

RECOMMENDATION ITU-R S.1709-1

Technical characteristics of air interfaces for global broadband satellite systems

(Question ITU-R 269/4)

(2005-2007)

Scope

This Recommendation proposes air interface characteristics which can be used as guidance by designers of broadband satellite networks. The substance of the text is divided into four Annexes, the first being a generic description of the network architecture of broadband satellite networks. The remaining Annexes each contain a summary of existing air interface standards that have been approved by various standardization bodies. Annex 2 contains a summary of TIA-1008-A dealing with Internet protocol (IP) over satellite (IPoS). Annex 3 contains a summary of the DVB-RCS standard as described in ETSI Document EN 301 790. Annex 4 contains a summary of the air interface specification for global broadband communications between earth stations and regenerative satellites based on ETSI BSM/RSM-A.

The ITU Radiocommunication Assembly,

considering

- a) that satellite telecommunications technology has the potential to accelerate the availability of broadband communications both on a global and regional basis;
- b) that operational experience with the deployment of broadband satellite networks has demonstrated the practicality and usefulness of these networks;
- c) that several different types of architectures are used in broadband satellite systems;
- d) that these varying uses have led to the development of various air interface standards in order to allow seamless transportation of broadband signals over different networks,

recommends

- 1 that when broadband radiocommunications are being designed based on the use of satellites, the generic satellite network architecture and protocol structures defined in Annex 1 may be used;
- 2 that when broadband radiocommunications are being provided between earth stations and geostationary satellites, the specifications contained in Annexes 2 to 4 may be used.

Annex 1

Generic network architecture for global broadband satellite systems

1 Introduction

The inherent characteristics of satellite communications, that is their wide-coverage, broadcast mode of operation and multicasting, make them capable of providing high-speed Internet connection and multimedia long-distance transmissions. There are many possible implementations of broadband by satellite, however, certain fundamental features such as protocol stacks, satellite dependant and independent functions, user-access to the system and air interface are very similar. This Recommendation addresses three distinct standardization efforts as follows:

- Telecommunication Industry Association (TIA) IPoS as summarized in Annex 2;
- European Telecommunication Standards Institute (ETSI) (2000) DVB, interactive channel for satellite distribution systems as summarized in Annex 3;
- Air interface specifications for global broadband communications between earth stations and regenerative satellites based on ETSI BSM/RSM-A as summarized in Annex 4.

These three standards as summarized in Table 1 could be applied for high-speed Internet access services either for individual households or collective residential services. Satellite interconnectivity with the terrestrial networks in a seamless fashion is very crucial for the broadband satellite service success. The architectures described in the following sections would provide a guidance to the system designers and the evaluators with respect to the system design and deployment. This Annex describes a global broadband network scenario along with common applications and services. In addition, the normal network topologies such as star and mesh are described. This Annex provides a basis for the remainder of the Recommendation describing the three standards development for broadband satellite networks. Appendix 1 to Annex 1 provides a list of references for all the specifications described in this Recommendation.

TABLE 1

Comparison Table between ETSI EN 301 790 V.1.3.1, TIA-1008-A and ETSI RSM-A

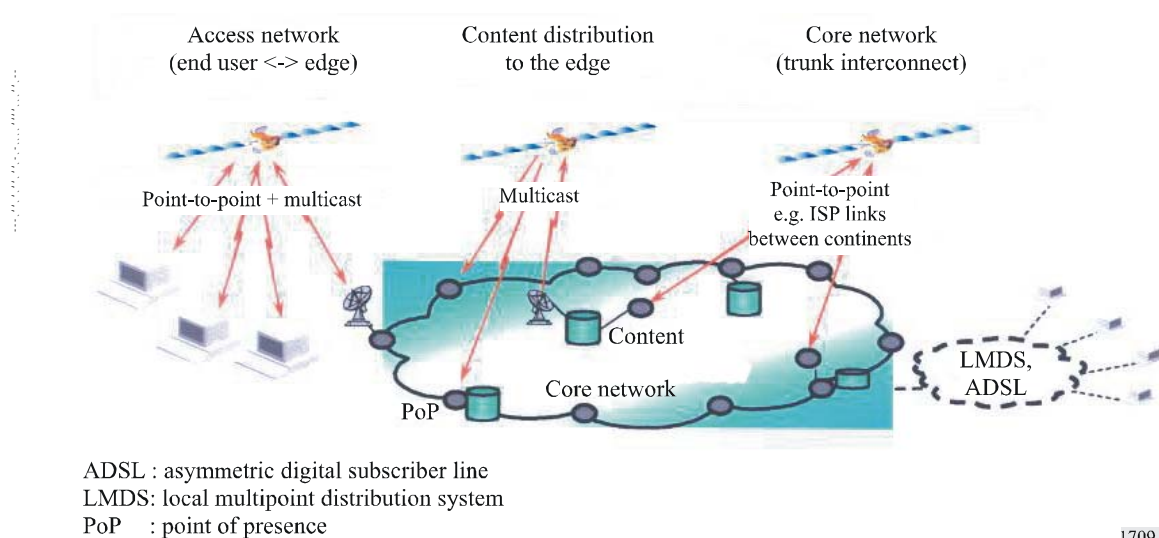
Item	ETSI EN 301 790	TIA-1008-A	ETSI RSM-A
Network topology	Star or mesh	Star	Star or mesh
Modulation	QPSK	CE-OQPSK	CE-OQPSK
Outbound traffic access method	DVB-S	DVB-S	High rate TDMA
Outbound traffic data rate (Mbit/s)	1 to 45	1 to 45	100, 133.33, 400
Inbound traffic access format	MF-TDMA	MF-TDMA	FDMA-TDMA
Inbound traffic data rate	No restriction	64 kbit/s, 128 kbit/s, 256 kbit/s, 512 kbit/s, 1 024 kbit/s, 2 048 kbit/s	128 kbit/s, 512 kbit/s, 2 Mbit/s, 16 Mbit/s
Protocols	DVB/MPEG2 TS outbound, AP/AAL5/ATM inbound	Multilayered protocol	IETF IP Network Protocols

2 Global network architecture

Figure 1 describes a global broadband satellite network architecture consisting of the following scenarios:

- *Access network*: providing services to end users.
- *Distribution network*: providing content distribution to the edge.
- *Core network*: providing trunking services.

FIGURE 1
Global broadband satellite network scenarios



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2.1 Services

Various services being provided by such a network include:

- Point-to-point
- Multicast/broadcast
- Content distribution.

2.2 Broadband applications

The various broadband applications supported by satellite networks are:

- Entertainment
 - Video-on-demand
 - TV distribution
 - Interactive games
 - Music applications
 - Streaming.
- Internet access
 - High-speed Internet access
 - Electronic messaging

- Multimedia applications
- Distance learning
- Telemedicine.
- Business
 - Videoconferencing
 - Business-to-business
 - Home security.
- Voice and data trunking
 - IP-transport
 - Voice-over-IP
 - File transfers.

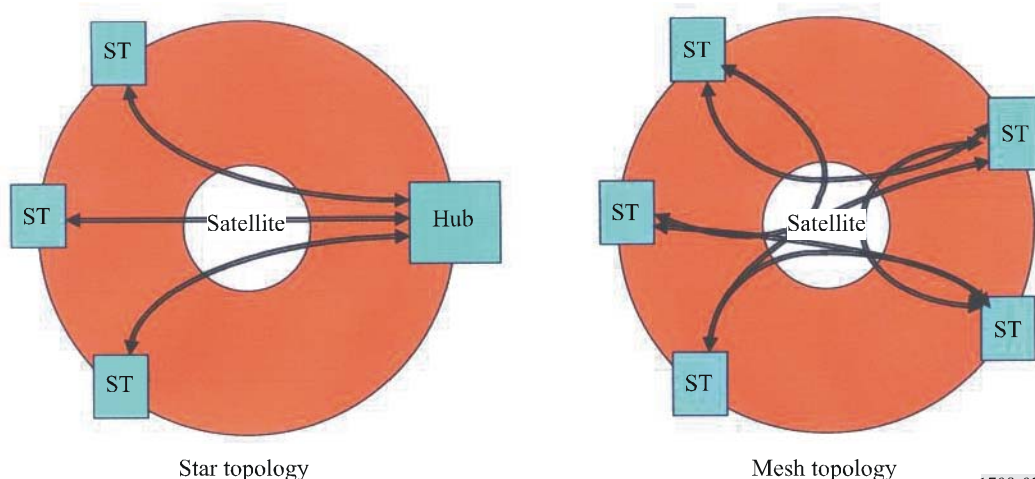
2.3 Topologies

The network may use either a mesh or star topology as illustrated in Fig. 2:

- A star network topology is defined by the star arrangement of links between the hub station (or Internet access point) and multiple remote stations. A remote station can only establish a direct link with the hub station and cannot establish a direct link to another remote station.
- A mesh network is defined by the mesh arrangement of links between the stations, where any station can link directly to any other station. The star topology can be considered as one special case of the mesh topology.

NOTE 1 – A star topology can be used to provide mesh connectivity by establishing an indirect link between remote stations via the hub station.

FIGURE 2
Star and mesh topology



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A global broadband satellite-system network may use either a non-regenerative or a regenerative satellite architecture:

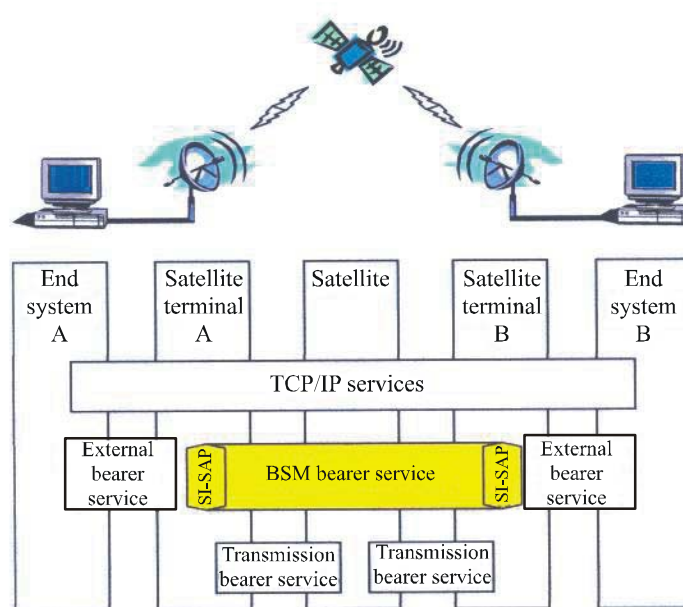
- A non-regenerative architecture refers to a single architecture, commonly called a “bent-pipe architecture”. This architecture does not terminate any layers of the air interface protocol stack in the satellite – the satellite simply transfers the signals from the user links to the feeder links transparently.
- A regenerative architecture is the range of other architectures that provide additional functionality in the satellite. In these architectures, the satellite functions terminate one or more layers of the air interface protocol stack in the satellite.

2.4 Services architecture

Figure 3 illustrates the various services e.g. standard IP services, broadband satellite bearer services, and the underlying radio transmission bearer services. The broadband satellite for multimedia (BSM) working group of ETSI developed a broadband service architecture handling these three types of services.

In order to separate the services that are common to all satellite systems from those that are specific to a given satellite technology, the service architecture defines a satellite-independent service access point (SI-SAP) as the interface between these upper and lower layers. This interface corresponds to the ends of the global broadband satellite system bearer services as shown in Fig. 3.

FIGURE 3
Global broadband satellite service architecture



TCP: transmission control protocol

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2.5 Protocol architecture

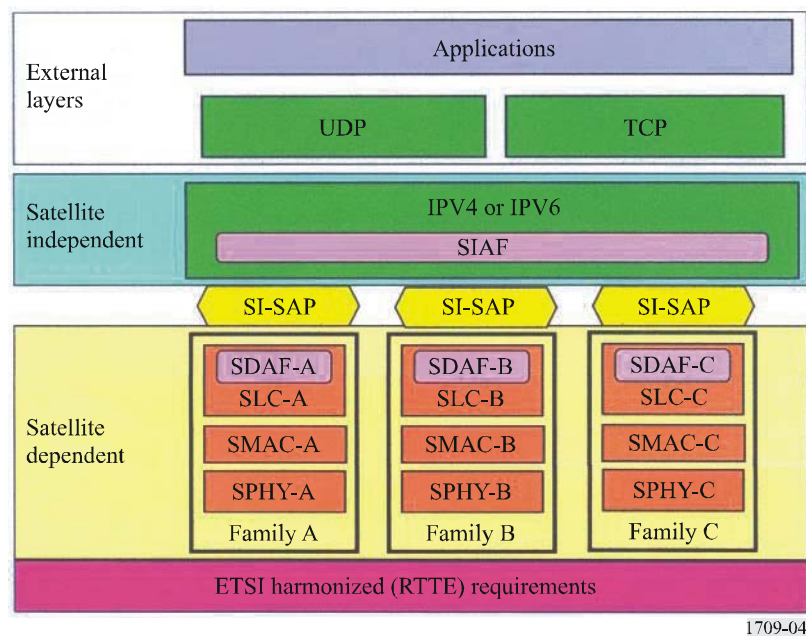
The global broadband satellite system identifies three groups of protocols:

- IETF IP network protocols;
- adapted global broadband satellite system protocols that are satellite system independent; and
- satellite technology dependent protocols.

The global broadband satellite system protocol architecture defines the SI-SAP interface that lies between the IP network layer and the lower layers. Immediately above and below the interface, the architecture defines two new adaptation layers that contain global broadband satellite system functions associated with the interface as shown in Fig. 4.

Figure 4 shows how the global broadband satellite-system architecture supports multiple alternative families of satellite dependent lower layer protocols. Each family corresponds to a different satellite technology, including both transparent and regenerative satellite and both 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 SI-SAP interface.

FIGURE 4
Global broadband satellite-system protocol architecture



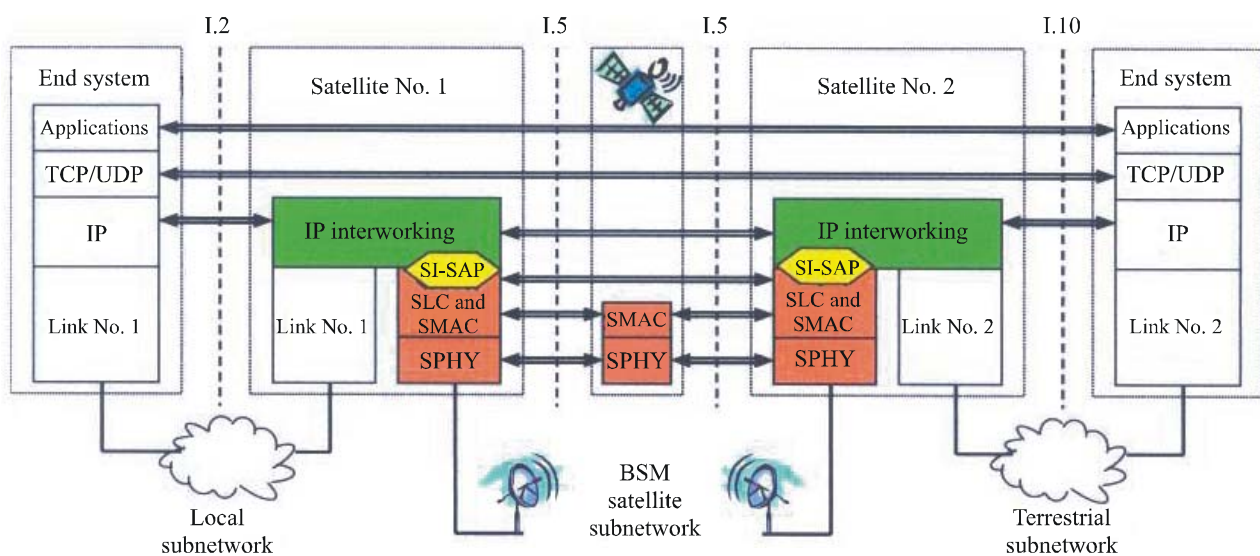
SIAF: satellite independent adaptation function
UDP: user datagram protocol

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

2.6 IP interworking

In the global Internet, a satellite IP-subnetwork should be treated just like any other IP-subnetwork since only a small number of hosts will be directly connected to the satellite subnetwork. Consequently, the main interworking guideline for IP services over a satellite subnetwork is that the IP layer protocols on the non-satellite side shall remain unchanged. Any changes to the protocols that are needed for operation over a satellite should be provided by a set of IP interworking functions that can be located at the edges of the satellite subnetwork as illustrated in Fig. 5. The SI-SAP architecture then provides a framework for developing a set of common IP interworking standards to ensure transparent interoperability between any satellite subnetwork and a non-satellite (e.g. terrestrial) IP-based subnetwork.

FIGURE 5
IP interworking



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Appendix 1 to Annex 1

List of references

These reference links describe the characteristics of standard TIA-1008-A as summarized in Annex 2.

	Document No.	Version	Status	Issued date	Location
TIA	TIA-1008-A		Published	October 2003	http://www.itu.int/md/R03-WP6S-C-0191/en

These reference links describe the characteristics of the DVB-RCS standard as summarized in Annex 3

		Document No.	Version	Status	Issued date	Location
	ETSI	EN 301 790	V1.3.1	Published	March 2003	http://webapp.etsi.org/workprogram/Report WorkItem.asp?WKI_ID=15626

These reference links describe the characteristics of the ETSI-SES/BSM/RSM-A specification as summarized in Annex 4.

		Document No.	Version	Status	Issued date	Location
	ETSI	ETSI TS 102-188-1	V1.1.2	Published	July 2004	http://webapp.etsi.org/workprogram/Report_WorkItem.asp?WKI_ID=20888
	ETSI	ETSI TS 102-188-2	V1.1.2	Published	July 2004	http://webapp.etsi.org/workprogram/Report_WorkItem.asp?WKI_ID=20892
	ETSI	ETSI TS 102-188-3	V1.1.2	Published	July 2004	http://webapp.etsi.org/workprogram/Report_WorkItem.asp?WKI_ID=20893
	ETSI	ETSI TS 102-188-4	V1.1.2	Published	July 2004	http://webapp.etsi.org/workprogram/Report_WorkItem.asp?WKI_ID=20895
	ETSI	ETSI TS 102-188-5	V1.1.2	Published	July 2004	http://webapp.etsi.org/workprogram/Report_WorkItem.asp?WKI_ID=20896

Appendix 2 to Annex 1

Abbreviations

For the purposes of this Recommendation, the following abbreviations apply:

ACF	Access control field
ACK-RET	Ack-return
BoD	Bandwidth on demand
BPSK	Binary phase shift keying
BSM	Broadband satellite multimedia
CoS	Class of service
CR	Constant rate
CRC	Cyclic redundancy check
CRWB	Constant rate with burst
DLL	Data link layer
DVB	Digital video broadcast

EDU	Extended data unit
FDMA	Frequency division multiple access
FEC	Forward error correction
GEO	Geosynchronous Earth orbit
HPB	High priority burst
HVUL	High volume up-link
IP	Internet protocol
kbit/s	Kilobits per second (thousands of bits per second)
LAN	Local area network
LVLL	Low volume low latency
M&C	Monitoring and control
MAC	Medium access control
Mbit/s	Megabits per second (millions of bits per second)
MGID	Multicast group ID
NCC	Network control centre
NPB	Normal priority burst
OQPSK	Offset quaternary phase shift keying
PA	Persistent aloha
PCR	Program clock reference
PDS	Packet delivery service
PDU	Protocol data unit
PEP	Performance enhancing proxy
PHY	Physical
PID	Packet IDentifier
PN	Pseudo-random number
PTO	Packet transmission opportunity
P-P	Point-to-point
QoS	Quality of service
QPSK	Quaternary phase shift keying
RF	Radio frequency
RS	Reed-Solomon
RSM	Regenerative satellite mesh
SA	Slotted aloha
SAM	Security access module
SAP	Service access point
SDU	Service data unit

SES	Satellite earth station
SI-SAP	Satellite independent-SAP
SLC	Satellite link control
SMAC	Satellite MAC
ST	Satellite terminal
TBTP	Terminal burst time plan
TCP	Transmission control protocol
TCT	Time-slot composition table
TDM	Time division multiplexing
TDMA	Time division multiple access
TIM	Terminal information message
UDC	Up-link data channel
UDP	User data protocol
UDTS	User data transport services
ULPC	Uplink power control
UW	Unique word
VoIP	Voice-over-IP

Annex 2

Air Interface Standard TIA-1008-A (IPoS)

CONTENTS

	<i>Page</i>
1 Introduction	11
2 Network architecture	11
2.1 Network segments	11
2.2 Network interfaces	12
2.3 Remote terminal characteristics	13
3 IPoS satellite interface	13
3.1 IPoS protocol reference model	13
3.2 Layer-wise functional partitioning	15
3.3 PHY layer	15
3.4 Outroute satellite transmission	15

	<i>Page</i>
3.5 Inroute satellite transmission	15
3.6 Data link layer (DLL)	16
3.7 Satellite link control (SLC) sublayer	16
3.8 Media access control (MAC) sublayer	16
3.9 Outroute multiplexing sublayer	17
3.10 Network adaptation layer	17

1 Introduction

The solution provided in this section is an introduction to the Internet Protocol over Satellite (IPoS) standard that has been developed by the U.S. based Telecommunications Industry Association (TIA). IPoS outroute carriers (i.e. the broadcast carriers from a hub or broadcast terminal to many remotes) use a statistical multiplexing scheme compliant with the DVB data format and the distribution of IP traffic to the remote terminals which is based on the DVB multiprotocol encapsulation. The multiplexing sublayer on the outroute carrier permits the hub to transmit several traffic types, programmes, or services within the same outroute carrier and controls the transmission of each individual programme. The IPoS multiplexing sublayer is based on the Digital Video Broadcast/Motion Pictures Expert Group (DVB/MPEG) statistical multiplexing format.

This Annex gives a technical overview of the IPoS specification. Section 2 describes the network architecture for the IPoS system and Section 3 describes the protocol architecture adopted for the satellite air interface between remote terminals and the hub.

2 Network architecture

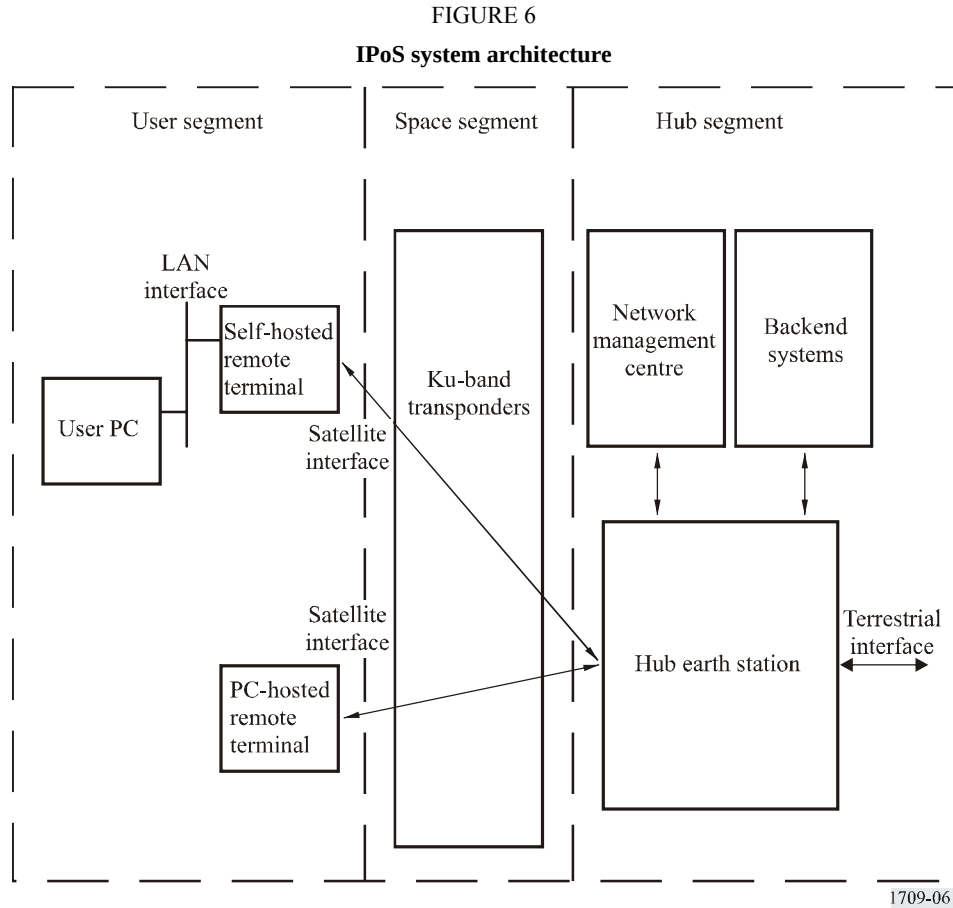
2.1 Network segments

IPoS is designed for use in a star satellite network that encompasses three major segments:

1. *Hub segment:* The hub segment supports Internet access of a large number of remote terminals via satellite. It is composed of large hub earth stations and related equipment through which all traffic flows.
2. *Space segment:* The space segment consists of bent-pipe transponders on geosynchronous satellites that allow transmission in both directions between the hub and remote terminals. IPoS parameters and procedures are somewhat independent of the underlying spectrum whether 6/4 GHz, 14/10-11 GHz, 30/20 GHz frequency bands, or even the 8/7 GHz frequency band used by the satellite transponders; however, there are physical requirements involving radio-frequency parameters that are specific for each particular frequency band. The present version of the IPoS physical (PHY) layer interface assumes IPoS services using 14/10-11 GHz satellites with spectrum that is designated for fixed-satellite service (FSS).
3. *User segment:* In general, the IPoS user segment consists of thousands of user terminals, each of them capable of providing broadband, IP communications to a remote site. User terminals are also referred to in this standard as remote terminals. The remote terminals support the user hosts, or personal computers (PCs), running the applications. This support of user PCs could be broadly categorized as:
 - *Single access point:* where the host and the remote terminal are connected, e.g. through a universal serial bus (USB) interface.

- *Customer premises LAN*: where the remote terminals provide access to a multiplicity of PCs. Customer LANs are considered external to the IPoS system.

Figure 6 illustrates the highest-level components in the IPoS architecture and identifies the major internal and external interfaces in the IPoS system.



2.2 Network interfaces

The main interfaces in the IPoS system are:

- *Terminal LAN interface*: This is the interface between the user hosts' computers, or PCs, and the remote terminals. The terminal LAN interface uses an Ethernet protocol that is not part of this standard.
- *IPoS satellite interface*: This is the interface where remote terminals and the hub exchange user, control, and management information. The IPoS satellite interface, or air interface, is the main focus of this standard.
- *Hub terrestrial interface*: This is the interface between the hub and the backbone connecting the hub to the external packet data networks, public Internet, or private data networks. The hub terrestrial interface uses IP protocols that are not part of this standard.

The IPoS satellite interface distinguishes between the two transmissions' directions:

- The outroute direction from the IPoS hub to the user terminals is broadcast over the entire bandwidth allocated to the outroute carrier. Because the IPoS outroute can multiplex a multiplicity of transmissions, it streams to many remote terminals.

- The inroute direction from the remote terminals to the IPoS hub is P-P, either using a bandwidth assigned by the hub for individual remote terminals or using a bandwidth shared by all terminals on a contention basis.

2.3 Remote terminal characteristics

The remote terminal is the access platform from which the user hosts access the services of the IPoS system. Whether or not a terminal requires the support of a PC is one of the critical methods used to categorize IPoS terminals. According to these criteria, there are two remote terminal categories:

- *PC-hosted*: This type of terminal is primarily oriented toward consumer applications. PC-hosted remote terminals operate as a PC peripheral, typically a USB peripheral, and significant support from the PC is required for operation. This support includes:
 - Downloading the peripheral's software.
 - Enabling performance enhancement function.
 - Commissioning and management functions.
- *Self-hosted*: Self-hosted terminals are aimed at all classes of customers, i.e. consumer, small office, home office (SOHO) and enterprise market segments. The self-hosted remote terminals do not require an external PC to support their operation in the IPoS system. Self-hosted terminals can be fully managed by the hub, e.g. self-hosted remote terminals can have their software downloaded, and their configuration parameters set by the hub.

Another criterion for categorizing remote terminals is the type of return channel that a terminal uses to send data to the hub. Accordingly, remote terminals can be classified into:

- *Satellite-return channel*: transmits back to the hub directly via the inroute satellite channels part of the IPoS system.
- *Receive-only with terrestrial return*: operates receive-only with respect to the satellite, using some form of terrestrial return capability (e.g. a dial-up connection).

Table 2 summarizes typical characteristics of the various types of remote terminals currently defined in the IPoS system.

TABLE 2
IPoS terminals typical characteristics

Terminal name/features	Hosting	Return channel
Low-cost, two-way, broadband satellite PC peripheral	PC	Satellite
Low-cost, two-way, broadband self-hosted terminal	Self	Satellite
Receive-only lowest-cost satellite broadband, PC peripheral	PC	Dial-up

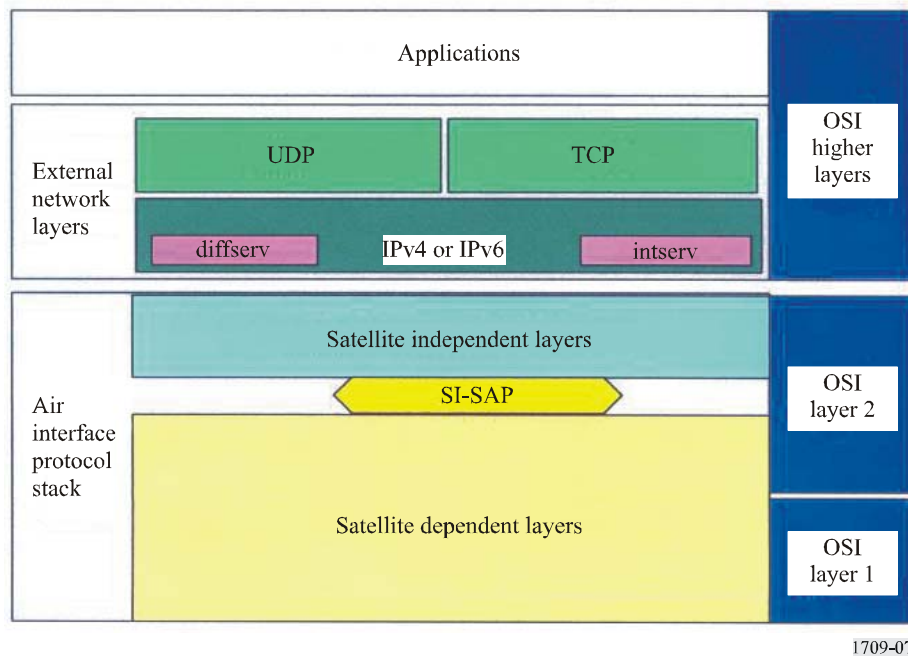
3 IPoS satellite interface

3.1 IPoS protocol reference model

The IPoS protocol is a multilayered peer-to-peer protocol providing the mechanisms to exchange IP traffic and signalling information between the entities in the hub and remote terminals.

The IPoS protocol is structured according to the broadband satellite multimedia (BSM) protocol architecture as defined in TR 101 984. This architecture provides a split between satellite-dependent functions and satellite-independent functions, as illustrated in Fig. 7.

FIGURE 7
Protocol reference model



The protocol architecture separates satellite-dependent functions and satellite-independent functions via an interface designated for the SI-SAP. The purpose of this split is as follows:

- Separate the satellite-specific aspects from the satellite-independent higher layer. This separation is designed to permit future market developments, in particular IP enhancements.
- Provide flexibility for the addition of more complex market segment-based solutions (e.g. performance enhancing proxy (PEP)).
- Elements above the SI-SAP can be ported with greater ease to new satellite systems.
- Extensibility to support new higher-layer functionalities without major reengineering of existing designs.

As shown in Fig. 7, the SI-SAP is positioned between the data link (layer 2) and network layers in the International Organization for Standardization (ISO) layering model. Elements above the SI-SAP can be, and indeed should be, designed without specific knowledge of the supporting satellite link layer. The satellite-independent layers in Fig. 7 are generic, including services not currently specified by IPoS such as IntServ, DiffServ, and IPv6.

The IPoS interface is organized into planes, layers, and directions of transmission over the satellite. There are three protocol planes:

- Plane 1:** *User-plane (U-Plane):* provides the protocols needed for reliable transport of IP traffic containing user information across the satellite interface.
- Plane 2:** *Control-plane (C-Plane):* contains the signalling protocols needed to support and control the satellite access connections and resources needed in the transport of user traffic.