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GENERIC TRAFFIC DESCRIPTORS IN MANAGING SERVICE QUALITY IN BISDN/ATM NETWORK

ABSTRACT

Traffic models for multiservice broadband networks differ significantly regarding simple analytic models applicable in telephone traffic and circuit-switch network. The paper presents a clear analysis of standardised traffic descriptors and quality parameters of the main services in BISDN/ATM. Traffic descriptors have been associated with the basic values and concepts developed within generic traffic theory. Part systematisation of traffic parameters has been performed as basis for formalised generalised description of parameters and effective quality management of ATM services.

KEY WORDS

traffic, teletraffic theory, BISDN/ATM, network service, quality

1. INTRODUCTION

In describing the traffic phenomenon and modelling of telecommunication systems it is possible to use a series of generic traffic notions and values that are at a generalised level common to all traffic systems, that is, transport and telecommunication systems. The establishment of generic theory of traffic is a generation task and a necessary condition for true foundations of transport sciences [1], [3]. Following these tendencies the subject of this paper is limited to the analysis of traffic descriptors that have been standardised (by ITU-T and ATM-Forum) for B-ISDN/ATM and study of their relation to the generic traffic terms.

The initial thesis is that it is possible to establish coherent conceptual associations between traffic descriptors for B-ISDN/ATM and generic traffic values, which contain a certain explorative and predicative capability. In order to establish such associations, it is necessary to carry out a systemic analysis of the current standardised descriptions of traffic descriptors and parameters/quality attributes of ATM services. Such analysis forms the basis for carrying out synthesis at a generalised level in accordance with the requirements of generic theory of traffic.

Research presented in this article is based on references [5], [6], [7], and previous works and actual research performed by the author [3]. Traffic descriptors of ATM network are specially analysed and systematised as well as relations between them. Practical application of the given concept is possible in the development of an integral quality management of ATM services.

2. APPROACH TO SYSTEMIC QUANTITATIVE DESCRIPTION OF ATM TRAFFIC

The objective of teletraffic theory is to offer generalised explanations of traffic phenomenon and to offer mathematised models that will enable:
- precise description and measurement of traffic,
- effective system design,
- traffic flows management, etc.

For teletraffic performed in classic telephone circuit-switched networks under stationary conditions, a simple expression for the traffic intensity or traffic load may be used:

$$A=\lambda \cdot T_S \quad \text{[Erl.]}$$

where:

λ – number of calls (connections) in the unit of time,

T_S – mean holding time,

A – traffic in Erlangs.

Different forms of telecommunication traffic are carried out by means of ATM network and these result from different forms of services (voice, data, fax, video, etc.) with different requirements regarding the bandwidth, delay, bit error rate (BER), etc. In order to use the simplified analytical models a possible approach is to define the traffic classes [8].

The advantages of such approach include:
- one set of parameters for a single class is sufficient,
- a single QoS per class is used,

- traffic buffering and management is done for each class separately,
- priorities may be respected.

The given approach has disadvantages because adequate parameters for single traffic modes (e.g. video traffic) have not been developed and there are problems in parallel association of certain transport modes.

The developed Markov's and non-Markov's models from the queuing theory allow description of buffer influence on the traffic flows [1]. However, a number of other questions regarding precise description of traffic flow, bundling, service quality, required capacities, allowed errors, etc. remain unanswered. Following the tendencies of systemic description of traffic in ATM (BISDN) network, we tend to introduce generic traffic descriptors related to the basic issues of service quality management.

3. ATM TRAFFIC PARAMETERS

Systemic approach to the study of ATM parameters requires identification of relevant ATM traffic parameters and the relations between them from a certain viewpoint. ATM traffic parameters are closely connected to the type of service and requirements of the transfer quality. Concrete traffic parameters are subject of contract between the user and the network. Traffic contract between the user and the network is negotiated by specifying characteristics of the user information, requirements regarding allowed network delay and transfer quality that should be supported by the ATM network. If the user does not comply with the contracted obligations, e.g. if too many cells are sent over a certain time, then the network operator can undertake action to neutralise the negative effects to other connections in the network.

Relevant traffic characteristics of user information are specified in the ATM source traffic descriptor. While connecting to source traffic descriptor (STD) a set of ATM traffic parameters is specified which can be formally described by the following notation:

$$STD_{ATM} = \\ = (ATY , PCR , ACR , MBS , MCR , R_{STP}) \quad (1)$$

where:

ATY – source type or application which generates traffic,

PCR – peak cell (generating) rate,

ACR – average cell (generating) rate,

MBS – maximum burst size,

MCR – minimum cell rate,

R_{TSP} – relations between parameters $STP_{ATM.}$

There is a distinction between source traffic descriptors (STD) and connection traffic descriptors (CTD) since STD originate from the end station call request whereas CTD are established at the switching node. The causes and variations of delays are:

- statistical multiplexing on bearer circuits,
- holding in ATM switching,
- network management cell insertion,
- "physical overhead in the lowest level of ATM".

When cells from several ATM connections are multiplexed to the common link, then the cells of one connection can wait due to cell insertion of the other connection. Similarly, some cells can have a delay due to the insertion of management (OAM) cells. This results in the introduction of a component in cells delay which can lead to problematic delay and special delay hesitation.

A parameter expressing cell delay variation and tolerance (CDTV) is set at the ATM switching node. The application can require guaranteed limits of variations or specified tolerance.

Connection traffic descriptors (CTD) necessarily include CDTV so that in formal expression the following holds:

$$CDT_{ATM} = (STD_{ATM} , CDTV , R_{CTD}) \quad (2)$$

where:

STD_{ATM} – source traffic descriptor,

CDTV – cell delay variation and tolerance,

R_{CTD} – relations between CTD parameters.

Not all the indicated traffic parameters are always relevant for all categories of services. Only PCR is used in all types of ATM services (according to ATM-Forum):

- CBR (*Constant Bit Rate*), corresponding to A service class;
- VBRrt (*Variable Bit Rate, real-time*), corresponding to B service class;
- VBRnrt (*Variable Bit Rate, non-real-time*) corresponding to C and D service class;
- UBR (*Unspecified Bit Rate*);
- ABR (*Available Bit Rate*);
- GFR (*Guaranteed Frame Rate*).

Other traffic parameters are not used in all types of services, e.g. ACR is used only for VBRrt and VBRnrt; parameter MCR is used for ABR and GFR services [7], [8].

4. SYSTEMATISATION AND FORMALISED DESCRIPTION OF THE QUALITY OF SERVICE (QOS) PARAMETERS

What the user considers important is the initial division of service quality parameters into:

- QoS parameters - "negotiable",
- QoS parameters - "non-negotiable".

The "negotiable" quality of service parameters can be formally expressed by:

$$QP_{NG} = (CLR , CTDmax , CDVptp , R_{QP}) \quad (3)$$

where:

QP_{NG} – *Negotiable QoS Parameters*,

CLR – *Cell Loss Ratio*

CTDmax – *Maximum Cell Transfer Delay*

CDVptp – *peak-to-peak Cell Delay Variation*

R_{QP} – relation between parameters.

"Non-negotiable" quality parameters can be formally represented by the expression:

$$GP_{NN} = (CER , SECBR , CMR , R_{QP}) \quad (4)$$

where:

QP_{NN} – *Non-negotiable QoS Parameters*

CER – *Cell Error Rate*

SECBR – *Severely Errored Cell Block Rate*

CMR – *Cell Misinsertion Rate*

CLR is defined as the ration of the number of lost cells (failed delivery) to the total number of transmitted cells on the virtual channel / route (VC/VP), i.e. it holds:

$$CLR = \frac{\text{Lost cells}}{\textit{Total transmitted cells}} \quad (5)$$

Graphical illustration of the CLR problem is given in Figure 1.

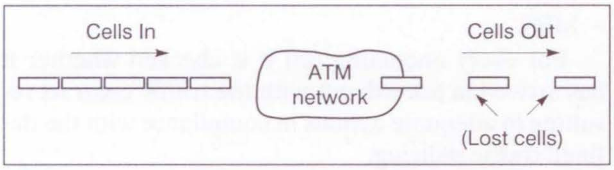

Figure 1 - Graphical illustration of CLR problem

Cell transfer delay is the time of cell passing through the network as indicated in Figure 2.

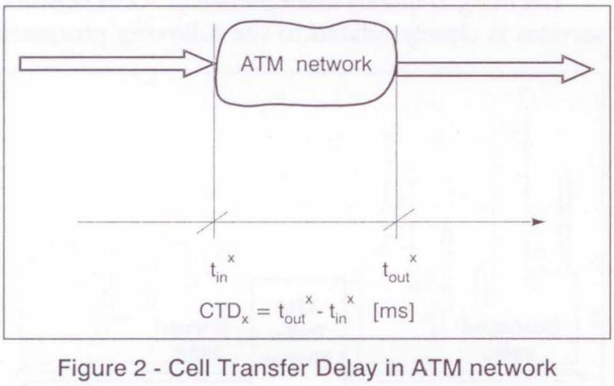

Figure 2 - Cell Transfer Delay in ATM network

Cell transfer delay components (CTD) include:

- propagation delay,
- transmission delay,
- switching delay,
- waiting for the service.

The parameter of max. CTD describes maximal time of cell transfer or delay that may still be accepted regarding service requirements. Cells that arrive after max. CTD are useless for further application and may be rejected.

Cell delay variation (CDV) indicates the deviation from the actual cell delivery time and the expected cell delivery time. The CDVptp (*peak-to-peak* CDV) parameter is the difference between the maximum CDV and minimum CDV. Delay variations are influenced by the following factors:

- traffic overload,
- ATM switch design,
- buffer capacity,
- number of nodes on the transfer route.

The scope of CDV values which is contracted ranges from 19 ms to 655350 ms, in increments of 10 ms.

The "non-negotiable" parameters are set by the network operator taking into consideration the service requirements.

Relative frequency of cells that have been transferred with an error (CER – *Cell Error Rate*) is determined by the expression:

$$CER = \frac{\text{Errored cells}}{\text{Succesfully transfered cells+Errored cells}} \quad (6)$$

SECBR parameter is calculated according to the expression:

$$SECBR = \frac{\text{Severely errored cell blocks}}{\textit{Total transmitted cell blocks}} \quad (7)$$

CMR parameter at a certain time of study (e.g. mean holding time) can be determined by the following expression:

$$CMR = \frac{\text{Misinserted cells}}{\text{Time interval}} \quad (8)$$

The existence of certain binary relations (yes/no) between certain influencing factors and quality parameters has been indicated in Table 1. The following influencing factors have been considered:

- *number of nodes,*
- *traffic load,*
- *propagation delay,*
- *media errors,*
- *switch design,*
- *buffer capacity,*
- *network failures.*

5. TRAFFIC CONTROL FUNCTIONS AND NETWORK MANAGEMENT

The network operator, that is, the network service provider has to implement relevant functional capabilities that will meet the user's requirements regard-

Table 1 - Relevant factors affecting QoS parameters (source [8])

QoS Parameters / Factors	CDV	CTD	CLR	CER	CMR	SECBR
Number of Nodes	×	×	×		×	
Traffic Load		×				
Propagation Delay			×	×	×	×
Media Errors	×	×	×			
Switch Design	×	×	×			×
Buffer Capacity	×	×	×	×	×	×
Network Failures			×	×		×

ing service quality with efficient, rational and safe traffic flow. This is a generic requirement imposed on all network operators, including ATM network operator.

ATM network allows a number of alternative possibilities related to service provision, i.e. operative management and control. Adequate management (decisions and actions) can satisfy the quality parameters for single applications. The engaged network resources and functions differ in single phases of the call: from request to final cell delivery at the destination. From the user's aspect it is crucial to insure adequate functions and end-to-end quality control, as presented in Figure 3.

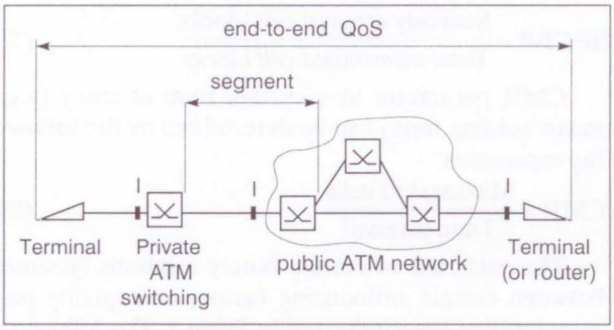

Figure 3 - Control and management levels of ATM network

Network functions can be considered through single phases of establishing a call and control of connection. During the first phase of setting up a call, the appropriate functions need to check the availability of sufficient network resources that will provide the connection. If the current resources are not sufficient for the set requirements, then negotiations regarding QoS parameters start.

When the call has been accepted, the network assigns a route or path to a virtual channel (VC) which realises the connection. Network resources along the path need to be informed by means of adequate signalling messages, in order to insure certain quality (QoS) parameters.

The management part of the network needs to control operatively the flow of traffic entities - ATM cells, so as to insure good quality of cell transfer and delivery to the destination. In case need arises, the network can require that the source slows down cell transmission, i.e. it may reject cells of low priority.

For the traffic control needs ITU-T has specified the generic cell rate algorithm (GCRA) technique, which defines relations between the parameters:

- PCR,
- CDTV,
- MCR,
- MBS.

For every oncoming cell it is checked whether it has arrived in accordance with the traffic contract resulting in adequate actions in compliance with the defined traffic policing.

In cases when the sources generate very bursty data, methods of traffic shaping are implemented so that the cell flow is re-distributed in time (see Figure 4).

The integral quality management of ATM network services is closely related to the following processes

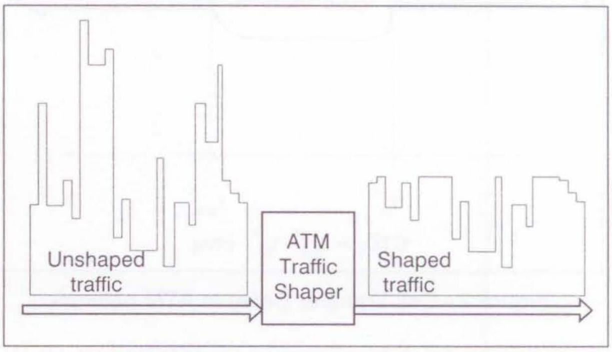

Figure 4 - Traffic Shaping

(groups of activities) which are treated as network management areas:

- *Configuration Management*;
- *Performance Management;*

- *Fault Management;*
- *Accounting Management;*
- *Safety Management.*

By accepting the concept of integral management of ATM service quality, the indicated areas may be treated as special business and technological processes.

6. CONCLUSION

Traffic descriptors of the BISDN/ATM network have certain generic traffic characteristics which are analogue or homomorphous to traffic descriptors in other traffic (transport and telecommunication) networks. The work presents an overview and initial systematisation of traffic parameters which may serve as basis for a generalised formalised description and effective quality management of ATM services. Further research is related to a more precise description of relations between identified parameters and their associating with the users' requirements.

LIST OF USED ABBREVIATIONS

ABR – *Available Bit Rate*
ACR – *Average Cell Rate*
ATM – *Asynchronous Transfer Mode*
BER – *Bit Error Rate*
B-ISDN – *Broadband Integrated Services Digital Network*
CBR – *Constant Bit Rate*
CDTV – *Cell Delay Variation and Tolerance*
CDVptp – *peak-to-peak Cell Delay Variation*
CER – *Cell Error Rate*
CLR – *Cell Loss Rate*
CMR – *Cell Misinsertion Rate*
CTD – *Connection traffic Descriptors*
CTDmax – *Maximum Cell Transfer Delay*
GCRA – *Generic Cell Rate Algorithm*
GFR – *Guaranteed Frame Rate*
ITU – *International Telecommunications Union*
MBS – *Maximum Burst Size*
MCR – *Minimum Cell Rate*
PCR – *Peak Cell Rate*
QoS – *Quality of Service*
SECBR – *Severely Errored Cell Block Rate*
STD – *Source Traffic Descriptors*
UBR – *Unspecified Bit Rate*
VBRnrt – *Variable Bit Rate, non real-time*
VBRrt – *Variable Bit Rate, real-time*

SAŽETAK

GENERIČKI PROMETNI DESKRIPTORI U FUNKCIJI UPRAVLJANJA KVALITETOM USLUGA U BISDN/ATM MREŽI

Prometni modeli za multiservisne širokopojasne mreže (multiservices broadband networks) bitno se razlikuju u odnosu na jednostavne analitičke modele primjenjive kod telefonskog prometa i mreže s komutacijom kanala (circuit-switch network). U radu je dana pregledna analiza standardiziranih prometnih deskriptora i parametara kvalitete nosećih usluga u BISDN/ATM. Prometni deskriptori asocirani su s osnovnim veličinama i konceptima koji se razvijaju u okviru generičke teorije prometa. Izvedena je djelomična sistematizacija prometnih parametara kao podloga za formalizirani poopćeni opis parametara i efektivno upravljanje kvalitetom ATM usluga.

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