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Foreword

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

Introduction

The present document presents an overview of PEP issues over satellites and focuses on BSM-related issues. It is based on current ETSI BSM architecture documents [i.1] and [i.2]. Also it is aligned with the relevant IETF standards. The IETF documented general PEP issues are described in RFC 3135 [i.3]. However, RFC 3135 [i.3] is not satellite specific and, more importantly, is now seven years old.

Also the present document is aligned with the Satlabs group solution called Interoperable PEP (I-PEP) that is aimed at DVB-RCS systems [i.4].

1 Scope

The present document aims to describe the current solutions for Performance Enhancing Proxies in broadband multimedia satellite systems. The range of PEPs considered includes TCP accelerators, TCP header compression and HTTP proxies. The PEPs are classified in terms of ease of implementation, interworking capability with other PEPs and performance potential.

Analysis of various PEP types/mechanisms and recommendations are made for using PEPs in BSM networks. Also recommendations are made for further work to support the introduction of PEPs in satellite systems, and in particular their introduction into the BSM architectures and standards.

2 References

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The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area. For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] ETSI TS 102 465: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); General Security Architecture".

[i.2] 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".

[i.3] IETF RFC 3135 (June 2001): "Performance Enhancing Proxies Intended to Mitigate Link-Related Degradations".

[i.4] I-PEP specifications, Issue 1a. Satlabs group recommendations (October 2005).

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

[i.5] ETSI TS 102 463: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Interworking with IntServ QoS".

[i.6] ETSI TS 102 464: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Interworking with DiffServ Qos".

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

[i.8] IETF RFC 4326: "Unidirectional Lightweight Encapsulation (ULE) for Transmission of IP Datagrams over an MPEG-2 Transport Stream (TS)".

[i.9] ETSI EN 301 790: "Digital Video Broadcasting (DVB); Interaction channel for satellite distribution systems".

[i.10] Xiplink.

NOTE: See http://www.xiplink.com/.

[i.11] Space Bel - SPB-FS-651-DS-001 (February 2004): "FastSat".

NOTE: Available at http://www.spacebel.be/FR/Space/FastSatDataSheet.pdf.

[i.12] HUGHES: "Delivering outstanding application performance over satellite".

NOTE: Available at: http://www.direcway.com/HUGHES/Doc/0/SIKPBJS69O6KP42VCE4K4ER2BF/Hughes%20PEP-H35661-A4-LR-091206.pdf.

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[i.16] S. Bellovin (February 1997): "Probable plaintext cryptanalysis of the IPSecurity protocols, Proceedings of the Symposium on Network and Distributed System Security".

[i.17] IETF RFC 5246 (August 2008): "The Transport Layer Security (TLS) Protocol Version 1.2".

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[i.19] G. Giambene, S. Kota (September - October 206): "Cross-layer Protocol Optimization for Satellite Communications Networks: A Survey", Int. Journal Sat. Communications and Networking, Vol. 24, pp. 323-341.

[i.20] G. Giambene, S. Hadzic: "A Cross-Layer PEP for DVB-RCS Networks", to be presented at the First International Conference on Personal Satellite Services 2009 (PSATS2009), March 18-19, 2009, Rome, Italy.

[i.21] P. Chini, G. Giambene, D. Bartolini, M. Luglio, C. Roseti: "Dynamic Resource Allocation based on a TCP-MAC Cross-Layer Approach for DVB-RCS Satellite Networks", Int. Journal Sat. Communications and Networking, Vol. 24, pp. 367-385, September-October 2006.

[i.22] C. Gomez, etal: "Web browsing optimization over 2.5G and 3G: end-to-end mechanisms vs. usage of performance enhancing proxies". Wireless Communications and Mobile Computing. 2008; 8:213-230. Wiley InterScience.

[i.23] ESA ARTES-1 programme, 2006: "Transport Protocol for DVB-RCS Interoperable PEP".

[i.24] C. Roseti and E.Kristiansen: "TCP behaviour in a DVB-RCS environment". In Proceedings 24th AIAA International Communications Satellite Systems Conference (ICSSC), San Diego, 2006.

[i.25] IETF RFC 4614 (September 2006): "A Roadmap for Transmission Control Protocol (TCP) Specification Documents".

[i.26] IETF RFC 2581 (April 1999): "TCP Congestion Control".

[i.27] Space Communications Protocol Specification (SCPS)-Transport Protocol (SCPS-TP). "Recommendation for Space Data System Standards, CCSDS 714.0-B-2". Blue Book. Issue 2. Washington, D.C.: CCSDS, October 2006.

[i.28] C. Dovrolis, P. Ramanathan, D. Moore, "What do packet dispersion techniques measure?", in Proceedings of IEEE INFOCOM, pp. 905-914, Apr. 2001.

[i.29] M. Karaliopoulos, R. Tafazzoli, B.G. Evans, "Providing Differentiated Services to TCP Flows Over Bandwidth on Demand Geostationary Satellite Networks", IEEE Journal on Selected Areas in Communications, vol. 22, No. 2, Feb. 2004.

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[i.31] M. Luglio, C. Roseti, F. Zampognaro, "Performance evaluation of TCP-based applications over DVB-RCS DAMA schemes", International Journal of Satellite Communications and Networking, Vol. 27, Issue 3, pp. 163-191, Published online 2 Mar 2009, DOI: 10.1002/sat.930.

[i.32] IETF RFC 5374: "Multicast Extensions to the Security Architecture for the Internet Protocol".

[i.33] IETF RFC 793: "Transmission Control Protocol".

[i.34] IETF RFC 1122: "Requirements for Internet Hosts - Communication Layers".

3 Definitions and abbreviations

3.1 Definitions

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

distributed PEP: PEP client and server are located at both ends of the satellite link (BSM ST and Gateway)

GateWay PEP (GW PEP): PEP server located near the BSM Gateway

integrated PEP: there is only one PEP entity residing with the satellite gateway (BSM Gateway)

interoperable PEP (I-PEP): functional architecture assumes a split-connection approach with the I-PEP server and a client both capable of supporting the I-PEP protocol

NOTE 1: The I-PEP protocol consists of a transport protocol heavily based on TCP and modified/augmented by SCPS-TP as well as a session protocol comprising several optional additions to support service and session management.

NOTE 2: Specified by the ESA/Satlabs [i.4] and aims to provide enhancement for satellite-based communications.

Performance Enhancing Proxy (PEP): network agents designed to improve the end-to-end performance of some communications protocol such as Transmission Control Protocol (TCP)

NOTE: More information on Transmission Control Protocol (TCP) is available at http://en.wikipedia.org/wiki/Transmission_Control_Protocol.

ST PEP: PEP client located near the BSM ST terminal

3.2 Abbreviations

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

ACCE	ACK-based Capacity and Congestion Estimation
ACK	ACKnowledgement
A-PEP	Application layer PEP
BDP	Bandwidth Delay Product
BSM	Broadband Satellite Multimedia
CCSDS	Consultative Committee for Space Data Systems
cwnd	congestion window (TCP)
DAMA	Demand Assignment Multiple Access
DNS	Domaine Name System
DVB-RCS	Digital Video Broadcasting - Return Channel for Satellites
ESP	Encapsulated Security Protocol
FSS	Fixed Service Satellite
FTP	File Transfer Protocol
GW PEP	GateWay PEP
HPEP	HTTP PEP
ICMP	Internet Control Message Protocol
IP	Internet Protocol
ISP	Internet Service Provider
LAN	Local Area Network
M-ESP	Modified ESP
MF-TDMA	Multi Frequency - Time Division Multiple Access
MIB	Management Information Base
ML-IPSEC	Multilayer IPSEC protocol
MPE	Multi Protocol Encapsulation
MSS	Maximum Segment Size
MTU	Maximum Transmission Unit
NCC	Network Control Centre
PEP	Performance Enhancing Proxy
QID	Queue ID
QIDSPEC	Queue ID SPECifications
QoS	Quality of Service
RTO	Retransmission Time Out
RTT	Round-Trip Time
RWIN	Receive WINdow
SACKs	Selective ACKnowledgements
SCPS	Space Communications Protocol Specification
SCPS-TP	Space Communications Protocol Specification-Transport Protocol
SID	Security association IDentity
SIP	Session Initiation Protocol
SI-SAP	Satellite Independent - Service Access Point
SSL	Secure Socket Layer
ST	Satellite Terminal
TBTP	Terminal Burst Time Plan
TCP	Transmission Control Protocol
TCPN	TCP Noordwijk
TF-ESP	Transport Friendly - ESP
TLS	Transport Layer Security
T-PEP	TCP (transport) layer - PEP
UDP	User Datagram Protocol
ULE	Unidirectional Lightweight Encapsulation
UMTS	Universal Mobile Telephone System
URL	Uniform Resource Locator
VPN	Virtual Private Network
X-SAP	Cross Layer Service Access Point

4 Need for PEPs in BSM networks

4.1 Performance improvement using standard end-to-end techniques

The original Internet adopted an end-to-end architecture, where a transport connection was between a pair of hosts, bound to a globally unique IP address and locally meaningful transport port at each end host. The literature background for end-to-end improvements to TCP and HTTP (without using PEPs) is presented in clauses A.1 and A.2.

There are two main reasons in favour of using end-to-end mechanisms for improving performance over satellite links:

1) End-to-end mechanisms are based on standard options and maintain end-to-end semantics. Thus, they are fully compliant with the Internet architecture.

2) Empirical results demonstrate a significant improvement, especially when adequate HTTP settings are used.

However, end-to-end techniques have the following drawbacks:

1) The design criteria of Internet servers aim to optimize server throughput. Such goal might be difficult to achieve, because the configuration of many Internet servers limits the number of parallel transport connections per session.

3) Certain parameters cannot be optimized at the same time for different access technologies. For example, the Bandwidth Delay Product (BDP, see annex A) in satellite networks is much larger than UMTS. Moreover, servers are by default unaware of the access technology used by a client.

4) At least one TCP Slow Start phase will still take place during a web page download, unless persistent connections are used. However, the configuration of many Internet servers seeks to minimize the amount of memory consumed per session, a side-effect of this is that servers often unwilling to hold state for connections which become passive.

5) Should multiple objects be hosted under different domain names, DNS lookup overhead cannot be avoided or reduced using end-to-end options.

6) The performance of end-to-end mechanisms reduces over paths that experience gaps in connectivity (e.g. due to a link outages). The reason is that a server is unable to distinguish between congestion and radio link losses. This can lead to unwanted activation of TCP congestion control mechanisms or timeouts and thus significantly reducing performance.

Considering the issues discussed above, optimization of current end-to-end methods can provide improvements, but as yet cannot provide optimal performance for satellite systems. An alternative solution is the use of PEPs (see clauses 4.2 and 4.3).

4.2 Motivation for using PEPs

The present document focuses on the current work in defining the PEP architecture for BSM satellite networks.

In general, the Internet transport protocol (namely TCP) exhibits suboptimal performance due to the following satellite characteristics:

- Long feedback loops: Propagation delay from a sender to a receiver in a geosynchronous satellite network can range from 240 to 280 milliseconds.
- Large bandwidth*delay products: TCP needs to keep a large number of packets "in flight" in order to fully utilize the satellite link.
- Asymmetric capacity: The return link capacity for carrying ACKs can have a significant impact on TCP performance.

An alternative solution to clause 4.1 is to place an entity called Performance Enhancing Proxy (PEP) somewhere between the endpoints of a communication link. We focus on TCP PEPs (T-PEP) and Application PEPs (A-PEP). clauses B.1, B.2 and B.3 present details on PEP types, transport and application layer PEPs. As a summary of this approach, among the TCP PEP proposals, one solution is represented by the splitting approach [i.3]. The rationale of the splitting concept is to separate the satellite portion from the rest of the network. This approach can be further be divided into two categories: Distributed PEPs where the PEP client and server are located at each end of the satellite link. The other category is Integrated PEPs with only one PEP entity residing with the satellite gateway. Typical TCP PEP improvements are:

- TCP Spoofing: Eliminates effects of satellite delay on TCPs slow start and window sizing.
- ACK Reduction: Reduces unnecessary acknowledgements to improve bandwidth efficiency.
- Flow Control: Employs network feedback to intelligently control traffic flow.
- Error Recovery: Works closely with flow control to recover damaged or lost packets.
- Traffic Prioritization: Classifies traffic by application protocol, matching this to the MAC layer.
- Connection Establishment Spoofing: Intelligently spoofs the TCP three-way handshake to speed up establishment of a connection.
- PEPs can also compress protocol information, or change protocol characteristics to match specific characteristics of the satellite channel.

In addition to TCP PEPs (T-PEP), there are other complementary solutions such as application layer PEPs (A-PEP), where web browsing is the major target for application PEPs. Typical application layer PEPs improvements are:

- HTTP pre-fetching: Intercepting requested Web pages, identifying Web objects referred to by the Web pages, downloading these objects in anticipation of the next user requests.
- Browser Cache Leveraging: Caching some web pages not residing in browser cache, improving efficiency.
- Bulk Transfer Prioritization: Prioritizes bulk transfers to prevent adverse effect on other Web traffic.
- Cookie Handling: Ensures accurate painting of Web pages with the proper cookies.
- Compression: Payload compression provides increased transmission speeds. In addition, header compression for TCP, UDP, and RTP protocols results in additional bandwidth savings.
- DNS caching techniques, to further improve bandwidth utilization.

Commercial PEPs normally combine some or all of the T-PEP and A-PEP techniques together such the Hughes [i.12], XipLink [i.10], FastSat [i.11], Newtec, TAS-F and STM PEPs. A summary of the various techniques used in PEP products is presented in annex C.

4.3 PEP terminal architecture and components

There are two possibilities for the location of ST PEP: one is being internal to the BSM ST as shown in figure 1a, where the PEP run as a software process above the SI-SAP in the ST itself. The other possibility, as shown in figure 1b, is that ST PEP is external to the BSM ST and connected to the BSM ST with an Ethernet cable. Figure 2 shows the PEP protocol stack with the BSM Gateway terminal architectures, where the common location is that the Gateway PEP is external to the BSM Gateway.

The PEP residing on the BSM ST side is called ST PEP (PEP client) and the one on the BSM gateway side is called Gateway PEP (GW PEP, PEP server). Both PEPs have a similar architecture with two interfaces, one to the BSM satellite network and one to terrestrial networks. On the satellite side, the ST/Gateway PEP are connected to BSM ST/Gateway through an Ethernet LAN (except the internal ST PEP). On the terrestrial network side, normally, the PEP terminal connects to host/hosts on the same LAN, while the gateway PEP connects to a content server through the general Internet. However, the Gateway PEP can be located remotely from the BSM Gateway terminal (such as Gateway PEP run by a service provider), more details are presented in clause 4.4.

Also, figures 1a, 1b and 2 show the Satellite Independent Service Access Point (SI-SAP) interface. It enables the BSM system to abstract the lower layer functions. It allows the network protocols developed in the satellite independent layer to perform over any BSM family (specific satellite technologies). Moreover, the SI-SAP also enables the use of standard Internet protocols for example address resolution, QoS, security and network management, directly over the satellite system or with minimal adaptation to satellite 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 upper layers software developments.

The transport protocol in the PEP is divided between standard TCP/UDP and PEP specific transport protocols. As shown in figures 1a, 1b and 2, the PEP specific transport protocol can be:

- A modified TCP (TCP+) such as the Hybla protocols [i.13], which is used in integrated PEP configurations, where only Gateway PEP will be used (no ST PEP).
- Standard Interoperable PEP Transport Protocol (I-PEP TP), recommended by Satlabs [i.4] and used in the distributed PEP configurations. The I-PEP TP is based on an extension set to TCP termed SCPS-TP, which was produced by the Consultative Committee for Space Data Systems (CCSDS).
- Proprietary distributed Transport Protocol (TP+), where company specific (non-standard) protocols are used.

The ST/Gateway PEPs can be managed either locally or remotely. For remote management, either SNMP or HTTP protocols can be used to communicate with the BSM management system. In both cases the PEP monitoring and configuration controls can be based on the standard MIB II and enterprise specific PEP MIBs.

The optimum PEP performance is expected to require a close matching between the PEP configuration and the QoS provisioning of the associated lower layer bearer services. In some PEP implementations, there is a customized (proprietary) signalling between the PEP and the Satellite terminal. Such signalling can be used for QoS monitoring of the terminal queues and adjusting rate control parameters accordingly to maximize the use of the satellite capacity.

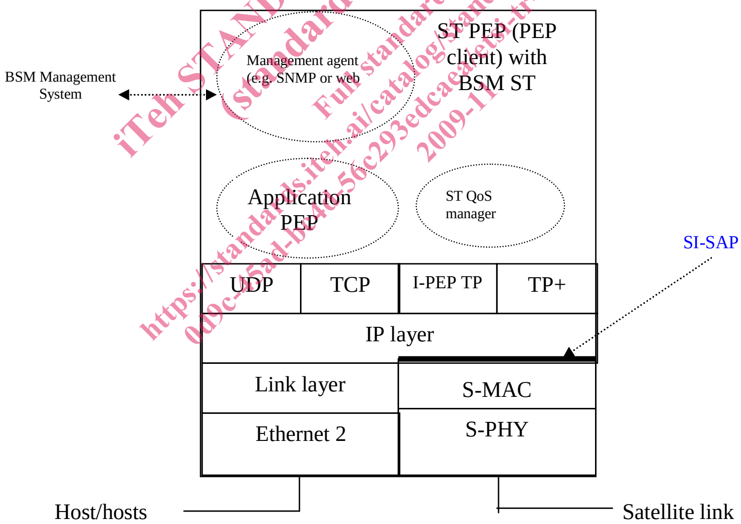

Figure 1a: BSM ST with internal PEP