CCITT SGXV
Working Party XV/I
Experts Group for ATM Video Coding

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SOURCE : Japan
TITLE : VBR coding under Usage Parameter Control
PURPOSE : Discussions

1. Introduction

Any practical VBR coding scheme must consider Usage Parameter Control imposed by the network. In this document one possible method of UPC is first described as information. Then its implications to VBR coding are discussed.

A demonstration tape is provided which compares VBR and CBR coding.

2. Usage Parameter Control

The following is a brief summary of one of the possible methods of UPC being discussed in CCITT SG XVIII. Note that the particular values used in this section are only to provide examples.

The part of the scheme is more fully described in Annex 3.

Call acceptance

Assuming the maximum available bandwidth of 150 Mbps:

- Peak $\leq$ 1.5Mbps $\Rightarrow$ Call acceptance by considering Mean only
- Peak = 1.5Mbps to 15Mbps $\Rightarrow$ by considering both Mean and Peak
- Peak $\geq$ 15Mbps $\Rightarrow$ Call acceptance by considering Peak only

Definition of Peak rate

- T_0 = minimum time between the two adjacent cells,

Average rate

- T_1 = time interval selected in such a way that autocorrelation for two adjacent time intervals T_1 is small enough,
- X_1 = maximum number of cells during T_1
- it is further suggested that T_1 is N times the integer multiple of T_0, where possible values of N is somewhere between 2^{10} and 2^{20}.

(i.e., T_1 = 280ms to 290sec   if Peak = 1.5Mbps, and
T_1 = 28ms to 29sec   if Peak = 15Mbps)

3. Discussions

Averaging window size

It is evident that if the averaging window size, T_1, is too small, eg. 1 frame interval, the advantage of VBR coding should be very limited. Therefore, it is necessary to clarify the relationship between the window size and the resulting advantage and to give that information to SG XVIII.

Coding parameter control under UPC

Assume some averaging window size is defined by the network for a particular peak rate. It is then necessary for a VBR encoder to establish a coding parameter control scheme that most utilize the VBR nature of the network. Some of the points are:

- An encoder must keep the actual average bit rate less than the declared average for the most of the time and save the bit amount for the future.
- Average bitrate monitoring at the encoder may have to use a moving window, if the timing information of monitoring by the network is not provided.
- The saved bit amount will be lost, if it is not used in the time interval corresponding to the window size.

In discussing the advantage of VBR coding, a coding parameter control scheme must consider the above mentioned details. Some guideline is required that all the simulation work for VBR coding will surely include a mechanism to meet the assumed UPC. An example scheme is described in Annex 2 to this document.

CBR coding as a special case of VBR coding

It is desirable to have a system which include CBR coding as a special case of VBR coding. Such system will provide flexibility in using ATM networks, in which the superiority between VBR and CBR may change according to the user requirement or future network growth.

End-to-end delay

VBR coding may offer smaller end-to-end delay, and this point, though neglected in most demonstration tapes, should be properly weighed in evaluating the subjective quality of VBR coded video. Studies are encouraged to reveal the relationship between the delay and the employed VBR coding scheme, putting special attention on the ratio of Peak to Mean bitrate.

4. Conclusion

VBR coding under UPC is discussed, and necessary future study is suggested.

Annex 1

Comparison of the image quality of VBR and CBR (with a demonstration tape).

Annex 2

An example coding scheme that meets UPC.

Annex 3

D. 1069 "Proposed user-declaring parameters for source traffic characteristics," by NTT submitted to CCITT SGXVIII meeting in Matsuyama (Nov. 26 to Dec. 7, 1990).

Comparison of the image quality of VBR and CBR
(with a demonstration tape)

SIMULATION CONDITIONS

Average bit rate : 10Mb/s within 0.5 second moving window without peak bit rate limitation.

Coding algorithm : Odd and even field are coded independently in 2 layered sub-band coding.

* Lower frequency (9.5Mb/s) : VBR: SM3 in MPEG1 under GOP=15; CBR: RM8 without loop filter
* Higher frequency (0.5Mb/s) : VBR: PCM; CBR: PCM

The same algorithm is used in VBR and CBR for higher frequency components.

Refresh frame : One frame within each 15 frames is coded in intraframe prediction considering distributive and retrieval services.

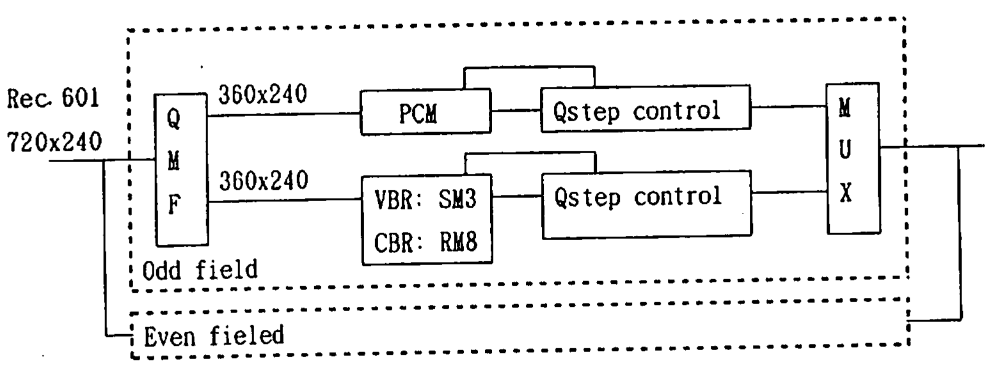


Fig. 1 Block diagram of coding algorithm

RESULT

SNR is shown in Table 1 and the image quality will be demonstrated by VTR.

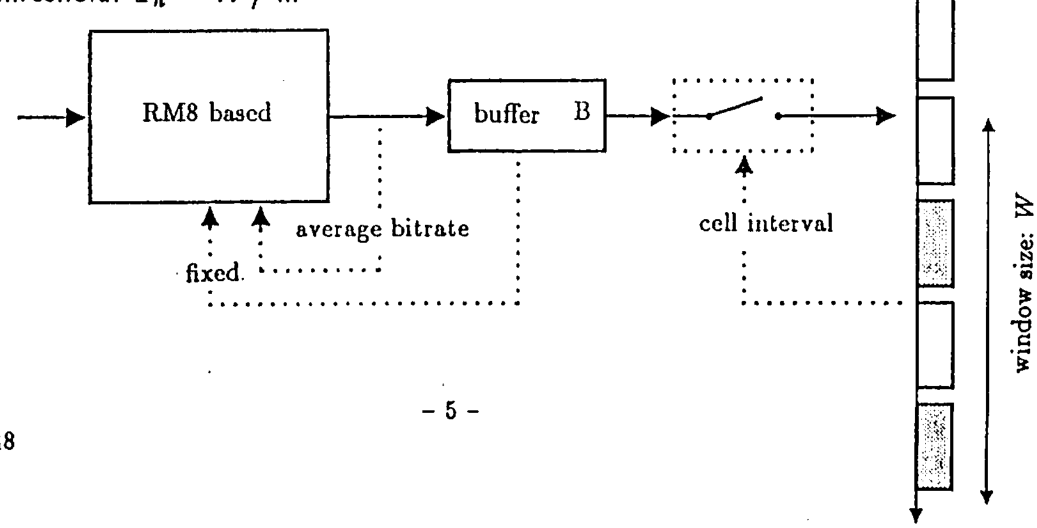
Table 1 SNR of VBR and CBR (dB)

		VBR	CBR
Flower garden	Lower freq.	35.18	33.25
	Higher freq.	36.44	36.44
	Total	31.97	30.77

Annex 2 to Document AVC-48

<u>An example coding scheme that meets UPC</u>

1. a VBR coder is RM8 based, and its (longterm) average bitrate is controlled through BOC with a buffer size as an parameter to determine its peak to mean ratio.
2. if $B_r \geq k \cdot B$, where B_r is the current buffer occupancy, B the buffer size, and $0 \leq k \leq 1$, the following macroblocks are fixed.
3. if $B_r \geq p$, where p = cell payload length, then a cell is sent with the minimum cell interval of d.
4. for each stepping widow of the size W, the number of the valid cells is counted, and if it is greater than T_h, then no more cells will be sent until the next stepping window comes.
5. computer simulation is done with the minimum time interval equivalent to one macroblock.
6. Parameters
   - line speed: C = 150.96 Mbps.
   - cell length: L = 53 byte.
   - cell payload length: p = 45 byte.
   - picture format: CIF (396 macroblocks / flame, 29.97 Hz.)
   - macroblock interval: T_0 = 1 / (396 x 29.97) = 30 T_c.
   - cell interval: T_c = L / C.
   - average bitrate: V_m = (C x p) / (L x n), given by n.
   - peak bitrate: V_p = (C x p) / (L x d), given by d.
   - window size: W, an integer multiple of 30.
   - window time: T_w = W x T_c.
   - threshold: T_h = W / n.



International Telegraph and Telephone Consultative Committee (CCITT)

Delayed Contribution No. D.1069

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Questions : 2,13/XVIII

Original : English

Date : 26 Nov. - 7 Dec., 1990

STUDY GROUP XVIII - CONTRIBUTION No. D.1069

SOURCE : NIPPON TELEGRAPH AND TELEPHONE CORPORATION (NTT)

TITLE : PROPOSED USER-DECLARING PARAMETERS FOR SOURCE TRAFFIC CHARACTERISTICS

Abstract - This contribution proposes following two points.

(1) User-declaring parameters for source traffic characteristics should express the cell stream behavior as seen by the ATM layer entities.

(2) Those parameters should be expressed by four parameters which are two kinds of time intervals (T0),(T1) and maximum numbers of cells (X0),(X1) sent on the same connection during each time interval (T0),(T1), respectively. These parameters should be applied commonly to a virtual channel (VC) and a virtual path (VP).

1. Introduction

In the section 2.4 of the draft Recommendation I.211, it is described that variable bit rates may be expressed by two parameters, a peak bit rate (Rp) measured over a short period of time (Ts), and a mean bit rate (Rm) measured over a longer period of time (T_L). On the other hand, in the section 1.1 of the draft Recommendation I.311, it is described that the traffic characteristics used may include measures that describe peak rate, average rate, burstiness and peak duration.

User declaring parameters expressing source traffic characteristics should be studied urgently so that they are included in 1992 recommendations which enable broadband signalling and the usage parameter control.

This contribution proposes specific user-declaring parameters which express source traffic characteristics as seen in the ATM layer.

2. Proposal

2.1 Proposed user-declaring parameters

Proposed user-declaring parameters are indicated in Fig.1. Peak rate should be expressed by a short time interval (T0) and the muximum number of cells (X0) sent during the time interval (T0). Average rate should be expressed by a time interval (T1) and the muximum number of sending cells (X1) during the time interval (T1). (T0) is normalized by cell sending time interval. (T1) is normalized by the time interval (T0). These parameters should be applied commonly to a virtual channel (VC) and a virtual path (VP).

2.2 Basic concepts

Basic concepts behind the proposal are as follow.

(1) Two kinds of traffic rates, peak rate and average rate, should be expressed.

(2) Burst length is expressed indirectly by the average rate. Refer to section 4.2 for detail.

(3) User-declaring parameters should be expressed with deterministic factor, so that the cell sending control at TE and the usage parameter control in the network can take place with no ambiguity. (See [1],[2])

3. Discussion

There are several reasons for proposing user-declaring parameters to be expressed by characteristics in the ATM layer.

3.1 Reasons for proposed parameters expresing ATM layer characteristics

Both the cell sending control in the terminal and the usage parameter control in the network are performed as the ATM layer functions. When user-declaring parameters express the traffic characteristics as seen in the higher layer, translation functions (f1) and (f2) shown in Fig.2-(a) are necessary. When these functions (f1) and (f2) are different, qualities requsted by the user can't be assured by the network. It is therefore necessary that (f1) and (f2) are the same. In this case, these functions might have to be standardized. On the other hand, as indicated in Fig.2-(b), if ATM layer parameters are used, these translation functions need not be standardized. The translation function f1 is needed in both cases as shown in Fig.2-(a) and (b), while (f2) is needed only in Fig.2-(a). Consequently, it is propoed that user-declaring parameters are expressed by characteristics in the ATM layer.

3.2 The comparison with the case of declaring communication speed

With our proposed parameters, one communication speed is expressed using two parameters: length of the time interval (T) and the number of cells (X) send during time interval (T).

The value of the time interval (T) should be selected taking the burst length into account. (cf. section 4.2) If the value of (T) is fixed, the flexibility of communication speed which user can select will be missed. This consideration tells us a drawback of the alternative method in which user tells the value of the peak and average communication speeds. The alternative is unable to choose preferable value of (T).

3.3 The comparison with the case of declaring service type

Another alternative for expressing source traffic characteristic is to indicate the service type to which unique values of T0, T1, X0, X1 are assigned. This alternative does not flexible enough to meet the growing and diversified demand for broadband communication services.

4. Examples of user-declaring parameter value selection

4.1 Peak rate

Paek rate is expressed as follow.

Likely choice : T0 = The minimum time interval of two adjacent cells on the same connection

X0 = 1

Other choice : T0 = The minimum time interval of sending n cells on the same connection

X0 = n (integer)

An example of the peak rate expression method is described in APPENDIX A.

4.2 Average rate

Preferable choice of the average rate parameters are as follow.

T1 = The time interval which corresponds to the time interval between two bursts on the same connection, or the time interval which is selected in such a way that autocorelation for two adjacent time intervals T1 is small enough.

X1 = the muximum number of sending cells during the time interval (T1)

An example of the average rate expression is indicated in APPENDIX B.

4.3 The burst length expression

As described in section 4.2, the burst legth can be expressed using T1 parameter.

It is recommended that the parameter (T1) should be larger than burst length. Otherwise the selected average rate will become equal to peak rate.

4.4 Variety of communication speed

(1) A large number of communication speeds should be available. Table A-3 in APPENDIX A shows the describing capability of the described method.

(2) Communication speeds of existing services, e.g. 64Kb/s, 384Kb/s and 1536Kb/s etc., should be available in B-ISDN network. But it is difficult to support these communication speed exactly in B-ISDN network for the reason that throughputs dedicated to meta-signalling, signalling and OAM are not specified so far. However, it will be possible to offer the communication speeds higher than but almost the same as the required communication speeds.

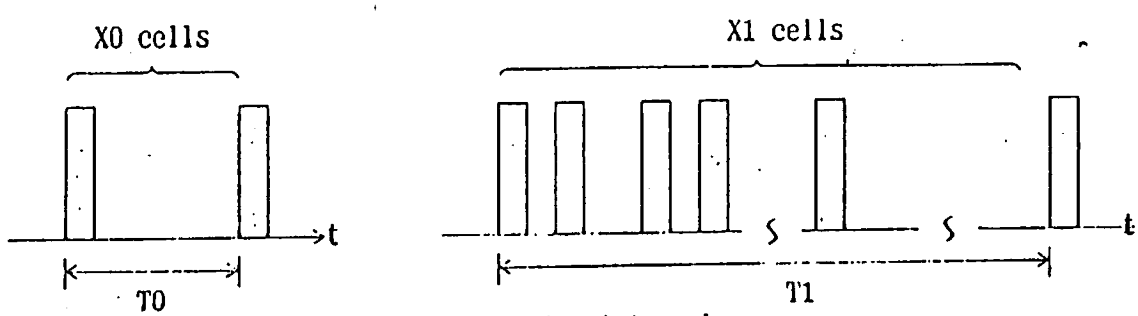
5. Conclusion

User-declaring parameters T0, T1, X0 and X1 for source traffic characteristics in the ATM layer are proposed.

References

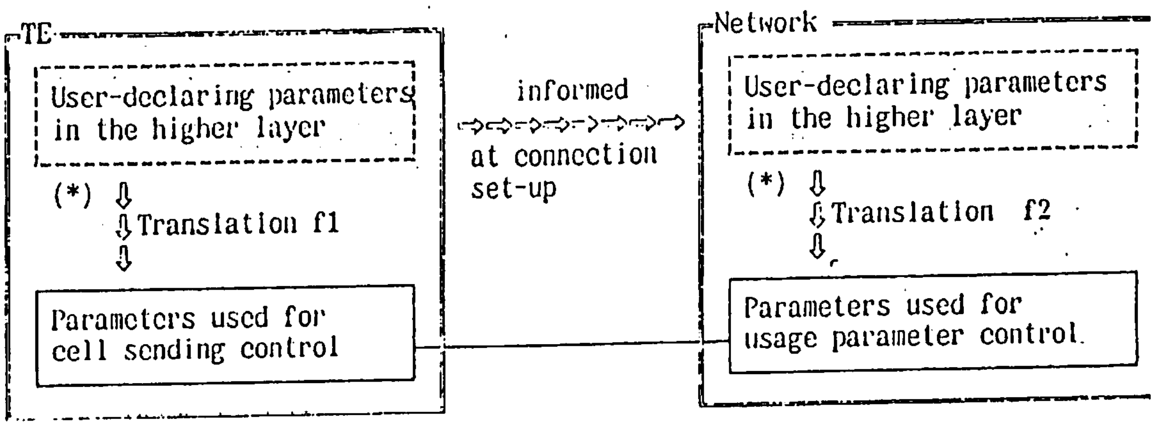
[1] Delayed Contribution No. D.0604/XVIII, January 1990, "Proposed user-declaring parameters for for source traffic characteristic" (Source: NTT).

[2] Delayed Contribution No. D.0908/XVIII, May 1990, "Proposed user-declaring parameters for for source traffic characteristic" (Source: NTT).



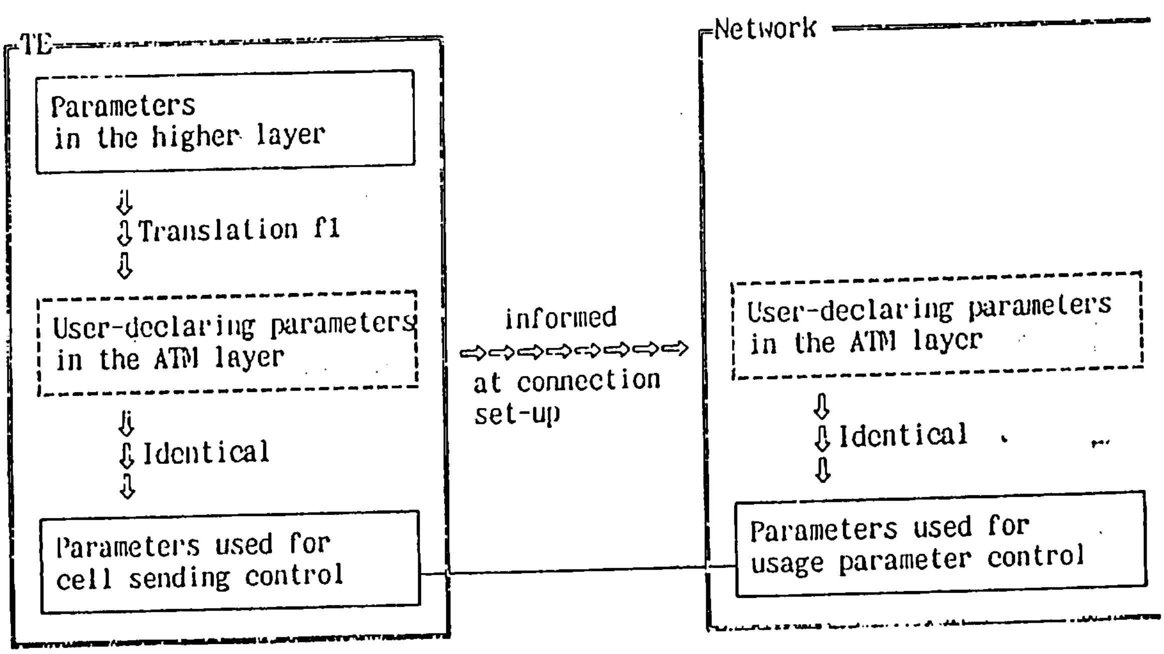
*1: T0 is normalized by cell sending time interval.
*2: T1 is normalized by the time interval T0.

Fig. 1 Proposed user-declaring parameters



* : It is necessary that f1 equals to f2.

(a) The case of informing as higher layer parameters



(b) The case of informing as ATM layer parameters

Fig. 2 Translation functions

A. Examples of peak rate expression method

A.1 Expression of X0

X0 is expressed by 4bits, allowing X0=1, ···, 15. [Fig. A-1]

Likely choice is X0=1.

	3	2	1	0
Example value	0	0	0	1

(1) The likely choice is X0=1.

FIG. A-1 Describing bits for X0

A.2 Expression of T0

T0 is expressed with the three-bit-length window (A1, A2, 1) floating in 16 bits as indicated below (Fig. A-2).

Likely choice is A1=A2=0.

3 bits window ⇦ ⇨

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Example value	0	0	0	0	0	0	A1	A2	1	0	0	0	0	0	0	0

In this case P=7, where P is 3 bit window's position

(1) T0 is expressed by three-bits-length window floating in 16bits.
(2) User can select T0 derived by the following formula.
$T0 = 2^{P} + A1 \times 2^{P+1} + A2 \times 2^{P+2}$
(3) (A1, A2, 1)=(001, 011, 101, 111)
The likely choice is A1=A2=0.

FIG. A-2 Describing bits for T0

A.3 Variety of peak rate

Users can select a peak bit rate out of 56 kinds, at most, of peaks bit rate in case of X0=1. Candidate peak rates in 155.52Mb/s interface are indicated in Table A-3.

Exact rate depends on actual throughput available to a user excluding throughput for OAM and signalling cells.

Table A-3 Example of peak rates

p	A1	A2	T0	Peak rate H4/n×X0
1	0	0	1	135.0 Mb/s
	1	0	3	45.0 Mb/s ×X0
	0	1	5	27.0 Mb/s ×X0
	1	1	7	19.3 Mb/s ×X0
2	0	0	2	67.5 Mb/s ×X0
	1	0	6	22.5 Mb/s ×X0
	0	1	10	13.5 Mb/s ×X0
	1	1	14	9.6 Mb/s ×X0
3	0	0	4	33.7 Mb/s ×X0
	1	0	12	11.2 Mb/s ×X0
	0	1	20	6.7 Mb/s ×X0
	1	1	28	4.8 Mb/s ×X0
4	0	0	8	16.8 Mb/s ×X0
	1	0	24	5.6 Mb/s ×X0
	0	1	40	3.3 Mb/s ×X0
	1	1	56	2.4 Mb/s ×X0
5	0	0	16	8.4 Mb/s ×X0
	1	0	48	2.8 Mb/s ×X0
	0	1	80	1.6 Mb/s ×X0
	1	1	112	1.2 Mb/s ×X0
6	0	0	32	4200 Kb/s ×X0
	1	0	96	1400 Kb/s ×X0
	0	1	160	840 Kb/s ×X0
	1	1	224	600 Kb/s ×X0
7	0	0	64	2100 Kb/s ×X0
	1	0	192	700 Kb/s ×X0
	0	1	320	420 Kb/s ×X0
	1	1	448	300 Kb/s ×X0
8	0	0	128	1054 Kb/s ×X0
	1	0	384	351 Kb/s ×X0
	0	1	640	210 Kb/s ×X0
	1	1	896	150 Kb/s ×X0
9	0	0	256	527 Kb/s ×X0
	1	0	768	175 Kb/s ×X0
	0	1	1280	105 Kb/s ×X0
	1	1	1792	75 Kb/s ×X0
10	0	0	512	263 Kb/s ×X0
	1	0	1536	87 Kb/s ×X0
	0	1	2560	52 Kb/s ×X0
	1	1	3584	37 Kb/s ×X0
11	0	0	1024	131 Kb/s ×X0
	1	0	3072	43 Kb/s ×X0
	0	1	5120	26 Kb/s ×X0
	1	1	7168	18 Kb/s ×X0
12	0	0	2048	64 Kb/s ×X0
	1	0	6144	21 Kb/s ×X0
	0	1	10240	13 Kb/s ×X0
	1	1	14336	9 Kb/s ×X0
13	0	0	4096	32 Kb/s ×X0
	1	0	12288	10 Kb/s ×X0
	0	1	20480	6 Kb/s ×X0
	1	1	28672	4 Kb/s ×X0
14	0	0	8192	16 Kb/s ×X0
	1	0	24576	5 Kb/s ×X0
	0	1	40960	3 Kb/s ×X0
	1	1	57344	2 Kb/s ×X0

1) It is assumed tentatively that payload which excludes the capacity of the meta-signalling, sinnalling and OAM is 135.00Mb/s.

2) The likely choices X0=1, A1=0 and A2=0 are shown with shadow.

APPENDIX B

B. Examples of average rate expression

B.1 Expresion of T1

T1 which is normalized by the time interval T0 described in APPENDIX A is expressed by the same method as that for the peak rate expression described in Fig. A-2 in APPENDIX A.

B.2 Expresion of X1

X1 is expressed by 16bits, allowing X0=1, ···, 65536. [Fig. B-1]

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Example value	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

FIG. B-1 Describing bits for X1

B.3 Variety of average rate

In data communications, cell sending timing can be delayed. Therefore, larger T1,X1 values can be selected by users. Data terminals easily control sending of cells depending on these T1,X1 values.

In voice or video communications, such delay-based cell sending control as in data communications is not desirable. Users will have to choose T1,X1 values which expresse the source traffic characteristics in good approximation. One example of deriving such suitable T1,X1 values is as follows:

The time interval T1 is selected to correspond to the time interval between two generating bursts on the same connection, or T1 is selected in such a way that autocorelation for two adjacent time intervals of length T1 is small enough. The T1 value as well as X1 value depend on the coding algolithm and scene patterns, etc.

B.4 Examples of T1 and X1 values

B.4.1 Example 1

When peak rate is 64Kb/s, average rate is 32Kb/s and the muximum burst length is 420msec (64cells) in 155.52Mb/s interface, following T0, X0, T1 and X1 values can be selected as indicated in Fig.B-2.

T0	2048	[P=12, A1=0, A2=0 in the table A-3]
X0	1	

T1	128	[P=8, A1=0, A2=0 in the table A-3]
X1	64	

Here, T0=2048 is derived from the peak rate 64Kb/s by using Table A-3.
X1=64 is derived from the muximum burst length 420msec (64cells).
T1=128 is derived from X1 and the ratio of average rate to peak rate.
(T1=X1 × the ratio of average rate to peak rate)

Fig.B-2 Example 1

B.4.2 Example 2

When peak rate is 45Mb/s, average rate is 10Mb/s and the muximum burst length is 20msec (2275cells) in 155.52Mb/s interface, following T0, X0, T1 and X1 values can be selected as indicated in Fig.B-3.

T0	3	[P=1, A1=1, A2=0 in the table A-3]
X0	1	

T1	10240	[P=12, A1=0, A2=1 in the table A-3]
X1	2275	

Here, T0=3 is derived from the peak rate 45Mb/s by using Table A-3.
X1=2275 is derived from the muximum burst length 20msec (2275cells).
T1=10240 is derived from X1 and the ratio of average rate to peak rate.
(T1=X1 × the ratio of average rate to peak rate)

Fig.B-3 Example 2