BROADBAND SATELLITE MULTIMEDIA (BSM) ARCHITECTURES

A FRAMEWORK FOR STANDARDS ACTIVITY IN ETSI

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Abstract: We describe recent progress in the development of functional architectures and their associated protocols. These architectures have been developed in the European Telecommunications Standards Institute (ETSI) by the TC-SES/ BSM working group where they are now being used to provide a framework for the standardization of Broadband Satellite Multimedia Systems (BSMS).

The basis for the BSM architectures is a clear separation between functions that are applicable to all satellite systems (satellite independent or SI) and the functions that are specific to a satellite technology (satellite dependent or SD). This clear separation benefits both operators and technology developers as the protocols and software developed at the SI layer can evolve without impacting expensive satellite technology. On the other hand satellite systems can also evolve without major rework of the large base of software necessary for satellite network operation. The architectures are now being used to develop a set of common IP interworking standards to ensure transparent interoperability between non satellite IP-based subnetworks and the BSMS. A first set of IP interworking standards have recently been published that address multicast group management and traffic classification and the next phase of work will add standards for IP address resolution, IP traffic management (including quality of service) and security. In parallel the BSM working group is working on families of air interface specifications: the first of these has recently been published and three more families are expected to be completed soon.

The work performed in the BSM working group benefits from recent developments in the Internet Engineering Task Force (IETF), the European Union IST programs and European Space Agency projects as well as internal R&D from ETSI members.

1. INTRODUCTION

The guiding concept behind the BSMS architecture is a clear separation between functions that are applicable to all satellite systems (satellite independent or SI) and the functions that are specific to a satellite technology (satellite dependent or SD) and hence define a satellite independent interface that can be used to provide essentially the same services across all implementations of the BSMS. While this should be true for all interworking aspects from layer 2 (i.e. bridging), layer 3 and above, this paper focuses on the IP suite of protocols that are targeted for the first generation of interworking scenarios.

1.1 IP Interworking aspects

In the global Internet, a BSMS is another subnetwork and only a small number of hosts will be directly connected to that BSMS. It is unrealistic to require that any IP host with traffic transiting a BSMS (at some point downstream) should modify its IP-layer protocols. Consequently, the main interworking guideline for IP services over a BSMS is that on the network side all IP layer protocols remain the same.

On the satellite side the IP layer protocols can, when applicable, be adapted to better respond to the specifics of the BSMS when compared with terrestrial wired and wireless technologies to accommodate a combination of:

- Longer delays
- Large delay-bandwidth product
- Bottleneck RF resources
- Natural multicasting capabilities
- Large coverage
- Multiple spot beams
- On-board switching and routing
- On-board bandwidth control
- Independence from ground infrastructure

This approach is not specific to BSMS and can be found in many IP networks in the Next Generation Networks (NGN) namely Virtual Private Networks and Mobile IP. When applicable protocols developed for these networks will be used over the BSMS. This ensures that the BSMS can be complementary to terrestrial infrastructure, reinforcing the inherent advantages of satellite systems for providing services to remote regions.

1.2 Client-server architecture

At the basis of the BSMS architecture is the client server concept. In essence any BSMS satellite terminal (ST) is a gateway from its attached internet hosts to the BSMS and in certain cases (hub terminals) from the global Internet to the BSMS. Because a ST will require BSMS-wide services for addressing, group management, resource allocation, security and admission, the use of a client/server architecture is appropriate in most cases.

The client/server architecture is a versatile, message-based and modular infrastructure. The client and server could be located anywhere. It is intended to improve usability, flexibility, interoperability and scalability as compared to centralized management. It is now widely used for network management and control and is central to the Internet functionality.

A client is defined as a requester of services and a server is defined as the provider of services. The BSM client requests IP services from the BSM network and the BSM servers provide the services to fulfill the request. A single ST can support both client and server software or provide the transit link to a remote server. This depends on the software architecture, the targeted services, the BSM network configuration and the operator's network management implementation.

2. BSMS SCENARIOS

BSMS can be separated into 3 main scenarios as illustrated in Figure 1:

- Access network, providing services to end users.
- Distribution network, providing content distribution to the edge.
- Core network, providing trunk interconnect services.

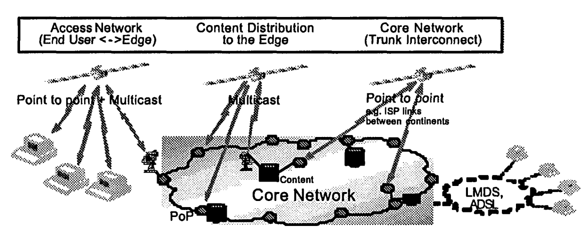

Figure 1. BSM network scenarios

The current work is focused on the Access Network scenarios, where two basic satellite topologies are defined:

- Star topology using a transparent or regenerative satellite system. In this scenario the STs are able to access terrestrial networks (e.g. the Internet) in one hop via a hub gateway;
- Mesh topology using a regenerative satellite system. In this scenario the network supports peer to peer communications between any pair of terminals/gateways in one hop using onboard processing on the satellite to provide the connectivity. The meshed configuration can also be supported over a transparent payload with double hop via the BSMS.

3. SERVICES ARCHITECTURE

A BSMS will be required to support a wide range of applications with different quality of service profiles. In general, it is not possible to predict the usage and the service requirements for many of these applications and hence it is not possible to optimise the BSMS for only one set of applications. This leads to the conclusion that the BSMS architectures should be flexible and capable of evolution so that they can track developments in the terrestrial networks and the satellite technologies and thus have a long technical lifetime

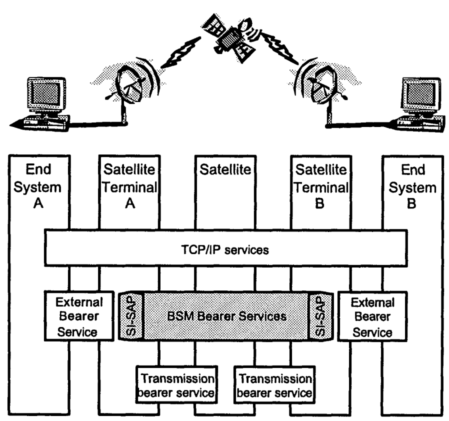

Figure 2. BSM service architecture

In order to clearly differentiate between services that are specific to a satellite technology from those that are common to all satellite systems, the BSMS architecture defines a satellite-independent service access point (the SI-SAP) as the interface between these upper and lower parts. This interface corresponds to the ends of the BSM bearer services as shown in Figure 2.

4. PROTOCOL ARCHITECTURE

The BSMS clearly identifies three groups of protocols:

- IETF IP network protocols;
- Adapted BSMS protocols that are satellite system independent; and
- Satellite technology dependent protocols.

The BSM protocol architecture also defines the SI-SAP interface which lies between the IP network layer and the lower layers. Immediately above and below this interface the architecture defines two new adaptation layers – the satellite independent adaptation functions (SIAF) and the satellite dependent adaptation functions (SDAF). These contain the BSMS functions associated with the interface as shown in Figure 3. The SIAF and the associated satellite IP layer functions in the satellite independent layers are the main focus of the BSM work.

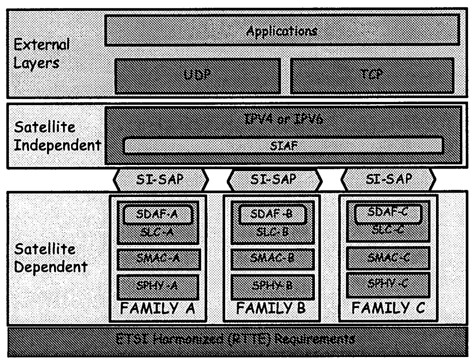

Figure 3. BSM protocol architecture

The SI-SAP can be functionally separated into:

- The user plane (U-plane), the traffic data path.
- The control plane (C-plane), to provide the control functions that enable data to be transferred.
- The management plane (M-plane), to interwork with network-wide management systems.

Only a small number of generic functions need to cross the SI-SAP. For example:

- data transfer (U-plane)
- address resolution (C-plane)
- resource reservation (C-plane)
- multicast group enable (C-plane)
- flow control (C-plane)

Figure 3 also shows how the BSMS architecture can support multiple alternative families of satellite dependent lower layer protocols. Each family corresponds to a different satellite technology, including both transparent and regenerative satellites and mesh and star topologies. Each of the families of satellite dependent lower layers can support these generic SI-SAP functions in different ways. Each family defines a satellite dependent adaptation function (SDAF) that is used to provide the mapping to and from the standard SI-SAP interface. The first of these, the RSM-A family for regenerative satellites, has recently been published and three more families are expected to be completed soon.

5. BSM ARCHITECTURE FOR UNICAST SERVICES

Figure 4 presents the BSM protocol stack for unicast services. The BSM protocols are based on the OSI layered protocol stack and reflects the basic philosophy defined in previous sections. For the IP services most of the BSM work for unicast services 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 or the RSM-A air interface.

Consequently the current specification work is focusing on:

- Address Resolution
- Routing
- Quality of Service
- Security

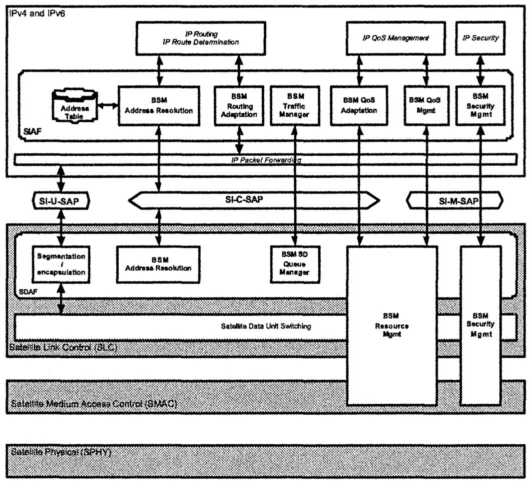

Figure 4. BSM unicast architecture

The SI-SAP provides an abstract interface allowing BSM protocols to be truly satellite 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 satellite 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 to be used over the BSMS.
- The QID enables the BSM data transfer (IP packets) to be queued, policed and transmitted properly across the BSMS.

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. The BSM queues can be defined by QoS specific parameters (e.g. 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). BSM queues can also be defined by downlink destination information (e.g. to mitigate downlink congestion as is the case for RSM-A).

All of the BSM services such as data transfer, address management, group advertisement etc. use SI-SAP primitives to define the exchanged information between the satellite independent upper layers and the satellite dependent lower layers via the SI-SAP.

6. BSM ARCHITECTURE FOR MULTICAST SERVICES

The BSM work on multicast services is focused on dynamic multicast group management at the IP layer where hosts join and leave multicast sessions "at any time". The essential aspects of the architecture cover:

- IP Multicast group management via the IGMP (Internet Group Management Protocol)
- IP Multicast routing protocols such as the PIM-SM and CBT
- Multicast address resolution
- Multicast Security

Figure 5 presents the BSM protocol stack specific to multicast, showing how the basic set of functions and SI-SAP primitives for unicast Internet connectivity is complemented by multicast specific functions. In the BSM the reduction of control traffic over the air interface is important, hence proxies will be used in addition to protocol adaptation. Proxie s, essentially virtual devices, are not illustrated in Figure 5, which shows protocols only. Figure 5 also indicates how multicast groups can be mapped onto satellite dependent functions.

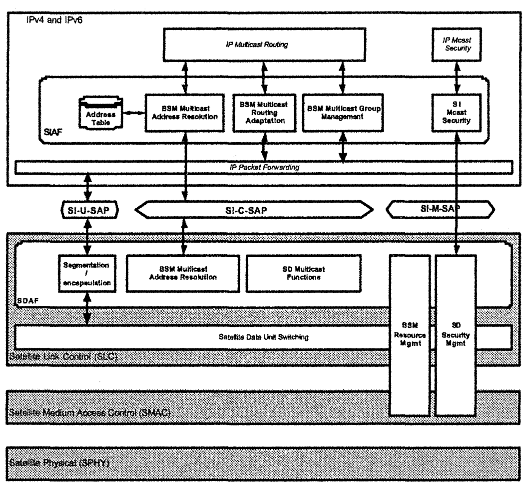

Figure 5. BSM multicast architecture

7. APPLICATIONS OF THE ARCHITECTURE

In this section we present how the BSM architecture has allowed the further specification of BSM services and will extend the current base of specifications to include more services. In this section, we present how the architecture can be used to ensure the adequate performance of IGMP adaptation and address resolution over the BSM.

7.1 IGMP Adaptation over the 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. For the BSM operations, 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 (to which the host is attached) receives the IGMP message and if necessary makes a request to the IGMP 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.

7.2 Address Resolution

In current satellite systems, the bindings between IP addresses and technology specific identifiers such as MAC addresses and PIDs are not uniform. Some are table based (e.g. the DVB INT tables), others are more dynamic (e.g. the RSM-A dynamic address resolution). The BSM work uses the concept of the BSM-ID to generate a consistent approach across all BSM families and provide a concrete approach for address resolution that more resembles the node discovery (ND) mechanisms of IPv6 than the Address Resolution Protocol (ARP). The output of this work is closely aligned with the IP over DVB IETF work.

8. CONCLUSION

This paper has presented an architecture for providing IP services over BSMS. This architecture builds on concepts from NGN and 3GPP as well as being aligned with current developments in the IETF especially in the working groups dedicated to multicast services and resource management.

The BSM architecture has been specifically developed to foster the development and specification satellite independent adaptation functions, in particular, the adaptation, when appropriate, of IP protocols for their transit over BSMS. The BSM specific concepts like the BSM-ID and the QID will be used to further specify data transfer and resource management. The work is only beginning but the results are already promising.

9. ACKNOWLEDGEMENTS

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