RECOMMENDATION ITU-R BO.1724

Interactive satellite broadcasting systems (television, sound and data)

(Question ITU-R 26/6)

(2005)

Scope

This Recommendation intends to specify the interactive satellite broadcasting systems (television, sound and data) under Question ITU-R 26/6 when a satellite return channel using geostationary-satellite systems is operated using the systems in Recommendation ITU-R BO.1211 for digital broadcasting-satellite services (BSSs).

Two systems are recommended for this subject. The first system is the European Telecommunication Standards Institute (ETSI) Standard ETSI EN 301 790V1.3.1, known as DVB-RCS. The second one is the Telecommunications Industry Association (TIA) Standard TIA 1008.

Normative texts for these specifications are given in URLs and descriptive summaries are provided in its Annexes.

The ITU Radiocommunication Assembly,

considering

a) that substantial progress in digital broadcasting technologies has resulted in the implementation of operating digital broadcasting satellite services (BSSs);

b) that ITU-R has developed Recommendations (ITU-R BO.1211 and ITU-R BO.1516) for digital multiprogramme television systems operating in the 11/12 GHz frequency range;

c) that it is important to ensure the maximum commonality and compatibility with other return channel solutions for the different broadcasting media;

d) that interactivity is recognized to be a desirable feature for broadcast services, the need for suitable systems being addressed by Question ITU-R 16/6, and that Question ITU-R 26/6 addresses the provision for anonymous reception for broadcasts;

e) that the interaction channel systems for interactive services should ensure the access to all the terminals within the downlink service area;

f) that the interaction channel solutions based on satellite should be compatible for individual and community reception systems (SMATV);

g) that the existence of a return channel may offer to the broadcasting entities the opportunity to provide interactive broadcasting services;

h) that there is a need to identify interfaces for the interconnection of the satellite-broadcasting systems with other broadcasting media;

j) that ITU-R has approved Recommendation ITU-R BT.1369 – Basic principles for a worldwide common family of systems for the provision of interactive television services;

k) that ITU-R has approved Recommendation ITU-R BT.1434 – Network independent protocols for interactive systems;

l) that ITU has developed Recommendations on interaction channel using public switched telephone network/integrated services digital network (PSTN/ISDN), mobile phone systems, cable systems, microwaves, etc., *recommends*

1 that, when a satellite return channel using geostationary-satellite systems is operated using the system in Recommendation ITU-R BO.1211 for digital BSSs, the following two standards may be used:

European Telecommunications Standards Institute (ETSI) Standard ETSI EN 301 790[1] V1.3.1 (2003-03): http://www.itu.int/ITU-R/study-groups/rsg6/etsi/index.html, or

Telecommunication Industry Agency (TIA) Standard TIA-1008: http://www.tiaonline.org

2 that the descriptive summaries of the standards provided in Annexes 1 and 2, as well as the comparison Table below, may be used to assist administrations in selecting an appropriate standard to meet their needs.

TABLE 1

Comparison Table for ETSI EN 301 790 V.1.3.1 and TIA-1008

Item	ETSI EN 301 790	TIA-1008
Broadcast channel	Rec. ITU-R BO.1211	Rec. ITU-R BO.1211
Return channel modulation	QPSK	CE-OQPSK
Return channel coding	Viterbi/Reed Solomon rates 1/2, 2/3, 3/4 or turbocode rates 1/3, 2/5, 1/2, 2/3, 3/4, 4/5, 6/7	Viterbi rate 1/2 or turbocode rate 1/2
Return channel data rate	No restriction	64, 128, 256 Ksymbol/s
Return channel spacing (minimum)	1.35 × symbol rate	1.25 × symbol rate
Return channel burst size	Variable length, defined as 1, 2 or 4 ATM cells, or 1, 2 × N: N = 1 to 12 MPEG2 cell(s)	Slotted Aloha – fixed length bursts (definable), dynamic stream – variable length bursts from specified minimum to full frame length
Return channel Media access control method	TDMA/FDMA bandwidth, transmission rate, coding rate, and duration of traffic slots are fixed or dynamic, slot by slot. Frequency hopping can be performed on a slot-by-slot basis	TDMA/FDMA (frequency assigned when inroute request made) – Can frequency-hop on a frame-by-frame basis
Return channel burst ARQ protocol?	Yes, as per IP on MPEG	Yes, with selective retransmit
Return channel bandwidth management	Continuous rate dynamic capacity, rate-based dynamic capacity, volume-based dynamic capacity, free capacity assignment	Slotted Aloha, dynamic stream with definable hangover period, inroute quality of service, constant bit rate

CE-OQPSK: constant envelope-offset quadrature phase shift keying
IP: Internet Protocol
MPEG: Moving Pictures Experts Groups

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[1] The word "shall" in this ETSI EN specification should be considered as "should" in this ITU-R Recommendation.

Annex 1

Descriptive summary of ETSI Standard EN 301 790 V1.3.1

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1 Introduction

This Annex provides a specification for the provision of an interaction channel for GSO satellite interactive networks with fixed return channel satellite terminals (RCSTs). This specification facilitates the use of RCST for individual or collective installation (e.g. SMATV) in a domestic environment. It also supports the connection of such terminals with in-house data networks. This specification may be applied to all frequency bands allocated to GSO satellite services.

2 Reference model of the satellite interaction network

2.1 Protocol stack model

For interactive services supporting broadcast to the end user with return channel, a simple communications model consists of the following layers:

Physical layer: where all the physical (electrical) transmission parameters are defined.

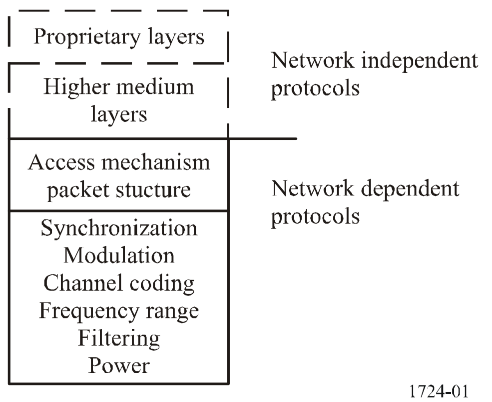
Transport layer: defines all the relevant data structures and communication protocols like data containers, etc.

Application layer: the interactive application software and runtime environment (e.g. home shopping application, script interpreter, etc.).

A simplified model of the OSI layers was adopted to facilitate the production of specifications for these layers. Figure 1 shows the lower layers of the simplified model and identifies some key parameters.

FIGURE 1

Layer structure for generic system reference model



The present text addresses the satellite interactive network dependent aspects only.

2.2 System model

Figure 2 shows the system model which is to be used within digital video broadcasting (DVB) for interactive services.

In the system model, two channels are established between the service provider and the user:

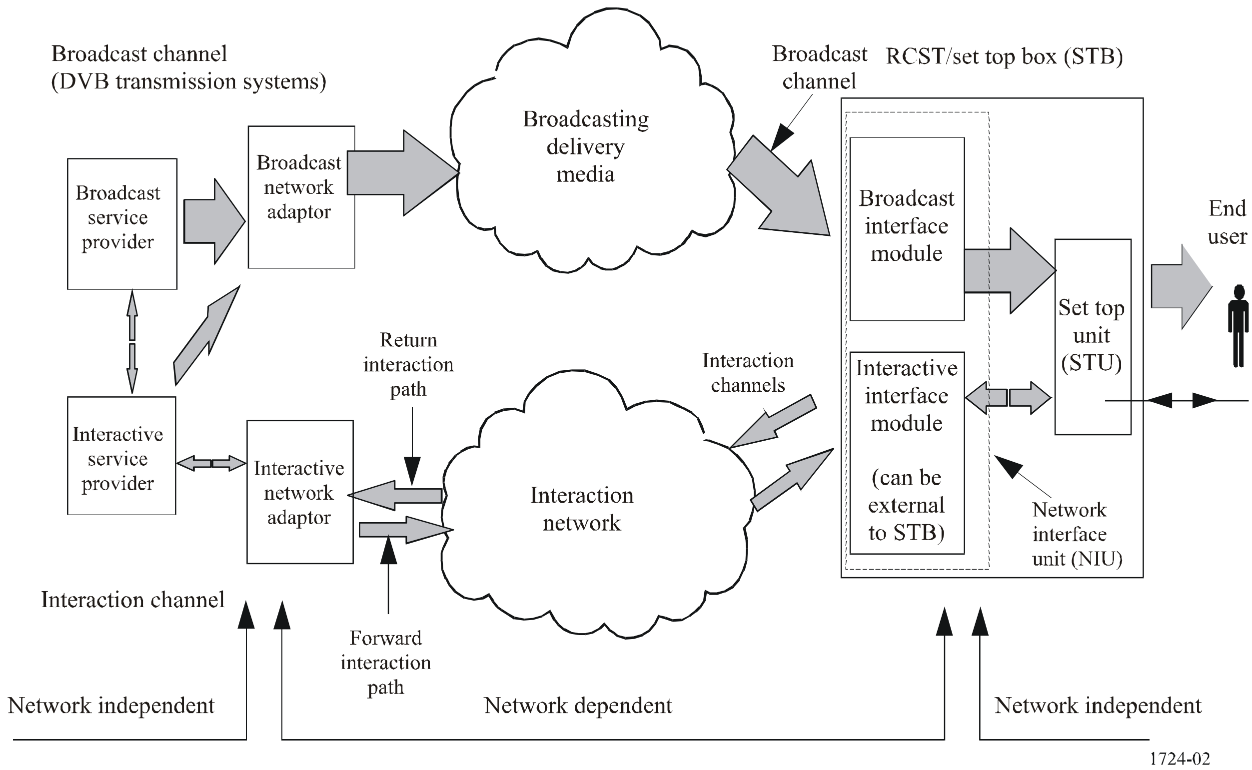
– *Broadcast channel*: A unidirectional broadband broadcast channel including video, audio and data is established from the service provider to the users. It may include the forward interaction path.

– *Interaction channel*: A bidirectional interaction channel is established between the service provider and the user for interaction purposes. It is formed by:
  – *Return interaction path (return channel)*: from the user to the service provider. It is used to make requests to the service provider, to answer questions or to transfer data.
  – *Forward interaction path*: from the service provider to the user. It is used to provide information from the service provider to the user and any other required communication for the interactive service provision. It may be embedded into the broadcast channel. It is possible that this channel is not required in some simple implementations which make use of the broadcast channel for the carriage of data to the user.

The RCST is formed by the network interface unit (consisting of the broadcast interface module and the interactive interface module) and the set top unit. The RCST provides interface for both broadcast and interaction channels. The interface between the RCST and the interaction network is via the interactive interface module.

FIGURE 2

A generic system reference model for interactive systems



2.3 Reference model of the satellite interactive network

An overall satellite interactive network, within which a large number of RCSTs will operate, will comprise the following functional blocks, as shown in Fig. 3:

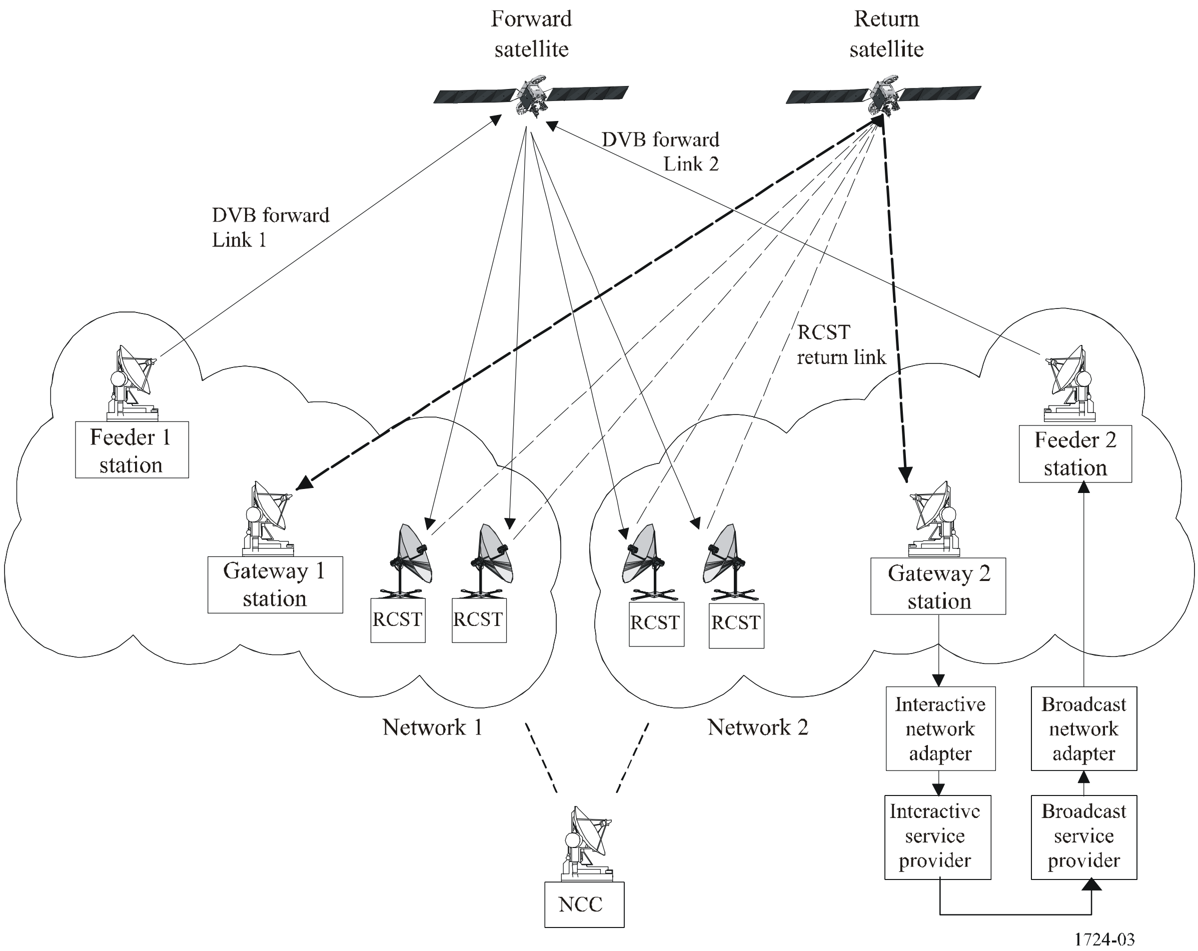
– *Network control centre (NCC)*: An NCC provides monitoring and control functions. It generates control and timing signals for the operation of the satellite interactive network to be transmitted by one or several feeder stations.

– *Traffic gateway (TG)*: A TG receives the RCST return signals, provides accounting functions, interactive services and/or connections to external public, proprietary and private service providers (e.g. databases, pay-per-view TV or video sources, software download, teleshopping, telebanking, financial services, stock market access, interactive games, etc.) and networks (e.g. Internet, ISDN, PSTN, etc.).

– *Feeder*: A feeder transmits the forward link signal, which is a standard satellite digital video broadcast (DVB-S) uplink, onto which are multiplexed the user data and/or the control and timing signals needed for the operation of the satellite interactive network.

FIGURE 3

Reference model for the satellite interactive network



The forward link carries signalling from the NCC and user traffic to RCST. The signalling from the NCC to RCST that is necessary to operate the return link system is called "forward link signalling" in the following. Both the user traffic and forward link signalling can be carried over different forward link signals. Several RCST configurations are possible depending on the number of forward link receivers present on the RCST.

3 Forward link

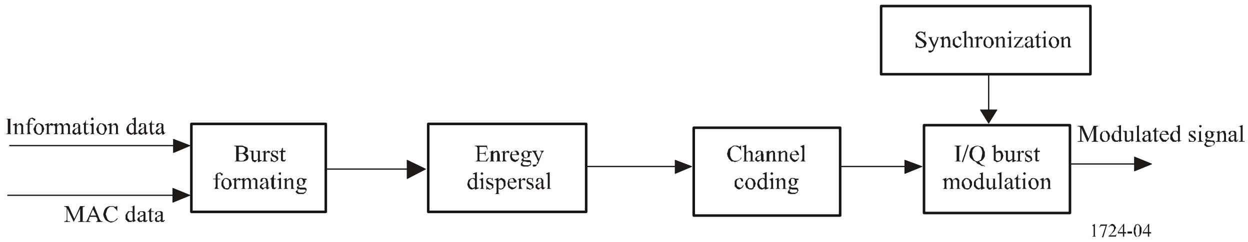
The RCST should be able to receive digital signals conforming to ETSI Standards EN 300 421, TR 101 202, ETS 300 802, EN 300 468, EN 301 192 and ETR 154.

4 Return link baseband physical layer specification and multiple access definition

Specifications for the baseband physical layer are given in this section. Figure 4 represents the generic digital signal processing to be performed at the RCST transmitter side, from the burst formatting of the serial information bit-stream, to the modulation representing the digital to analogue conversion. The signal processing to be performed by each subset is described in the following sections.

FIGURE 4

Block diagram of the RCST return link baseband signal processing



4.1 RCST synchronization

4.1.1 Timing control

The synchronization of the RCST is an important feature of the satellite interactive network. Constraints are imposed on the RCST to obtain an efficient TDMA system with minimum interference between users and maximum throughput, although they can be minimized if the NCC performs tasks such as satellite frequency translation error and common-mode Doppler compensation for RCST carrier frequency. For this reason, the synchronization scheme is based on information contained within the forward link signalling as follows:

– network clock reference (NCR);

– signalling in DVB/MPEG-2 transport stream (TS) private sections.

The NCR is distributed with a specific PID within the MPEG-2 TS that carries the forward link signalling. The NCR distribution follows the PCR distribution mechanism as defined in ISO/IEC 13818-1, which is usually derived from an MPEG video encoder, whereas here the NCR is derived from the NCC reference clock. The NCC reference clock will have an accuracy of 5 ppm or better.

4.1.2 Carrier synchronization

The MPEG-2TS that carries the forward link signalling contains an NCR information which provides a 27 MHz reference of the NCC reference clock to the RCST. The RCST reconstructs the reference clock from the received NCR information as implemented in MPEG decoders for MPEG-2 transport streams (MPEG-2 TS). The RCST then performs a comparison to determine the offset between the local reference clock which controls the RCST up-converter local oscillator and the reference clock recovered from the received NCR. It then compensates the carrier frequency according to this offset. This local carrier synchronization provides a way of adjusting the transmit frequency of all RCST on the network to almost the same frequency.

Normalized carrier frequency accuracy should be better than 10^{-8} (root mean square).

4.1.3 Burst synchronization

The RCST retrieve the centre frequency, the start time and the duration of their transmit bursts by examining the forward link signalling.

The contention between RCST on the return link is resolved as described in this specification.

The bursts are sent according to the burst time plan (BTP) received in the forward link signalling. The BTP is expressed in terms of centre frequency and absolute start time (given in NCR-counter value) of superframes and associated frequency and time offsets of burst allocations along with a description of the time-slot properties. A superframe always starts at a given value of the RCST local NCR counter, which serves as a reference for all burst allocations within the superframe. For the purpose of synchronizing to the network the RCST reconstructs, in addition to the reference clock, the absolute value of the NCC reference clock. The RCST compares the reconstructed value with the NCR value given by the BTP. The time reference for counting time-slots occurs when the values are equal.

Burst synchronization accuracy is expected to be within 50% of a symbol period. The resolution is 1 NCR count interval. The burst synchronization accuracy is the worst-case deviation of the scheduled start of burst time and the actual start of burst time at the transmitter output. The scheduled start of burst time is the point in time when the ideal reconstructed NCR equals the value written in the TBTP for that burst. The ideal reconstructed NCR is defined as observed at the output of an ideal delay-less DVB-S receiver. Compensation for the receiver delay, if required to achieve the specified accuracy, is done by the RCST.

4.1.4 Symbol clock synchronization

The symbol clock for the transmitter should be locked to the NCR based clock, in order to avoid a time drift with respect to the NCC reference clock. The RCST need not compensate for a symbol clock Doppler.

Symbol clock accuracy is expected to be within 20 ppm from the nominal symbol rate value in the time-slot composition table (TCT). The symbol clock rate has a short-term stability that limits the time error of any symbol within a burst to 1/20 symbol duration.

4.2 Burst format

There are four types of bursts: traffic (TRF), acquisition (ACQ), synchronization (SYNC) and common signalling channel (CSC). The burst formats are described in the following.

4.2.1 TRF burst formats

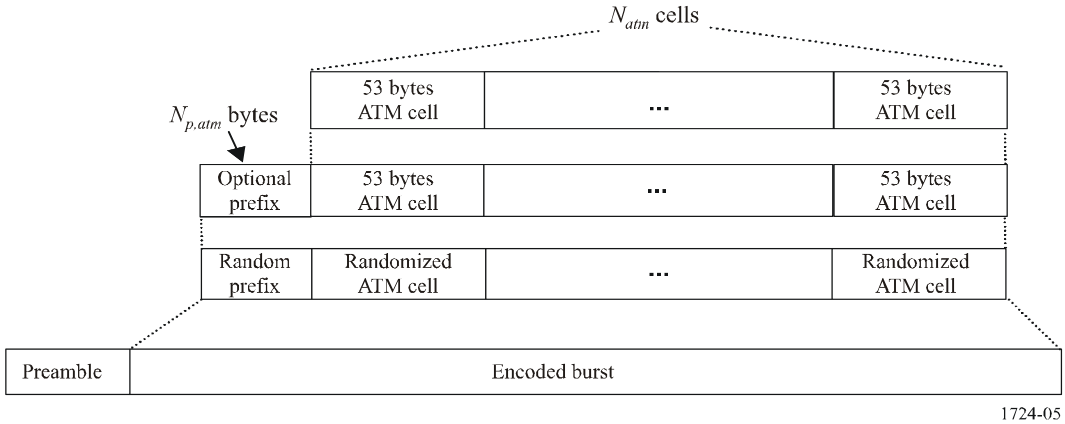
TRF bursts are used for carrying useful data from the RCST to the gateway. Two types of traffic bursts carrying either asynchronous transfer mode (ATM) cells or MPEG-2 TS packets are defined here below. A TRF is usually followed by a guard time to decrease transmitted power and compensate for time offset.

4.2.1.1 ATM TRF burst

The payload of an ATM traffic burst is composed of N_{atm} concatenated ATM cells, each of length 53 bytes, plus an optional $N_{p,atm}$ byte prefix. ATM cells follow the structure of an ATM cell but do not necessarily support ATM classes of service. See Fig. 5 for a description of the ATM TRF burst.

FIGURE 5

Composition of an ATM TRF burst



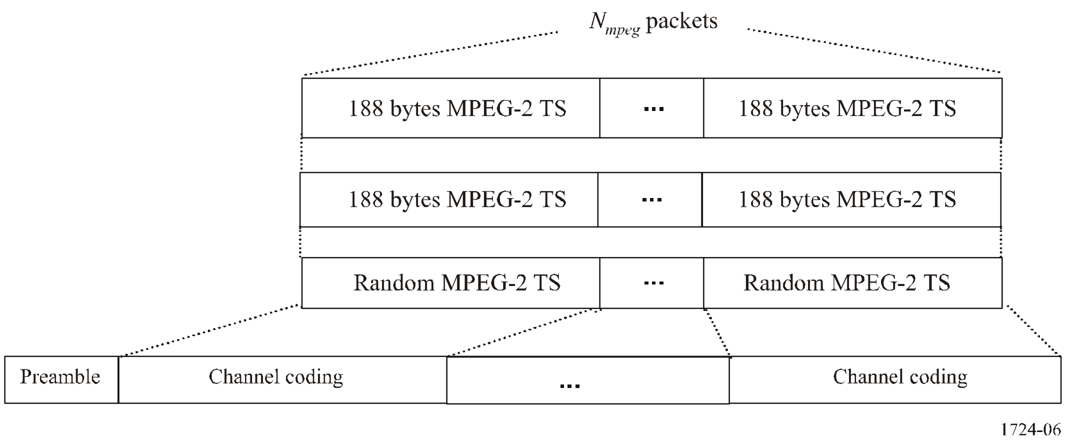
4.2.1.2 Optional MPEG-2TS TRF burst

In the case that MPEG-2 TS packets are the basic containers' a burst contains N_{mpeg} concatenated MPEG-2 TS packets, each of length 188 bytes. The burst is composed of several channel coding blocks. See Fig. 6 for a description of the MPEG-2 TS TRF burst.

RCST can deduce the number of MPEG-2 packets in a TRF time slot from the time_slot_duration field of the TCT, after subtracting the time duration of other fields. Transmission of MPEG-2 TS TRF bursts is optional. The RCST will inform the NCC that it supports this mechanism in the CSC burst.

FIGURE 6

Composition of the optional TRF burst carrying MPEG-2 TS packets



4.2.2 Synchronization (SYNC) and acquisition (ACQ) burst formats

SYNC and ACQ bursts are required to accurately position RCST burst transmissions during and after logon. Two separate burst types are defined for this purpose (SYNC and ACQ) as defined in the following paragraphs.

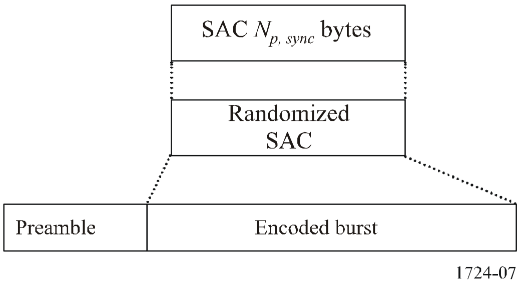
4.2.2.1 Synchronization (SYNC) burst format

A SYNC burst is used by an RCST for the purpose of maintaining synchronization and sending control information to the system. SYNC bursts are composed of a preamble for burst detection, and an optional $N_{p,sync}$ byte satellite access control (SAC) field, with the appropriate error control coding. Like a TRF, a SYNC is usually followed by a guard time to decrease transmitted power and compensate for time offset. Figure 7 depicts the SYNC burst. The extent to which the SYNC burst is used depends on the capabilities of the NCC.

NOTE 1 – SYNC bursts can be used in contention mode.

FIGURE 7

Composition of a SYNC burst



4.3 Modulation

The signal should be modulated using QPSK, with baseband shaping.

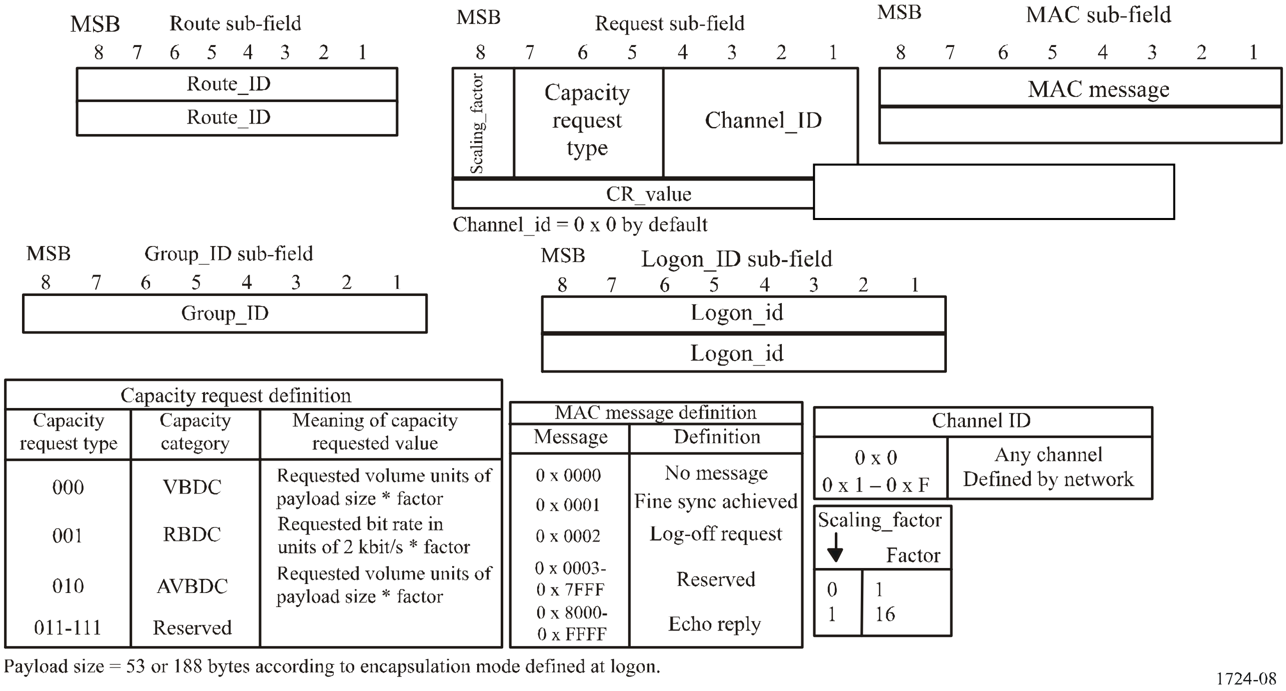
4.4 MAC messages

All methods described below can be used by RCST for capacity requests and MAC messages. One or more of the methods may be employed in a satellite interactive network. For the particular implementation, the RCST are configured at the time of logon by the logon initialize descriptor that is transmitted in a terminal information message (TIM).

The SYNC and the optional prefix attached to ATM TRF bursts contain the SAC field composed of signalling information added by the RCST for the purpose of requesting capacity on the session, or other additional MAC information. The SAC is composed of optional sub-fields that are defined in Fig. 8.

FIGURE 8

Composition of the SAC field



VBDC: volume-based dynamic capacity

RBDC: rate-based dynamic capacity

AVBDC: absolute VBDC

5 Protocol stack

On the return link the protocol stack is based on ATM cells or optional MPEG-2 TS packets mapped onto TDMA bursts. For transmission of IP datagrams, the protocol stacks used on the return link are as follows:

– ATM based return link: IP/AAL5/ATM;

– optional MPEG return link: multiprotocol over MPEG-2 transport streams encapsulation.

In the forward link the protocol stack is based on the DVB/MPEG-2 TS standard (see TR 101 154). For transmission of IP datagrams, the protocol stacks used on the forward link are as follows:

– multiprotocol encapsulation over MPEG-2 transport streams;

– optionally IP/AAL5/ATM/MPEG TS in data piping mode so as to enable direct terminal-to-terminal communications in regenerative satellite systems.

Figures 9 and 10 show examples of protocol stacks for traffic and signalling, respectively.

FIGURE 9

Example of a protocol stack for user traffic with Type A RCST (IP/AAL5/ATM/MPEG-2/DVBS is optional in the forward link)

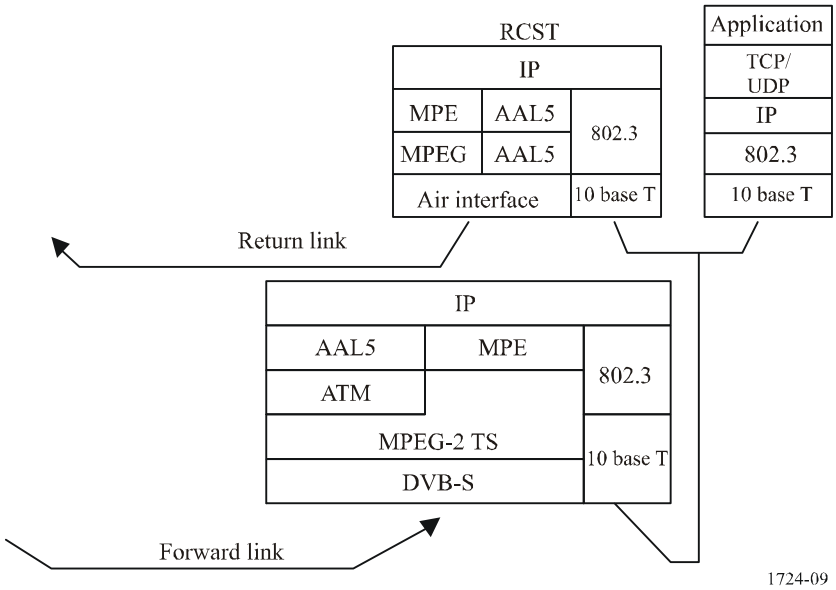
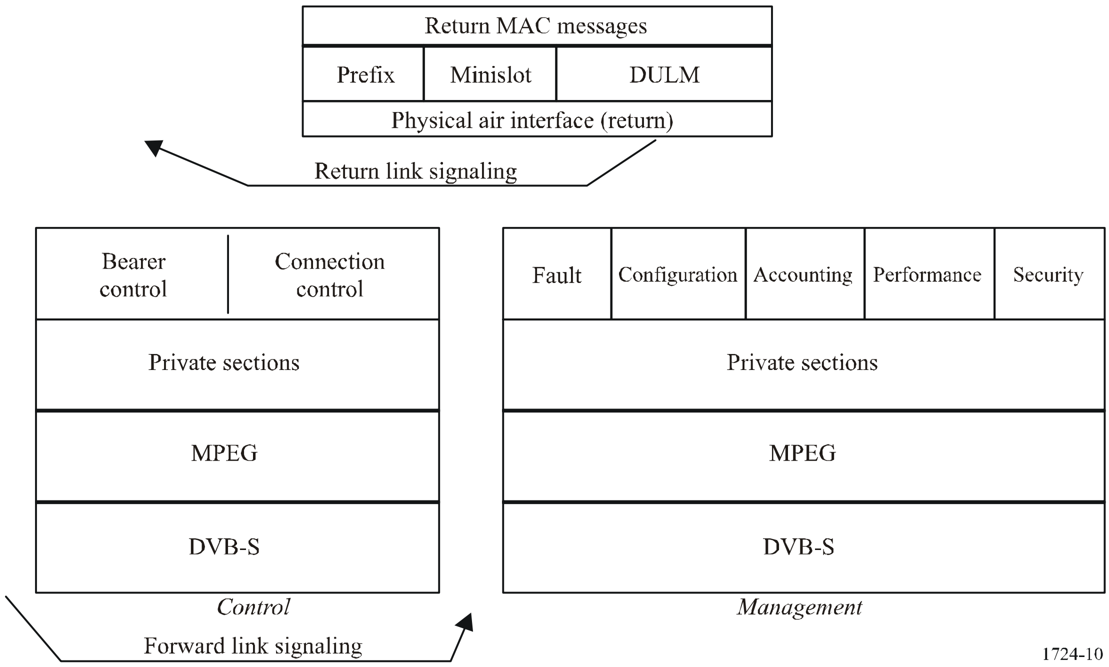


FIGURE 10

Protocol stack for signalling



DULM: data unit labelling method

6 Capacity request categories

The time-slot allocation process supports five capacity categories:

– continuous rate assignment (CRA);
– rate-based dynamic capacity (RBDC);
– volume-based dynamic capacity (VBDC);
– absolute volume-based dynamic capacity (AVBDC);
– free capacity assignment (FCA).

6.1 Continuous rate assignment (CRA)

CRA is the rate capacity which should be provided in full for each and every superframe while required. Such a capacity is negotiated directly between the RCST and the NCC.

6.2 Rate-based dynamic capacity (RBDC)

RBDC is the rate capacity which is requested dynamically by the RCST. The RBDC capacity should be provided in response to explicit requests from the RCST to the NCC, such requests being absolute (i.e. corresponding to the full rate currently being requested). Each request should override all previous RBDC requests from the same RCST, and should be subject to a maximum rate limit negotiated directly between the RCST and the NCC.

To prevent a terminal anomaly resulting in a hanging capacity assignment, the last RBDC request received by the NCC from a given terminal should automatically expire after a time-out period whose default value is two superframes, such expiry resulting in the RBDC being set to zero rate. The time-out can be configured between one and 15 superframes (if set to 0, the time-out mechanism is disabled) by the optional mechanism of § 8.4.2.

CRA and RBDC can be used in combination, with CRA providing a fixed minimum capacity per superframe and RBDC giving a dynamic variation component on top of the minimum.

6.3 Volume-based dynamic capacity (VBDC)

VBDC is the volume capacity which is requested dynamically by the RCST. The VBDC capacity is provided in response to explicit requests from the RCST to the NCC, such requests being cumulative (i.e. each request adds to all previous requests from the same RCST). The cumulative total per RCST should be reduced by the amount of this capacity category assigned in each superframe.

6.4 Absolute volume-based dynamic capacity (AVBDC)

AVBDC is the volume capacity which is requested dynamically by the RCST. This VBDC capacity is provided in response to explicit requests from the RCST to the NCC, such requests being absolute (i.e. this request replaces the previous ones from the same RCST). The AVBDC is used instead of VBDC when the RCST senses that the VBDC request might be lost (for example in the case of contention minislots).

6.5 Free capacity assignment (FCA)

FCA is the volume capacity which should be assigned to RCST from a capacity which would be otherwise unused. Such a capacity assignment is automatic and does not involve any signalling from the RCST to the NCC. It should be possible for the NCC to inhibit FCA for any RCST (whether one or multiple terminals).

FCA should not be mapped to any traffic category, since availability is highly variable. The capacity assigned in this category is intended as a bonus capacity which can be used to reduce delays on any traffic which can tolerate delay jitter.

7 Multiple access

The multiple-access capability is either fixed or dynamic slot multi-frequency time division multiple access (MF-TDMA). RCST should indicate their capability by using the MF-TDMA field present on the CSC burst.

7.1 MF-TDMA

The satellite access scheme is MF-TDMA. MF-TDMA allows a group of RCST to communicate with a gateway using a set of carrier frequencies, each of which is divided into time-slots. The NCC will allocate to each active RCST a series of bursts, each defined by a frequency, a bandwidth, a start time and a duration.

8 Security, identity, encryption

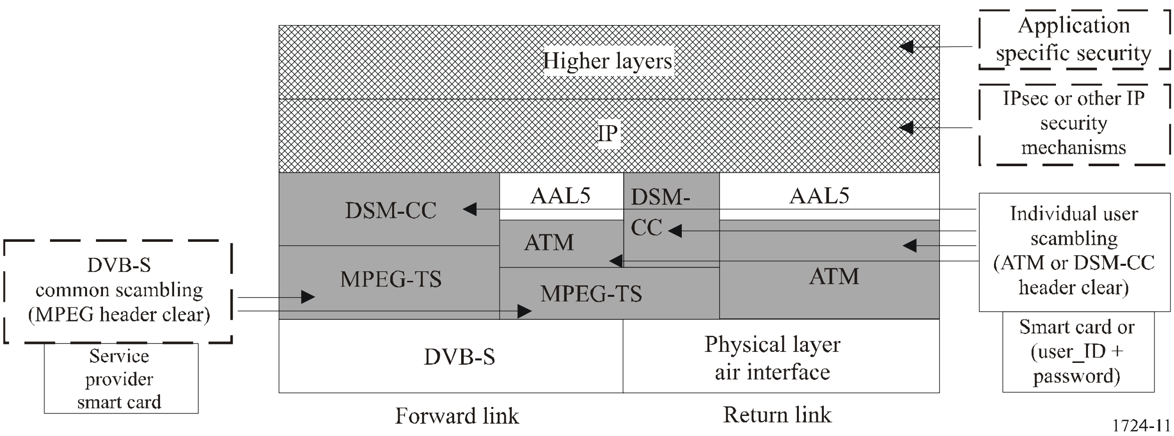
Security is intended to protect the user identity including its exact location, the signalling traffic to and from the user, the data traffic to and from the user and the operator/user against use of the network without appropriate authority and subscription. Three levels of security can be applied to the different layers:

– DVB common scrambling in the forward link (could be required by the service provider);
– satellite interactive network individual user scrambling in the forward and return link;
– IP or higher layer security mechanisms (could be used by the service provider, the content provider).

Although the user/service provider could use its own security systems above the data link layer, it may be desirable to provide a security system at the data link layer so that the system is inherently secure on the satellite section without recourse to additional measures. Also, since the satellite interactive network forward link is based on the DVB/MPEG TS Standard, the DVB common scrambling mechanism could be applied, but is not necessary (it would just add an additional protection to the entire control stream for non-subscribers). This concept is shown in Fig. 11.

FIGURE 11

Security layers for satellite interactive network (example)



Annex 2

Descriptive summary of TIA Standard TIA-1008

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1 Introduction

This Annex provides another specification for the provision of an interaction channel for GSO satellite interactive networks with fixed return channel satellite terminals (RCSTs). This specification also facilitates the use of RCST for individual or collective installation (e.g. SMATV) and supports the connection of such terminals with in-house data networks. This specification may be applied to all frequency bands allocated to GSO satellite services.

The solution provided in this Annex is an introduction to the Internet Protocol over Satellite (IPoS) standard that has been developed by the Telecommunications Industry Association (TIA) in the United States of America. 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 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

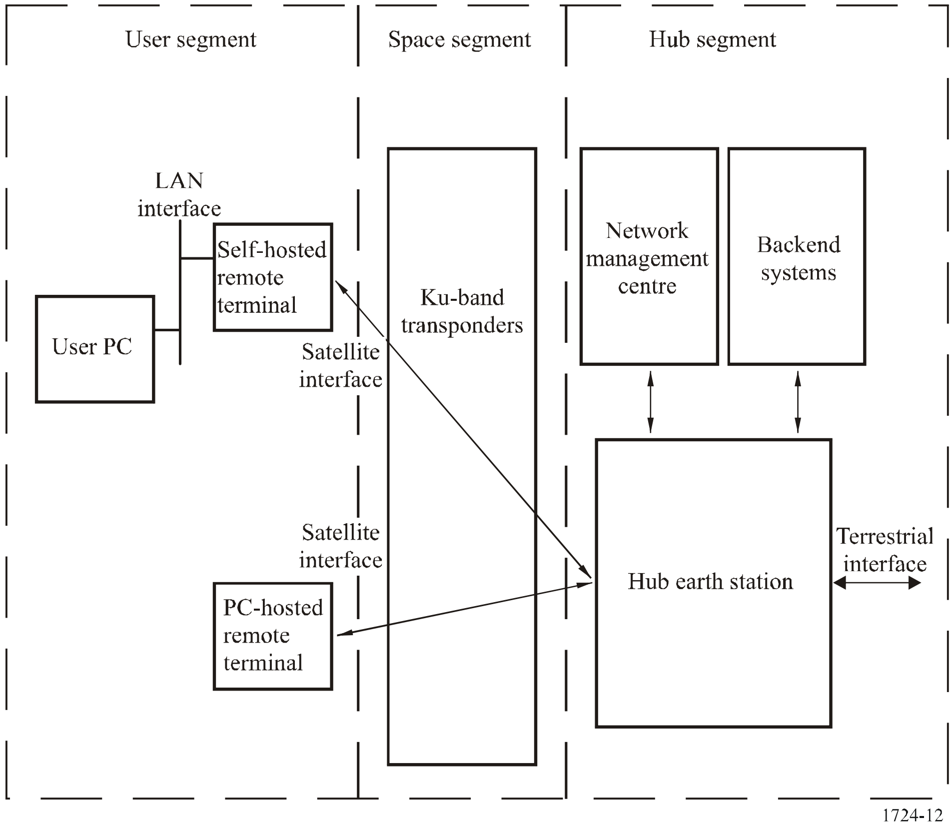
IPoS is designed for use in a star satellite network that encompasses three major segments:

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 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 layer (PHY) interface assumes IPoS services using commercial satellites with spectrum that is designated for fixed-satellite services (FSSs).
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 local area network (LAN)*: where the remote terminals provide access to a multiplicity of PCs. Customer LANs are considered external to the IPoS system.

Figure 12 illustrates the highest-level components in the IPoS architecture and identifies the major internal and external interfaces in the IPoS system.

FIGURE 12

IPoS system architecture



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 users control and manage 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 point-to-point, 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 and self-hosted.

2.3.1 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.

2.3.2 Self-hosted

Self-hosted terminals are aimed at consumers and users of small/home offices. The self-hosted remote terminals do not require an external PC to support their operation in the IPoS system. Self-hosted terminals could 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.

2.3.3 Return channel type

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
Two-way, broadband satellite PC peripheral	PC	Satellite
Two-way, broadband self-hosted terminal	Self	Satellite
Receive-only 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 BSM protocol architecture as defined in the ETSI technical report Standard TR 101 984. This architecture provides a split between satellite-dependent functions and satellite-independent functions, as illustrated in Fig. 13.

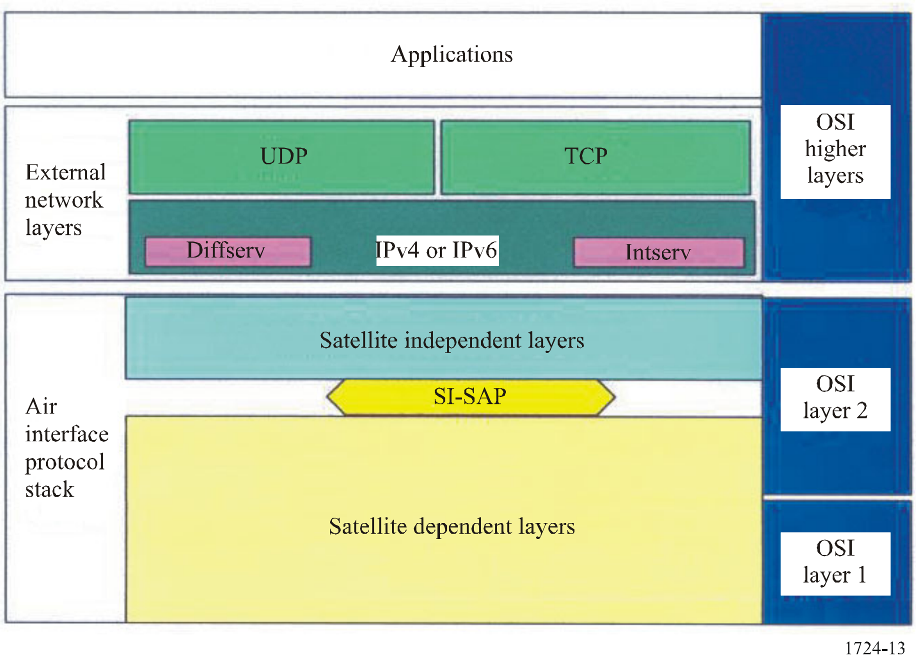
The protocol architecture separates satellite-dependent functions and satellite-independent functions via an interface designated the satellite independent-service access point (SI-SAP). The purpose of this split is as follows:

– 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 proxies (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. 13, 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. 13 are generic, including services not currently specified by IPoS such as IntServ, DiffServ and IPv6.

FIGURE 13

Protocol reference model



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

Plan 1: *User plane (U-Plane)*: provides the protocols needed for reliable transport of IP traffic containing user information across the satellite interface.

Plan 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.

Plan 3: *Management plane (M-Plane)*: concerned with the administration and messaging related to the commissioning of remote terminals, the billing of the users, performance, and alarm reporting. The management plane is outside the scope of this standard.

Each of the IPoS planes is logically divided into three protocol sublayers. The protocol sublayers are used to decompose the overall system functionality into groupings of functions at the same abstraction level.

– *PHY*: provides the lower-level functionality related to modulation, error control of the information, and signalling streams transported across the interface.
– *Data link control (DLC) layer*: provides the multiplexing of the various streams as well as reliable and efficient transport services.
– *Network adaptation layer*: controls user access to the satellite and controls radio resources needed for this access.

3.2 Physical layer (PHY)

The PHY function provides the transmission and reception of the modulated waveforms used to transport the data provided by the data link and higher layers over the satellite. At the PHY, there is no distinction between the transport methods provided for U-Plane and C-Plane or M-Plane information. This distinction is made at higher layers.

The services provided by the PHY layer are grouped into the following categories:

– The initial acquisition, synchronization, and ranging procedures with the hub, including the timing alignment of the transmissions with the frame structure of the inroute carriers and the adjustment of the power transmitted by the remote terminals.
– The modulation, coding, error correction, scrambling, timing, and frequency synchronization of information flows, provided by the DLC's U-Plane and C-Plane to the outroute and inroute carriers.
– The performance of local measurements such as received E_{bt}/N_0, recovered clock, and status and supervision of the physical parameters (such as timing) and their reporting to higher layers.

3.2.1 Outroute satellite transmission

IPoS outroute carriers use a statistical multiplexing scheme compliant with the DVB data format and the distribution of IP traffic to the remote terminals is based on the DVB multiprotocol encapsulation. Symbol rates from 1 MSymbol/s to 45 MSymbol/s are supported at FEC rates 1/2, 2/3, 3/4, 5/6 and 7/8.

3.2.2 Inroute satellite transmission

An IPoS inroute uses OQPSK modulation at transmission rates of 64, 128, or 256 kSymbol/s when using rate 1/2 convolutional encoding or at transmission rates of 128 or 256 kSymbol/s when using Turbo FEC encoding.

IPoS uses demand-assigned MF-TDMA on its inroutes to allow terminals to transmit to the hub. The IPoS inroute has a 45 ms TDMA frame length divided into a variable number of slots. Transmissions from a terminal to the hub are referred to as a "burst." A burst requires an integral number of slots for overhead and then carries an integral number of slots of data. These overhead slots are used to provide the burst preamble and to allow adequate time between bursts to ensure that consecutive bursts do not overlap in time.

3.3 Data link layer (DLL)

The DLL provides the actual transport service over the IPoS network. It is divided into the following sublayers:

– satellite link control (SLC)

– MAC

– outroute multiplexing sublayer.

3.3.1 Satellite link control sublayer

The SLC layer is the sublayer of the DLC that is responsible for transmission of packets between remote terminals and the hub.

IPoS supports different delivery methods over the outroute and inroute directions.

A reliable error-free delivery method is used in the inroute direction using selective retransmissions. In this reliable delivery method, the receiving SLC entities deliver only error-free data packets to the higher layers.

Over the outroute where the transmission errors are very low (typical BER = 10^{-10}, the transmit SLC delivers each data packet only once without retransmission of errored or missing packets.

The functional responsibilities of the SLC are:

– generation of session IDs and mapping incoming packets into the corresponding session;

– encryption of specific IP PDU (protocol data units) for user-to-user data privacy;

– segmentation and reassembly, which performs segmentation/reassembly of variable-length higher layer data packets into smaller PDU;

– delivery of data in sequence to the peer using the reliable/unreliable mode of delivery.

3.3.2 Media access control sublayer

The services or functions provided by the MAC layer can be grouped into the following categories:

– *Data transfer*: This service provides transfer of MAC interactions between peer MAC entities. This service does not provide any data segmentation; therefore, the upper layers provide the segmentation/reassembly function.

– *Reallocation of radio resources and MAC parameters*: This service performs control procedures for identifiers that are allocated to a particular DLC layer by the network layer for an interval of time or on a permanent basis. It also performs procedures for the establishment and termination of transfer modes over the DLC layer.

– *Error detection*: Procedures for the detection of procedural errors or errors occurring during the transmission of frames.

3.3.3 Outroute multiplexing sublayer

In the outroute direction, the multiplexing sublayer permits the hub to transmit several traffic types, programs, or services within the same outroute carrier and controls the transmission of each individual programme. The IPoS multiplexing sublayer is based on the DVB/MPEG statistical multiplexing format.

In this DVB/MPEG format, all the frames or packets associated with one of the traffic types have the same programme identifier (PID). At the remote terminals, a demultiplexer breaks the outroute multiplex into specific transport streams with the remote terminal filtering only those that match the PID addresses configured in the terminal.

IPoS remote terminals are configured to filter two types of PID associated with the following types of transport streams, which are relevant to the IPoS system:

Type 1: PSI tables, which provide both IPoS and non-IPoS terminals with configuration of services. The IPoS terminals receive the PSI tables to determine the specific configuration of the IPoS system.

Type 2: IPoS user and control information, which is transported in the IPoS logical channels. The information contained in the IPoS logical channels can be targeted to all, a group, or individual IPoS terminals.

Outroute DVB/MPEG packets are broadcast over the entire outroute carrier bandwidth with IPoS terminals filtering those packets that do not match their own addresses. The addressing scheme is included as part of the transport packet header and MAC header.

3.4 Network adaptation layer

The network adaptation layer function provides the following major subfunctions:

– *IP packet transport*: This function performs the functions necessary to determine the Class of Service of the IP packet-based on packet type, application type, destination, and internal configuration.

– *Traffic management*: This function performs the traffic shedding and policing functions on IP packets before they are offered to the IPoS transport services.

– *PEP*: This function improves the performance of certain applications for improving service over a satellite link. PEP is often used to reduce the degradations in throughput experienced by TCP applications because of the delays and losses in satellite links.

– *Multicast proxy*: This proxy adapts IP multicast protocols (e.g. PIM-SM) to the appropriate IPoS transport services to provide the multicast.

The network adaptation layer is not part of the IPoS air interface specification.