ETSI TS 102 464 V1.2.1 (2015-12)

Satellite Earth Stations and Systems (SES);
Broadband Satellite Multimedia (BSM);
Interworking with DiffServ QoS

Reference
RTS/SES-00357

Keywords
broadband, interworking, IP, multimedia, QoS, satellite

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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 BSM architecture is characterized by the separation between common Satellite-Independent (SI) protocol layers and alternative lower Satellite-Dependent (SD) layers, which are connected through the Satellite Independent Service Access Point (SI-SAP) [1]. The general issues concerning the architecture of BSM systems are described in ETSI TR 101 984 [i.1], further specific requirements and functional models for Quality of Service (QoS) concerning IP-over-satellite aspects are presented in ETSI TR 101 985 [i.2] and ETSI TR 102 157 [i.3].

In general the SI-SAP offers an agnostic interface to whichever SD layer is used. So QoS provision in the BSM architecture has to face the issue of traversing the SI-SAP interface by means of standardized signalling, which is expected to enable on one side maintaining compatibility with existing QoS functions required in the IP layers and above, and on the other side communication to the lower layer entities deputed to QoS accomplishment.

At the IP layer, two principal techniques for QoS provision exist: DiffServ [7], and RSVP/IntServ [4], [5]. At the SD layers more sophisticated QoS methods are closely linked to lower layer resource management and control, they strongly depend on the satellite technology adopted and on the particular implementation.

For QoS provision in a BSM network the concept of QIDs (Queue Identifiers) is a key concept [2]. They represent abstract queues, each with a defined class of service, for transfer of IP packets to the SD layers. The satellite dependent lower layers are responsible for assigning satellite capacity and/or particular forwarding behaviour to these abstract queues according to defined properties. The reader should in particular refer to ETSI TS 102 463 [i.14], for a detailed description of QIDs and of the associated primitives.

1 Scope

The aim of the present document is to define an open specification for enabling QoS for IP-based multimedia satellite systems, based on the DiffServ model. If IP packets entering the BSM network require a particular QoS treatment, they have to be mapped onto QIDs. The choice of the QID to be used inside the BSM network is thus particularly important. So the present document specifies the allocation of the QIDs and their mapping to IP QoS classes, when DiffServ is used to provide QoS at IP layer. The present document assumes the QoS functional architecture described in ETSI TS 102 462 [2].

The present document describes in detail how QIDs are defined, how they are allocated and handled by the BSM network, and the requirements needed by sending and receiving Satellite Terminals (STs) in a BSM network to provide QID management functionalities. The present document also defines the primitives that should be used across the SI-SAP when allocating QIDs, when mapping DiffServ Code Points (DSCPs) and IP services to QIDs, when mapping QIDs to SD queues.

Details on the QID mapping are presented with some examples. Some cases are presented to show the potential evolution from a simple QoS solution with quasi-static QID allocation to more sophisticated services with dynamic resource reservation.

The combination of DiffServ with multicast transmissions is out of scope of the present document, as well as the use of Explicit Congestion Notification (ECN), which was linked to DiffServ only for historical reasons, as the ECN bits are the two least significant bits of the IPv4 ToS octet. This is better explained in clause 4.

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.

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

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

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

[3] IETF RFC 3168: "The Addition of Explicit Congestion Notification (ECN) to IP", September 2001.

[4] IETF RFC 1633: "Integrated Services in the Internet Architecture: an Overview", June 1994.

[5] IETF RFC 2210: "The Use of RSVP with IETF Integrated Services", September 1997.

[6] IETF RFC 2474: "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers", December 1998.

[7] IETF RFC 2475: "An Architecture for Differentiated Service", December 1998.

[8] IETF RFC 2597: "Assured Forwarding PHB Group", June 1999.

[9] IETF RFC 3246: "An Expedited Forwarding PHB (Per-Hop Behavior)", March 2002.

[10] IETF RFC 3247: "Supplemental Information for the New Definition of the EF PHB (Expedited Forwarding Per-Hop Behavior)", March 2002.

[11] IETF RFC 3260: "New Terminology and Clarifications for Diffserv", April 2002.

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 TR 101 984: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Services and architectures".

[i.2] ETSI TR 101 985: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; IP over Satellite".

[i.3] ETSI TR 102 157: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; IP Interworking over satellite; Performance, Availability and Quality of Service".

[i.4] IETF RFC 2998: "A Framework for Integrated Services Operation over Diffserv Networks", November 2000.

[i.5] IETF RFC 4080: "Next Steps in Signaling (NSIS): Framework", June 2005.

[i.6] Satellite Access Technologies: Leading Improvements For Europe.

NOTE: Available at http://www.satlife.org

[i.7] Wittig, Manfred; Casas, Jose-Maria. "A communications switchboard in the sky: AmerHis". ESA Bulletin, No. 115. August 2003.

[i.8] S. Chacón, J-L. Casas, A. Cal, R. Rey, J. Prat, A. Rodriguez, J. de la Plaza, C. Nieto, F. Ruiz Piñar. Multimedia Applications of the Integrated Broadcast Interaction System (IBIS). ESA Workshop on Digital Signal Processing, Lisbon (Portugal), October 2001.

[i.9] ETSI TS 102 429-1: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Regenerative Satellite Mesh - B (RSM-B); DVB-S/DVB-RCS family for regenerative satellites; Part 1: System Overview".

[i.10] "SatLabs System Recommentations v2.0", November 2006.

NOTE: Available at http://satlabs.org/.

[i.11] S. Floyd and V. Jacobson "Random Early Detection Gateways for Congestion Avoidance". IEEE/ACM Transactions on Networking, Vol. 1, Issue 4, August 1993.

[i.12] ETSI TS 102 429-3: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Regenerative Satellite Mesh - B (RSM-B); DVB-S/DVB-RCS family for regenerative satellites; Part 3: Connection control protocol".

[i.13] ETSI TS 102 402: "Satellite Earth Station and systems (SES); Broadband Satellite Multimedia; Transparent Satellite Star - A (TSS-A); DVB-S/DVB-RCS for transparent satellites; Sub-family 1 (TSS-A1)".

[i.14] ETSI TS 102 463: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Interworking with IntServ QoS".

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.

bearer service: type of telecommunication service that provides the capability for the transmission of signals between user-network interfaces

Behaviour Aggregate (BA): collection of packets with the same DS code point crossing a link in a particular direction

Best-Effort (BE) service: service that offers no QoS guarantees, just end-to-end connectivity

NOTE: When using queuing to prevent congestion BE queues are always the first ones to experience packet drop.

BSM Bearer service: telecommunication service that a BSM subnetwork provides between a pair of SI-SAPs in different STs

Class of Service (COS): way to divide traffic into separate categories (classes) to provide appropriate QoS services to each class within the network

classification: examination of an IP packet to determine the COS to which the packet should belong

code point: specific value of the DSCP portion of the DS field

NOTE: Recommended code points should map to specific standardised Per-Hop Behaviours (PHBs). Multiple code points may map to the same PHB.

connection oriented: communication method in which communication proceeds through three well-defined phases: connection establishment, data transfer, and connection release

connectionless: communication method that allows the transfer of information between users without the need for connection establishment procedures

control plane: plane with a layered structure that performs the call control and connection control functions and deals with the signalling necessary to set up, supervise and release calls and connections

data link layer: second layer of the OSI model it provides connectivity between segments of the network (bridging); in addition the data link may perform session control and some configuration

delay variation (or delay jitter): difference in delay between successive packet arrivals (of the same flow) at the egress of the network

Differentiated services (DiffServ): services based on statistical (aggregated flows) guarantees and resulting in "soft" QoS

NOTE: Using packet markings (code points) and queuing policies it results in some traffic to be better treated or given priority over other (use more bandwidth, experience less loss, etc.).

Differentiated Services Codepoint (DSCP): value which is encoded in the DS field, and which each DS node use to select the PHB which is to be experienced by each packet it forwards

Differentiated Services field (DS field): six most significant bits of the (former) IPv4 TOS octet or the (former) IPv6 Traffic Class octet

DS domain: contiguous set of DS nodes which operate with a common service provisioning policy and set of PHB groups implemented on each node

flow: flow of packets is the traffic associated with a given connection or connectionless stream having the same source host, destination host, class of service, and session identification

Integrated services (IntServ): using RVSP this results in deterministic reservation of network resources and QoS for specific traffic and/or for specific IP flows

marking: to set the class of service or DSCP of a packet

metering: process of measuring the temporal properties (e.g. rate) of a traffic stream selected by a classifier

NOTE: The instantaneous state of this process may be used to affect the operation of shaping, or dropping.

Network Control Centre (NCC): equipment at OSI Layer 2 that controls the access of terminals to a satellite network, including element management and resource management functionality

Per-Hop Behaviour (PHB): externally observable forwarding treatment applied at a differentiated services-compliant node to a behaviour aggregate

policing: process of discarding packets (by a dropper) within a traffic stream in accordance with the state of a corresponding meter enforcing a traffic profile

Quality of Service (QoS): ability to segment traffic or differentiate between traffic types in order for the network to treat certain traffic differently from others. QoS encompasses both the service categorization and the overall performance of the network for each category.

NOTE: It also refers to the capability of a network to provide better service to selected network traffic over various technologies and IP-routed networks that may use any or all of the underlying technologies.

QoS Parameters: parameters that will be specified or monitored to ensure QoS

service levels: end-to-end QoS capabilities of the network which will enable it to deliver a service needed by a specific mix of network traffic

NOTE: The services themselves may differ in their level of QoS.

Service Level Agreement (SLA): agreement between a Service Provider (SP) and its subscriber (or between an SP and an access network operator), characterized by the choice of one data transfer capability and the allocation attribute related to this transfer capability

NOTE: An SLA can also include elements related to traffic policy and availability. It is agreed upon at the initiation of the contract and normally remains the same for all the contract duration.

Traffic Conditioning Agreement (TCA): agreement specifying classifier rules and any corresponding traffic profiles and metering, marking, discarding and/or shaping rules which are to apply to the traffic streams selected by the classifier

NOTE: A TCA encompasses all of the traffic conditioning rules explicitly specified within an SLA along with all of the rules implicit from the relevant service requirements and/or from a DS domain's service provisioning policy.

transfer capability: capability of transfer of information through a network

NOTE: This term can be used to characterize a telecommunications service or bearer.

user plane: plane with a layered structure that 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:

AF	Assured Forwarding
AF/BE	Assured Forwarding – Best Effort
AQM	Active Queue Management
BA	Behavior Aggregate
BE	Best Effort
BoD	Bandwidth on Demand
BSM	Broadband Satellite Multimedia
BSM_ID	BSM IDentifier
BSMQRM	BSM QID Resource Manager
C2P	Connection Control Protocol
CBWFQ	Class Based Weighted Fair Queuing
COPS	Common Open Policy Service
CS	Class Selector
DAMA	Demand Assignment Multiple Access
DiffServ	Differentiated Services (IETF)
DS	DiffServ
DSCP	DiffServ Code Point
DVB-RCS	Digital Video Broadcasting with Return Channel via Satellite
DVB-S	Digital Video Broadcasting - Satellite
ECN	Explicit Congestion Notification
EF	Expedited Forwarding
EXP/LU	Experimental / Local Use
FCA	Free Capacity Assignment
HP	High Priority
IANA	Internet Assigned Numbers Authority
IETF	Internet Engineering Task Force
IntServ	Integrated Services (IETF)
IP	Internet Protocol
L2	Layer 2
LP	Low Priority
MAC	Medium Access Control
MF	MultiField
MPE	Multi-Protocol Encapsulation
MPEG	Moving Pictures Expert Group
MPEG2-TS	MPEG2 - Transport Stream
MS	Management Station
NCC	Network Control Centre
NSIS	Next Steps In Signalling
OSI	Open Standards Institute
PHB	Per-Hop Behavior
PID	Packet IDentifier
QID	Queue IDentifier
QIDSPEC	QID Qos SPECifications
QoS	Quality of Service
RBDC	Rate Based Dynamic Capacity
RC	Request Class
RCST	DVB-RCS Terminal
RED	Random Early Detection
RFC	Request For Comments
RSGW	Regenerative Satellite GateWays
RSM-B	Regenerative Satellite Mesh-B
RSVP	Resource ReserVation Protocol
SD	Satellite Dependent
SDAF	Satellite Dependent Adaptation Functions
SI	Satellite Independent
SIAF	Satellite Independent Adaptation Functions
SI-SAP	Satellite Independent-Service Access Point

SLA	Service Level Agreement
SNMP	Simple Network Management Protocol
SP	Service Provider
ST	Satellite Terminal
STQRM	ST QID Resource Manager
TCA	Traffic Conditioning Agreement
TCP	Transmission Control Protocol
ToS	Type of Service
TSS-A	Transparent Satellite Star-A
UDP	User Datagram Protocol
VBDC	Volume Based Dynamic Capacity
VCI	Virtual Circuit Identifier
VPI	Virtual Path Identifier
WFQ	Weighted Fair Queuing
WRED	Weighted Random Early Detection

4 Overview

DiffServ is an IETF solution to provide "scalable service differentiation on the Internet" [7]. Its main idea is to aggregate IP flows by means of IP-layer packet marking using the DSCP (DiffServ code point) field of the IP header, and to provide the aggregate with the same QoS level.

So within DiffServ domains, QoS treatments are only provided based on the DSCP marked in each packet's IP header. In order to obtain a particular level of service, it is necessary to mark packet headers with the correct DSCP when the packets enter the DS (DiffServ) domain. The correct DSCP is determined by pre-defined policies and SLAs, or optionally set dynamically by means of signalling protocols (such as NSIS, RSVP, etc.). The IP packets (or flows) marked with the same DSCP constitute a Behavior Aggregate (BA), and they receive from a DiffServ node the same level of service, i.e. the same Per-Hop Behavior (PHB).

If the BSM system belongs to a DiffServ domain, PHBs have to be translated into QoS treatments that the packets receive from one particular ST when they are forwarded over the satellite. So DSCPs need to be carefully mapped to SD classes of service. Since SD classes are system dependent, it is necessary to abstract from the lower layers and to provide the SI layers with a common and agnostic interface. For this reason central to the DiffServ capability, and more in general to the QoS capability of BSM systems, is the concept of QIDs (Queue Identifiers) as outlined in ETSI TS 102 462 [2] and ETSI TS 102 463 [i.14]).

QIDs represent the abstract queues available at the SI-SAP, they should be seen as an association between IP queues used by DiffServ and layer-2 (L2) queues. Each QID offers a defined class of service for transfer of IP packets to the SD layers. Thus QID are abstract queues in the sense that they can be seen as a mapping between IP and SD queues, but they have real properties in the sense that they represent to the SI layers the real properties of the SD queues.

The satellite dependent lower layers are responsible for assigning satellite capacity to these abstract queues according to the specified queue properties. The QID is not limited to a capacity allocation class, it relates also to forwarding behaviour with defined properties. All these QID properties have an impact into the properties of the IP DiffServ queues which the QID is associated to.

The BSM system will most likely be only a portion of the overall path traversed by packets which require end-to-end QoS. The transmission from an ST to the satellite and down to another ST (or hub) is considered, at IP layer, as one single hop, or at maximum as two hops, in case of a BSM mesh network topology where routing is performed on-board the satellite. In a BSM system the single IP hop is shared among many STs, and this makes the QoS problem challenging.

The present document will analyze the way to provide QoS only inside the BSM system, i.e. over one single IP hop, by means of the DiffServ paradigm, and the most appropriate way to handle the SD resources. So the provision of end-to-end QoS is out of the scope of the present document. It is assumed that the QoS treatment expected by each particular IP flow or packet from the BSM is known to the BSM system by means of external information or signalling (e.g. SLA). The BSM system will take this information into account in the SD resource management.

The satellite hop remains one single IP hop also in case of broadcast or multicast. This is a very important aspect which makes the use of DiffServ over BSM system very powerful, and very simple with respect to terrestrial QoS-aware multicasting, where the service level has to be monitored over a multicast tree, and thus along different paths. Nevertheless DiffServ-aware multicast transmissions are out of scope of the present document.

For the sake of clarity, the following IETF definitions shall apply to the present document [11]:

- the Differentiated Services field (DS field) is the six most significant bits of the (former) IPv4 TOS octet or the (former) IPv6 Traffic Class octet;
- the Differentiated Services Codepoint (DSCP) is a value which is encoded in the DS field, and which each DS node should use to select the PHB which is to be experienced by each packet it forwards.

Thus the two least significant bits of the IPv4 TOS octet and the IPv6 Traffic Class octet are not used by Diffserv. They have been assigned for use of Explicit Congestion Notification (ECN) [3] and so their use is out of scope of the present document. DSCP markings may be used in the future to modify (or signal alternative semantics) for the operation of ECN.

5 DiffServ BSM Functional Architecture

5.0 Aim and Scope

This clause clarifies the entities and functionalities involved in the QoS management process, when the DiffServ paradigm is adopted. This DiffServ functional architecture is compliant with the one presented in ETSI TS 102 462 [2].

5.1 Overall BSM DiffServ Architecture

A BSM system may constitute part of a DiffServ domain, compliant with the architecture presented in IETF RFC 2475 [7]. The domain is referred to as the BSM DS domain. The domain may extend beyond the STs, but in general the satellite will be the critical part of the domain for the management of the resources in case of QoS provision.

The STs are the edge nodes of the BSM system, but they might be or not be the edge nodes of the BSM DS domain. Figure 1 details the architecture shown in ETSI TS 102 462 [2], and highlights four possible scenarios for the BSM DS domain topology, which are relevant to this discussion:

- case (1): ST directly connected to a BSM DS host;
- case (2): ST connected to a BSM DS router via one or more hops;
- case (3): ST directly connected to an external DS router;
- case (4): ST directly connected to a non-DS router.

In each of these cases the ST might need to perform different DS functions both in the user and in the control plane, this is intrinsically linked to the way DS works. In particular in a DS domain the edge routers perform a number of important operations: traffic classification, packet marking, traffic policing, traffic shaping, and, optionally, admission control and resource reservation (see ETSI TS 102 462 [2], clause 8.1, for a detailed explanation of these mechanisms). On the other hand DS core nodes only apply the appropriate PHB to IP packets based on the marked DSCP: IP packets are forwarded to the appropriate IP queue (this operation can be defined as DSCP classification). So depending on whether an ST is at the edge of the BSM DS domain or not, it might need to perform these operations or not. This will be discussed in detail for the four cases in clause 5.2.1.