INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.966

(02/99)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital transmission systems – Digital sections and digital line system – Digital section and digital transmission systems for customer access to ISDN

Access digital section for B-ISDN

ITU-T Recommendation G.966

(Previously CCITT Recommendation)

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

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ITU-T RECOMMENDATION G.966

ACCESS DIGITAL SECTION FOR B-ISDN

Summary

The purpose of this Recommendation is to define the characteristics of a B-ISDN access digital section for the B-ISDN customer access between the broadband user-network interface (at the T_B reference point) and the first ATM equipment on the network side of the B-NT1 (at V_{B1} reference point).

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As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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Recommendation G.966

ACCESS DIGITAL SECTION FOR B-ISDN

(Geneva, 1999)

1 Scope

This Recommendation defines the characteristics of the B-ISDN access digital section for the B-ISDN customer access between the B-ISDN user-network interface (at the T_B reference point, defined in Recommendation I.413 [9]) and the first ATM equipment on the network side of the B-NT1 (at V_{B1} reference point).

Both homogeneous and non-homogeneous access digital sections are possible, depending on the functionality required. This Recommendation applies to the non-homogeneous B-ISDN access digital section where the bit rate used for the UNI is different from the bit rate of other parts of the section. In this case, transmission path termination and TC sublayer functions are provided by the access digital section.

In the case of a homogeneous B-ISDN access digital section, where the bit rates are the same for the UNI and the other parts of the section, transmission path termination and TC sublayer functions are not required. This case is outside the scope of this Recommendation.

In this Recommendation and unless otherwise indicated, the term B-TE is used to indicate terminating layer 1 aspects of B-TE, B-TA and B-NT2 functional groups (as defined in Recommendation I.413 [9]). The term B-ET is used to indicate terminating layer 1 aspects of the first ATM equipment on the network side of the B-NT1 (at V_{B1} reference point). When the term B-TE indicates terminating layer 1 aspects of B-TE, then according to Recommendation I.413 [9], the S_B and T_B reference points coincide.

2 References

The following ITU-T 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.

[1]   ITU-T Recommendation G.704 (1998), *Synchronous frame structure used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels*.

[2]   ITU-T Recommendation G.803 (1997), *Architecture of transport networks based on the synchronous digital hierarchy (SDH)*.

[3]   ITU-T Recommendation G.821 (1996), *Error performance of an international digital connection operating at a bit rate below the primary rate and forming part of an integrated services digital network*.

[4]   ITU-T Recommendation G.826 (1999), *Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate*.

[5]   ITU-T Recommendation G.827 (1996), *Availability parameters and objectives for path elements of international constant bit rate digital paths at or above the primary rate*.

[6]   ITU-T Recommendation G.902 (1995), *Framework Recommendation on functional access networks – Architecure and functions, access types, management and service node aspects.*

[7]   ITU-T Recommendation I.311 (1996), *B-ISDN general network aspects.*

[8]   CCITT Recommendation I.321 (1991), *B-ISDN protocol reference model and its application.*

[9]   ITU-T Recommendation I.413 (1993), *B-ISDN user-network interface.*

[10]   ITU-T Recommendation I.414 (1997), *Overview of Recommendations on layer 1 for ISDN and B-ISDN customer accesses.*

[11]   ITU-T I.432.x-series Recommendations, *B-ISDN user-network interface – Physical layer specification.*

         NOTE – This reference applies to Recommendations I.432.1, I.432.2, I.432.3, I.432.4 and I.432.5.

[12]   ITU-T Recommendation I.610 (1999), *B-ISDN operation and maintenance principles and functions.*

[13]   ITU-T Recommendation I.732 (1996), *Functional characteristics of ATM equipment.*

[14]   ITU-T Recommendation I.751 (1996), *Asynchronous transfer mode management of the network element view.*

[15]   ITU-T Recommendation M.3610 (1996), *Principles for applying the TMN concept to the management of B-ISDN.*

[16]   ITU-T Recommendation G.783 (1997), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks.*

[17]   ITU-T Recommendation G.784 (1994), *Synchronous digital hierarchy (SDH) management.*

[18]   CCITT Recommendation G.774 (1992), *Synchronous digital hierarchy (SDH) management information model for the network element view.*

[19]   ITU-T Recommendation G.805 (1995), *Generic functional architecture of transport network.*

3   Definitions and abbreviations

3.1   Definitions

This Recommendation defines the following terms:

3.1.1   broadband access digital section: is defined in Recommendation I.414 [10] as the section between the user-network interface at reference point T_B and the reference point V_{B1}.

3.1.2   homogeneous access digital section: is defined as an access digital section where the bit rate used for the UNI is the same as the bit rate of other parts of the section.

3.1.3   non-homogeneous access digital section: is defined as an access digital section where the bit rate used for the UNI is different from the bit rate of other parts of the section.

In addition, this Recommendation uses terms defined in other ITU-T Recommendations:

Broadband exchange termination (B-ET), **Broadband network termination 1 (B-NT1)**: Recommendation I.413 [9].

B-ISDN customer access: Recommendation I.414 [10].

Communication function (CF): Recommendation M.3610 [15].

3.2 Abbreviations

This Recommendation uses the following abbreviations:

AIS	Alarm Indication Signal
AN	Access Network
ATM	Asynchronous Transfer Mode
BER	Bit Error Ratio
B-ET	Broadband Exchange Termination
BIP	Bit Interleaved Parity
B-ISDN	Broadband Integrated Services Digital Network
B-LT	Broadband Line Termination
B-NT1	Broadband Network Termination 1
B-NT2	Broadband Network Termination 2
B-TA	Broadband Terminal Adapter
B-TE	Broadband Terminal Equipment
CF	Communication Function
CLP	Cell Loss Priority
CRC	Cyclic Redundancy Check
DS	Digital Section
EDC	Error Detection Code
FC	Failure Condition
GFC	Generic Flow Control
HEC	Header Error Control
HOP	High Order Path
HOPA	High Order Path Adaptation
HOPT	High Order Path Termination
LCD	Loss of Cell Delineation
LOC	Loss of Continuity
LOF	Loss of Frame synchronization
LOM	Loss of Multiframe
LOP	Loss of Pointer
LOS	Loss of Signal
MPH	Management (entity) PHysical (layer) primitive
MPH-EI	MPH Error Indication
MS	Multiplex Section
MSA	Multiplex Section Adaptation
MST	Multiplex Section Termination
OAM	Operations and Maintenance
OCD	Out of Cell Delineation
PDH	Plesiochronous Digital Hierarchy

PH	PHysical (layer)
P-LOP	Path Loss of Pointer
P-PLM	Path Payload Mismatch
P-TIM	Path Trace Identifier Mismatch
P-UNEQ	Path Unequipped
RAI	Remote Alarm Indication
RDI	Remote Defect Indication
Reg	Regenerator
RS	Regenerator Section
RSA	Regenerator Section Adaptation
RST	Regenerator Section Termination
SDH	Synchronous Digital Hierarchy
SN	Service Node
SNI	Service Node Interface
STM	Synchronous Transmission Multiplex
TC	Transmission Convergence
TM	Transmission Media
TML_{LM}	Transmission Layer for Layer Management
TMN	Telecommunications Management Network
TP_A	Transmission Path Adaptation
TP_A_{LM}	Transmission Path Adaptation for Layer Management
TP_A_T	Transmission Path Adaptation for Transfer function
TP_T	Transmission Path Termination
TP_T_{LM}	Transmission Path Termination for Layer Management
TP_T_T	Transmission Path Termination for Transfer function
UNI	User-Network Interface
VCI	Virtual Channel Identifier
VP	Virtual Path
VPI	Virtual Path Identifier
VPT	Virtual Path Termination

4   Reference configuration

Figure 1 shows the boundaries of the B-ISDN access digital section, which consists of the functional groups broadband network termination 1 (B-NT1), broadband line termination (B-LT) and the digital transmission system.
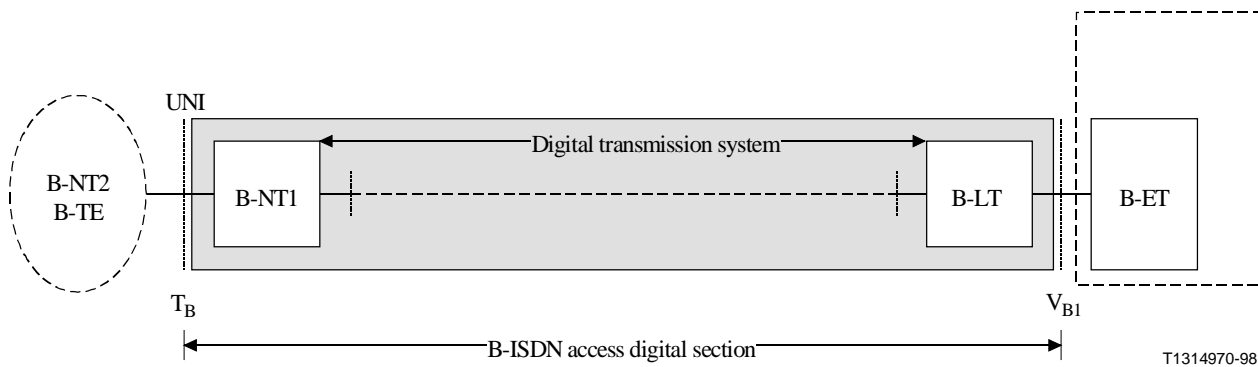
Figure 1/G.966 – B-ISDN access digital section and access digital transmission system

The concept of the B-ISDN access digital section is used in order to allow a functional description and a definition of the requirements of this part of public broadband networks.

NOTE – From a functional point of view, the information transferred via the reference points T_B and V_{B1} is different and therefore the B-ISDN access digital section is not symmetrical.

At the B-ISDN access digital section termination points, Recommendations I.413 [9] and I.432.x [11] (T_B reference point) and I.414 [10] (V_{B1} reference point) apply.

The concept of a digital transmission system is used in order to describe the characteristics of an implementation, using a specific medium, in support of the B-ISDN access digital section. Implementation rules for the access digital transmission system shall not be restricted by this Recommendation.

4.1 Application

The B-ISDN access digital section may be applied to any digital transmission system spanning from the B-NT1 to the first ATM equipment on the network side of the B-NT1. This first ATM equipment (i.e. VP connection point) can be the service node (B-ET) for the direct access connection element implementation case or any type of ATM equipment located within an access network for the remote access connection element implementation case according to Recommendation G.902 [6].

NOTE – The direct access connection element implementation case can be considered a special case of remote access connection element implementation case where no ATM equipment on the network side of the B-NT1 is located in the access network. Thus the B-ISDN access digital section will be the simplest case of an access network.

The functions of B-ISDN access digital section must be independent of the different access connection element implementation cases.

At its two interfaces (at the T_B reference point and at the digital transmission system), the B-NT1 functional group shall be able to support different physical media dependent characteristics as well as different transfer capabilities (i.e. bit rate available for ATM cells). This capability of the B-NT1 functional group enables the application for UNIs for which no digital transmission system is defined (e.g. 25 Mbit/s, 51 Mbit/s).

5 Functional configuration

In order to describe the functional configuration of B-ISDN access digital section the termination points of regenerator sections, digital multiplex sections and transmission paths have to be identified. As an example, one possible functional configuration is depicted in Figure 2.

NOTE – In some applications, the B-LT may provide regenerator section sublayer functions only.
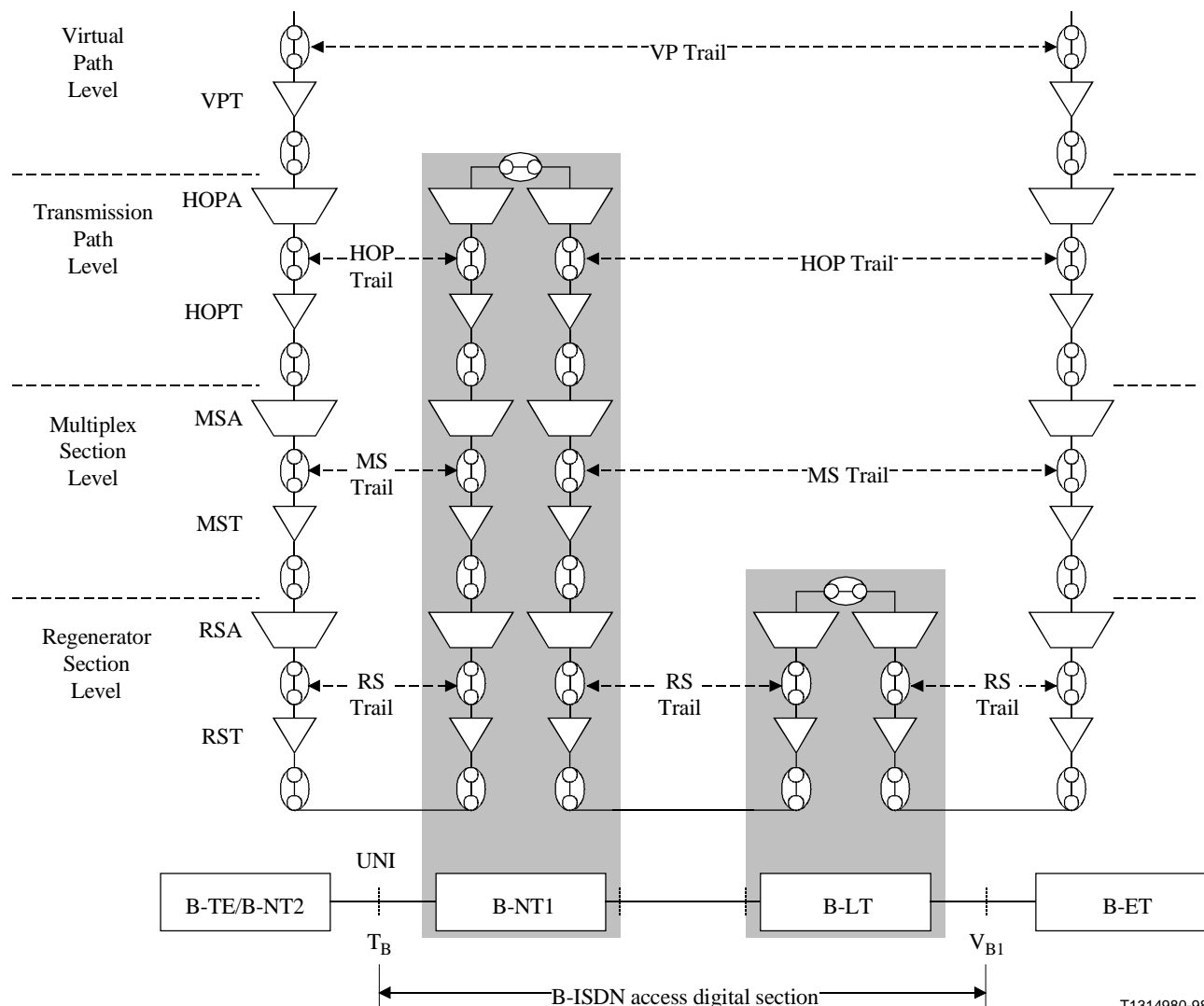
HOPA	High Order Path Adaptation	MSA	Multiplex Section Adaptation
HOPT	High Order Path Termination	MST	Multiplex Section Termination
RSA	Regenerator Section Adaptation	RST	Regenerator Section Termination
VPT	Virtual Path Termination		

Figure 2/G.966 – Example for functional configuration of B-ISDN access digital section with function levels according to ITU-T Recommendation I.311 [7]

5.1 Relationship between TMN and the B-ISDN access digital section

The B-ISDN management concepts for maintenance aspects of configuration, fault and performance management of B-ISDN customer accesses as well as the relation of the TMN and its functional interfaces to B-ISDN customer accesses are defined in Recommendation M.3610 [15].

The capability to exchange maintenance information between B-NT1 and B-ET is defined in Recommendation M.3610 [15] as Communication Function (CF) to manage the B-ISDN access digital section. Such communication through non-TMN interfaces to pass real time management information between B-ET and B-NT1 is illustrated in Figure 3, for both the direct access and the remote access. In case of the remote access, the functions of B-ET are split according to Recommendation G.902 [6].
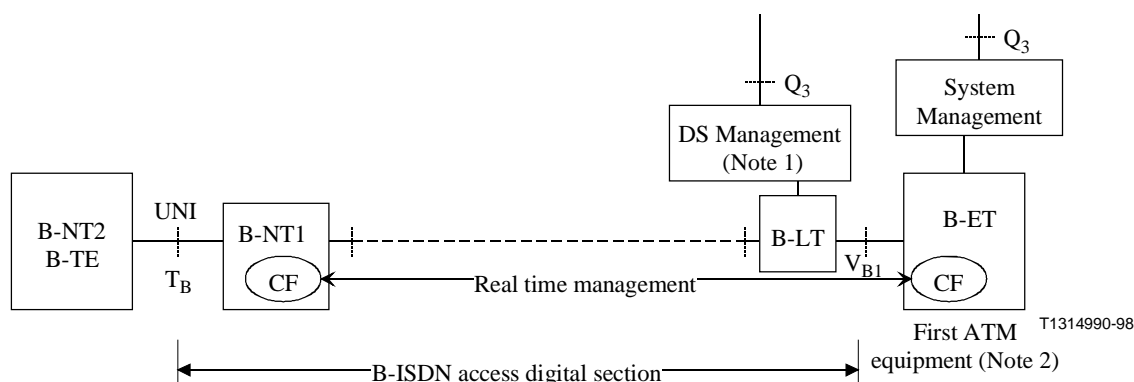
NOTE 1 – The DS Management and System Management are shown as separate functional entities but may be combined in one physical entity.

NOTE 2 – In case of direct access, this will be the SN.

**Figure 3/G.966 – Maintenance capabilities controlled by
the Communication Function (CF)**

There is a necessity for a separate management interface for the B-ISDN access digital section because access digital sections, access networks and transport networks can be owned and operated by different organizations. This interface mainly supports management functions from the network point of view, i.e. functions immediately required for maintenance, configuration and control of the B-ISDN access digital section.

In the general model of B-ISDN access digital section, the management interface should be associated with the B-LT because this may be the most cost-effective point for implementation of TMN access within the B-ISDN access digital section. Furthermore it could be advantageous to implement a common TMN interface for several B-LT located next to each other.

Management functions, however, must be implemented in all entities of the B-ISDN access digital section to guarantee the required maintenance and control capabilities. The management information shall be transferred by appropriate signals between the B-LT and the B-NT1. Thus the TMN interface located near the B-LT will also receive all information relating to the B-NT1 as well as B-NT1 control operations which are supported via this interface. The implementation of the required signals within a digital transmission system is not in the scope of this Recommendation.

Furthermore management information has to be transferred to management interfaces located in the adjacent entities at user side and network side. This real time management function should also be performed by a set of appropriate signals assigned to the UNI or SNI, respectively. This information relates primarily to the availability of the B-ISDN access digital section for services of higher layers (management point of view for services).

6 Main functions

6.1 Functions of B-ISDN access digital section

The B-ISDN access digital section should support the main functions depicted in Figure 4. The B-ISDN access digital section performs functions related to both the physical medium dependent sublayer and the transmission convergence sublayer according to the B-ISDN reference model (refer to Recommendation I.321 [8]).
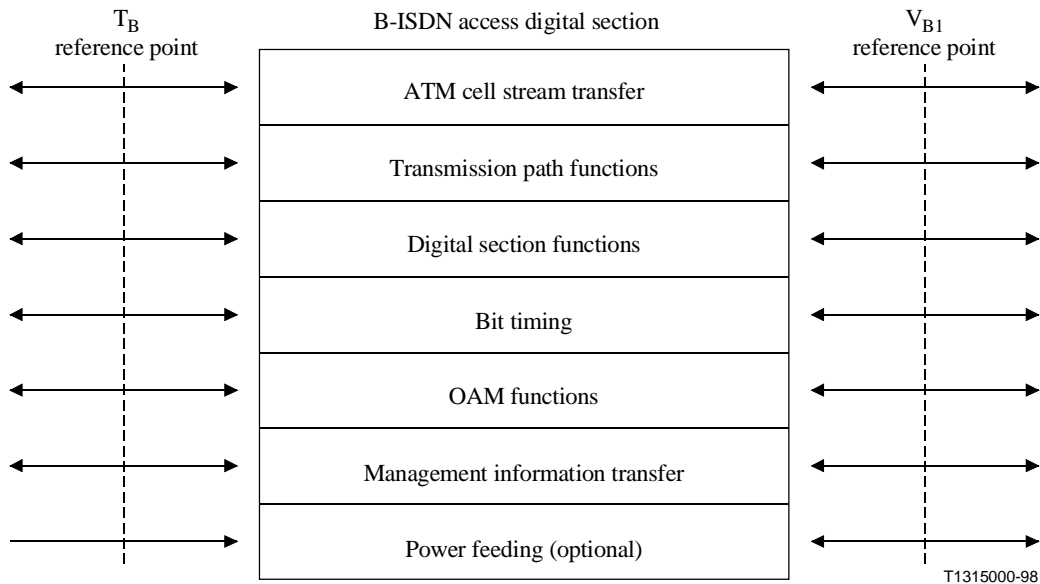
Figure 4/G.966 – Functions supported in the B-ISDN access digital section

The UNI specifications (Recommendations I.432.x [11]) do not support an activation/deactivation procedure in the physical layer. Thus an activation/deactivation function for the B-ISDN access digital section is not required as long as no transmission system will request such procedures. For that reason the activation/deactivation function is left for further study.

The UNI specifications (Recommendations I.432.2, I.432.3, I.432.4) are written on the assumption of a homogeneous access digital section, and therefore do not assume TC sublayer termination functionality within the B-ISDN access digital section.

6.1.1 ATM cell stream transfer

Bidirectional transmission of ATM cell streams within the payload of an appropriate digital transmission system (joint transmission of user cells and cells transferring control or OAM information).

6.1.2 Transmission path functions

Comprising all TC sublayer functions needed to adapt the ATM cell streams to different kinds of digital transmission systems:

• **Cell synchronization**: mechanism to detect cell boundaries (cell delineation).

• **Cell header error control**: protection of cell header information by appropriate HEC procedures, including error detection and error correction.

• **Transmission frame adaptation**: adaptation of cell streams to different transmission frame types used in digital transmission systems within the DS_B.

*   **Cell rate adaptation**: adaptation of cell rates to different capabilities of digital transmission systems within the DS_B, i.e. insertion and deletion of idle cells (cell rate decoupling).

TC sublayer termination functions are defined in the ATM equipment Recommendation I.732 [13].

Transmission path functions are defined in the appropriate transmission technology, for example Recommendation G.783 [16] for SDH transmission paths.

6.1.3   Digital section functions

Functions to be used in digital transmission systems for synchronization purposes:

*   **Frame synchronization**: mechanism to detect transmission frame boundaries (optional only for frame based transmission systems).
*   **Octet timing**: provision of timing information relating to the octet or byte that may be derived from the frame clock (optional depending on the digital transmission system used).

Digital section functions are defined in the appropriate transmission technology equipment Recommendations, for example Recommendation G.783 [16] for SDH digital sections.

6.1.4   Bit timing

Transmission of timing information relating to the signal element or bit in the physical medium dependent sublayer.

6.1.5   OAM functions

Support of the required OAM functions of the TC sublayer according to Recommendations I.610 [12] and I.732 [13] for maintenance and control of the B-ISDN access digital section by the management plane, and the appropriate physical layer Recommendations. (For example, Recommendations G.783 [16] and G.784 [17] for SDH being the physical layer.)

6.1.6   Management information transfer

Capabilities for management information transfer at transmission path, digital section and regenerator section level may be provided by allocation of appropriate transmission frame overhead bytes (case of framed transmission systems) or by special OAM cells (case of cell based transmission systems).

The real time management information through non-TMN interfaces for B-NT1 maintenance capabilities which are controlled by the Communication Functions (CFs) of B-NT1 and B-ET according to Recommendation M.3610 [15] shall be provided. For this communication, the ATM specific overhead functions described in Recommendation I.732 [13] and principal fault and performance management mechanisms specified in Recommendation I.751 [14] should be applied for the TC sublayer. For the physical layer (transmission path and digital section), the appropriate physical layer Recommendations (for example, Recommendations G.784 [17] and G.774 [18]) should be applied.

6.1.7   Power feeding

Power feeding of B-NT1 over the UNI at T_B reference point (optional) as described in Recommendations I.432.x [11].

6.2   General functional architecture of B-NT1

The B-NT1 functional group acts as a boundary between the access connection element and the customer premises equipment.

In Figure 5, the application of the functional architecture for a generalized ATM equipment (as defined in Recommendation I.732 [13]) to the B-NT1 functional group is illustrated. It is based on the B-ISDN protocol reference model described in Recommendation I.321 [8].
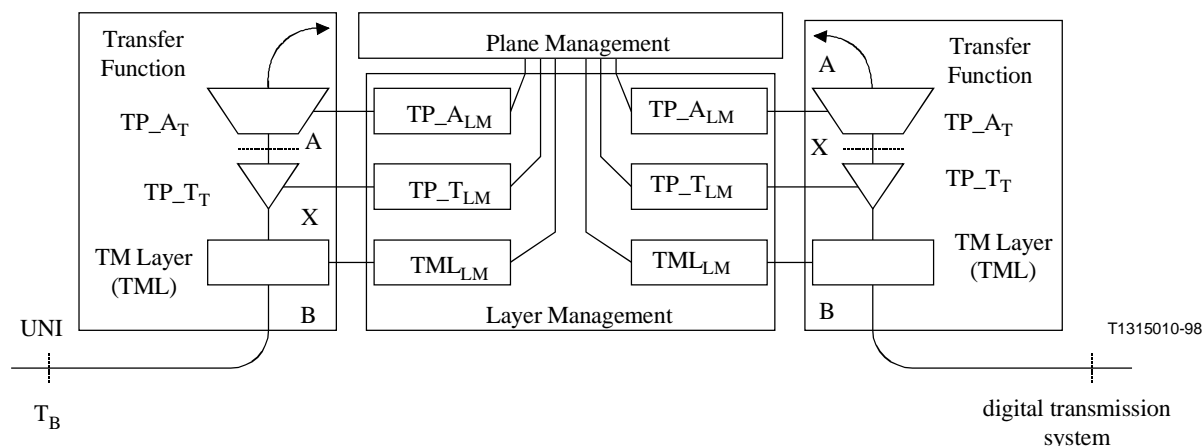
NOTE – Reference points A and B are defined (in Recommendation I.732 [13]) to indicate information flow directionality.

Reference point X is defined (in Recommendation I.732 [13]) for relating this generalized functional architecture to other network element functional architectures developed in ITU-T Recommendations.

Figure 5/G.966 – General functional architecture of the B-NT1

This generalized functional architecture divides the B-NT1 into the following functional areas: transfer functions, layer management functions, plane management and timing functions.

6.2.1   Transfer functions

The transfer functions of the functional group B-NT1 are related to the physical layer of the B-ISDN protocol reference model.

6.2.1.1   Section/path adaptation, section termination and lower layer functions

The section/path adaptation, section termination and lower physical layer functions are independent of the processing of the ATM cells. These functions are directly associated with the physical layer.

The physical layer specifications for the UNI (at reference point T_B) are provided in Recommendations I.432.x [11].

For the digital transmission system, the specifications in the relevant ITU-T Recommendations (e.g. SDH, PDH, etc.) apply here. Support of additional digital transmission systems is not precluded as national or network provider options.

6.2.1.2   Transmission path termination

The transmission path termination (TP_T) function terminates a transmission path by extraction and insertion of the appropriate overhead. These functions are defined in Recommendation I.732 [13].

The specifications for the UNI (at reference point T_B) are provided in Recommendations I.432.x [11].

For the digital transmission system, the specifications in the relevant ITU-T Recommendations (e.g. SDH, PDH, etc.) apply here. Support of additional digital transmission systems is not precluded as national or network provider options.

6.2.1.3   Transmission path adaptation

The transmission path adaptation (TP_A) function adapts an ATM cell structure to a transmission path signal structure. These functions are defined in Recommendation I.732 [13] as transmission path/virtual path adaptation (TP/VP_A).

According to the required functions for the B-ISDN access digital section (see 6.1), the B-NT1 functional group shall provide the following transmission path adaptation functions:

a)   Cell rate decoupling (between the directions B to A and A to B) by idle cell extraction/insertion.

b)   HEC processing: HEC verification (B to A) and HEC generation/insertion (A to B).

c)   Scrambling: cell information field descrambling (B to A) and cell information field scrambling (A to B).

d)   Cell delineation (B to A).

e)   Mapping: cell stream extraction (B to A) and cell stream insertion (A to B).

f)   Upper layer notification of loss of physical layer.

For the detailed specification of these transmission path adaptation functions, reference should be made to the description provided in Recommendation I.732 [13].

The functions above the transmission path adaptation (i.e. virtual path adaptation, virtual path termination) are not required by the B-NT1 functional group.

6.2.2   Layer management functions

Management information associated with a given transfer layer function is passed to (or received from) the corresponding layer management functions, i.e. for processing of configuration, fault detection, performance monitoring. Configuration, fault and performance information may be passed to plane management for further processing and/or communication to external network management entities and/or operating systems. Layer management functional blocks correspond one-to-one with transfer functional blocks.

Due to this one-to-one relationship no description of the layer management functions is included in this Recommendation. For the specification of the required TC sublayer management functions, related to the corresponding transfer function, reference shall be made to Recommendation I.732 [13]. For the physical layer management functions, reference shall be made to ITU-T Recommendations for the particular physical layer technology, for example G.783 [16] for SDH.

6.2.3   Plane management functions

Plane management deals with the set of functions applicable to management of the functional group B-NT1 as a whole or those functions related to the relationships with management systems external to the B-ISDN access digital section. It includes coordination between layer management entities.

Plane management includes the communication function (CF), which is responsible for the real-time communication between B-NT1 and B-ET across the V_{B1} reference point.

6.2.4   Timing functions

These functions deal with the actions required to synchronize the interfaces to a clock source. In normal operation, timing for the B-NT1 functional group is locked to the timing received from the B-ET-Layer 1 in the first ATM equipment on the network side of the B-NT1 and derived from the digital transmission system.
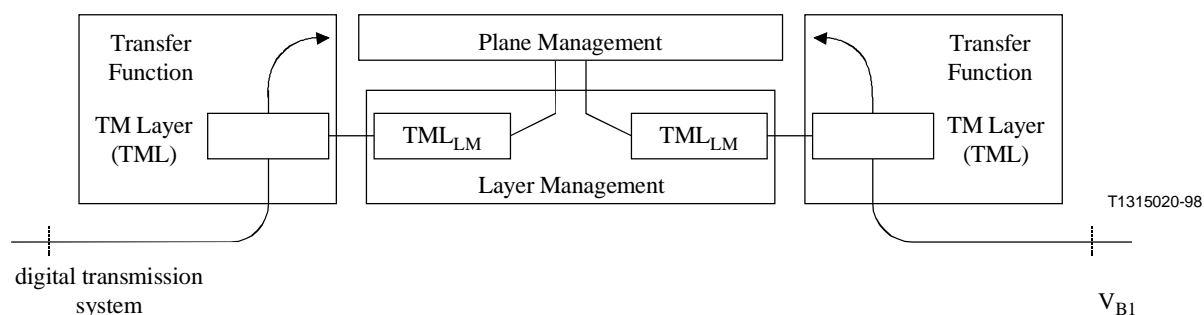
The specifications for the UNI (at reference point T_B) are provided in Recommendations I.432.x [11].

For the digital transmission system, the specifications in the relevant ITU-T Recommendations (e.g. SDH, PDH, etc.) apply here. Support of additional digital transmission systems is not precluded as national or network provider options.

6.3 General functional architecture of B-LT

This generalized functional architecture divides the B-LT into the following functional areas: transfer functions, layer management functions, plane management and timing functions.

In Figure 6 the application of the functional architecture to the B-LT functional group is illustrated. It is based on the B-ISDN protocol reference model described in Recommendation I.321 [8].

Figure 6/G.966 – General functional architecture of the B-LT

6.3.1 Transfer functions

The transfer functions of the functional group B-LT are related to the physical layer of the B-ISDN protocol reference model.

6.3.1.1 Section/path adaptation, section termination and lower layer functions

The section/path adaptation, section termination and lower physical layer functions are independent of the processing of the ATM cells. These functions are directly associated with the physical layer.

For the digital transmission system, the specifications in the relevant ITU-T Recommendations (e.g. SDH, PDH, etc.) apply here. Support of additional digital transmission systems is not precluded as national or network provider options.

6.3.2 Layer management functions

Management information associated with a given transfer layer function is passed to (or received from) the corresponding layer management functions, i.e. for processing of configuration, fault detection, performance monitoring. Configuration, fault and performance information may be passed to plane management for further processing and/or communication to external network management entities and/or operating systems. Layer management functional blocks correspond one-to-one with transfer functional blocks.

Due to this one-to-one relationship, no description of the layer management functions is included in this Recommendation. For the specification of the required layer management functions, related to the corresponding transfer function, reference shall be made to the appropriate physical layer ITU-T Recommendation, for example G.783 [16] in the case of SDH.

6.3.3 Plane management functions

Plane management deals with the set of functions applicable to management of the functional group B-LT as a whole or those functions related to the relationships with management systems external to the B-ISDN access digital section.

6.3.4 Timing functions

These functions deal with the actions required to regenerate the bitstream. In normal operation, timing for the B-LT functional group is locked to the timing received from the B-ET-Layer 1 in the first ATM equipment on the network side of the B-LT and derived from the digital transmission system.

7 Network performance

The network performance of the B-ISDN access digital section may be described by various parameters, including the following:

• availability;

• cell transfer delay;

• cell transfer delay variation;

• error performance;

• input and output jitter.

NOTE – This Recommendation does not contain any limits for these parameters. It must be taken into account that these values are dependent on the transmission system technology to be applied and are described in the appropriate Recommendations.

In general the B-ISDN access digital section has to fulfil the performance requirements according to Recommendation G.826 [4] and the availability parameters specified in Recommendation G.827 [5].

8 Operation and maintenance

8.1 OAM functions

The application of management functions according to Recommendation I.610 [12] and the appropriate physical layer Recommendations to the B-ISDN access digital section has two main objectives:

– Supervision of availability and failure detection:

• supervision of B-ISDN access digital section regardless of the customer installation at the UNI;

• failure detection and indication;

• failure information transfer with a minimum time delay to the concerned entities and the TMN to assure the required system protection.

– Support of management plane functions:

• monitoring of transmission performance by appropriate forward error detection and correction procedures;

• notification of management plane about performance data;

• failure localization functions in the function units (e.g. for detection of line interruptions or loss of power);

• control functions for maintenance or test facilities.

These B-ISDN access digital section OAM functions must be assigned to the OAM levels F1 to F3 of the physical layer according to Recommendation I.610 [12] and the appropriate equivalent physical layer Recommendations. OAM levels corresponding to the different layers of a layered network (refer to Recommendation G.805 [19]) characterize the entities processing the assigned OAM information and define termination points for the corresponding information transfer. Figure 7 shows the application of these OAM levels to DS_B. In this example all possible OAM levels are depicted. These levels may not necessarily exist in every implementation. If an OAM level does not exist in an implementation, the assigned OAM functions are performed by the next higher OAM level. The OAM levels F4 and F5 of the ATM layer are not considered in the scope of this Recommendation because a VP connection end point or VP segment end point does not exist within the B-ISDN access digital section.

The type of required OAM mechanisms and their assignment to OAM levels is dependent on the digital transmission system technology. Generally all transmission system specific OAM functions defined in other Recommendations should be applied and enhanced by B-ISDN and ATM specific functions.
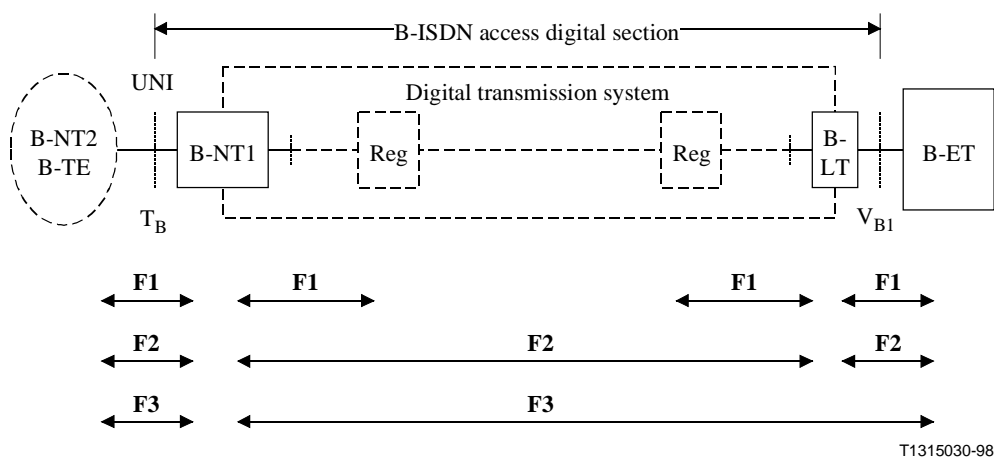
**Figure 7/G.966 – Flows of OAM levels F1 to F3 within
the B-ISDN access digital section (example)**

NOTE – In some applications, the B-LT may provide regenerator section sublayer functions only, and the OAM flows will be altered accordingly.

8.1.1 Monitoring functions

There are several possibilities for implementation of monitoring functions within the B-ISDN access digital section. For example the monitoring information can be transferred periodically towards the management entities and will be processed there, or it may be transferred only if errors occur. Otherwise the entities of the B-ISDN access digital section may have their own registers and counters for data processing and send status reports on request towards the management plane.

8.1.1.1 Failure detection

The failure detection functions of the B-ISDN access digital section should be based on the functions defined for the user side and network side in the appropriate UNI Recommendations. The B-ISDN access digital section must support the indication of failure states between B-TE and B-ET. At the T_B reference point, the signals defined in Recommendations I.432.x [11] have to be used. Where possible, failures have to be indicated to both B-TE and B-ET.

Failure events within the B-ISDN access digital section are:

- loss of signal (LOS);
- loss of frame synchronization (LOF) for frame based transmission systems;
- loss of cell delineation (LCD);
- invalid AU4 pointer (LOP) for SDH based transmission systems;
- omission of F1 or F3 OAM cells for cell based transmission systems;
- exceeding of BER limit;
- loss of power at B-NT1;
- detection of alarm indication signals in direction of transmission (AIS);
- detection of remote defect indication signals in opposite direction of transmission (RDI).

The failure detection algorithms can be separated into transmission system specific algorithms (e.g. LOS or LOF detection) and special algorithms related to ATM cell transfer. For the first group, the specific Recommendations for the appropriate transmission system technology have to be applied. For the second group, the UNI Recommendations contain the required information.

8.1.1.2   Performance monitoring

The B-ISDN access digital section has to deliver the required information to the management plane to evaluate the transmission performance according to Recommendations G.821 [3] and G.826 [4]. This information can be transferred directly, or else counters and registers within the elements of the B-ISDN access digital section may be used for data processing and sending status reports to the management plane.

Transmission errors should be registered both on bit level by Error Detection Code (EDC), e.g. BIP, CRC procedures within conventional transmission systems and on cell level by the HEC algorithm according to Recommendations I.432.x [11].

The following performance parameters should be registered within the B-ISDN access digital section and transferred periodically or on request to the management plane:

- detected transmission errors and error ratios;
- power feeding state at B-NT1 (optional);
- information about the duration of failures.

8.1.2   Control functions

For further study.

8.2   OAM procedures

Recommendations I.432.x [11] defines the UNI network side at reference point T_B as a functional block, supporting the OAM procedures at this reference point and primitive procedures between physical layer and ATM layer respectively between physical layer and management plane in the B-ET. Thus this block contains the functional groups B-NT1, B-LT and B-ET (physical layer).

This concept can be described by means of a state machine, called G state machine in Recommendations I.432.x [11]. State machines can be considered as virtual function units, describing the functional behaviour of entities at their terminating points. This behaviour is described with the help of state transition tables, which specify the actions to be taken on occurrence of different events, depending on the entity's current state.

In order to depict the functional behaviour of B-ISDN access digital section at terminating points T_B and V_{B1} within the user access, it is necessary to define two different state machines at UNI network side. One of them characterizes the behaviour of the B-ISDN access digital section (DS state machine) and the other the physical layer of B-ET (B-ET state machine). This approach illustrated in Figure 8 allows to separate the OAM functions between these two state machines.
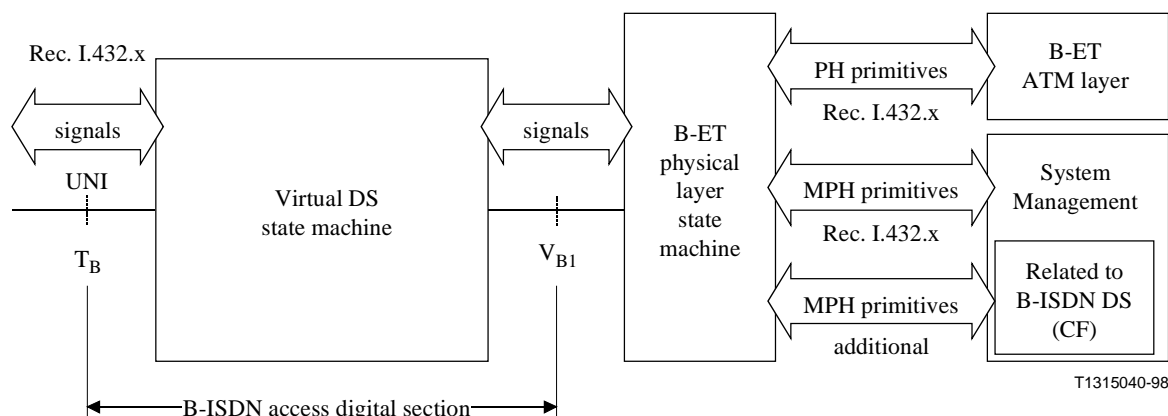
Figure 8/G.966 – B-ISDN access digital section state machine and B-ET state machine

The B-ET state machine contains the necessary procedures to interact with the ATM layer and the management plane to fulfil the requirements according to Recommendations I.432.x [11].

For the description of customer access, the B-ISDN access digital section state machine must be further partitioned into separate state machines for the B-NT1 (B-NT1 state machine) and the B-LT (B-LT state machine) (see Figure 9).

The B-NT1 state machine supports the required UNI procedures according to ITU-T Recommendations I.432.x [11] and communicates with the B-LT state machine by an appropriate set of signals.

The B-LT state machine has connections to the B-NT1 state machine and the B-ET state machine by means of signals. At the location of B-LT all information required by management plane from the network point of view must be accessible, e.g. for failure localization or evaluation of transmission performance.

The B-ET state machine recognizes the B-ISDN access digital section state from higher layers point of view and thus from service point of view. The essential management information in this context is the availability of the physical layer service for the ATM layer.
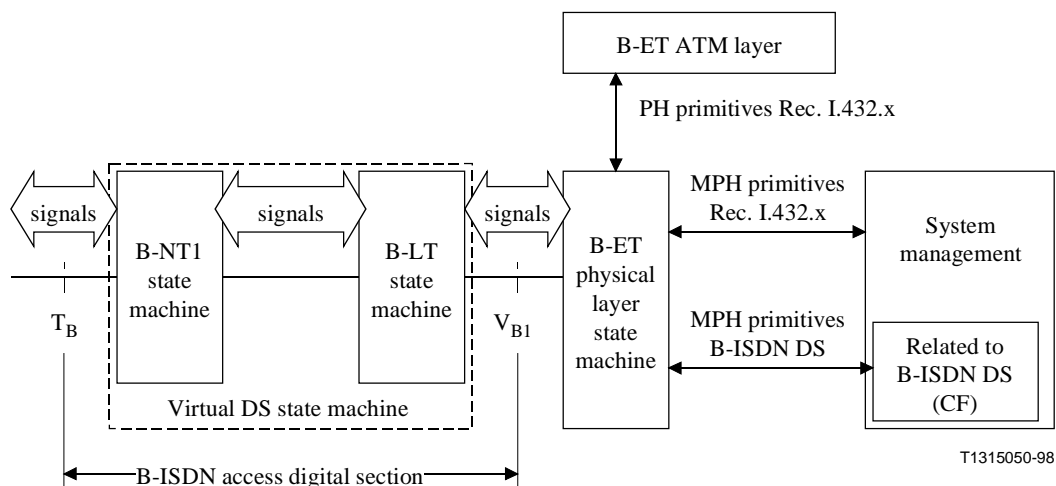
Figure 9/G.966 – B-NT1 state machine and B-LT state machine

The following signals related to maintenance, as specified in Recommendations I.610 [12] and I.432.x [11], are used as indicated below:

• Indication of LOS, LOF, LOP and LCD are generated within the functional groups.

• Multiplex Section-AIS, Path-AIS, Multiplex Section-RDI, Path-RDI are signals transmitted/received across the interfaces.

ANNEX A

B-ET physical layer state transition table

The following primitives should be used between the physical layer and the ATM layer (primitives PH) or between the physical layer and the management entity (primitives MPH).

PH-AI   PH Active Indication.

PH-DI   PH Deactive Indication.

MPH-AI   MPH Active Indication (is used as error recovery and initialization information).

MPH-EI n   MPH Error Indication with parameter "n". Parameter "n" indicates the failure condition as shown in the table below:

MPH-EI primitive	Meaning
MPH-EI 1	failure condition FC1
MPH-EI 2	failure condition FC2
MPH-EI 3	failure condition FC3
MPH-EI 4	failure condition FC4
MPH-EI P	Loss of power at B-ET
MPH-EI L	FC1V at B-ET
MPH-EI ET	B-ET internal failure
MPH-EI 0	Loss of power at B-NT1

The B-ET states have been numbered to form classes of problems as follows (states ET3.x are not used):

ET0.x B-ET problems.

ET1 Operational.

ET2.x B-ISDN access digital section problems, including V_{B1} and possibly concurrent user side (at T_B reference point) problems.

ET4.x User side (at T_B reference point) problems.

The following symbols are used within the B-ET state transition tables:

"—" no change of state.

"/" impossible situation or not detectable event.

The applicability of failure conditions to locations is illustrated in Figure A.1.

Note that the tables do not include the behaviour when Path Loss of Pointer (P-LOP), Path Unequipped (P-UNEQ), Path Trace Identifier Mismatch (P-TIM), Path Payload Mismatch (P-PLM) and LCD fault conditions are active while at the same time there is no LOS/LOF fault condition.
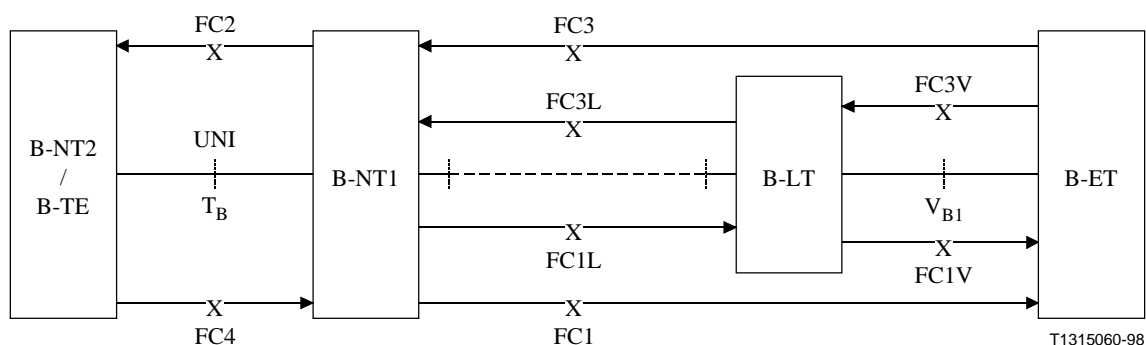
Figure A.1/G.966 – Applicability of failure conditions to locations

Table A.1/G.966 – B-ET state table – Physical layer state transition table

State	ET0.1	ET0.2	ET0.3	ET1	ET2.1	ET2.2	ET2.3	ET2.4	ET4.1	ET4.2
Operational or failure condition as seen from the B-ET	Power off at B-ET	Power on at B-ET or FC1V	B-ET Internal Failure	Operational	FC1	FC3	FC3 & FC4	B-NT1 power off	FC2	FC4
Signals transmitted towards reference point V_{B1}	No signal	Signal with P-RDI (Note 3) (Note 4)	Signal with AIS	Normal operational signal	Signal with P-RDI (Note 3) (Note 4)	Normal operational signal	Normal operational signal (Note 4)	Signal with MS-RDI and P-RDI (Note 3) (Note 4)	Normal operational signal	Normal operational signal (Note 4)
Event										
Loss of power B-ET	/	MPH-EI P ET0.1	MPH-EI P ET0.1	PH-DI MPH-EI P ET0.1	MPH-EI P ET0.1	MPH-EI P ET0.1	MPH-EI P ET0.1	MPH-EI P ET0.1	MPH-EI P ET0.1	MPH-EI P ET0.1
Return of power B-ET	ET0.2	/	/	/	/	/	/	/	/	/
Normal operational signal	/	PH-AI MPH-AI ET1	/	— ET1	PH-AI MPH-AI ET1	PH-AI MPH-AI ET1	(Note 1)	PH-AI MPH-AI ET1	PH-AI MPH-AI ET1	PH-AI MPH-AI ET1
FC1	/	MPH-AI MPH-EI 1 ET2.1	MPH-EI 1 (Note 2)	PH-DI MPH-EI 1 ET2.1	— ET2.1	MPH-EI 1 ET2.1	MPH-EI 1 ET2.1	— ET2.4	MPH-EI 1 ET2.1	MPH-EI 1 ET2.1
FC2	/	MPH-AI MPH-EI 2 ET4.1	/	PH-DI MPH-EI 2 ET4.1	MPH-AI MPH-EI 2 ET4.1	MPH-AI MPH-EI 2 ET4.1	(Note 1)	MPH-AI MPH-EI 2 ET4.1	— ET4.1	MPH-AI MPH-EI 2 ET4.1
FC3	/	MPH-AI MPH-EI 3 ET2.2	MPH-EI 3 (Note 2)	PH-DI MPH-EI 3 ET2.2	MPH-AI MPH-EI 3 ET2.2	— ET2.2	MPH-AI MPH-EI 3 ET2.2	MPH-AI MPH-EI 3 ET2.2	MPH-EI 3 ET2.2	(Note 1)
FC4	/	MPH-AI MPH-EI 4 ET4.2	/	PH-DI MPH-EI 4 ET4.2	MPH-AI MPH-EI 4 ET4.2	(Note 1)	MPH-AI MPH-EI 4 ET4.2	MPH-AI MPH-EI 4 ET4.2	MPH-EI 4 ET4.2	— ET4.2
Loss of power B-NT1	/	MPH-AI MPH-EI 0 ET2.4	MPH-EI 0 (Note 2)	MPH-EI 0 ET2.4	MPH-AI MPH-EI 0 ET2.4	(Note 1)	MPH-EI 0 ET2.4	/	(Note 1)	MPH-EI 0 ET2.4
FC3 & FC4	/	MPH-AI MPH-EI 3 MPH-EI 4 ET2.3	MPH-EI 4 (Note 2)	(Note 1)	MPH-AI MPH-EI 3 MPH-EI 4 ET2.3	MPH-EI 4 ET2.3	— ET2.3	MPH-AI MPH-EI 3 MPH-EI 4 ET2.3	(Note 1)	MPH-EI 3 ET2.3

Table A.1/G.966 – B-ET state table – Physical layer state transition table *(concluded)*

State	ET0.1	ET0.2	ET0.3	ET1	ET2.1	ET2.2	ET2.3	ET2.4	ET4.1	ET4.2
FC1V at B-ET	/	— ET0.2	MPH-EI L (Note 2)	PH-DI MPH-EI L ET0.2	MPH-EI L ET0.2	MPH-EI L ET0.2	MPH-EI L ET0.2	MPH-EI L ET0.2	MPH-EI L ET0.2	MPH-EI L ET0.2
B-ET internal failure	/	MPH-AI MPH-EI ET ET0.3	— ET0.3	PH-DI MPH-EI ET ET0.3	MPH-EI ET ET0.3	MPH-EI ET ET0.3	MPH-EI ET ET0.3	MPH-EI ET ET0.3	MPH-EI ET ET0.3	MPH-EI ET ET0.3
B-ET failure recovered	/	/	ET0.2	/	/	/	/	/	/	/

NOTE 1 – This event does not occur while in this state. It is assumed that failure conditions (FCs) are detected one by one in a random order, i.e. simultaneous occurrence or disappearance of two or more failure conditions is assumed not to occur.

NOTE 2 – The ET issues the MPH-EI appropriate to the failure condition but remains in the same state as it was before the event occurred. The ET makes provision that this MPH-EI is not issued repetitively.

NOTE 3 – For digital transmission systems according to Recommendation G.704 [1], the RDI function is implemented using the RAI signal.

NOTE 4 – "Loss of physical layer" is notified to upper layer.

ANNEX B

B-ISDN access digital section state transition tables

This annex specifies the allocation of signals to the DS_B state transition tables for the B-ISDN access digital section.

The B-ISDN access digital section state transition table (DS_B state table) is described in Table B.1. The DS_B states have been numbered to form classes referring to problems as follows:

DS0.x   Powering problems.

DS1   B-ISDN access digital section operational.

DS2.x   B-ISDN access digital section internal failure (e.g. FC1).

DS3.x   B-ISDN access digital section interface problem (e.g. FC4).

DS4.x   B-ISDN access digital section internal failure AND interface problems.

The following symbols are used within the DS_B state transition tables:

"—"   no change of state.

"/"   impossible situation or not detectable event.

Note that the tables do not include the behaviour when P-LOP, P-UNEQ, P-TIM, P-PLM and LCD fault conditions are active while at the same time there is no LOS/LOF fault condition.

State number	DS0.0	DS0.1	DS0.2	DS0.3	DS0.4	DS1	DS2.1	DS2.2	DS2.3
Operational or failure condition	Power off at B-NT1 & B-LT	Power off at B-NT1 & no FC3V	Power off at B-NT1 & FC3V	Power off at B-LT & no FC4	Power off at B-LT & FC4	Operational	FC1L and not FC3L and not FC3V and not FC4	FC3L and not FC1L and not FC3V and not FC4	FC1L and FC3L and not FC3V and not FC4
Signals transmitted towards reference point T_B	No signal	No signal	No signal	Normal operational signal (Note)	Normal operational signal with MS-RDI and P-RDI (Note)	Normal operational signal	Normal operational signal (Note)	Normal operational signal (Note)	Normal operational signal (Note)
Signals transmitted towards reference point V_{B1}	No signal	Signal with P-AIS	Signal with P-AIS and MS-RDI	No signal	No signal	Normal operational signal	Signal with P-AIS	Signal with P-RDI (Note)	Signal with P-AIS
Loss of power B-NT1	/	/	/	DS0.0	DS0.0	DS0.1	DS0.1	DS0.1	DS0.1
Return of power B-NT1	DS0.3	DS1	DS3.5	/	/	/	/	/	/
Loss of power B-LT	/	DS0.0	DS0.0	—	—	DS0.3	DS0.3	DS0.3	DS0.3
Return of power B-LT	DS0.1	/	/	DS1	DS3.4	/	/	/	/
LOS/LOF or MS-AIS at B-NT1 (network side) (FC3L)	/	/	/	—	—	DS2.2	DS2.3	—	—
Signal without MS-AIS at B-NT1 (network side) (no FC3L)	/	/	/	/	/	—	—	DS1	DS2.1
LOS/LOF or MS-AIS at B-LT (user side) (FC1L)	/	—	—	/	/	DS2.1	—	DS2.3	—
Signal without MS-AIS at B-LT (user side) (no FC1L)	/	/	/	/	/	—	DS1	—	DS2.2
LOS/LOF at B-NT1 (user side) (FC4)	/	/	/	DS0.4	—	DS3.4	DS3.4	DS4.1	DS4.1
MS-RDI at B-NT1 (user side) (FC2 and no FC4)	/	/	/	—	DS0.3	DS3.2	—	—	—
Signal without MS-RDI at B-NT1 (user side) (no FC2 or FC4)	/	/	/	—	DS0.3	—	—	—	—
LOS/LOF at B-LT (network side) (FC3V)	/	DS0.2	—	/	/	DS3.5	DS4.2	DS3.5	DS4.2
MS-RDI at B-LT (network side) (FC1V and no FC3V)	/	—	DS0.1	/	/	DS3.1	—	—	—
Signal without MS-RDI at B-LT (network side) (no FC1V or FC3V)	/	—	DS0.1	/	/	—	—	—	—

Table B.1/G.966 – B-ISDN access digital section state transition table *(concluded)*

State number	DS3.1	DS3.2	DS3.3	DS3.4	DS3.5	DS3.6	DS4.1	DS4.2
Operational or failure condition	only FC1V	only FC2	only FC1V and FC2	FC4 and not FC3L and not FC3V	FC3V and not FC1L and not FC4	FC3V and FC4	FC4 and FC3L and not FC3V	FC1L and FC3V and not FC4
Signals transmitted towards reference point T_B	Normal operational signal (Note)	Normal operational signal	Normal operational signal (Note)	Signal with P-RDI and MS-RDI (Note)	Normal operational signal (Note)	Signal with MS-RDI and P-RDI (Note)	Signal with MS-RDI and P-RDI (Note)	Normal operational signal (Note)
Signals transmitted towards reference point V_{B1}	Normal operational signal	Normal operational signal (Note)	Normal operational signal (Note)	Normal operational signal (Note)	Signal with P-RDI and MS-RDI	Signal with MS-RDI and P-RDI (Note)	Signal with P-RDI (Note)	Signal with P-AIS and MS-RDI
Loss of power B-NT1	DS0.1	DS0.1	DS0.1	DS0.1	DS0.2	DS0.2	DS0.1	DS0.2
Return of power B-NT1	/	/	/	/	/	/	/	/
Loss of power B-LT	DS0.3	DS0.3	DS0.3	DS0.4	DS0.3	DS0.4	DS0.4	DS0.3
Return of power B-LT	/	/	/	/	/	/	/	/
LOS/LOF or MS-AIS at B-NT1 (network side) (FC3L)	DS2.2	DS2.2	DS2.2	DS4.1	—	—	—	—
Signal without MS-AIS at B-NT1 (network side) (no FC3L)	—	—	—	—	—	—	DS3.4	—
LOS/LOF or MS-AIS at B-LT (user side) (FC1L)	DS2.1	DS2.1	DS2.1	—	DS4.2	—	—	—
Signal without MS-AIS at B-LT (user side) (no FC1L)	—	—	—	—	—	—	—	DS3.5
LOS/LOF at B-NT1 (user side) (FC4)	DS3.4	DS3.4	DS3.4	—	DS3.6	—	—	DS3.6
MS-RDI at B-NT1 (user side) (FC2 and no FC4)	DS3.3	—	—	DS3.2	—	DS3.5	DS2.2	—
Signal without MS-RDI at B-NT1 (user side) (no FC2 or FC4)	—	DS1	DS3.1	DS1	—	DS3.5	DS2.2	—
LOS/LOF at B-LT (network side) (FC3V)	DS3.5	DS3.5	DS3.5	DS3.6	—	—	DS3.6	—
MS-RDI at B-LT (network side) (FC1V and no FC3V)	—	DS3.3	—	—	DS3.1	DS3.4	—	DS2.1
Signal without MS-RDI at B-LT (network side) (no FC1V or FC3V)	DS1	—	DS3.2	—	DS1	DS3.4	—	DS2.1
NOTE – "Loss of physical layer" is notified to upper layer.								

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