INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

E.716
(10/96)

SERIES E: TELEPHONE NETWORK AND ISDN

Quality of service, network management and traffic engineering – Traffic engineering – ISDN traffic engineering

User demand modelling in Broadband-ISDN

ITU-T Recommendation E.716

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION E.716

USER DEMAND MODELLING IN BROADBAND-ISDN

Summary

This Recommendation deals with the characterization of user demand as manifested at the User-Network Interface (UNI). This Recommendation focuses on those aspects of user demand modelling that are specific to Broadband ISDN using Asynchronous Transfer Mode (ATM), and summarizes Recommendation E.711 (which covers user demand modelling in ISDN), in those aspects that are common for narrow-band and Broadband ISDN.

Source

ITU-T Recommendation E.716 was prepared by ITU-T Study Group 2 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 8th of October 1996.

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

CONTENTS

Recommendation E.716

USER DEMAND MODELLING IN BROADBAND-ISDN

(Geneva, 1996)

1 Scope

This Recommendation deals with the characterization of user demand as manifested at the User-Network Interface (UNI). This Recommendation focuses on those aspects of user demand modelling that are specific to Broadband ISDN using Asynchronous Transfer Mode (ATM), and summarizes Recommendation E.711 (which covers user demand modelling in ISDN), in those aspects that are common for narrow-band and Broadband ISDN.

2 References

The following Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision: all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

- CCITT Recommendation E.711 (1992), *User demand modelling*.
- ITU-T Recommendation E.735[1], *Framework for traffic control and dimensioning in B-ISDN*.
- ITU-T Recommendation E.736[1], *Methods for cell level traffic control in B-ISDN*.
- ITU-T Recommendation E.737[1], *Dimensioning methods for B-ISDN*.
- ITU-T Recommendation I.150 (1995), *B-ISDN asynchronous transfer mode functional characteristics*.
- ITU-T Recommendation I.210 (1993), *Principles of telecommunication services supported by an ISDN and the means to describe them.*
- ITU-T Recommendation I.311 (1996), *B-ISDN general network aspects*.
- ITU-T Recommendation I.361 (1995), *B-ISDN ATM layer specification*.
- ITU-T Recommendation I.371 (1996), *Traffic control and congestion control in B-ISDN*.

3 Definitions

In order to specify key concepts (e.g. call attributes and call pattern) in subsequent clauses of this Recommendation, it is helpful to clarify the use herein of the terms "ATM connection" and "call". An "ATM connection" refers to either a Virtual Channel Connection (VCC) or a Virtual Path Connection (VPC), see Recommendation I.150. A VCC or a VPC may be point-to-point or may be

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[1] Presently at the stage of draft.

point-to-multipoint. A VCC or a VPC is a connection with unidirectional communication, i.e. with only one direction of transmission[2].

A call consists of at least two ATM connections: one VCC in each direction of communication or one VPC in each direction of communication. A call may consist of multiple ATM connections in each direction of a point-to-point configuration or towards each end-point of a multipoint configuration. For example, a multimedia call may use, in each direction, one ATM connection for a video teleconference and another for the transport of data files.

4 Abbreviations

For the purposes of this Recommendation, the following abbreviations are used:

ATM	Asynchronous Transfer Mode
B-ISDN	Broadband Integrated Services Digital Network
B-ISUP	Broadband-ISDN User Part
CAC	Connection Admission Control
CLP	Cell Loss Priority
CPE	Customer Premises Equipment
NPC	Network Parameter Control
QOS	Quality of service
STD	Source Traffic Descriptor
UNI	User-Network Interface
UPC	Usage Parameter Control
VC	Virtual Channel
VCC	Virtual Channel Connection
VCI	Virtual Channel Identifier
VP	Virtual Path
VPC	Virtual Path Connection
VPI	Virtual Path Identifier

5 Introduction

Recommendation E.711 deals with user demand modelling in ISDN. This Recommendation mainly focuses on those aspects of user demand modelling that are specific to Broadband ISDN using Asynchronous Transfer Mode (ATM), and summarizes Recommendation E.711 in those aspects that are common for narrow-band and Broadband ISDN.

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[2] Note that, as specified in Recommendation I.150, at a B-ISDN interface there are two directions of transmission. When a routing field value [a virtual path identifier (VPI) for a VPC or a VPI/virtual channel identifier (VPI/VCI) for a VCC] is assigned to a VP or VC link, the same value is assigned for each direction of transmission. The traffic characteristics and the resources allocated for each direction of communication may be the same or may be different. The bandwidth in one of the directions may be equal to zero (unidirectional communication without any reverse information). Also, the bandwidth in one direction may only be large enough to carry ATM layer management information (unidirectional communication with reverse management information).

The term "user demand" means the demands of the user for telecommunication services through the network to satisfy the user's information transfer needs. It includes not only the requests made by the user but also the requests received by the user that were made by others attempting to communicate with the said user. Through the mediation of its Customer Premises Equipment (CPE) and of the CPEs of the other user involved in the communication, user demand is manifested at its User-Network Interface (UNI), in a way which will also depend on the characteristics of the involved CPEs.

This Recommendation deals with the characterization of user demand as manifested at the UNI. For modelling purposes, user demand at the UNI will be seen as an arrival process of "call demands" of different types[3]. Thus the characterization of user demand requires:

– characterization of the types of call demands which the user generates or receives, which is covered in clause 6;

– characterization of the arrival process of call demands of the different types, which is covered in clause 7.

This Recommendation identifies parameters to be used for the above characterization. The parameters chosen are those that have a relevant impact on network performance and thus are relevant to modelling the traffic offered by the user to the network, in particular, to the ATM layer in the user plane, and to the signalling layer (layer 3 for Recommendation Q.2931 and layer 4 for B-ISUP) and lower layers in the control plane.

The purpose of this Recommendation is to present parameters that are important for the definition of dimensioning methods and traffic control algorithms (including connection admission control algorithms). This Recommendation gives guidance to network operators on which parameters of user demand need to be estimated, through measurements or through other means, to be used as input for dimensioning or for traffic controls. How the identified parameters are used for these purposes is not covered by this Recommendation but by the Recommendations of the E.730- and E.740-Series.

6 Modelling of a call demand

6.1 General

Call demand is the basic manifestation at the UNI of the user demand. A call demand consists of:

1) the sequence of call attempts made by the user or by its Customer Premises Equipment (CPE); and

2) the subsequent call, if it is finally established.

For traffic engineering purposes, a call demand is defined by a set of call attributes and by a call pattern[4]:

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[3] Note that a call demand, that is, the demand for a call, is considered as the **basic** manifestation of user demand, instead of call or call attempt which has been traditionally used. In contrast to a call, a call demand includes any reattempts needed in the establishment phase of the call. A sequence of reattempts without final success is also considered a call demand.

[4] The term "call attributes" has the same meaning as the term "connection characteristics" used in Recommendation E.711. The change intends to emphasize that they are characteristics or attributes of the whole call demand, not of one of its connections. "Call attributes" and "call pattern" are used instead of "call demand attributes" and "call demand pattern" for simplicity. Also for simplicity, if the call has been established, then the term "call" will frequently be used instead of "call demand".

– call attributes are those attributes of the call demand that identify the resources needed by the call demand in the network, both in the user and control planes; they describe the connections required and how they are established; most of the call attributes match with attributes defined in Recommendation I.210;
– the call pattern is defined in terms of sequences of events at the user-network interface and of the times between these events.

The call pattern, together with the call attributes, must be sufficient to define the impact of the call on network performance, and to quantify the resources which have to be allocated to the call and the duration of this allocation.

6.2 Call attributes

As mentioned in 6.1, call attributes are defined by a set of attribute values that identify the resources needed by the call demand. The call attributes are:

– establishment of communication (by control plane functions or by management plane functions; semipermanent, on demand or on reservation);
– communication configuration (point-to-point, multipoint, broadcast; number of points and their location);
– number of ATM connections, in each direction, between each pair of points;
– use of Virtual Channel Connections (VCCs) or user-to-user Virtual Path Connections (VPCs)[5];
– associated with each ATM connection, the components of the traffic contract (see Recommendation I.371), which are:
  1) the source traffic descriptor;
  2) the cell delay variation tolerance; and
  3) the quality of service class;
– signalling access protocol, layers 1/3 (currently, there is just one signalling access protocol, Recommendation Q.2931);
– supplementary services; the list of supplementary services which are significant for traffic engineering is for further study.

In practice, when call demand modelling is made for a specific traffic engineering task, only some of the above-mentioned attributes are significant.

6.3 Call pattern and traffic variables

As mentioned in 6.1, the call pattern of a call demand is defined in terms of sequences of events at the user-network interface and of the times between these events.

The call pattern is described by a set of traffic variables. These traffic variables are expressed as statistical variables (that is, as random variables or as parameters related to the distribution of random variables). This allows a large variety of call demands to be modelled by the same call pattern. Call demands with the same types of events but a different number of such events

[5] When a user-to-user VPC is established, the VCCs established by the user within this VPC are not viewed by the network as additional connections, and the user's traffic on a VCC is viewed as part of the traffic of the VPC. Thus, in this case, the call will be considered, in the context of this Recommendation, to be constituted by the involved user-to-user VPCs, while the individual VCCs are not considered to constitute a call.

(e.g. different number of reattempts), or different times between them (e.g. different holding times), could be modelled by the same call pattern.

Two kinds of traffic variables can be distinguished, call traffic variables and cell traffic variables[6]. Both of them describe sequences of events at the user-network interface and time between these events, but the definition of event is different in each case.

– for call traffic variables, an event is the transmission across the user-network interface of an ATM cell which completes a signalling message of the set-up, renegotiation or release phases of the call; the event is not only defined by the arrival time of the cell but also by the content of the signalling message;

– for the cell traffic variables, an event is the transmission across the user-network interface of any ATM cell; the event is defined by: the cell arrival time, the connection of the call to which the cell belongs, the payload type and the value of the CLP bit.

NOTES

1 The definition of call traffic variables in relation to the transmission across the UNI of signalling messages only applies to calls established by control plane functions. The definition for calls established by management plane functions is for further study.

2 In the case of congestion in the network, at call level or at cell level, or in the case of feedback controls from nodes within the network, the call pattern will depend not only on user demand but also on network conditions. The way of characterizing the impact of user demand on the call pattern in these situations is for further study.

6.3.1 Call traffic variables

For call demands in which the call attributes do not change during the call (i.e. call demands in which all ATM connections in the call are essentially set up simultaneously and released simultaneously and whose attributes are not renegotiated), the most relevant call traffic variables are:

– variables defining the call attempt arrival process:
  - mean number of reattempts in case of non-completion;
  - mean time between call attempts;

– mean total holding time of the call.

For call demands in which the call attributes change during the call, the above call traffic variables have to be complemented. For a given call attribute, additional traffic variables, useful for dimensioning control plane resources, are:

– mean number of demands to change the call attribute per call;

– variables defining the arrival process of change attempts for each change demand of the call attribute:
  - mean number of attempts in case of non-completion;
  - mean time between attempts.

  In case of closely related call attributes whose change is usually requested simultaneously and requires the same action of the control plane (e.g. different parameters of the STD), the above traffic variables would not refer to a single call attribute but to the group of closely related attributes.

[6] Cell traffic variables is the specific name for Broadband ISDN based on ATM techniques of transaction traffic variables, which is used in Recommendation E.711 as the common name for both narrow-band and Broadband ISDN.

As a consequence of the change requests, the set of call attributes varies during the call. For each set of call attributes that the call has during its existence, additional traffic variables, useful for dimensioning user plane resources, are:

– mean time in which the call has each given a set of call attributes.

Further study is required for a more complete definition of call traffic variables.

6.3.2 Cell traffic variables

Cell traffic variables are used to describe any cell arrival process in an ATM connection of a call.

In the case of calls established by control plane functions, one of the sequences of events in the call pattern is the transmission of cells on the signalling virtual channels (see Recommendations I.311 and I.361) established for the set-up, renegotiation and release of the connections for user data.

For an ATM connection for user data, the sequence of events of primary interest in this Recommendation is the transmission of user-data cells, i.e. for VCCs, cells with payload types 0 through 3 and for VPCs, cells with Virtual Channel Identifiers (VCIs) greater than 31. If user-data cells with high priority [Cell Loss Priority (CLP) bit equal to zero, see Recommendation I.371] and with low priority (CLP=1) are generated in a connection, then relevant sequences of events can be:

1) the transmission of user-data cells with CLP=0;
2) the transmission of user-data cells with CLP=1; and
3) the transmission of the aggregate (CLP=0 or CLP=1).

Of secondary interest in this edition of Recommendation E.716 are the sequences of events for OAM cells (for VCCs, cells with payload types 4 and 5, and for VPCs cells with VCI values 3 or 4) and for resource management cells (for VCCs, cells with payload type 6, or for VPCs, cells with VCI value 6).

The term "cell arrival process" is used herein for the sequence of events in the call pattern corresponding cells of a given type on a given ATM connection during a certain period of time (normally the duration of the connection or the time between renegotiations but, in case of connections of very long duration, the characterization could be made over shorter periods such as the reference period used for engineering of the network). The concepts used to characterize the cell arrival process are largely motivated by interest in user-data cells, but can be also applied to cells of other types.

The cell traffic variables must identify all the characteristics of the cell arrival process that are significant for evaluating its impact on network performance. Note, however, that cell traffic variables are not necessarily significant for traffic engineering purposes. See 6.3.3 for more details.

In the following subclauses a number of different approaches are presented for defining cell traffic variables[7]. Other approaches are for further studies. For given applications or for given services, guidelines on which approach is more appropriate are for further study.

6.3.2.1 Variables related to the burst structure of the cell stream

For certain types of cell streams, it is appropriate to distinguish an alternance of "bursts", or periods of activity when cells are actually emitted at roughly constant rate, and periods of "silence" or inactivity while the source remains quiescent. More generally, the source may have different levels of activity, each level defined by a cell arrival intensity.

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[7] These approaches apply for characterization of the cell arrival process during finite periods of time. In the theoretical case of infinite periods, the assumption of stationarity of the cell arrival process is required.

If the source traffic is handled by multiplexers with a small buffer (i.e. around 100 cells), the information needed to characterize the source is only the cell arrival rate in each state together with the probability that the source is in that state at an arbitrary instant. This information is called the distribution of the instantaneous cell rate. If the whole distribution cannot be known, the knowledge of the maximum rate as well as the mean and, if possible, the variance of the rate provides valuable information to evaluate the impact of the source on network performance [1].

When multiplexer buffers are large, the instantaneous rate distribution has to be complemented with information about the stochastic process that determines how the source changes from one state to another. The description of this stochastic process can be very complex.

The description may be simpler for an on/off source, i.e. a source which has only two states: an on state in which cells are emitted at constant rate and an off state in which no cells are emitted. If the behaviour of the source allows to assume that the length of successive bursts and silences are independent, the stochastic process is determined by the burst cell rate and the distributions of burst and silence durations. As an approximation, the distributions of burst and silence durations can be succinctly described by their mean and variance (in the case of the silence duration even a description based only on the mean can be sufficient if many sources are multiplexed). If the rate during the on state has slight variations which do not allow to consider it as constant, a variable related to $q(r)$ as explained in 6.3.2.4, with r slightly greater than the on average rate, may be used to complete the characterization.

If successive periods of the on/off source are dependent, however, it is necessary also to specify the nature of this correlation (e.g. bursts may themselves occur in bursts). In this case, as well as in the case that the source has many states, it may be simpler to use the traffic variables presented in the next subclauses.

6.3.2.2 Variables related to the number of cell arrivals in time intervals

In this approach, the cell traffic variables characterize the distribution of the number $N(t)$ of cell arrivals in an interval of length t randomly taken within the period in which the characterization is made. If the whole distribution of $N(t)$ for any value t were known, the source would be accurately (although not completely) characterized[8]. Given the large amount of information that this would require, some authors [2], [3], [4], [5], [6], [7], [10] and [11] have proposed to use the first moments of the distribution function of $N(t)$.

The most important part of the distribution of $N(t)$ for evaluating the impact of the source on network performance is the tail. If the functional form of the distribution of $N(t)$ is known for the source, the tail behaviour may be derived from the first moments. In this case, the characterization based on the first moments of $N(t)$ is adequate. It is risky to make a general assumption on the distribution of $N(t)$ of any source (e.g. Gaussian) because it may be inadequate for some sources. When the type of distribution of $N(t)$ is known, it is normally a characterization based on the first moments for some values of t.

The first moment, i.e. the mean number of cell arrivals in an interval of duration t is equal to the cell arrival rate (the reciprocal of the mean interarrival time) multiplied by the value of t. Thus, any value of t is applicable for this first moment.

For the second moment, several values of t should be considered to take into account the correlation. The relevant values of t are related to the queue lengths of interest in the multiplexers which handle the source (apart from the multiplexer speed and load) [7], [10] and [11]. Some measurements in

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8 Note that although the source may be accurately characterized, it is not completely characterized by the distribution of $N(t)$. In general, all finite dimensional joint distributions of $N(t)$ over distinct intervals need to be known for a complete characterization.

data networks [8], [12] and of the output of VBR codecs [9] show that they exhibit the so-called self-similar behaviour. This means that the variance of $N(t)$ may be expressed as:

$$\mathrm{var}[N(t)]=k\,t^{c}$$

Where k ($k > 0$) and c ($1 \le c \le 2$) are constants defining the source. For self-similar traffic $c > 1$. For those sources in which the above expression holds, it would be sufficient to know the second moment for two values of t to infer it for any other value of t.

Some authors [3] and [4] also propose the use of the third moment of $N(t)$. Its utility depends on the type of distribution which can be assumed for $N(t)$.

6.3.2.3 Variables based on cell interarrival times

In this approach, the cell traffic variables describe the distribution of $S(k)$, the sum of k consecutive interarrival times [2], [13], [14]. Since $S(k)$ is linked to $N(t)$ presented in 6.3.2.2 by:

$$\frac{d}{dt}\Pr\{N(t) > k\} = \lambda\left(\Pr\{S(k+1) > t\} - \Pr\{S(k) > t\}\right)$$

where λ is the mean arrival rate, the characterization made with $S(k)$ may be equivalent to that made with $N(t)$.

Nevertheless, as the distribution of $N(t)$ for a superposition of sources is easier to derive from the distribution of $N(t)$ of the individual sources than in the case of $S(k)$, the approach based on $S(k)$ has been less studied.

6.3.2.4 Variables related to the number of cell arrivals exceeding a rate

In this approach, the cell arrival process of a source is characterized through the performance observed in a queue fed by the source alone [15], [16] and [17]. More precisely, consider a system with deterministic service time $1/r$ (i.e. output rate r cells per unit time) and infinite queue space, fed by the source alone. Denote by $q(r)$ the unfinished work in the system[9]. These cell traffic variables describe the distribution of $q(r)$. If the whole distribution of $q(r)$ for any value of r were known, the source would be accurately (although not completely) characterized. However, for a practical use, the knowledge of the mean cell rate along with a few quantiles of the distributions of $q(r)$ for particular values of r may be enough to obtain an acceptable characterization of the source.

An example of choice of values of r and quantiles of the distribution of $q(r)$ is as follows [15].

$$\Pr\{q(r_1) > b_1\} = P_1$$
$$\Pr\{q(r_2) > b_2\} = P_1$$
$$\Pr\{q(r_2) > b_3\} = P_2$$

where:

– P_1 is a negligible probability compared to the cell loss requirements in the network;

– r_1 is a rate which, except for variations over short time scales, can be considered as the maximum rate of the source, which implies that b_1 will be small;

– r_2 is a rate between the mean cell rate and r_1;

– P_2 is a probability on the order of 0.05 to 0.5.

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9 The unfinished work is measured as the number of cells in the queue plus a fraction corresponding to the pending work of the cell in service.

If a more accurate characterization is needed, several values of P_2 (for the same r_2) or even several values of r_2 could be used.

6.3.3 Relationship between cell traffic variables and parameters of the source traffic descriptor

According to Recommendation I.371, the user declares during the call set-up phase (or during the renegotiation phase) a set of traffic parameters which describe the traffic characteristics of the requested connection. This set of parameters constitute the Source Traffic Descriptor (STD). The STD is used by the Connection Admission Control (CAC) function of the network to decide whether the connection is accepted or rejected. The connection is accepted only when sufficient resources are available to establish the call at its required quality of service and to maintain the agreed QOS of existing calls. While the connection is established, the network monitors and controls the declared parameters by means of usage/network parameter control (UPC/NPC).

There is a close liaison between cell traffic variables and parameters of the STD since both of them describe the traffic. However, there are fundamental differences:

– The parameters of the STD need an operational (i.e. algorithmic or rule-based) definition since at all times during the call both the user and the network operator should be able to determine whether submitted cells are conforming to the STD. In contrast, the cell traffic variables have a statistical definition.

– The values of the STD are determined when the connection is established (and possibly renegotiated during the connection) and apply for the given realization of the cell arrival process; the cell traffic variables need not hold for a given realization.

– The parameters of the STD represent a deterministic bound on the behaviour of the source, since should the traffic exceed the declared parameters, actions can be taken against the connection; on the other hand, cell traffic variables represent the probabilistic behaviour of the source and can provide a more thorough characterization of the source traffic.

As stated in clause 5, the identification of parameters which have a significant impact on network performance is useful for the definition of dimensioning methods and traffic control algorithms. Cell traffic variables are useful for defining Connection Admission Control (CAC) algorithms and for setting STD parameters. However, their usefulness for defining dimensioning methods and the need of the operators to estimate their values for user data depend on the CAC adopted. For this purpose, CAC procedures can be divided into three classes as follows:

1) The information on the cell arrival process used by the CAC to accept or reject a connection is only the STD declared for the new and currently established connections. This CAC does not allocate resources according to connection traffic characteristics, but by assuming "worst case"[10] traffic characteristics compatible with the declared STDs. With this CAC policy, for dimensioning it is necessary to estimate the STDs (which the users will declare), but not the cell traffic variables of the connections.

    NOTE – An important special case is an ATM connection for which a constant bit-rate service is requested by the user. For such connections the network operator will likely allocate resources for the full requested bandwidth, irrespective of the cell arrival process on the connections.

2) Apart from the declared STDs, the CAC also takes into consideration expected traffic characteristics of the new and currently established connections. For example, the CAC could allocate resources according to the expected traffic characteristics of the connections

[10] By worst case we imply those traffic characteristics compatible with the declared traffic descriptor requiring the greatest resource allocation to meet the QOS requirements.

based on historical measurements that correlate the declared STD with cell traffic variables for the connection. As another example, the CAC might allocate resources based on the declared STDs and on engineering factors, where the latter could be obtained from historical measurements. Thus, depending on the particularities of this class of CAC, for dimensioning it may be necessary to estimate the cell traffic variables of the connections.

3) Apart from the declared STDs, the CAC takes into consideration real-time measurements of the currently established connections. Thus, the traffic characteristics of the connections have an impact on the CAC policy. Consequently, for dimensioning it is necessary to estimate both STD and cell traffic variables of the connections.

7 User characterization

7.1 General

From a traffic engineering point of view, users sharing the same CPE should not be characterized individually, but rather as an ensemble which is called the CPE user set. The CPE user set is taken to be the user or set of users that share, through a single CPE, the access lines to the network.

User characterization has to be done for each CPE user set, in order to dimension its access lines to the network, and for each population of CPE user sets that could share network resources.

7.2 Characterization of a CPE user set

A CPE user set is characterized by the generating process of its originating and terminating call demands. In the initial phase this process may be approximated by the rate of call demands of each type during a reference period. The type of a call demand, according to 6.1, is given by the following characteristics:

– set of call attributes;

– call pattern.

Every difference in call attributes or traffic variables could give rise to a different type. However, depending on the specific traffic engineering task some of the call attributes and traffic variables may not be relevant, and they need not be considered to distinguish call demand types (e.g. the number of reattempts may not be relevant for dimensioning user plane resources). Even call demands with different values of a certain call attribute or traffic variable may be considered as only one type, characterized by, for instance, the mean value of this attribute or variable (e.g. mean number of ATM connections, or mean cell rate per call). Also call demands with similar values of a call attribute or of a traffic variable may be aggregated as only one type (e.g. all the incoming calls in an exchange without differentiating the origin of the calls, or all the calls with peak cell rate of its connections comprised within a certain range). In this way, a list with a moderate number of call demand types can be obtained. This list will depend on each specific traffic engineering task; thus, this Recommendation cannot specify any particular list.

A practical procedure for the CPE user set characterization is to determine the telecommunication services that it demands and to proceed, for each telecommunication service, in the following way:

– estimate the call demand rate for the telecommunication service during the reference period;

– define the call demand types for this telecommunication service;

– estimate the proportion of call demands for the telecommunication service which are of each of the types defined, during the reference period;

– calculate from the previous results, by a simple multiplication, the rate for each call demand type during the reference period.

7.3 Characterization of a population of CPE user sets

A population of CPE user sets is characterized by averaging over the population the call demand rate per CPE user set for each call demand type during the reference period. For call demand type *j*, this averaged call demand rate is denoted *r(j)*. A practical procedure for this characterization is the following:

– divide the population of CPE user sets into CPE user set classes, each class formed by CPE user sets with similar traffic behaviour; examples of CPE user set classes are residences and small, medium and large businesses;

– estimate P_i, the number of CPE user sets of class *i* divided by the total number of CPE user sets in the whole population;

– characterize each CPE user set class *i*, that is, estimate for each CPE user set class *i* (following a procedure analogous to that of 7.2), the average value, over the CPE user sets of class *i*, of the call demand rate per CPE user set for each call demand type *j* during the reference period; let this rate be $r_i(j)$;

– average over the whole population by the formula:

$$r(j) = \sum_{\forall i} P_i \cdot r_i(j)$$

8 History

This is the first issue of Recommendation E.716.

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