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ETSI

European Telecommunications Standards Institute

ETSI Secretariat

Postal address: F-06921 Sophia Antipolis CEDEX - FRANCE
Office address: 650 Route des Lucioles - Sophia Antipolis - Valbonne - FRANCE
X.400: c=fr, a=atlas, p=etsi, s=secretariat - **Internet:** secretariat@etsi.fr

Tel.: +33 92 94 42 00 - Fax: +33 93 65 47 16

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Foreword

This European Telecommunication Standard (ETS) has been prepared by the Network Aspects (NA) Technical Committee of the European Telecommunications Standards Institute (ETSI).

The need has been identified for the support of applications that require guaranteed constant bandwidth and specified transfer delay on a Distributed Queue Dual Bus (DQDB) subnetwork.

Therefore, the DQDB protocol has to be enhanced for the provision of Constant Bit Rate (CBR) connection types.

This final draft ETS addresses the use of pre-arbitrated functions as defined in IEEE Standard 802.6 [1] to support CBR connection types.

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1 Scope

This European Telecommunication Standard (ETS) details enhancements to the Distributed Queue Dual Bus (DQDB) access method as defined in IEEE Standard 802.6 [1] in order to provide Constant Bit Rate (CBR) connection types for the support of existing services (guaranteed constant bandwidth, specified transfer delay) on MANs, using semi-permanent connections in the range of n x 64 kbit/s to 2 Mbit/s bit rate capability. Therefore, signalling protocol specifications are outside the scope of this ETS.

This ETS does not cover the broadband specific aspects and the interworking of MANs with broadband networks. For the broadband related aspects the CBR services are defined in CCITT Recommendations I.362 and I.363 and the protocol reference model to be used in the Asynchronous Transfer Mode (ATM) based networks to support these services is included in CCITT Recommendation I.321.

Annex B provides the Protocol Implementation Conformance Statement (PICS) proforma for this ETS, in compliance with the relevant requirements, and in accordance with the relevant guidance, given in ISO/IEC 9646-2.

2 Normative references

This ETS incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed below. For dated references, subsequent amendments to or revisions of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] IEEE Standard 802.6 (1990): "Distributed Queue Dual Bus (DQDB) Subnetwork of a Metropolitan Area Network (MAN)".

[2] CCITT Recommendation G.101 (1988): "The transmission plan".

[3] CCITT Recommendation G.114 (1988): "Mean one-way propagation time".

[4] CCITT Recommendation G.131 (1988): "Stability and Echo (General characteristics of the 4-wire chain formed by the international circuits and national extension circuits)".

[5] CCITT Recommendation G.823 (1988): "The Control of jitter and wander within digital networks which are based on the 2 048 kbit/s hierarchy".

3 Definitions

For the purposes of this ETS, the definitions defined in IEEE Standard 802.6 [1] apply.

In addition, this Clause contains those definitions that are considered to be essential for the understanding of this ETS.

Access delay: the time which an octet spends in the transmit queue of a CBR access unit before it can gain access to the bus.

Basic data rate: a data rate out of the following list:

- 64 kbit/s;
- 192 kbit/s;
- 384 kbit/s;
- 768 kbit/s;
- 1 536 kbit/s;
- 2 048 kbit/s.

The use of the term "basic data rate" implies that the Pre-Arbitrated (PA) slot generation process for a CBR connection at a basic data rate is based on the frequency parameter pairs (M, N) where M=1 and N=2, 4, 8, 16, 48 or M=2 and N=3.

CBR Access Unit (CAU): a DQDB node supporting a CBR interface.

CBR Convergence Functions (CCF) block: consists of the CCF transmit functions block and the CCF receive functions block.

CBR Service User (CSU): sends and receives octets at a constant bit rate across a CBR interface of a DQDB subnetwork.

CCF receive functions block: receives octets from the PA functions block and stores them in a buffer. It forwards the octets to the CBR service user at precisely regular intervals according to the rate of the CBR service.

CCF transmit functions block: receives service octets from the CBR interface. It stores these octets in a buffer until they are requested by the PA functions block. Then they are passed on to the PA functions block.

Common Functions (CF) block: provides functions which are needed by some or all of the other functional blocks in the local DQDB layer subsystem. It provides the DQDB layer function of relaying the slot octets and management information octets between the service access points to the local physical layer subsystem.

Composite slot-switching: the service octets of a CBR connection may gain access to an offset in the payload of a PA slot on one of the busses if, and only if, the pair virtual channel identifier of the PA slot, offset is contained in a list of such pairs associated at connection set-up with the CBR connection on that bus.

Compound data rate: is a (necessarily unique) sum of two or more basic data rates. The use of the term "compound data rate" implies that the PA slot generation process for a CBR connection at a compound data rate consists in generating the PA slots for the basic data rates of which it is the sum.

Constant Bit Rate (CBR): the time characteristic of an event or signal recurring at known periodic time intervals, i.e. guaranteed constant bandwidth, specified transfer delay.

NOTE: The term for this characteristic which is used in IEEE Standard 802.6 [1] is "CBR".

CBR Service Data Unit (CSDU): are presented by the CSU at the specified rate for the CBR connection. Similarly, the CBR service periodically delivers a CSDU to a CSU at the rate specified for the connection.

Dedicated slot-switching: the service octets of a CBR connection may gain access to an offset in the payload of a PA slot on one of the busses if, and only if, the Virtual Channel Identifier (VCI) of the PA slot has been associated at connection set-up with the CBR connection on that bus.

Delay end-to-end, one way: the time it takes for a CBR service octet to be transferred between two corresponding terminal equipments.

Frame: refers to the 125 µs transmission frame of the Physical Layer Convergence Procedure (PLCP).

Frequency: is a pair of positive integer numbers (M, N). It implies that the PA slot generation for a CBR connection is required to maintain the frequency of M slots every N frames.

PA functions block: controls the transfer in PA segment payloads of CBR service octets received from the CBR convergence functions block. For this purpose it maintains one transmit table and one receive table.

Receive table: is part of the PA receive functions block. It associates a CBR connection end-point identifier with the bus and with the VCI of the PA slots on which the service octets of the connection are received.

Slot number: slots in a frame are numbered by starting with the first slot fully contained in the frame and numbering from 1 to the last slot fully contained in that frame.

Transmit table: is part of the PA transmit functions block. It associates a CBR connection end-point identifier with the bus and with the VCI of the PA slots on which the service octets of the connection are transmitted.

Variability: is the maximum difference in the slot number between the k-th and the (k+M)-th PA slots allocated to a connection with slot generation frequency = (M, N).

4 Symbols and abbreviations

For the purposes of this ETS, the symbols and abbreviations defined in IEEE Standard 802.6 [1] apply.

In addition, those symbols and abbreviations that are essential for the understanding of this ETS are listed:

CAU	CBR Access Unit
CBR	Constant Bit Rate
CCF	CBR Convergence Functions
CF	Common Functions
CRC	Cyclic Redundancy Check
CSDU	CBR Service Data Unit
CSU	CBR Service User
DQDB	Distributed Queue Dual Bus
HCS	Header Check Sequence
HOB	Head Of Bus
ISPBX	Integrated Services Private Branch Exchange
LM-ACTION	Layer Management Action
MAC	Media Access Control
MSS	MAN Switching System
NMP	Network Management Process
PA	Pre-Arbitrated
PBX	Private Branch Exchange
PDU	Protocol Data Unit
PICS	Protocol Implementation Conformance Statement
PLCP	Physical Layer Convergence Procedure
QA	Queued Arbitrated
SDH	Synchronous Digital Hierarchy
VCI	Virtual Channel Identifier
V_{def}	default Variability

5 Basic principles

The CBR capability shall provide for the following data rates defined by CCITT:

- 64 kbit/s;
- 384 kbit/s;
- 1 536 kbit/s;
- 2 048 kbit/s.

The CBR capability provides for these basic data rates and combinations thereof, e.g. n x 64 kbit/s.

The PLCP of a DQDB subnetwork providing CBR capability shall have a 125 µs frame structure. In order to allow for simple and efficient bandwidth allocation/management algorithms, the Head Of Bus (HOB) node shall generate slots used for CBR services which fit as a whole into a single 125 µs frame. Therefore, the use of a 1,5 Mbit/s or 2 Mbit/s transmission system for the DQDB subnetwork is excluded. All other standardised PLCPs are supported.

6 DQDB layer service model

The CBR service provided by the DQDB layer is described abstractly by means of the service primitives notation defined in ISO/TR 8509.

NOTE: The abstract description does not constrain an implementation in any way. For example, an implementation might use a service data unit consisting of a number of octets or only a single bit.

The primitives used to describe the service are the following:

- CSU-DATA request;

- CSU-DATA indication.

CSDUs to be sent via the CBR service are presented by the CSU at the specified rate for the constant bit rate connection. Similarly, the CBR service periodically delivers a CSDU unit to a CSU at the rate specified for the connection.

CSU-DATA request

Function:

- this primitive requests the transfer of a CSDU over an established CBR connection.

Semantics of the Service Primitive:

- CSU-DATA request;

- the CSDU parameter conveys a single CSDU.

When generated:

- this primitive is generated by an CSU whenever a CSDU is required to be transferred over a connection.

Effect on receipt:

- the receipt of this primitive by the DQDB layer results in the DQDB layer attempting to transfer the CSDU over the established connection. CSDUs are transferred in the same order in which they are submitted by the CSU.

CSU-DATA indication

Function:

- this primitive indicates the arrival of a CSDU over an established CBR connection.

Semantics of the service primitive:

- CSU-DATA indication (CSDU).

The CSDU parameter conveys a single CSDU.

When generated:

- this primitive is generated by the DQDB Layer to deliver a CSDU that has arrived over an established CBR connection.

Effect on receipt:

- the effect of receipt of this primitive is dependent upon the CSU;

- the CSDUs shall be received by the receiving CSU in the same order in which they were sent by the sending CSU.

7 Functional architecture

7.1 Access method

CBR service octets will be carried in the payload of PA slots. For the format of PA slots see Clause 8. In particular, the payload of PA slots contains 48 octets. PA slots are generated by the slot generation function at the HOB according to algorithms which are discussed in subclause 7.2.

Dedicated slot-switching shall be used for the nodes to gain access to CBR bandwidth in the payload of the PA-slots on a DQDB bus.

In dedicated slot-switching, the octets of the payload of a PA-slot are associated with only one connection, and there is a one-to-one correspondence between CBR connections and VCIs in the headers of PA-slots on each bus.

NOTE: This is in contrast to "composite slot-switching" where different octet positions in one PA slot may be associated with different connections. There is no contradiction between the two access methods as dedicated slot-switching may be viewed as just a particular way to use composite slot-switching.

7.2 Slot generation function at the HOB

In order to achieve interoperability of equipment it has to be specified how the PA slots associated with a CBR connection (i.e. with a particular VCI) are generated by the HOB. The bandwidth provided by all PA slots with a particular VCI defines a CBR connection on a DQDB subnetwork.

For a PLCP based on CCITT Recommendation G.703 at 34 Mbit/s or at 140 Mbit/s, all slots are fully contained in a frame and may be used as PA slots.

For certain PLCPs, however, slots can cross frame boundaries. Furthermore, the number of slots which are fully contained in a frame varies between Max and Max+1 where Max is an integer. In this case, in order to simplify PA slot generation procedures, only the first Max complete slots in a frame may be used as PA slots.

For the PLCP for CCITT Recommendations G.707, G.708 and G.709 SDH based systems at 155 Mbit/s, the payload of the PLCP frame is 2 340 = 44 x 53 + 8 octets. Here, the mapping of slots onto PLCP frames has been defined such that slots are allowed to cross frame boundaries. Any given PLCP frame will contain either 43 or 44 complete slots, i.e. Max = 43.

The slot generation process for a CBR connection is characterised at a minimum by the parameters of "frequency" (see subclause 7.2.1) and "variability" (see subclause 7.2.2). The slot generation process is further characterised by the attributes "basic" or "compound" (which are mutually exclusive). The term "basic" means that the rate of the channel is a "basic data rate", i.e. a data rate associated with a particularly simple slot generation process (see subclause 7.2.3). The term "compound" means that the CBR connection is obtained by combining the bandwidth of two or more connections at basic data rates (see subclause 7.2.4).

7.2.1 Frequency and periodicity

Frequency

The frequency parameter determines the average rate of the CBR channel. In general, CBR bandwidth allocations are of the form "M slots every N frames". To make bandwidth allocation simple, M and N may be constrained. PA slot generation by the HOB shall maintain the frequency of M slots every N frames for each CBR connection.

NOTE: This definition requires two parameters, M and N, to specify frequency which have to be included in the LM-ACTION invoke (PA VCI ADD HOB) service primitive (see Clause 10 below).

Periodicity

When frequency = (M, N) the HOB is required to generate the PA slots with a particular VCI periodically with period N in the following sense: the k-th and the (k + N)-th PLCP frames (125 µs transmission frames) shall contain the same number of PA slots with that particular VCI for k = 0,1,2,....

7.2.2 Variability

According to the periodicity requirement above the number of PA slots per frame associated with a connection repeats every N frames. However, nothing is implied about the slot position within each frame, hence variability is allowed there.

Slots in a frame can be numbered by starting with the first slot fully contained in the frame and numbering from 1 to the last slot fully contained in that frame. Using this definition of slot number, variability V is defined as the maximum difference in the slot number between the k-th and the (k + M)-th PA slots allocated to a connection with slot generation frequency (M, N):

$$V = \max \{ | S(k) - S(k+M) | \}$$

where S(k) is the slot number of the k-th PA slot allocated to a connection and the max is taken over k = 0,1,2,....

The minimum variability is V = 0. A default value, V_{def}, shall be chosen that all HOB stations will support such that the possibility of CBR connections with no more variability than V_{def} can be assured. This default value is chosen to be V_{def}= 0.

Minimum variability

For a PLCP based on CCITT Recommendation G.703 at 34 Mbit/s or at 140 Mbit/s, the k-th slot in each PLCP frame appears with precisely the same offset (i.e. precisely the same number of octets from the beginning of the frame). Therefore, when V = 0 for a connection, PA slot appearances for that connection are precisely periodic with period N frames, ignoring PLCP induced jitter.

Minimum variability would be supported for any given CBR connection by allocating to that connection the same slot number(s) in each frame that contains slots for that connection (not necessarily in every frame).

For the PLCP for CCITT Recommendations G.707, G.708 and G.709 SDH based systems at 155 Mbit/s, the offset of the k-th complete slot within a PLCP frame varies. It can be shown that the offset of the k-th complete slot will never be identical between adjacent frames and will occasionally change by as much as 45 octets. Between non-adjacent frames, the change in offset for a given slot number depends on the distance between frames. In the general case, the offset of a given slot number will vary by up to 52 octets (i.e. one less than the length of a slot).

7.2.3 Basic data rates

A basic data rate is one of the data rates out of the list below. It is associated with a particularly simple slot generation process based on simple frequency parameter pairs.

For M=1, N may take on the values 1, 2, 4, 8, 16 and 48. For M=2, N=1 or N=3. For all other values of M, N is equal to 1. These frequency parameter pairs define the basic data rates given in table 1.

Table 1

M	N	basic data rate (in kbit/s)
1	48	64
1	16	192
1	8	384
1	4	768
1	2	1 536
2	3	2 048

Therefore, the smallest granularity of CBR bandwidth to be allocated is 64 kbit/s, sufficient for a voice connection. A 64 kbit/s connection is supported by allocating one PA-slot every 48 frames to the VCI for that connection.

$$\text{i.e. } 64 \text{ kbit/s} = \frac{1 \text{ slot x } 48 \text{ octets x } 8 \text{ bits}}{48 \text{ frames x } 125\ \mu\text{s}}$$

When frequency = (1, N) (i.e. when one slot is generated every N frames) the default variability V = 0 implies that PA slots associated with a given connection are generated at precisely regular intervals. This is not the case for frequency = (2, 3), equivalent to a data rate of 2 048 kbit/s (see also Annex A, subclause A.2.3).

NOTE: Each of the data rates mentioned in Clause 5 above is a basic data rate.

7.2.4 Compound data rates

A compound data rate is a sum of basic data rates. Hence, a CBR connection at a compound data rate is obtained by combining the bandwidth of two or more connections at basic data rates. As 64 kbit/s is a basic data rate it is clear from this definition that any data rate of the form n x 64 kbit/s which is not a basic data rate is a compound data rate. It is, however, desirable to reduce the number of basic data rates of which the compound data rate is composed, as this reduces the maximum access delay.

Inspection of the list of data rates of subclause 7.2.3 shows that the representation of a compound data rate of the form n x 64 kbit/s (n<=32) as a sum of basic data rates with a minimum number of summands is unique. At most five addenda are needed. (Examples: 1 600 kbit/s = 1 536 + 64 kbit/s, 23 x 64 kbit/s = (12 + 6 + 3 + 1 + 1) x 64 kbit/s).

Compound data rates are useful by providing more flexibility in the definition of CBR connections. The finer granularity of data rates of CBR connections can avoid a waste of bandwidth.

PA-slot Frequency in Support of compound data rates

Bandwidth for a compound data rate d = d1 + d2 + ... + dn with basic data rates d1, d2, ... , dn is allocated by simultaneously allocating bandwidth for those basic data rates, i.e. the bandwidth allocation is of the form "M1 slots every N1 frames plus M2 slots every N2 frames plus ..... plus Mn slots every Nn frames". n different "LM-ACTION invoke (PA VCI ADD HOB)" messages (see Clause 10) are needed.

Bandwidth allocation for a connection with a compound data rate d = d1 + d2 + ... + dn is considered successfully completed when the HOB has confirmed that PA-slots with the specified VCI are generated for n connections with rates d1, d2 and dn respectively. Hence, bandwidth allocation for compound data rates concerns only the bandwidth management which is not subject to standardization. As far as the slot generation function in the HOB and the communication between bandwidth manager and HOB are concerned, there are only basic data rates.

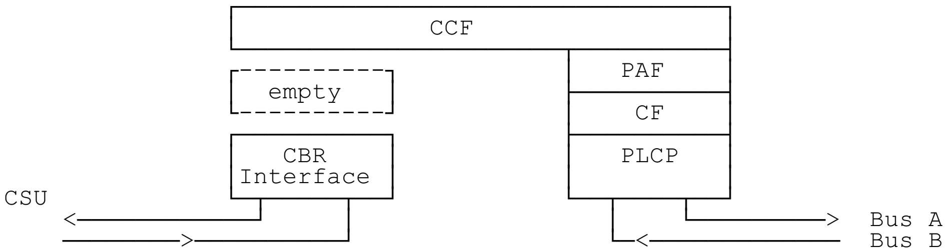
As the representation of a compound data rate as the sum of basic data rates with a minimal number of terms is unique for all data rates of the form n x 64 kbit/s (n < = 32) and as it is clear from subclause 7.2.3 how PA-slots for basic data rates are generated by the HOB there is also a clear understanding of how PA-slots for these compound data rates are generated by the HOB. This allows the design of DQDB nodes with interfaces for these compound data rates.

7.3 Functions at a DQDB node supporting a CBR interface

7.3.1 Overview

A CAU is a DQDB node supporting a CBR interface.

An overview of its functional blocks is given in figure 1.



CSU = CBR Service User.
CCF = CBR Convergence Functions.
PAF = Pre-Arbitrated Functions.
CF = Common Functions.
PLCP = Physical Layer Convergence Procedure.

Figure 1: Functions at a DQDB Node supporting a CBR interface

A CAU preserves the octet sequence integrity, i.e. the CF block delivers octets to the PLCP in the same order in which they were received by the CCF block from the CSU, and the CCF block delivers octets to the CSU in the same order in which they were received by the CF block from the PLCP layer.

7.3.2 Common functions block

As far as the provision of CBR service is concerned the role of the CF block shall be as specified in the IEEE Standard 802.6 [1], section 5.4, except for the additions concerning the PA slot generation by the HOB station which are dealt with in subclause 7.2.

7.3.3 PA-functions block

The PA functions block controls the transfer in PA segment payloads of CBR service octets received from CCF blocks.

The PA functions block maintains two tables, a transmit table and a receive table. Each table associates each connection end-point identifier and the corresponding CCF with the one pair (bus, VCI) characterising the PA slots used to carry the octets on the connection.

For the maintenance of these tables the LM-ACTIONs invoke (OPEN CE CCF) and invoke (CLOSE CE CCF) and the corresponding reply actions are used (see Clause 10).

7.3.3.1 PA-transmit functions

The PA-transmit functions block receives octets from the CCF block and maps these octets onto offset positions in the payload of PA slots according to the entries of a transmit table maintained by the PA functions block. The PA-transmit functions block examines the VCIs of PA-slots passing on the bus and receives the corresponding offset signals. When the VCI is found to be valid the transmit table is searched for a matching entry. When a matching entry has been found, for each of the following 48 offset signals, a service octet is requested from the corresponding CCF block and is forwarded to the CF block.

7.3.3.1.1 Transmit interactions between PA functions block and common functions block

When the common functions block receives an ACF with the BUSY bit set to one and the SL_TYPE bit set to one (i.e. the ACF of a PA slot), it then delivers a copy of the octets of the PA segment header to the PA functions header to the PA functions block as they pass on the bus in the common functions block. It also asserts the OFFSET_SIGNAL control to the offset of the PA segment payload as each octet passes on the bus in the common functions block. If the PA functions block is to write an octet at the offset asserted by OFFSET_SIGNAL, then it OR-writes it as the octet passes along the bus in the common functions block.

7.3.3.1.2 PA segment header validation

Upon receipt of a PA segment header, the PA functions block validates the correctness of the PA segment header using the Header Check Sequence (HCS) (see subclause 8.2.1.4), and then:

1) if the HCS is not valid, then the PA segment payload shall be ignored;

2) if the HCS is valid, then the value of VCI received in the PA segment header is used for processing the associated PA segment payload.

7.3.3.2 PA receive functions

In the reverse direction, the PA receive functions block receives octets from the common functions block and forwards them to the CCF blocks to which they are destined according to the entries in the receive table.

The PA receive functions involve examining the VCI in the PA segment header of PA slots on bus x (x = A or B) and determining whether it is currently associated with reception for a CCF block at the node.

7.3.3.2.1 Receive interactions between PA functions block and common functions block

When the common functions block receives an ACF with the BUSY bit set to one and the SL_TYPE bit set to one (i.e. the ACF of a PA slot), it then delivers a copy of the octets of the PA segment header to the PA functions block as they pass on the bus in the common functions block. It also delivers a copy of each octet of the PA segment payload to the PA functions block and asserts the OFFSET_SIGNAL control to the offset of the PA segment payload as the octet passes on the bus in the common functions block.

7.3.3.2.2 PA segment header validation

Upon receipt of a PA segment header, the PA functions block validates the correctness of the PA segment header using the HCS (see IEEE Standard 802.6 [1], section 8.2.1.4), and then:

1) if the HCS is not valid, then the PA segment payload shall be ignored;

2) if the HCS is valid, then the value of VCI received in the PA segment header is used for processing the associated PA segment payload, as described in subclause 7.3.3.2.3.

7.3.3.2.3 CBR convergence function selection

If the VCI in the PA segment header is accepted as valid, according to subclause 7.3.3.2.2, then the PA functions block stores the VCI and the bus on which it was received and compares it with the set of receive [VCI, bus] values in the receive table associated with all CCF blocks at the node, and then:

1) if the comparison does not match the receive [VCI, bus] value for any CCF block at this node no action is taken;

2) if the comparison does match the receive [VCI, bus] value for an CCF block at this node, the PA function block delivers the octets in the payload of this segment to that CCF block.

7.3.4 CBR convergence functions block

There is one type of CCF for each CBR interface and there is one instance of an CCF block for each CBR service user connected to the node.

The PA functions block will receive and transmit CBR service octets at a guaranteed average rate, but they will not necessarily be evenly distributed. The irregularity in arrival will depend on the distribution of PA slots generated by the slot marking function at each active HOB function. The function of a CCF is, if necessary, to provide buffering to smooth any irregular arrival of CBR service octets from the PA functions block to the arrival rate expected by the CSU.

7.3.4.1 CBR convergence transmit function

The CCF block receives CBR service octets across the CBR interface. It stores these octets in a buffer until they are requested by the PA functions block. They are passed on to the PA functions block.

Before transmission begins the CCF has to additionally delay the octets queued for transmission so that the transmit buffer does not become empty. The additional delay depends on the service rate and the nature of the PA slot generation process for the CBR connection which is permitted by subclause 7.2 for each data rate. Applicable delay values can be computed from the algorithms given in this ETS.

The CCF block receives CSU-DATA request primitives at a constant rate, according to the requirements of the CSU.

When the CCF block receives an CSU-DATA request it places the CBR service octet received as the CSDU in a transmit buffer, which is used to store the CSDUs in the order received from the CSU. When the PA functions block asserts the SEND_SIGNAL to the CCF block, it delivers the octet at the head of the transmit buffer to the PA functions block. The definition of a CCF will specify the actions taken if the transmit buffer either underflows or overflows.

7.3.4.2 CBR convergence receive function

The PA functions block delivers CBR octets to the CCF block as they are received. On receipt of a CBR service octet, the CCF places it in a receive buffer, which is used to store the octets in the order received from the PA functions block.

The CCF block is required to generate CSU-DATA indication primitives according to the requirements of the CSU. To support this function, the CCF block uses a 125 µs clock derived by the DQDB layer subsystem from the Ph-TIMING-MARK indication primitives received at the node.

When the CCF block is required to send an CSU-DATA indication, it delivers the octet at the head of the receive buffer as the CSDU in an CSU-DATA indication.

The CBR convergence receive function is required to generate CSU-DATA indications according to the requirements of the CSU.

The definition of an CCF will specify the actions taken if the receive buffer either underflows or overflows.

7.3.5 CBR interfaces

The method for providing CBR bandwidth on a DQDB subnetwork described in the previous subclauses allows for the specification of nodes with a variety of CBR interfaces. The specification of these interfaces is outside the scope of this ETS.

8 Protocol data unit format

8.1 PA slot

A PA slot is used to transfer CBR service octets. For the format of slots see IEEE Standard 802.6 [1], section 6.2.

8.2 PA segment

Each PA segment contains a header of 4 octets and a payload of 48 octets, as shown in figure 2.

PA Segment header	PA Segment payload
(4 octets)	(48 octets)

Figure 2: PA segment format

A PA segment is carried in a PA slot. A PA slot shall be generated by the slot marking function at the head of the bus with the BUSY bit of the ACF set to 1, the SL_TYPE bit of the ACF set to 1, and all other bits of the ACF set to 0. The BUSY bit and SL_TYPE bit of the PA slot should remain unchanged at all times, but the REQ bits in the ACF may be operated on according to the rules of the distributed queue. The slot marking function at the head of the bus shall also write the PA segment header (see subclause 8.2.1), which is carried by the PA slot. The slot marking function at the head of the bus shall set every bit in the PA segment payload to 0.

8.2.1 PA segment header fields

The PA segment header contains the fields shown in figure 3. The length of each field is shown in bits. These fields are written by the slot marking function at the head of the bus and should remain the same as the slot passes along the bus.

VCI	Payload Type	Segment Priority	HCS
(20 bits)	(2 bits)	(2 bits)	(8 bits)

Figure 3: PA segment header fields

8.2.1.1 VCI

The 20-bit VCI provides a means to identify the virtual channel to which the PA segment belongs. There is a single VCI space that is shared by all services.

The VCI value corresponding to all bits being set to zero is not available to refer to an active virtual channel.

The VCI value with all bits set to 1 is reserved for use by the connectionless Media Access Control (MAC) service and is not available for use with PA segments.

8.2.1.2 Payload_Type

The 2-bit Payload_Type field indicates the nature of the data to be transferred. User data is indicated by the value Payload_Type = 00. All other values are reserved for future use.

The use of the Payload_Type field in PA segments is under study. The default value of Payload_Type to be used in PA segments is 00.

8.2.1.3 Segment_Priority

The 2-bit Segment_Priority Field is reserved for future use with multiport bridging. The field shall be set to the value 00.

8.2.1.4 Segment HCS

The 8 bit HCS field provides for detection of errors and correction of single-bit errors in the PA Segment header. The HCS contains an 8-bit Cyclic Redundancy Check (CRC) calculated on the PA segment header field, using the following standard generator polynomial of degree eight:

$$G(x) = x8 + x2 + x + 1$$

The HCS shall be encoded by the slot marking function at the HOB function. The contents (treated as a polynomial) of the PA segment header are multiplied by x^8 and then divided (modulo 2) by G(x) to produce a remainder. This remainder is the HCS, where the coefficient of the highest term is the leftmost bit.

Error detection using the HCS is mandatory at a node that supports the optional function of reading and/or writing the PA segment payload.

As a typical implementation, at the node with the active HOB function, the initial remainder of the division is preset to all zeros and is then modified by division of the PA segment header (excluding the HCS field) by the generator polynomial G(x). The resulting remainder is inserted into the HCS field, with the most significant bit inserted first.

At all destination node(s) that support the optional function of reading and/or writing the PA segment payload, the initial remainder is preset to all zeros. The serial incoming bits of the received PA segment header (including the HCS bits), when divided by the generator polynomial G(x) results, in the absence of transmission errors in a remainder of all zeros.

8.2.2 PA segment payload

The PA segment payload is 48 octets long. It consists of 48 CBR service octets.

9 Protocol performance constraints

9.1 Delay constraints

The delay constraints which a DQDB subnetwork shall meet in order to be able to support CBR connection types depend on the specific application and on the overall network configuration into which the subnetwork is embedded.

It is shown in Annex A, Clause A.2, that the specifications in this ETS imply that the delay constraints are met for the applications listed in Annex A, Clause A.1, for a large variety of network configurations.

9.1.1 Delay constraints for voice connections

The use of CBR connection types for voice transmission implies that the delay constraints for voice have to be met.

The delay constraints for voice which are applicable here are:

- 25 ms delay end-to-end, one way, for a connection without echo compensation (see ETSI Technical Report TE 10.05);

- 5 ms delay in private networks from the network connection point to the TE, one way (see ETSI Technical Report TE 10.05).

9.2 Jitter constraints

Although the specification of the CBR interface is outside the scope of this ETS, the requirements for jitter and wander for 64 kbit/s and 2 Mbit/s as specified in CCITT Recommendation G.823 [5] shall be met at the CBR interface (see figure 1).

9.3 Synchronisation constraints

This ETS covers only that case where the CBR service user equipment derives its clock from the DQDB node attached to the MAN Switching System (MSS). In the case that the CSU uses its own clock, the user equipment shall ensure interworking.

9.4 Reconfiguration constraints

The establishment of CBR connections as well as bandwidth management are outside the scope of this ETS. For any implementation, constraints due to reconfiguration of a looped access facility should be taken into consideration.

10 DQDB layer management interface in support of CBR service

The LM-actions required to support CBR service are described in this Clause.

The first group of two LM-ACTIONS is needed to establish and release the relationship between the CCF block and the PA functions block, i.e. to maintain the transmit table and the receive table of the PA functions block i.e.:

- LM-ACTION invoke (OPEN_CE_CCF);
- LM-ACTION invoke (CLOSE_CE_CCF); and
- the corresponding "reply" actions.

The second group of LM-ACTIONS is formed by:

- LM-ACTION invoke (PA_VCI_ADD_HOB);
- LMACTION invoke (PA_VCI_DEL_HOB); and
- the corresponding "reply" actions.

These two groups are needed to tell the HOB to generate, and, stop generating, respectively, PA-slots with an indicated VCI.

LM-ACTION invoke (OPEN_CE_CCF):

NOTE 1: There is always one CCF per CSU. Therefore, for each CSU, there is a single connection end-point which is represented at the CCF to CSU boundary. This is mapped to the relationship between the PA functions block and the CCF.

NOTE 2: The CCF could be performing a null function.

Managed object:

The identified connection end-point between an CCF and an CSU, the relationship between the CCF and the PA functions block for that connection end-point and the list of bus and VCI pairs used by the PA functions block to transmit and receive CBR service octets for the node.

Function:

This primitive informs the PA function and the CCF of a new CBR connection, and associates a connection end-point between the CCF and an CSU with the parameters needed to communicate on the connection.

Semantics of the Service Primitive:

```
LM-ACTION invoke (
                    OPEN_CE_CCF,
                    cep_id,
                    TRANSMIT  (
                              tx_bus,
                              tx_vci,
                              ),
                    RECEIVE   (
                              rx_bus,
                              rx_vci,
                              )
                    )
```

The cep_id parameter identifies the connection end-point for the opened connection. The set of TRANSMIT parameters include tx_bus and the tx_vci value which specify the bus and the VCI used to send CBR service octets. The set of RECEIVE parameters include rx_bus and the rx_vci value which specify the bus and the VCI used to accept CBR service octets. The values that can be associated with either tx_bus or rx_bus are as follows:

- BUS_A; or
- BUS_B.

When generated:

This primitive is generated when an CBR connection is opened.

Effect on receipt:

The DQDB layer functions associate the connection end-point with the specified parameters and enable information flow on the opened connection. An LM-ACTION reply is generated to indicate the success or failure of the invocation in the form of a status report. The general form of this reply is given in IEEE Standard 802.6 [1], section 9.1.1.1.

Additional comments:

None.

LM-ACTION invoke (CLOSE_CE_CCF)

Managed object:

The identified connection end-point between a CBR convergence function and the user of the service provided by that convergence function.

Function:

This primitive instructs a CCF to disassociate a connection end-point from two [bus, VCI]-pairs in the transmit table and the receive table respectively as a result of the connection being closed.

Semantics of the service primitive:

```
LM-ACTION invoke (
                  CLOSE_CE_CCF,
                  cep-id
                  )
```

The cep_id parameter identifies the connection end-point associated with the connection that has been closed.

When generated:

This primitive is generated when a CBR connection is closed.

Effect on receipt:

The convergence function that receives this primitive disassociates the specified connection end-point from the two [bus, VCI]-pairs previously assigned to it.

An LM-ACTION reply is generated to indicate the success or failure of the invocation in the form of a status report. The general form of this reply is given in IEEE Standard 802.6 [1], section 9.1.1.1.

Additional comments:

None.

LM-ACTION invoke (PA_VCI_ADD_HOB)

Managed object:

The list of PA VCIs and associated attributes that the slot marking function uses to mark slots at the head of a bus.

Function:

This primitive directs the slot marking function in the node with an active HOB function to mark slots as PA in accordance with the given parameters.

Semantics of the service primitive:

```
LM-ACTION invoke (
                   PA VCI ADD HOB,
                   VCI,
                   bus,
                   frequency,
                   variability
                   )
```

The VCI parameter specifies the value of the VCI field to be inserted in the PA segment header at the head of the specified bus (the default values of the payload type and the segment priority type of a PA segment header are both 00).

The value of the bus parameter is either bus A or bus B.

The frequency parameter is a pair (M, N) of (positive) integer numbers (see subclause 7.2.1).

The variability parameter is an integer number V (see subclause 7.2.2).

When generated:

This primitive is generated when the Network Management Process (NMP) in the node containing the active HOB function has been instructed to start generating PA slots containing the specified VCI.

Effect on receipt:

Receipt of this primitive causes the slot marking function in the node containing the active HOB function to start generating PA slots in accordance with the parameters given.

An LM-ACTION reply is generated to indicate the success or failure of the invocation in the form of a status report. The general form of this reply is given in IEEE Standard 802.6 [1], section 9.1.1.1.

LM-ACTION invoke (PA_VCI_DEL_HOB)

Managed Object:

The list of PA VCIs and associated attributes that the slot marking function uses to mark slots at the head of a bus.

Function:

This primitive directs the slot marking function in the node with an active HOB function to cease generating PA slots for the specified VCI.

Semantics of the service primitive:

```
LM-ACTION invoke (
                  PA_VCI_DEL_HOB,
                  VCI,
                  bus
                  )
```

The VCI parameter specifies the VCI for which PA slots on the specified bus should no longer be generated.

When generated:

This primitive is generated when the NMP in the node containing the active HOB function has been instructed to cease generating PA slots for a specified VCI.

Effect on receipt:

Receipt of this primitive causes the slot marking function in the node containing the active HOB function to cease generating PA slots on the specified bus with the specified VCI.

An LM-ACTION reply is generated to indicate the success or failure of the invocation in the form of a status report. The general form of this reply is given in IEEE Standard 802.6 [1], section 9.1.1.1.

Additional Comments:

None.

Annex A (informative): Applications

A.1 Identified applications

This Clause lists the applications that have been identified and gives a brief definition of each.

A.1.1 Interconnection of CBR terminals

An example of the use of this application is the interconnection of Integrated Services Private Branch Exchanges (ISPBXs) at the E1 rate (2 048 kbit/s). This is an application that provides interconnection between two entities which are supported by nodes on a DQDB. The entities generate, and receive, a CBR stream of data with an E1 payload. The DQDB subnetwork is required to carry the payload between any two participating nodes via the PA capability.

A.1.2 Video applications

They fall into the category of low to medium bandwidth compressed digital video, i.e. 384 kbit/s to 44,2097 Mbit/s. There are two types of compressed video information, namely CBR / variable image quality and variable bit rate / constant image quality. These two types have different application requirements and, hence, may be supported by different services on a DQDB subnetwork. When, however, a variable bit rate video application is to be supported by CBR connection types it is necessarily considered as a CBR application whose rate equals the peak rate of the variable bit rate application.

A.1.3 Voice applications

The enhancements to the DQDB protocol should not preclude supporting such applications.

A.1.4 Multi-application support

This refers to the ability to simultaneously support multiple applications on the same subnetwork from any given station, e.g. voice and video. By meeting the requirements of all other applications, this type of application can be automatically supported.

A.1.5 Multimedia applications

Multimedia applications are defined as applications which require the simultaneous use of video, voice and text/graphics. This results in generating signals which are sequences of CBR and bursty information which may be carried in separate channels or may be multiplexed in one channel. They are in specific timing relationships. These timing relationships are such that the information remain meaningful and intact, e.g. a voice describing a specific graphic image or narrating a text will be played while the image or text is on the screen. Another example is maintaining synchronisation between a motion picture and a voice accompanying it. However, when video and voice are multiplexed by the terminal into a single data stream - as is the case for CCITT Recommendations H.221, H.261 and MPEG1, the network performance does not affect synchronisation. When voice and video are carried in separate channels then network performance has to be such that synchronisation at the receiving end is possible whether it is carried out by the terminals or by the network. This implies that differences in delay are required to be bounded.

A.2 Delay considerations

An inspection of the list of applications given in Clause A.1, shows that voice applications have the most stringent delay requirements.

The delay constraints for voice connections are given in subclause 9.1.

A voice connection may extend across one or more ISPBX. In order to be able to calculate the end-to-end delay for a voice connection it is necessary in that case to have a bound for the delay incurred in ISPBXs.

This bound is:

- 0,45 ms delay, one way, in an ISPBX.

The delay incurred in various network components is calculated in subclause A.2.1.

The end-to-end delay for CBR connections at various bit rates is calculated in subclause A.2.2 for two examples of network configurations.

The access delay for 2 048 kbit/s connections is discussed, in subclause A.2.3 and an additional constraint concerning the generation of PA slots associated with this type of connections is proposed.

A.2.1 Delay in network components

A.2.1.1 Transmission delay

Delay values independent of the bit rate of the connection

Propagation delay:

In optical fibre there is a propagation delay of 5 ms every 1 000 km.

(Speed of light in glass = 2 x 10^5 km/s).

Phase synchronisation delay:

The overall delay depends on the network configuration and the way timing information is distributed. However, no precise values are presently available. Its contribution will be small, however. So it is not taken into account here.

A.2.1.2 Delay in the CBR Access Unit (CAU)

(For the CAU see subclause 7.3).

Delay values dependent on the bit rate of the connection

It is shown here that a delay is incurred which equals the packetisation delay D_p. D_p is defined as the time which is needed to fill the payload of a PA-slot (48 octets) at the given speed of the connection. D_p is calculated by the following formula:

$$D_p = \text{segment payload size / bit rate of connection}$$
$$= 48 \times 8 \text{ bit} / n \times 64 \text{ kbit/s}$$
$$= 6 / n \text{ ms}$$

for a CBR connection of n x 64 kbit/s.

Table A.1 gives some examples of packetisation delay.

Table A.1: Packetisation delay

bit rate/kbit/s	63	84	1 536	2 048
packetisation delay	6 ms	1 ms	250 µs	187,5 µs

The average distance between two consecutive PA-slots associated with a given CBR connection shall equal D_p. It is assumed here that they are generated at a fixed frequency which gives the lowest delay.

The access mechanism is now examined in more detail.

The first octet which arrives at the buffer of the sending CAU from the sending CSU just after a PA-slot associated with the connection has passed on the bus, has to wait the time D_p until the arrival of the next associated PA-slot. At the receiving CAU, this octet can be immediately transmitted to the receiving CSU.

The last octet which arrives at the buffer of the sending CAU from the sending CSU just before a PA-slot associated with the connection passes on the bus does not have to wait. At the receiving CAU, this octet has to wait the time D_p until it can be transmitted to the receiving CSU (because it is the last octet received in a PA-slot).

For octets in an intermediate position it is easily seen that the sum of the delays at the sending CAU and at the receiving CAU also equals D_p.

This shows that the unavoidable delay in fact equals D_p for all octets of a CBR connection.

This delay is a lower bound for the actual access delay. The latter one depends on the pattern with which PA-slots are generated and on additional processing delay, which in turn depends on the implementation.

A.2.1.3 Delay in a DQDB-DQDB bridge

At every bridge, an access delay is incurred which may assume any value between 125 µs and the packetisation delay with equal probability, even though the information has already been packetised. The reason for this is that the processes which generate PA-slots with given VCIs in the two subnetworks are not synchronised. When PA-slots for a given connection are generated with a fixed frequency (the inverse of the packetisation delay) then it may happen that such a PA-slot arrives at the bridge from subnetwork 1 just after a PA-slot arrived at the bridge from subnetwork 2, and then the access delay approaches the packetisation delay. This is illustrated in figure A.1. As the probability for this worst case is not negligible it is assumed for the following that the delay in a DQDB-DQDB bridge equals the packetisation delay.

```
subnetwork1 ─────┴────────────────────┴────────────────────┴───>
                 |                                              time
subnetwork2 ───┴─────────────────────┴────────────────────┴─────>
                 |<── access ──>|
                      delay
```

NOTE: In contrast to the above, in a pure ATM network the packetisation delay is incurred only once, namely at the access.

Figure A.1: Access delay in a DQDB-DQDB bridge

A.2.1.4 DQDB-ATM gateway

Direction DQDB to ATM:

No access delay is incurred as an ATM-cell may be sent as soon as it is filled. (It is assumed that the payload of a PA slot is mapped onto the payload of an ATM cell).

Direction ATM to DQDB:

Here, additional delay is unavoidable to compensate for ATM-cell jitter. It depends on the load of the ATM-network and on the number of queues along the route of the connection. A tight upper bound for a long-distance connection is 1,5 ms.

A tight upper bound for the cumulative processing delay in the ATM-nodes along a connection is 0,5 ms.

The access delay is as in DQDB-DQDB bridges.

A.2.2 End-to-end delays for CBR connections - some examples

In this subclause, two configurations including DQDB-subnetworks are considered, which are relatively simple and likely to occur in real situations:

- configuration 1 is a configuration where a near end and a far end TE are connected to two different public DQDB-MANs via a Private Branch Exchange (PBX), a private DQDB backbone and an access DQDB network. The two public DQDB MANs are linked via a DQDB-DQDB bridge;

- configuration 2 is the same configuration as configuration 1, however, for this configuration, the public MANs are linked via an ATM node.

The end-to-end delay (one way) for connections at 64 kbit/s, at 384 kbit/s and at 1 536 kbit/s is given in table A.3, with various end-to-end distances and for both configurations. For connections at 2 048 kbit/s, it is assumed that the additional constraint proposed in subclause A.2.3 is satisfied. Then their delay is bounded by that for connections at 1 536 kbit/s. Consequently, connections at 2 048 kbit/s are not included here.

Table A.2 below gives that part of the delay which is incurred in the CAU, in gateways or bridges.

The following delay components were taken into account:

Total delay over 2 ISPBXs: < 0,9 ms.

Propagation delay: 5 ms / 1 000 km.

Delay in ATM-network (without propagation delay): < 2 ms.

Access delays in CAU, bridges, gateways: see table A.2.

The following delay components were not taken into account:

- processing time in nodes of DQDB-subnetworks;

- phase synchronisation delay;

- delay at the interface between ISPBX and TE.

Table A.2: Cumulative delay in CAU, bridges, gateways

Configuration No.	bit rate of connection	delay
1 2	64 kbit/s 64 kbit/s	6 * 6 ms 6 * 6 ms
1 2	384 kbit/s 384 kbit/s	6 * 1 ms 6 * 1 ms
1 2	1 536 kbit/s 1 536 kbit/s	6 * 0,25 ms 6 * 0,25 ms

Table A.3: End-to-end delay

Configuration No.	bit rate kbit/s	distance km	delay ms
1 1	64 64	100 1 000	37,4 41,9
2 2	64 64	1 000 3 000	43,9 53,9
1 1	384 384	100 1 000	7,4 11,9
2 2	384 384	1 000 3 000	13,9 23,9
1 1	1 536 1 536	100 1 000	2,9 7,4
2 2	1 536 1 536	1 000 3 000	9,4 19,4

Tables A.2 and A.3 clearly show that voice connections at 64 kbit/s would be impossible without echo compensation, no matter what the end-to-end distance is.

For connections at 384 kbit/s, delay is still high and may be critical in cases like in configuration 1 (MAN-configuration).

Delay in the case of 1 536 kbit/s connections is not critical.

By our assumption above, delay in the case of connections at 2 048 kbit/s is always less than or equal to that for 1 536 kbit/s connections, hence is also not critical.

A.2.3 Access delay for CBR connections at 2 048 kbit/s

When frequency = (1, N) (i.e. when one slot is generated every N frames) the default variability V = 0 implies that PA slots associated with a given connection are generated at precisely regular intervals. This is not the case for frequency = (2, 3), equivalent to a data rate of 2 048 kbit/s as may be seen from figure A.2.

In figure A.2, three connections at 2 048 kbit/s are defined: one by the PA slots with VCI = C; one by those with VCI = D; and one by those with VCI = E. In all three cases, frequency = (2, 3) and V = 0, but the maximum access delay varies considerably.

In fact, in the case of VCI = C, an octet in the transmit buffer has to wait a maximum of 3 frames, equivalent to 375 µs. In the case of VCI = D, an octet in the transmit buffer has to wait a maximum of only 2 frames, equivalent to 250 µs. In the case of VCI = E, an octet in the transmit buffer has to wait a maximum of only 1,5 frames, equivalent to 187,5 µs.

As a reasonable compromise between reducing access delay and keeping bandwidth allocation simple, one may require as an additional constraint that all slots associated with a 2 048 kbit/s channel are generated at the same position, i.e. with the same slot number, in each frame. Then a maximum access delay of 250 µs could be guaranteed. This is for further study.

A.3 Feasibility of bandwidth allocation

Though not part of this ETS this Clause provides justification for the ETS by demonstrating how it may allow simple and efficient bandwidth management algorithms to be used. The following discussion assumes the use of the frequency parameters as defined in subclauses 7.2.1 and 7.2.3 and the default variability V = 0 as defined in subclause 7.2.2. Methods for managing CBR connections characterised by any other pair of frequency parameters (M, N) or with V > 0 are for further study.

A.3.1 Frame groups

Given the allowed values of the frequency parameters M and N, each CBR connection will have PA slots generated with a period of no more than 48 frames and the PA slots will be generated to fill the same slot number(s) in each period. Therefore, it is possible to represent any CBR connection by considering a group of 48 consecutive frames, or a frame group that repeats itself periodically. Figure A.1 shows a representation of such a frame group as a table, of matrix form, with slots for each frame numbered 1 to Max, where Max is the number of slots contained in a frame when slots do not cross frame boundaries, and Max is the number defined in subclause 7.2, when slots do cross frame boundaries. (Examples are Max = 9 for CCITT Recommendation G.703 at 34 Mbit/s, Max = 12 for DS-3 and Max = 43 for CCITT Recommendations G.707, G.708 and G.709 SDH based systems at 155 Mbit/s.)

Each entry contains the SL type of the corresponding slot (Queued Arbitrated (QA) or PA) and the VCI. The default value is SL type = 0 and VCI = 1 . . . 1 (i.e. the slot is a QA slot for use by the connectionless MAC service). The slot generation function reads this table row by row generating the slot headers with a period of 48 PLCP-frames, according to the information contained in this table (with some modifications for the PLCP for CCITT Recommendations G.707, G.708 and G.709 SDH based systems at 155 Mbit/s). In the example of figure A.2, the SL type and the default VCI are omitted.

For convenience, the frames in the frame group are numbered from 0 to 47. This numbering is arbitrary and is only used to help explain the concepts of bandwidth allocation discussed here.

In terms of the frame group, a 64 kbit/s channel is represented by any single slot position somewhere in the group. For example, if slot 1 of frame 1 is allocated to a 64 kbit/s connection with a VCI A, then the HOB will generate that slot with the VCI A in every frame group.

Similarly, a 1 536 kbit/s channel is represented by a series of 24 slots in a frame group. Given the frequency and variability constraints, these slots will appear in every second frame and always in the same slot number. Therefore, a 1 536 kbit/s connection with VCI B could be allocated slot Max-1 of all odd number frames (1, 3, 5, . . . ,47).

A 2 048 kbit/s channel is represented by a series of 32 slots in a frame group. In this case, two slots (with VCIs C, D or E) associated with the channel may be distributed arbitrarily within three consecutive frames. The frequency and variability constraints then imply that this pattern is repeated every three frames with exact periodicity (some modifications apply to the case of PLCP frames for CCITT Recommendations G.707, G.708 and G.709 SDH based systems at 155 Mbit/s). If the additional constraint proposed in subclause A.2.3 applies (namely that the two slots shall carry the same slot number) then the situation necessarily looks as represented by the slots with VCI D in figure. A.2.

Figure A.2 shows five connections as above represented in a frame group.

NOTE: All other slots not used by the PA slots are available for QA slots.

	1	2	....	Max/2	....	Max–1	Max
0	VCI C	VCI C		VCI E			VCI D
1	VCI A					VCI B	VCI D
2	VCI E						
3	VCI C	VCI C		VCI E		VCI B	VCI D
4							VCI D
5	VCI E					VCI B	
6	VCI C	VCI C		VCI E			VCI D
7						VCI B	VCI D
8	VCI E						
9	VCI C	VCI C		VCI E			VCI D
...							
46							
47	VCI E					VCI B	

Figure A.2: Frame group with five connections (see subclause A.3.1)

A.3.2 Valid connections in a frame group

Using the frame group, it is clear that only certain combinations of slot and frame numbers may be used for a given connection. First of all, each connection is required to have all slots allocated in the same slot number. For all basic data rates except 2 048 kbit/s this follows from the default variability constraint. For 2 048 kbit/s, we assume in this subclause that this has been imposed as an additional constraint as described in subclause A.2.3. After the particular slot number for a connection is selected, frame numbers shall be selected according to the following sets in order to meet the frequency requirements. It can be demonstrated that each set of frame numbers satisfies the frequency requirements and that the list is exhaustive for all basic data rates.

Table A.4

M	N	Data rate	Valid sets of frame numbers
1	48	64 kbit/s	any number 0-47
1	16	192 kbit/s	(k, k+16, k+32) for k=0, 1, ..., 15
1	8	384 kbit/s	(k, k+8, k+16, ..., k+40) for k=0,1,..., 7
1	4	768 kbit/s	(k, k+4, k+8, ..., k+44) for k=0,1,2,3
1	2	1 536 kbit/s	(k, k+2, k+4, ..., k+46) for k=0, 1
2	3	2 048 kbit/s	(0, 1, 3, 4, 6, 7, ..., 45, 46) or (1, 2, 4, 5, 7, 8, ..., 46, 47) or (0, 2, 3, 5, 6, 8, ..., 45, 47)

A.3.3 Bandwidth allocation algorithms

Using the frame group concept to describe the allocation of bandwidth to CBR connections, it is easier to discuss allocation algorithms. Here we consider a simple algorithm with acceptable results. More elaborate, still simple algorithms, which produce even better results, may exist.

A simple algorithm

Consider the five types of connections at less than 2 048 kbit/s. Each type of connection may be supported with more than one set of frame numbers according to subclause A.3.2. In fact, the number of possible sets for a given connection type is N and the N sets are disjoint. What this means is that, for any given slot number, if we restrict the CBR connections using that slot number to one particular type then we will be able to fit N such connections into that slot. As long as we select from the valid set of frame numbers, connections may be set up or taken down arbitrarily with maximum efficiency (i.e. considering only one slot and one connection type, up to N connections can always be accommodated without regard to the placement of each individual connection). Therefore, these connections will always be able to be packed in the optimal way using the slot number.

This property allows implementation of a simple algorithm for allocating bandwidth. When the first request for a connection arrives, the bandwidth manager arbitrarily designates one slot number (say 4) to hold that connection, and that slot number is marked with the type of the connection (say M=1, N=8). When another request arrives, the bandwidth manager will do one of two things. If the new request is of the same type as the existing connection, then it will be assigned to the same slot number. If not, a new slot number is designated (say 12) and marked with the type of the new connection (say M=1, N=2).

This procedure is extended in the same manner for each new connection. If an entire slot number is used up with a particular connection type, then another slot number may be designated for that connection type. If desired, limits may be put on the number of slot numbers that can be designated for any connection type, or on the overall bandwidth available for CBR connections.

Disconnections may also occur from time to time. If disconnections free up an entire slot number, then its designation for a particular connection type is removed. Disconnections may sometimes cause more than one slot number to be partially used for the same connection type, but in this case no rearrangement of the connections is attempted. The slots of those slot numbers not used for PA slots will still be available for QA slots.

For 2 048 kbit/s connections (M=2, N=3) one proceeds in a similar way. One slot number is used for this type of connection only, and one connection is assigned the same slot position number in all frames using one of the valid sets of frame numbers (assuming that the additional constraint on 2 048 kbit/s connections mentioned in subclause A.2.3 is satisfied). The slots of those slot numbers not used for PA slots will still be available for QA slots.

Compound data rates:

Bandwidth allocation for compound data rates consists of allocating bandwidths for two or more basic data rates using the same VCI (see subclause 7.2.4). Hence, the simple algorithm can be used also for compound data rates.

Annex B (normative): Protocol implementation conformance statement

B.1 Introduction

To evaluate conformance of a particular implementation, it is necessary to have a statement of which capabilities and options have been implemented for a given OSI protocol. Such a statement is called a Protocol Implementation Conformance Statement (PICS). The PICS can have a number of uses, including:

a) use by the protocol implementor, as a check-list to reduce the risk of failure to conform to the standard through oversight;

b) use by the supplier and acquirer, or potential acquirer, of the implementation, as a detailed indication of the capabilities of the implementation, stated relative to the common basis for understanding provided by the standard PICS proforma;

c) use by the user, or potential user, of the implementation; as a basis for initially checking the possibility of interworking with another implementation;

NOTE: While interworking can never be guaranteed, failure to interwork can often be predicted from incompatible PICS.

d) use by a protocol tester, as the basis for selecting appropriate tests against which to assess the claim for conformance of the implementation.

The supplier of a protocol implementation which is claimed to conform to this ETS, shall complete this PICS proforma.

B.1.1 Instructions for completing this PICS proforma

The supplier of a protocol implementation which is claimed to conform to this ETS shall complete a copy of the PICS proforma provided and shall provide the information necessary to identify both the supplier and the implementation in Clauses B.2, B.3, B.4, and B.5.

Clauses B.2 and B.3 have to be completed as indicated with the information necessary to identify fully the supplier or client, the implementation and the relevant protocol, including the versions supported, the amendments and corrigenda.

Clauses B.4 and B.5 are fixed-format questionnaires which are completed in the rightmost column by simply marking an answer to indicate a choice ("yes" or "no").

Clause B.4 can only be answered with "yes", if all mandatory capabilities and features in Clause B.5 have been answered with "yes".

Clause B.5 is divided into subclauses each containing a group of individual features. In the first column, "Item", each feature is identified by a number; the second column, "Feature", contains in a short form, the question to be answered; the third column, "Reference", contains the reference or references to the material that specifies the feature in the main body of this ETS; the forth column, "Status", specifies the status of the item, whether support is mandatory, optional, conditional, prohibited or not applicable; the fifth column, "Predicate", contains the reference item for conditional items; the sixth column, "Value", provides space to specify certain values of a feature; and the last column, "Support", provides space for the appropriate answer and for referencing to additional information.

A supplier may also provide, or be required to provide, further information, categorised as either additional information or exception information. When present, each kind of further information shall be provided in a further subclause of items labelled X<i> respectively for cross-referencing purposes; where <i> is any unambiguous identification for the item (e.g. simply a numeral). There are no other restrictions on its format and presentation.

B.1.2 Definitions

B.1.2.1 Status column notation

In this PICS proforma, the following abbreviations are used in defining the status type of a feature, parameter, or capability:

m	mandatory
o	optional
o.1	optional: support of at least one of the options with status o.1 is required
c	conditional
x	prohibited
-	not applicable

B.1.2.2 Support column notation

In this PICS proforma, the following abbreviations are used in defining the support of a feature, parameter, or capability:

y	yes
n	no

B.2 Identification of the Implementation

Implementation:

Version:

System in which the implementation resides:

Supplement information for full identification:

Relationship to the system conformance statement:

Supplier or client:

Address for queries about the PICS:

B.3 Identification of the protocol

Identification of the protocol specification:

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Protocol versions supported:

Identification of amendments and corrigenda to this PICS proforma which have been completed as part of this PICS:

B.4 Global statement of conformance

Have all mandatory capabilities in Clause B.5 been implemented?

Y[ ] N[ ]

NOTE: Answering "no" to the above question indicates non-conformance to the protocol standard.

B.5 Major capabilities and features

B.5.1 Properties of the PLCP

Table B.1

Item	Feature	Reference	Status	Predicate	Value	Support
7.1.1	PLCP-frame reception time	5	m		125 µs	Y[ ] N[ ]

B.5.2 Slot generation function at the HOB

Table B.2

Item	Feature	Reference	Status	Predicate	Value	Support
7.2.1	HOB supports PA slot generation	7.2	m			Y[ ] N[ ]
7.2.2	PA-slots do not cross PLCP-frame boundaries	5 and 7.2	m			Y[ ] N[ ]
7.2.3	Frequency parameters (M,N) supported by HOB	7.2.1	m o m o m m		(1,48) (1,16) (1,8) (1,4) (1,2) (2,3)	Y[ ] N[ ] Y[ ] N[ ] Y[ ] N[ ] Y[ ] N[ ] Y[ ] N[ ] Y[ ] N[ ]
7.2.4	Periodicity	7.2.1	m			Y[ ] N[ ]
7.2.5	Default variability	7.2.2	m		0	Y[ ] N[ ]
7.2.6	Basic Data Rates	7.2.3	m o m o m m		64 kbit/s 192 kbit/s 384 kbit/s 768 kbit/s 1 536 kbit/s 2 048 kbit/s	Y[ ] N[ ] Y[ ] N[ ] Y[ ] N[ ] Y[ ] N[ ] Y[ ] N[ ] Y[ ] N[ ]

Remark: 7.2.6 is a consequence of 7.2.3.

B.5.3 Functions at a DQDB node supporting a CBR interface

Table B.3

Item	Feature	Reference	Status	Predicate	Value	Support
7.3.1	CAU preserves octet sequence integrity	7.3.1	m			Y[ ] N[ ]
7.3.2	Transmit table associates each connection end-point identifier with a pair (bus, VCI)	7.3.3	m			Y[ ] N[ ]
7.3.3	Receive table associates each connection end-point identifier with a pair (bus, VCI)	7.3.3	m			Y[ ] N[ ]
7.3.4	PA segment header vali-dation using HCS	8.1.1.4	m			Y[ ] N[ ]
7.3.5	Transmit buffer in CBR Convergence transmit functions block	7.3.4.1	m			Y[ ] N[ ]
7.3.6	Actions on transmit buffer underflow/over-flow	7.3.4.1	m			Y[ ] N[ ]
7.3.7	Receive buffer in CBR Convergence receive functions block	7.3.4.2	m			Y[ ] N[ ]
7.3.8	Actions on receive buffer underflow/over-flow	7.3.4.2	m			Y[ ] N[ ]
7.3.9	125 µs-clock at CCF block derived from Ph-TIMING-MARK indication	7.3.4.2	m			Y[ ] N[ ]

Remark: Items 7.3.2 and 7.3.3 jointly realise dedicated slot-switching as in subclause 7.1 of this ETS.

B.5.4 Protocol Data Unit (PDU) format

Table B.4

Item	Feature	Reference	Status	Predicate	Value	Support
7.4.1	PA-slot format as in IEEE Standard 802.6 [2], section 6.2	8.1	m			Y[ ] N[ ]
7.4.2	PA-segment format as in 8.2	8.2	m			Y[ ] N[ ]

B.5.5 DQDB layer management service in support of CBR connection type

Table B.5

Item	Feature	Reference	Status	Predicate	Value	Support
7.5.1	LM-Action invoke/reply (OPEN_CE_CCF) as described in 10.	10	m			Y[ ] N[ ]
7.5.2	LM-Action invoke/reply (CLOSE_CE_CCF) as described in 10.	10	m			Y[ ] N[ ]
7.5.3	LM-Action invoke/reply (PA_VCI_ADD_HOB) as described in 10.	10	m			Y[ ] N[ ]
7.5.4	LM-Action invoke/reply (PA_VCI_DEL_HOB) as described in 10.	10	m			Y[ ] N[ ]

Annex C (informative): Bibliography

The following documents are used for informative purposes within this ETS.

CCITT Recommendation G.703 (1991): "Physical/electrical characteristics of hierarchical digital interfaces".

CCITT Recommendation G.707 (1991): "Synchronous digital hierarchy bit rates".

CCITT Recommendation G.708 (1991): "Network node interface for the synchronous digital hierarchy".

CCITT Recommendation G.709 (1991): "Synchronous multiplexing structure".

CCITT Recommendation H.221 (1990): "Frame structure for a 64 to 1920 kbit/s channel in audiovisual teleservices".

CCITT Recommendation H.261 (1990): "Video codec for audiovisual services at p x 64 kbit/s".

CCITT Recommendation I.321 (1991): "B-ISDN protocol reference model and its application".

CCITT Recommendation I.362 (1991): "B-ISDN ATM adaption layer (AAL) functional description".

CCITT Recommendation I.363 (1991): "B-ISDN ATM adaption layer (AAL) specification".

ISO/IEC 9646-2 (1991): "Information technology - Open systems Interconnections - Conformance testing methodology and framework - Part 2: "Abstract test suite specification (see also CCITT Recommendation X.290 (1988))".

ISO/TR 8509 (1987): "Information processing systems - Open Systems Interconnection - Service conventions".

EWOS/ETSI PT 5 (1990): "Technical Report on OSI conformance testing methodology and procedures in Europe".

ISO/IEC JTC 1/SC 21 N5078 (1990): "Catalogue of PICS proforma notations".

ETSI Technical Report TE 10.05: "Overall Transmission Plan Aspects of a Private Branch Network for Voice Connections with Access to the Public Network".

History

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