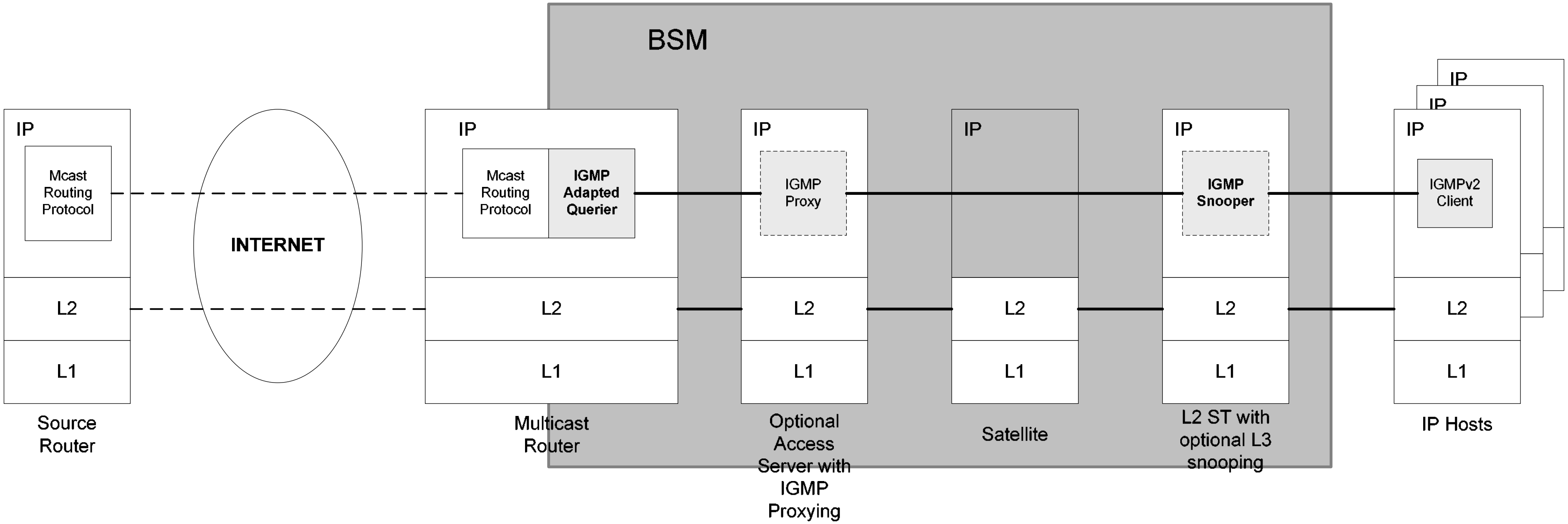

Figure 4: IGMP architecture with layer 2 ST (switching) and optional IGMP proxying and snooping

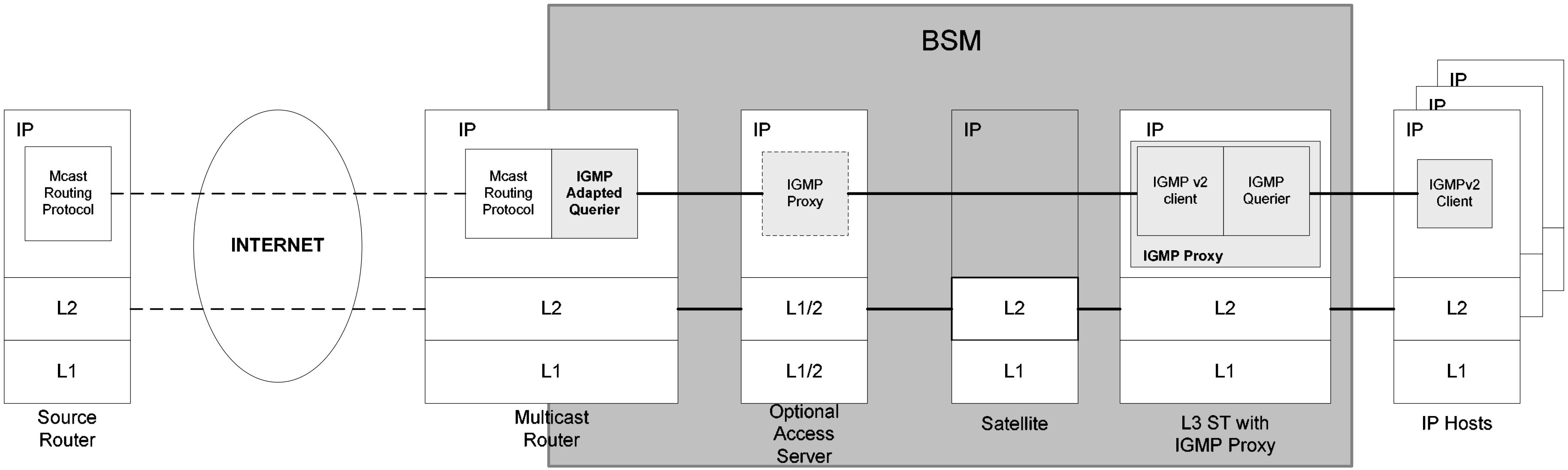

Figure 5: IGMP architecture with layer 3 ST (routing) with optional IGMP proxying

5.4 BSM multicast routing

While IGMP is not strictly a routing protocol, it controls the packet forwarding behaviour by managing who is a member of a multicast group. Once the distribution tree and actual routing information has been established in the tables and once packets have been replicated (or not replicated) the forwarding of packets will use a similar mechanism as for unicast routing: the multicast routing table will provide the forwarding address to BSM port mapping and the packet will be sent to the actual port. This clause describes how multicast routing protocols could be used over a BSM network.

5.4.1 Sparse-mode protocols over BSM

Figure 6 presents an overview of the PIM-SM over BSM adaptation as an example of a sparse mode protocol over the BSM (Core Base Trees or CBT would be other examples). PIM-SM is illustrated because it an accepted IETF protocol. Details of this adaptation will be provided in the appropriate TS when it becomes available. A feature of the routing adaptation is the need to reduce double hops through the BSM when it can be avoided especially over meshed networks.

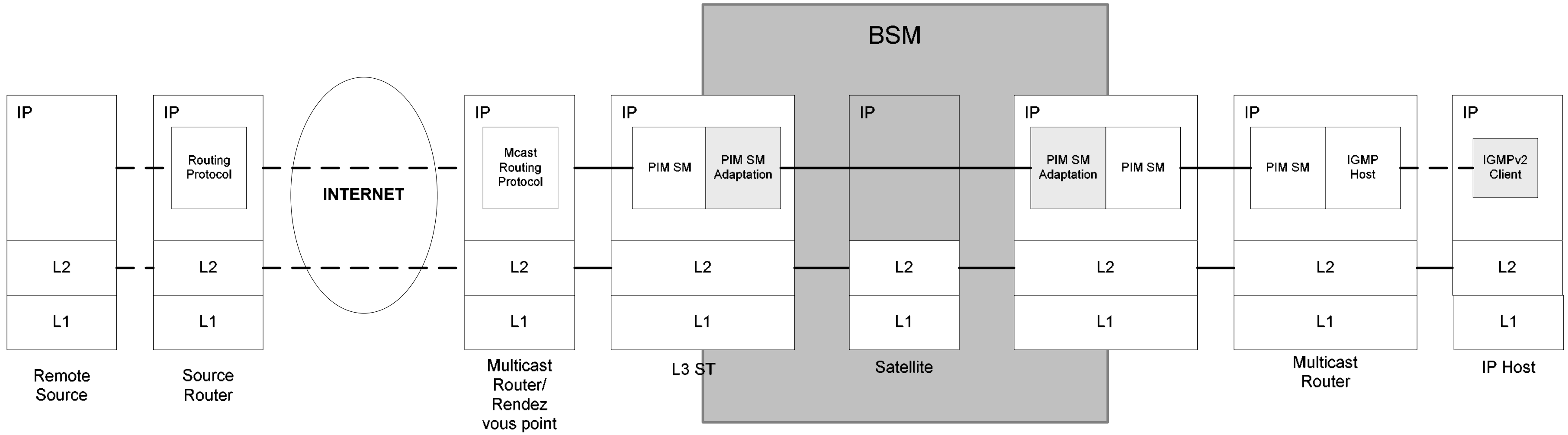

Figure 6: PIM-SM over BSM overview

5.4.2 Other multicast routing protocol adaptation

As other multicast routing protocols are used over the BSM other adaptation will become available.

5.5 Multicast address resolution

Multicast address resolution has both similar and non-similar characteristics when compared to unicast address resolution. If a router gets a multicast IP address that is not recognized it sends it to the appropriate BSM server that knows about the appropriate multicast tree topology, IP multicast addresses and the mapping to and from the BSM multicast addresses. This process also relates to the group management described in previous clauses.

5.6 Service discovery

Finding the address of the content to listen to is a multiple level protocol in the BSM that could be automated in some cases:

1) From the content find the IP address; this is done manually via a web page, media guides, etc.; this is the service discovery part.

2) From the multicast IP address find the specific satellite independent BSM multicast address of the channel to listen to (address resolution).

3) From the BSM multicast address find the physical channel to tune to. This involves BSM lower layer functions as well as in some case the actual IP multicast addresses (see annex A).

6 Scenario

This clause describes the sequence of events that enable multicast over the BSM.

- The end user finds a URL or the IP address to the content that is to be received.
- A join message is sent to the group manager indicating that the host to which this user is connected wishes to receive the content.
- The local proxy verifies if this group is available and if the user (and/or host) is entitled to receive the content.
  - If the group is available and the user (and/or host) is authorized the host address is added to the list of destinations. The connection handling features of the SI-SAP ensure the multicast address is connected to the appropriate lower layer resources.
  - If the group is not there, the proxy can request it dynamically to the group manager across the air interface or wait for a refresh of available groups. Then the host can be added to the distribution if the security allows it.
  - If the user is not authorized or the group is unavailable the process stops.
- The host is added to the multicast tree; periodically this tree is rebuilt to balance traffic and perform maintenance; the adaptation in the ST ensures that the required signalling traffic is handled efficiently.
- Multicast traffic flows from the source to the requesting hosts.
- When the user disconnects, leave messages are sent and handled by the proxy and/or server. Pruning of the tree may occur if the user was alone on a branch.

Annex A (informative): SI-SAP multicast mapping for DVB networks

The mapping of specific multicast protocol to Satellite Dependent protocols is described in figure A.1. Figure A.1 highlights the fact that the DVB semantics are not know above the SI-SAP but the DVB specific information to setup actual access to the multicast content is cached at the SDAF layer and indexed by the appropriate BSM identifier. From the SIAF to the lower layers the overall mapping involves multiple steps. For example, the mapping of IP multicast groups, addresses and QoS requirements to specific channels in the satellite transmission involves steps above and below the SI-SAP. The mapping of a certain multicast content addresses to a DVB Packet IDentifier (PID) in the DVB TS stream is currently done for example by the DVB RCS MMT tables or DVB INT tables. Since the DVB model does not include an abstraction layer for the BSM this mapping will involve the use of SI-SAP semantics to keep the satellite dependant information hidden at the higher layers.

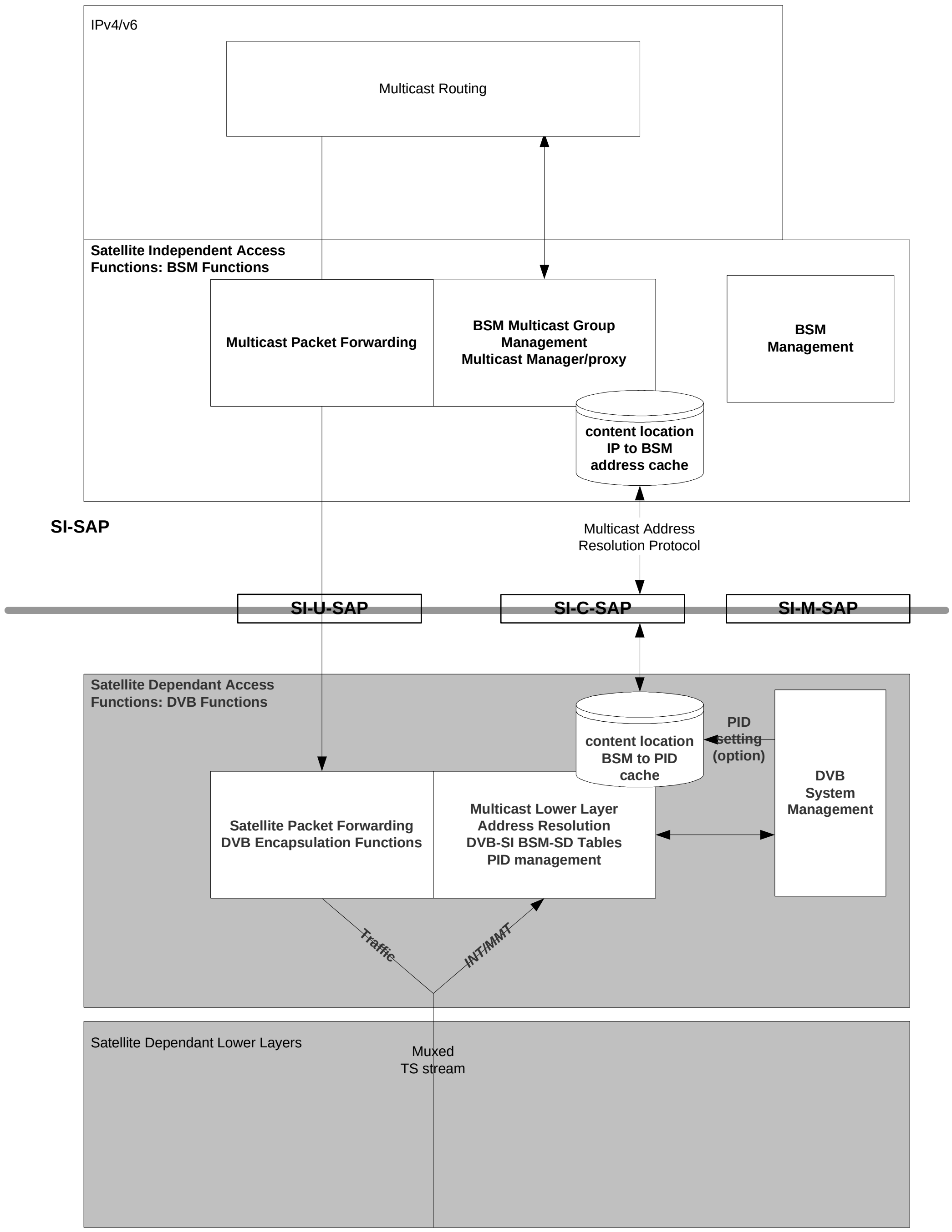

Figure A.1: DVB SI-SAP mapping for multicast

Annex B (informative): BSM multicast options

Table B.1 summarizes the BSM multicast options.

Table B.1: BSM multicast options

	A Number of sources	B Control architecture	C Topology	D Signalling traffic	E User traffic	F Comments
1	Single (e.g. via Gateway)	Single central control, connected to the source	Star/ no-OBP	Single hop	Single hop	No support for sources other than Gateway.
2	Multiple (Gateway and STs)	Single central control, connected to the Gateway	Star/ no-OBP	Single hop	Double hop (ST-Hub-ST)	Source data from remote sources must be tunnelled via the ST to Gateway as first hop.
3	Multiple	Single central control, not all connected to the Gateway	Star/no-OBP	Double hop	Double hop	Same as above; STs can suppress traffic that is not required.
4	Multiple	Multiple; one per source, co-located with source	Mesh/ OBP	Single hop	Single hop	Multiple control messages required (one per source).
5	Multiple	Single central control	Mesh/ OBP	Single hop	Single hop	Most control messages need a single hop.

Annex C (informative): Bibliography

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- ETSI TR 101 985: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; IP over Satellite".
- ETSI TR 102 156: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; IP interworking over satellite; Multicasting".
- ETSI TS 102 292: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM) services and architectures; Functional architecture for IP interworking with BSM networks".
- ETSI TS 102 293: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM) services and architectures; IP Interworking over satellite; Multicast group management; IGMP adaptation".

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