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THE INTERNATIONAL
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E.712

(10/92)

TELEPHONE NETWORK AND ISDN

QUALITY OF SERVICE, NETWORK MANAGEMENT AND TRAFFIC ENGINEERING

USER PLANE TRAFFIC MODELLING

Recommendation E.712

FOREWORD

The CCITT (the International Telegraph and Telephone Consultative Committee) is a permanent organ of the International Telecommunication Union (ITU). CCITT 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 Plenary Assembly of CCITT which meets every four years, establishes the topics for study and approves Recommendations prepared by its Study Groups. The approval of Recommendations by the members of CCITT between Plenary Assemblies is covered by the procedure laid down in CCITT Resolution No. 2 (Melbourne, 1988).

Recommendation E.712 was prepared by Study Group II and was approved under the Resolution No. 2 procedure on the 30th of October 1992.

CCITT NOTES

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

2) A list of abbreviations used in this Recommendation can be found in Annex A.

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Recommendation E.712

USER PLANE TRAFFIC MODELLING

(1992)

1 Introduction

In Recommendation E.711 the user demand is characterized by means of his call demands and by the description of each type of call demand. On the basis of the information provided by this user characterization, Recommendation E.712 derives the values of the traffic parameters required for dimensioning the 1 to 3 layer resources of ISDN user plane.

The resources involved by the user plane traffic are:

– customer accesses (Basic, Primary and their multiplexes): B- and D-channels;

– resources of ISDN Exchanges: switching networks, packet handlers, etc.;

– trunk groups.

2 General approach

In ISDN, call demands with different connection characteristics can be offered to the same group of resources. Depending on the kind of resources, dimensioning may require to separately characterize the traffic components corresponding to call demands with some different connection characteristics.

First, there is a distinction of two main traffic components according to the connection characteristic information transfer mode. Each of these two components (circuit switched and packet switched) may be further split up into new components, according to the other connection characteristics of their call demands.

Thus, the approach for the modelling of the traffic offered to a group of resources is:

– to identify the call demands which make use of this group of resources;

– to identify the connection characteristics which imply the split up of the traffic due to these call demands into traffic components;

– to describe and quantify these traffic components by means of a set of parameters derived from those defined in Recommendation E.711.

This approach will be followed in § 3 to model the circuit switched traffic and in § 4 for the packet switched traffic.

3 Modelling of circuit switched traffic

3.1 *Observations on the concept of group of resources*

In the first implementations of the ISDN, the number of channels or circuits reserved per call will be the same for both directions of the information flow. This number is given for each call by the direction in which the information transfer rate is higher. In this situation, the B-channels of an ISDN access or the channels (slots) of a trunk group are referred here as a group of resources, with independence of the direction of the information flow.

In further implementations of the ISDN, when the connection characteristic "Symmetry" of the call pattern takes the values unidirectional or bidirectional asymmetric, the number of channels reserved per call may be different in each direction of the information flow. In this situation, the channels carrying each direction of the information flow have to be separately dimensioned (the final dimensioning being given by the direction in which the required number of channels is higher). Thus, the channels of each direction should be considered, in the context of this Recommendation, as a different group of resources.

3.2 *Identification of call demands using a group of resources*

To identify the call demands using a group of resources the following connection characteristics should be considered:

- communication configuration: This characteristic, in the wide sense considered in Recommendation E.711, § 2.2, defines the position of the end-points involved in the communication; this, together with the routing strategy, determines if a certain group of resources may be used by a call demand.
- information transfer capability;
- establishment of communication;
- information transfer rate.

The last three characteristics should be considered since different groups of resources may be provided for call demands with certain values of these connection characteristics (e.g. resources only used for single channel connections or only traffic on demand).

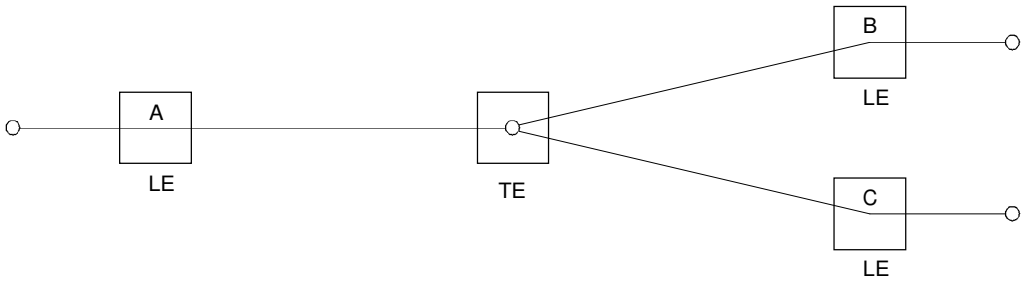
3.3 *Split up into traffic components*

When call demands with different connection characteristics share the same group of resources, different components of the offered traffic have to be separately characterized. For circuit switched traffic these components are distinguished according to the following criteria:

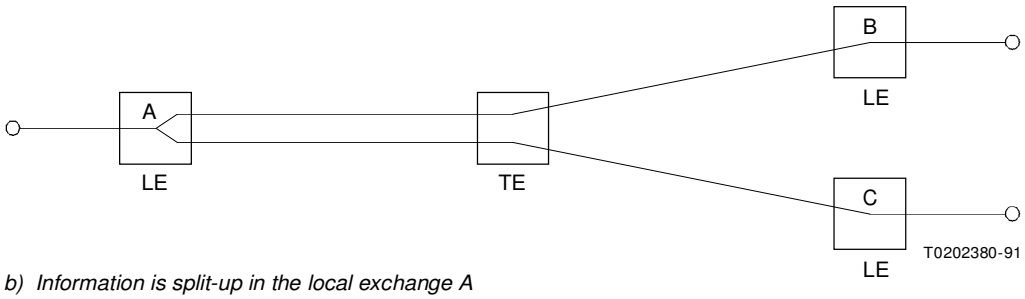
a) the number of resources required per call: the connection characteristics of the call demand determining this number are:
   - the information transfer rate: in the first situation of § 3.1, it is the rate in the direction in which the rate is higher; in the second situation, it is the rate in the direction under consideration. When this rate is $n \times 64$ kbit/s, n B-channels of the ISDN access or n channels of a trunk group are required for each call;
   - the communication configuration: in multipoint connections several resources of the same group can be required by a call, depending on the place where the information is split; Figure 1/E.712 gives two examples of a three points communication; if the information transfer rate is $n \times 64$ kbit/s, n resources are required in each trunk group in example a), while in example b), $2 \times n$ resources are required in the trunk group between the local exchange A and the transit exchange, and n resources in each of the other two trunk groups;

b) the existence of any restriction on the allocation of several resources for the same call; time-slot sequence integrity (TSSI) is required for $n \times 64$ kbit/s communications when the values of the information transfer capability is unrestricted or 8 kHz structured; one technique to obtain this integrity is to allocate the n channels (slots) on the same PCM primary multiplex, or even to assure that the n channels are contiguous; traffic components with different restrictions in the allocation should be distinguished;

c) call routing: it is related to the general call routing strategy and to the connection characteristic "communication configuration" of the call demand, which defines the position of the end-points involved in the communication. Traffic components offered to the considered group of resources in a first choice have to be distinguished from those which only are offered if overflow from previous groups. Among the last ones, components for which the previous choices are different have also to be distinguished;



a) Information is split-up in the transit exchange



b) Information is split-up in the local exchange A

LE Local exchange
TE Transit exchange

FIGURE 1/E.712

Two examples of implementation of a three-points communication

d) procedure for the establishment of the communication: for those resources sharing traffic of call demands with different values of this connection characteristic, the traffic components on reservation and on demand have to be separately characterized;

e) any characteristic which could motivate a different priority or protection treatment: a different treatment (e.g. by means of service protection methods) of different traffic components can be motivated by some of the above-mentioned criteria, e.g. single slot versus multi-slot calls, first choice traffic versus overflow traffic, or calls on demand versus reserved calls. In addition, other characteristics can also motivate a different priority or protection treatment, e.g. traffic components with different GOS objectives (corresponding to different values of the general attribute/connection characteristic "Quality of Service"). Service protection methods may also be applied between traffic components corresponding to different services or to the two set-up directions of two-way trunk groups, even although these traffic components have the same GOS objectives and the same values of the other above-mentioned characteristics. The reason for this protection is to avoid that the overload of traffic component can deteriorate the GOS of the other ones. In all the cases in which a different priority or protection treatment between traffic components may be required, each of these traffic components has to be separately characterized.

The identification of other criteria, as e.g. different supplementary services, which could motivate a further distinction of traffic components is for further study.

3.4 *Parameters describing each traffic component*

Once the different traffic components offered to a group of resources have been distinguished according to criteria of § 3.3, each component has to be characterized.

Note – In case of alternative routing, the dimensioning of a trunk group does not only require the characterization of the traffic components which in a first or subsequent choice can be offered to the considered trunk group, but also the characterization of all the other components offered to the network cluster to which the trunk group belongs.

Each traffic component is characterized by:

– the relevant connection characteristics of the component: they are the same which, according to § 3.3, can motivate a separate characterization of the component, i.e. number of required resources per call, restrictions on the allocation of resources, call routing, establishment of the communication and GOS objective;

– the value and the generating process of the traffic offered by the component: the generating process is for further study; nevertheless in a first step it may be considered pure chance traffic, from the point of view of the call arrival process when it is offered to the first choice resources. The value of the traffic offered is discussed in § 3.5;

– additional traffic parameters related to certain traffic components: e.g. in case of reservation traffic, the quantification of some parameters related to the reservation time (interval between the reservation request and the start of the reserved time) and to the reserved time is required. A description of these parameters requires further study. Additional traffic parameters may also be required to describe some supplementary services. These parameters are also for further study.

3.5 *Quantification of traffic offered*

The traffic offered to a group of resources due to the traffic component m is given by:

$$A_m = A'_m \cdot d_m \qquad \text{with } A'_m = \lambda_m \cdot h_m$$

where:

– λ_m is the arrival rate of call demands of the traffic component m;

– h_m is the mean holding time of the resources per call demand of the traffic component m,

– d_m is the number of resources required per call demand of the traffic component m.

A'_m describes the traffic offered from the point of view of number of simultaneous call, while A_m describes the traffic offered from the point of view of number of resources simultaneously busy. In case of traffic offered to first choice resources, A'_m may be considered pure chance traffic, while A_m has to be considered batch traffic with batch size equal to d_m. Thus, neither A'_m alone nor A_m alone fully describe the traffic process. Any one of them needs to be complemented with the value of d_m.

From the user characterization made in Recommendation E.711, the value of A'_m (and thus $A_m = A'_m \cdot d_m$) can be obtained as follows.

3.5.1 *ISDN accesses*

For the B-channels of the ISDN accesses of a CPE, A'_m is given by:

$$A'_m = \sum_{i,j,k,} 'rc(i,j,k) \cdot f_m(i,j) \cdot h(i,j,k)$$

where:

– $rc(i,j,k)$, as defined and derived in § 3.2 of Recommendation E.711, is the rate of originating or terminating call demands of the set of users of the CPE (CPE user set) corresponding to the telecommunication service i, set of connection characteristics j and call pattern k;

– $f_m(i,j)$ is a factor which takes the value 1 or 0 depending on whether the calls of the types i,j belong or not to the traffic component m;

– $h(i,j,k)$ is the mean total holding time of the B-channels per call demand of type (i,j,k).

The rates $rc(i,j,k)$ must refer to the reference period. The definition of the reference period is for further study.

$h(i,j,k)$ has to include the holding time of the B-channels due to all the attempts of the call demand. Number of uncompleted call attempts per completed and per uncompleted call demand has to be estimated, as well as the holding time per uncompleted and per completed call attempt. These parameters are derived from the call variables defined in § 2.3.1 of Recommendation E.711.

3.5.2 *Other groups of resources*

In the case of resources of ISDN exchanges or trunk groups, the first step is to identify the users which can offer traffic to the group of resources. As two or more users are involved in a call demand, two criteria can be followed to identify the user which offers traffic to these resources:

– to assume that the user which offers traffic to the group of resources, among the ones involved in a call demand, is chosen according to a position criteria, as, e.g. the closest one to the group of resources. This criterion is more usual when the closest user can be clearly identified, as e.g. for a trunk group connecting a local and a transit exchange, in which the closest user is the one of the mentioned local exchange. With this assumption, the traffic offered to the group of resources is derived from the originating and terminating call demands of the closest users;

– to assume that the user which offers traffic to the group of resources, among the ones involved in a call demand, is the one which originates the call. This criterion may be practical, e.g. for evaluating the traffic offered to a trunk group connecting two local exchanges. This traffic is derived, following this criterion, from the originating call demands of the users of both exchanges.

Once the population of users or, more precisely, the population of CPE user sets offering traffic to the considered group of resources has been identified according to one of the two above-mentioned criteria, this population is characterized according to § 3.3 of Recommendation E.711. From this characterization, A'_m is obtained by:

$$A'_m = N \cdot \sum_{i,j,k} rc(i,j,k) \cdot f_m(i,j) \cdot h(i,j,k)$$

where:

– N is the number of CPE user sets in the population (this number is equal to the number of CPEs, since a CPE user set is the set of users accessing the network through a CPE);

– $rc(i,j,k)$ is the mean value per CPE user set in the population of the rate of call demands type (i,j,k), calculated, as indicated in § 3.3 of Recommendation E.711, as the weighted average of its mean value in each class of CPE user sets. (Both originating and terminating types of call demands or only originating types have to be considered depending on the criterion followed to identify the users.);

– $f_m(i,j)$ has the same meaning as in § 3.5.1;

– $h(i,j,k)$ is the mean total holding time of the resources of the group per call demand of type (i,j,k).

If the user demand modelling is made just for quantifying the traffic offered to a certain group of resources, the number of call demand types (i,j,k) defined should be equal or slightly greater than the number of traffic components to be distinguished. To each traffic component m will correspond one or few call demand types for which $f_m(i,j)$ is equal to 1.

Note that the mean total holding time per call demand may be different for different groups of resources, depending on the instants along the call in which the resource(resources) is(are) seized and released. This difference is normally greater for uncompleted attempts and for the signalling time of completed attempts. Anyway, these holding times can be derived from the call variables defined in § 2.3.1 of Recommendation E.711 and from the network operation.

It may occur that the users which offer traffic to a group of resources are located in different network or geographical areas with heterogeneous characteristics: either general characteristics (e.g. proportions of classes of CPE user sets in the population different for each area) or characteristics related to the considered group of resources (e.g. rates of call demands per CPE user set using a two-way trunk group connecting two local exchanges different for the CPE user sets of each exchange). In these situations, it may be more practical to characterize separately the users of each area, to evaluate the traffic offered from each area and, finally, to add them to obtain the total traffic offered.

4 Modelling of packet switched traffic

4.1 *Provision of packet switched services in ISDN*

Recommendation X.31 and Q.931 describe provisioning of packet switched services in ISDN. The purpose of this section is to point out the features of this provisioning which are relevant for traffic engineering.

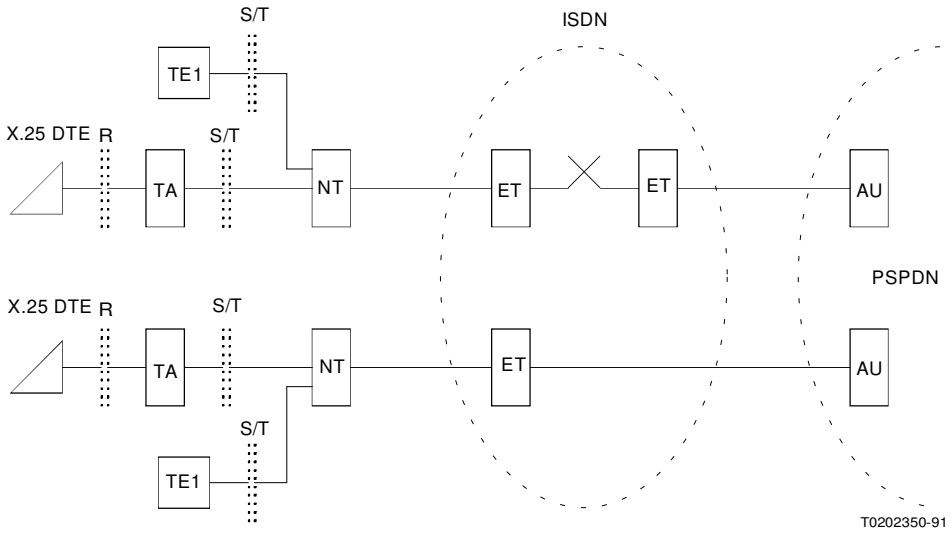
Two main services for packet switched data transmission are defined for packet mode terminals connected to the ISDN, namely:

– case A access to PSPDN;

– case B use of an ISDN virtual circuit service.

In case A a 64 kbit/s circuit switched connection through the ISDN is provided to connect a B-channel of the user access and an access port, called access unit (AU), of a PSPDN (see Figure 2/E.712). D-channel cannot be used in this case. Only one user terminal can use this connection; however, several X.25 virtual calls between the terminal and other users can be simultaneously carried. This connection may be permanent or established on demand. In the case of demand, the circuit connection can be requested by the user or by the access unit (AU). In case of request by the user, he has to provide the number identifying the appropriate AU using Q.931 protocol. In the reverse case, the AU provides the number identifying the user terminal. When the circuit connection has been established, X.25 protocol is used to establish virtual call(s), the ISDN being transparent to this procedure. In the case of on-demand connection, either the user or the AU have to request its release when the last virtual call finishes.

In case B the ISDN provides the virtual circuit service. For this purpose, packet handling (PH) functions are implemented in ISDN. In this case B or D-channel can be used at the user access. In case of the use of a B-channel the calling user directly requests the packet switched service using Q.931 protocol and the network provides a connection to packet handling function. After that, the call progresses using X.25 protocol. In case of the use of a D-channel the call progresses directly using X.25 protocol. In both cases a 64 kbit/s circuit connection either on-demand or permanent is used between the ET and the PH function. If both calling and called parties are ISDN users, they could be connected to different PH functions. These PH functions could be interconnected through the PSPDN.



B-channel is used

AU Access unif
TA Terminal adaptor
NT Network termination 2 and/or 1
ET Exchange termination
TE Terminal equipment 1
DTE Data terminal equipment
Reference points (see Recommendation I.411)

Note 1 – The figure is only an example of many possible configurations and is included as an aid to the text.

Note 2 – Solid line connections respresent circuit switched connections.

FIGURE 2/E.712

Access to a PSPDN

The multiplexing possibilities depend on the use of B or D-channel:

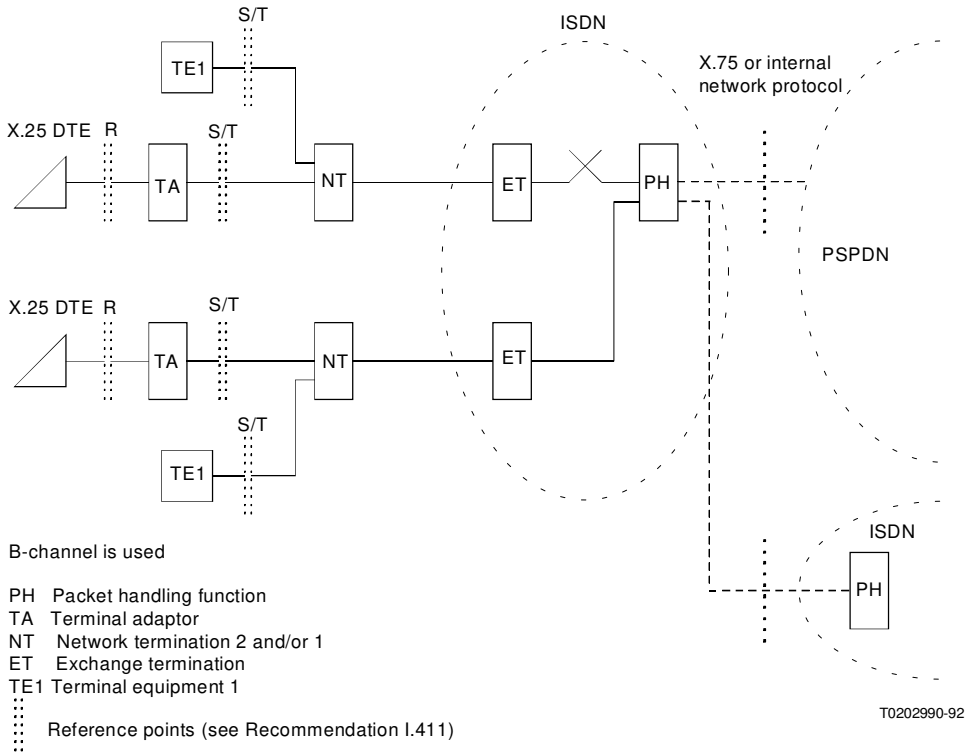
– in case of use of B-channel (see Figure 3/E.712) the channel and the 64 kbit/s circuit connecting it to the PH can be simultaneously used by the virtual calls of only one terminal. Thus, from the traffic point of view this case is similar to case A;

– in case of use of D-channel (see Figure 4/E.712), the D-channel can be simultaneously used by the virtual calls of several user terminals. In addition a frame concentrator could be provided to perform a statistical multiplexing of the calls carried by a group of D-channels into a reduced number of 64 kbit/s circuits connected to the PH functions.

4.2 *Identification of call demands using a group of resources*

The connection characteristics of a call demand, as defined in Recommendation E.711, identifies if a call demand uses a certain group of resources.

The first connection characteristic to be considered is the information transfer mode: it is circuit switched in case A and packet switched in case B.



Note 1 – The figure is only an example of many possible configurations and is included as an aid to the text.

Note 2 – Solid line connections represent circuit switched connections and dashed line connections packet switched connections

FIGURE 3/E.712

Virtual circuit service – Access by B-channel

In case A, the following connection characteristics have also to be considered:

– communication configuration: it defines the position of the user and of the AU involved in the communication;

– information transfer capability (unrestricted or restricted digital);

– establishment of communication.

In case B, the connection characteristics to be considered are:

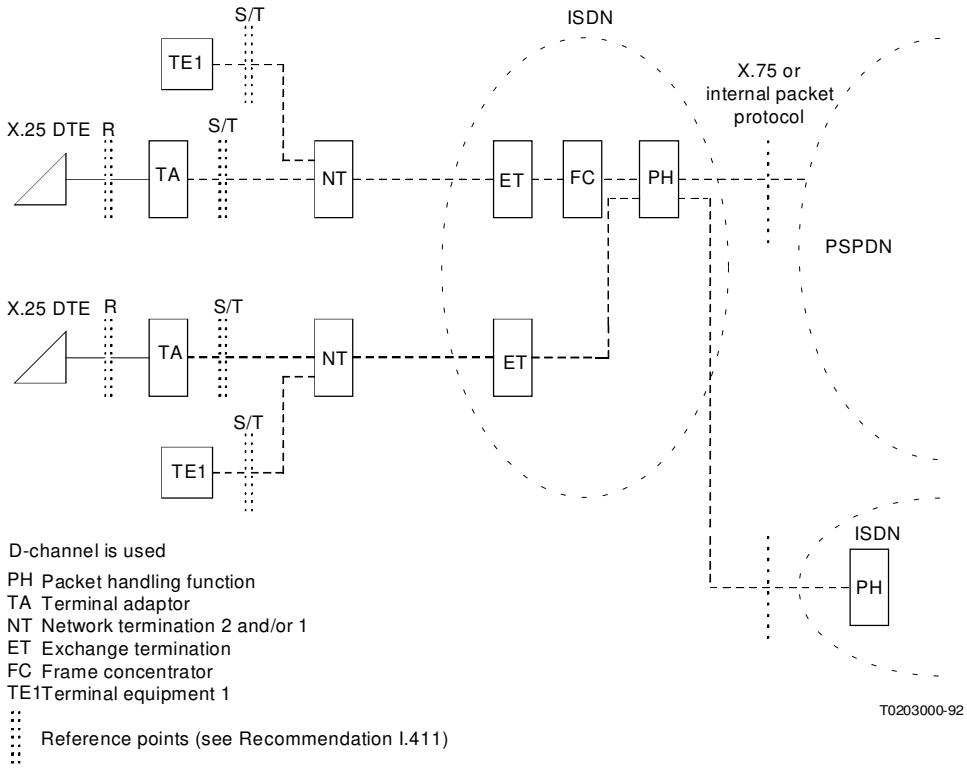
– access channel (B or D);

– communication configuration: it defines the position of the end users.

Additional connection characteristics to be considered, either in case A or B, are for further study.

4.3 *Traffic components and their parameters*

For packet switched traffic the components and the corresponding parameters to be considered for dimensioning purposes depend on the type of resources used on the access and in the network.



Note 1 – The figure is only an example of many possible configurations and is included as an aid to the text.

Note 2 – In some implementations the PH functions logically belonging to the ISDN may reside physically in a node of the PSPDN. The service provided is still the virtual circuit service.

Note 3 – Dashed line connections represent packet switched connections.

FIGURE 4/E.712

Virtual circuit service-access by D-channel

4.3.1 *ISDN accesses*

4.3.1.1 *B-channels*

The traffic offered to the B-channels of the ISDN accesses of a CPE due to packet switched traffic component is given by the traffic using an access type A or B as previously described. From the traffic point of view, when the access is a B-channel, case A and case B have to be dealt with in the same way.

Taking into account that the B-channel is used in circuit switched mode in both cases A and B, and that it is not necessary to distinguish the two directions of transmission, the parameters to be considered to characterize the traffic are:

– rate of (virtual) call demands;

– (virtual) call duration;

multiplexing coefficient of virtual calls, given by the mean number of simultaneous calls originated and terminated in the same user terminal when it is active (i.e. when it is connected through a B-channel either to an AU or a PH).

The multiplexing coefficient, which depends on the user behaviour and on the characteristics of the terminal, has to be considered since several simultaneous virtual calls to/from a same terminal are carried by the same B-channel.

4.3.1.2 *D-channels*

The user traffic offered to the D-channels due to the packet switched components (added to the control plane traffic) must be characterized in terms of:

– rate of (virtual) call demands;

– number of packets per (virtual) call;

– length of packets.

The two directions must be distinguished as the packet flow may be different in each direction.

In spite of the general characteristics of the packet arrival law for each call and for the superposition (multiplexing) of several calls, the mean values can be used in a first step to characterize these traffics (see Recommendation E.711).

4.3.2 *Resources in the network*

4.3.2.1 *Circuits to access AU or PH*

The circuits used in the network to link the users accesses to the AU or PH are directly correlated to the use of B-channels and of D-channels.

A concentration function may or may not be performed by the exchange for a group of B-channels (circuit type concentration) or a group of D-channels (e.g. a frame concentrator).

If no function of concentration is performed by the exchange, then a circuit will correspond to each B-channel and to each D-channel.

In any case it is always necessary to determine:

– When B-channel is used, the total amount of traffic to each destination; for case A it means traffic between the groups of users and the AUs; for case B it means traffic between the group of users and the PHs. As described for B-channels in § 4.3.1 the parameters to be considered are only the rate of call demands, the call duration and the multiplexing coefficient.

– When D-channel is used, the total amount of traffic between a group of D-channels and each PH. As described for D-channels in § 4.3.1 the parameters to be considered are mainly related to the total rate of packets to transfer in each direction and their length.

4.3.2.2 *Circuits between PHs*

The total amount of traffic between each pair of PHs has to be determined. The parameters to be considered are mainly related to the total number of packets to transfer in each direction and their length.

4.3.2.3 *AU and PH functions*

For each of these resources it is necessary to determine the total rate of calls, their duration and the rate of packets to handle. The rate of calls allows the dimensioning of the call handling processors and, taking account of their duration, allows the dimensioning of the memory resources. The rate of packets allows the dimensioning of the packet handling processors.

4.4 *Quantification of traffic offered*

Following Recommendation E.711, and taking into account the previous considerations, the total amount of traffic offered in the user plane to the different resources of the network can be calculated.

4.4.1 *ISDN accesses*

4.4.1.1 *B-channels*

For the B-channels of the ISDN accesses of a CPE, the traffic due to packet-switch, A_{BP}, is given by:

$$A_{BP} = \frac{1}{C_M} \cdot \sum_{i,j,k} rc(i,j,k) \cdot f(i,j) \cdot h(i,j,k) \qquad \text{(Erl)} \qquad C_M \geq 1$$

where:

– $rc(i,j,k)$ is the rate of originating or terminating call demands of the set of users of the CPE (CPE user set) corresponding to the telecommunication service i, set of connection characteristic j and call pattern k;

– $f(i,j)$ is 1 for packet call types (i,j) which are case A or case B with use of B-channel; for calls case B with use of D-channel, $f(i,j) = 0$;

– $h(i,j,k)$ is the call duration of the call demands of type (i,j,k);

– C_M is the multiplexing coefficient defined in § 4.3.1. Above formula assumes that C_M is the same for all the terminals of the CPE. Otherwise, the part of A_{BP} corresponding to each terminal should be separately evaluated, the total A_{BP} being obtained by addition.

4.4.1.2 *D-channels*

The total load measured in bit/s, due to packet-switched traffic, offered to the D-channels of a CPE in each direction is given by:

$$B_{DP}(d) = \sum_{i,j,k} rc(i,j,k) \cdot f(i,j) \cdot p(i,j,k,d) \cdot [l(i,j,k,d) + \alpha(d) \cdot l'] \quad \text{(bit/s)}$$

where:

– $rc(i,j,k)$ is the rate of originating or terminating call demands of the type (i,j,k) of the CPE user set;

– $f(i,j)$ is 1 for packet call types (i,j) which are case B with use of D-channel; otherwise, $f(i,j) = 0$;

– $p(i,j,k,d)$ is the mean number of packets per call demand of the type (i,j,k), including layer 3 control packets, in the direction d ($d = 1$ in one direction and $d = 2$ in the other one);

– $l(i,j,k,d)$ is the mean length of those packets, including bits of layer 2 protocol;

– $\alpha(d)$ is the mean number of layer 2 control frames per packet, in the direction d;

– l' is the length of those layer 2 control frames.

4.4.2 *Resources in the network*

As was said in § 3.5.2, the first step to quantify the traffic offered to a group of resources is to identify the users which can offer traffic to them. Two criteria can be followed to identify the user, among the ones involved in a call demand, which offer traffic to the considered group of resources:

– the closest user to the group of resources, regardless of the fact that this user has originated or received the call;

– the user which has originated the call.

Once the population of users, or more precisely, the population of CPE user sets offering traffic to the group of resources has been identified according to one of the two above-mentioned criteria, this population is characterized according to § 3.3 of Recommendation E.711, by these variables:

– N, number of CPEs in the population;

– $rc(i,j,k)$, mean value per CPE user set in the population of the rate of call demands type (i,j,k), (both origination and terminating types of call demands or only origination types have to be considered depending on the criterion followed to identify the users);

– $f(i,j)$, which takes the value 1 or 0 depending on whether the calls of the types i,j use the group of resources;

– $h(i,j,k)$ is the mean call duration of the calls of the type (i,j,k);

– C_M is the multiplexing coefficient of the terminals of the population of CPEs;

– $p(i,j,k,d)$ is the mean number of packets per call demand of the type (i,j,k), including layer 3 control packets, in the direction d(d = 1 or 2);

– $l(i,j,k,d)$ is the mean length of those packets, including bits of layer 2 protocol;

– $\alpha(d)$ is the mean number of layer 2 control frames per packet, in the direction d;

– l' is the length of those layer 2 control frames.

Note – For evaluating the traffic offered to the circuits between B-channels and AU or between B-channels and PH, the variables $p(i,j,k,d)$, $l(i,j,k,d)$, $\alpha(d)$ and l' are not needed. For circuits between D-channels and a PH or between two PHs, $h(i,j,k)$ and C_M are not needed. For AUs and PHs, C_M, $\alpha(d)$ and l' are not needed.

Based on the above variables, the traffic offered to a group of resources is calculated as follows:

a) *Circuits between B-channels and an AU or between B-channels and PH*

$$A = N\frac{1}{C_M} \cdot \sum_{i,j,k} rc(i,j,k) \cdot f(i,j) \cdot h(i,j,k) \qquad \text{(Erl)} \qquad C_M \geq 1$$

For circuits between B-channels and AU, only calls case A can have $f(i,j,) = 1$ and for circuits between B-channels and a PH, only calls case B using B-channels can have $f(i,j) = 1$.

The above formula assumes that C_M is the same for all the terminals of the population. Otherwise, the traffic offered by each terminal (or set of terminals with a same value of C_M) has to be separately evaluated, the total traffic being obtained by addition.

b) *Circuits between D-channels and PH or between two PHs*

The load in each direction, measured in bit/s, is given by:

$$B(d) = N \cdot \sum_{i,j,k} rc(i,j,k) \cdot f(i,j) \cdot p(i,j,k,d) \cdot [l(i,j,k,d) + \alpha(d) \cdot l'] \quad \text{(bit/s)}$$

For circuits between D-channels and a PH, only calls case B using D-channels can have $f(i,j) = 1$, and for circuits between two PHs, only calls case B (using B or D-channel) can have $f(i,j) = 1$.

c) *AU and PH functions*

The dimensioning of these functions require to know:

– the rate of handled calls, C:

$$C = N \cdot \sum_{i,j,k} rc(i,j,k) \cdot f(i,j) \qquad \text{(calls/s)}$$

– the rate of handled packets, P:

$$P = N \cdot \sum_{i,j,k} rc(i,j,k) \cdot f(i,j) \cdot [p(i,j,k,1) + p(i,j,k,2)] \qquad \text{(pack/s)}$$

– the mean number of simultaneous calls, A:

$$A = N \cdot \sum_{i,j,k} rc(i,j,k) \cdot f(i,j) \cdot h(i,j,k) \qquad \text{(Erl)}$$

For AU function, only calls case A can have $f(i,j) = 1$, and for PH function, only calls case B can have $f(i,j) = 1$.

ANNEX A

(to Recommendation E.712)

Alphabetical list of abbreviations used in this Recommendation

AU Access unit

CPE Customer premises equipment

DTE Data terminal equipment

ET Exchange termination

FC	Frame concentrator
GOS	Grade of service
ISDN	Integrated services digital network
LE	Local exchange
NT	Network termination
PCM	Pulse code modulation
PH	Packet handling
PSPDN	Packet switched public data network
TA	Terminal adaptor
TE	Transit exchange
TE1	Terminal equipment 1
TSSI	Time-slot sequence integrity