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

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

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**V-interfaces at the digital local exchange (LE) –  
V5.1 interface (based on 2048 kbit/s) for the  
support of access network (AN)**

ITU-T Recommendation G.964

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TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

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## V-interfaces at the digital local exchange (LE) – V5.1 interface (based on 2048 kbit/s) for the support of access network (AN)

### Summary

This Recommendation defines a V interface (V5.1) for the connection of an access network (AN) to a local exchange (LE) for the support of the following access types:

- analogue telephone access;
- ISDN basic access with a NT1 separate from the AN or integrated in the AN, based on ITU-T G.960 and ITU-T I.430;
- other analogue or digital accesses for semi-permanent connections without associated outband signalling information,

with flexible (provisioned) information channel (bearer channel) allocation but without concentration capability within the AN.

The electrical and functional interface specification uses the 2048 kbit/s parts of ITU-T G.703, ITU-T G.704 and ITU-T G.706.

The signalling from the PSTN user port is converted into a stimulus protocol with a functional part for the signalling path using layer 3 multiplexing for the information from the different user ports.

The information from the ISDN D-channels is frame relayed in the access network using the mechanisms defined in ITU-T Q.922.

A control protocol defined in this Recommendation is used for the exchange of the individual port status and control functions required for the coordination with the call control procedures in the local exchange.

In order to coordinate the traffic demands in the various protocols, 1, 2 or 3 communication channels can be provisioned to transport the various protocols and frame relayed information. The data link layer for the protocols is defined on the basis of ITU-T Q.920 and ITU-T Q.921.

Interface V5.1 is upgradable to V5.2 through re-provisioning and by implementation of the additional functionality.

Major differences between the first V5.1 Recommendation (1994) and this version are:

- additional definitions in clause 3;
- permanent leased line service has been clarified in clause 6;
- clause 8.7.4 adds flow control on LAPV5-DL;
- clause 13.3 adds conditional information elements that affect the messages for PSTN and Control protocol;
- clauses 13.4.7.11 to 13.4.7.13 add three information elements to the V5 PSTN protocol (listed in Table 7);
- Tables 29 to 31 have been updated and completed. The last part of the LE table was missing in the previous version. A proposal is to renumber the tables and use Table 29 (three part/pages) for the AN side and Table 30 for the LE side (also three pages). These changes have not been done since it affects the Table references in clause 14 as well.

- additional clause to Annex B (B.14);
- Annex C has highest number of changes. The most important are:
  - system startup (Clause C.13);
  - startup of PSTN data link (Clause C.14);
  - data link failure and reset (Clause C.15);
  - PSTN restart procedure (Clause C.16);
  - states in the system management procedures (Clause C.17);
  - control protocol layer 3 protection mechanism errors (Clause C.18);
  - timers (Table C.1);
  - failure on layer 1 (Clause C.20);
  - restarting of interface (Clause C.21);
  - handling of timer TV1 (related to variant and ID check) (Clause C.22);
  - alignment of blocking/unblocking (Clause C.23).
- Annex J added.

## Source

ITU-T Recommendation G.964 was revised by ITU-T Study Group 15 (2001-2004) and approved under the WTSA Resolution 1 procedure on 1 March 2001.

## FOREWORD

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The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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

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# ITU-T Recommendation G.964

## V-interfaces at the digital local exchange (LE) – V5.1 interface (based on 2048 kbit/s) for the support of Access Network (AN)

### 1 Scope

This Recommendation specifies the electrical, physical, procedural and protocol requirements for the V5.1 interface between an Access Network (AN) and the Local Exchange (LE) for the support of the following access types:

- analogue telephone access;
- ISDN basic access with a line transmission system conforming to ITU-T G.960 [4] for the case with a NT1 separate from the AN;
- ISDN basic access with a user-network interface according to ITU-T I.430 [3] at the user side of the AN (i.e. the interface at the T reference point);
- other analogue or digital accesses for semi-permanent connections without associated outband signalling information,

with flexible (provisioned) information channel (bearer channel) allocation but without concentration capability within the AN.

This Recommendation does not specify the implementation of the requirements within the AN and does not constrain any implementation alternative as long as the functionality at the V5.1 interface as specified in this Recommendation is met.

A complementary Recommendation specifies interface V5.2 which is based on the V5.1 interface. Interface V5.1 shall be upgradable to interface V5.2. The concept and the requirements for the upgrade are defined in Annex F.

Annex A provides an overview of the service scenarios and architecture taken as the conceptual basis for the specification of the V5.1 interface.

Annex B defines the use of the protocol information elements for the definition of the national PSTN protocols and information flow diagrams to the PSTN protocol specification. Annex I provides the definition of the layer 3 PSTN protocol error detection.

Annex C specifies the basic requirements of the management function in the LE and the AN to support correct operation and control of the configuration.

Annex D describes the protocol architecture for the ISDN and PSTN user port status control information transfer.

Annex E provides an overview of frame formats used in the V5.1 interface.

Abbreviations used in this Recommendation are listed in Annex G.

Appendix I gives the bibliography.

## 2 References

The following ITU-T Recommendations 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 are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations listed below. A list of currently valid ITU-T Recommendations is regularly published.

- [1] ITU-T G.703 (1998), *Physical/electrical characteristics of hierarchical digital interfaces*.
- [2] ITU-T G.704 (1998), *Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels* and ITU-T G.706 (1991), *Frame alignment and cyclic redundancy check (CRC) procedures relating to basic frame structures defined in Recommendation G.704*.
- [3] ITU-T I.430 (1995), *Basic user-network interface – Layer 1 specification*.
- [4] ITU-T G.960 (1993), *Access digital section for ISDN basic rate access*.
- [5] ITU-T Q.920 (1993), *ISDN user-network interface data link layer – General aspects* and ITU-T Q.921 (1997), *ISDN user-network interface – Data link layer specification*.
- [6] ITU-T Q.931 (1998), *ISDN user-network interface layer 3 specification for basic call control*.
- [7] ITU-T G.823 (2000), *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy*.
- [8] ITU-T O.9 (1999), *Measuring arrangements to assess the degree of unbalance about earth*.
- [9] ITU-T O.151 (1992), *Error performance measuring equipment operating at the primary rate and above*.
- [10] ITU-T Q.824.5 (1997), *Configuration management of V5 interface environments and associated customer profiles*.
- [11] ITU-T Q.831 (1997), *Fault and performance management of V5 interface environments and associated customer profiles*.

## 3 Definitions

For the purposes of this Recommendation, the following definitions apply, together with those given in Recommendations referenced.

**3.1 access network (AN):** A system implemented between the local exchange (LE) and user, replacing part or the whole of the local line distribution network.

The functions associated with the V5 interface(s) of an AN can be configured and operated flexibly via a management Q-interface.

NOTE – An AN may consist of multiplexing, cross-connect and transmission functions. The V5-interface Recommendation is independent of the transmission media used inside the AN. An AN may support services which are outside the scope of this Recommendation. Examples can be found in clause 6. Additional information can be found in Annex A.

**3.2 B-channel number:** A B-channel number identifies a B-channel on the ISDN basic access subscribed to for connections on demand, i.e. 1, 2.

**3.3 bearer channel:** A 64 kbit/s time slot in the V5.1 interface allocated for a B-channel of an ISDN user port or a PCM encoded 64 kbit/s channel from a PSTN user port.

**3.4 communication path (C-path):** Any one of the following information types:

- the layer 2 data link carrying the control protocol;
- the layer 2 data link carrying the PSTN signalling;
- all the ISDN Ds-data from one or more user ports;
- all the ISDN p-data from one or more user ports;
- all the ISDN f-data from one or more user ports.

NOTE – This definition includes the possibility that there is more than one C-path of the same information type, each allocated to a different C-channel. Refer to 8.4 for details about the different information types.

**3.5 communication channel (C-channel):** A 64 kbit/s time slot on a V5.1 interface used to carry one or more communication paths all of different types.

**3.6 conditional information element (C):** Conditional information element which is considered: a) mandatory if the presence conditions are fulfilled; or b) optional otherwise.

NOTE – In error-handling procedures, a conditional IE is handled as a mandatory or a conditional IE depending on the presence conditions. The absence of a conditional IE in a message is a protocol error only if the presence conditions of the IE are met.

**3.7 control:** Control is concerned with status and control of user ports, V5.1-interface layer's 1 and 2 establishment, and other common procedures.

**3.8 envelope function address (EFaddr):** An EFaddr is an address used in the LAPV5-EF frame to identify different V5-enveloping function sublayer connections, each of them used to support a relaying mechanism for the LAPD frames of each of the ISDN user port or messages corresponding to the V5.1-layer 3 protocols (e.g. PSTN protocol, control protocol). It shall be present in every LAPV5-EF and its purpose is to provide a common envelope both in frames in which the LAPV5-EF information field is terminated by the AN (e.g. LAPV5-DL frames used by the PSTN protocol and control protocol) and those where the payload is terminated outside the AN (ISDN LAPD frames from the ISDN user ports). It shall be a 13-bit number, binary coded.

**3.9 frame relay function:** The statistical multiplexing in an AN of ISDN D-channel frames from an ISDN access layer 2 onto a V5-communication channel and demultiplexing for ISDN D-channel frames received on a V5-communication channel.

NOTE – Furthermore, it indicates that ISDN D-channel frames are minimally processed, and that they in principle are just relayed from an input layer 2 to an output layer 2, without performing the complete set of layer 2 functions. The term "frame relay" should not be confused with the ISDN Frame Mode Bearer service, which is defined in, e.g., ITU-T Q.922 and ITU-T Q.933, nor should it be confused with dedicated packet networks for high-speed data transfer, referred to as Frame Relay networks.

**3.10 interface ID:** A unique number of a V5.1 interface of an AN which is labelled through the Q-interfaces of the AN and LE. It shall be a 24-bit number.

**3.11 LAPV5-frame:** A LAPV5-frame is the frame format used within a V5.1 interface for all types of signalling, packetized data or control information.

**3.12 layer 3 address (L3addr):** A L3addr is an address within layer 3 messages of EFaddr types PSTN signalling or control only. Its purpose is to uniquely reference a user port or a common control function. In the case of a PSTN user port, this shall be a 15-bit number. In the case of an ISDN user port or a common control function, this shall be a 13-bit number.

**3.13 line circuit (LC):** User port for the support of the PSTN access, or the analogue or digital access for the semi-permanent leased line.

**3.14 local exchange (LE):** An exchange on which user lines are terminated via an AN.

The functions associated with the V5 interface(s) on a LE can be configured and operated flexibly via a management Q-interface.

NOTE – An LE may also directly terminate user lines but these are outside the scope of this Recommendation.

**3.15 mandatory information element (M):** A mandatory information element must always be present in the message.

NOTE – The absence of a mandatory IE in a message is a protocol error.

**3.16 optional information element (O):** An optional information element may be present in the message. The absence of an optional IE in a message is not a protocol error in any case.

**3.17 permanent leased line (PLL):** A permanently established connection between two user-network interfaces routed through a leased line network which is separate from the switched digital network.

**3.18 permanent line (PL) capability:** A capability for an ISDN basic access to have one or both B-channels used for permanent leased line service.

The PL reduces the access capability at the user-network interface for switched and semi-permanent services.

**3.19 pre-defined:** When a parameter is stated as being pre-defined within a V5 interface, the parameter is not required to be presented to the equipment via the Q-interface. Instead, the parameter is either intrinsically provided within the equipment or is provided on installation or re-equipping of the equipment via a local interface. As a guide, it can be assumed that a quantity that is pre-defined will be kept as a constant for the lifetime of the equipment. A pre-defined parameter may take on one of several values depending, for example, upon the country of installation or the national PSTN protocol supported.

**3.20 presence conditions:** The presence conditions are defined for all conditional IEs and they provide information about the situations where the conditional information element shall be considered as mandatory in a message.

**3.21 provisioned:** A parameter is said to be provisioned if the Q-interface has the capability to verify and change it. Such a parameter may have a default value and/or may be altered by a local interface.

**3.22 provisioning variant:** The provisioning variant is a unique label of a complete provisioning data set applied via the Q-interfaces.

**3.23 relevant port:** A provisioned user port which the management considers to be available for service.

**3.24 repeated information element:** An information element shall be considered as a repeated information element when that information element has an identifier that has already occurred in the message.

**3.25 semi-permanent leased line:** A permanently established connection between two user-network interfaces routed through the switched digital network (see also Annex A).

**3.26 time slot number:** A time slot number identifies a time slot of 64 kbit/s within the 2048 kbit/s V5.1 interface (see ITU-T G.704 and ITU-T G.706 [2]). The range of time slot numbers shall be 0 to 31.

**3.27 user port:** The physical port implemented in the AN to provide the relevant interface functions towards the user. The user port is addressed by a logical address used in the relevant protocols on the V5 interface.

**3.28 V5 data link address (V5DLaddr):** A V5DLaddr is an address used in the LAPV5-DL frames to identify different V5-data link sublayer connections, each of them used to support a particular V5.1-layer 3 protocol (e.g. PSTN protocol, control protocol). It shall be present in every LAPV5-DL frame and shall be a direct copy of the EFaddr. It shall be a 13-bit number, binary coded.

NOTE – The V5DLaddr field has been included within the LAPV5 frames for structural compatibility with other protocols (e.g. ITU-T Q.920 and ITU-T Q.921 [5]).

**3.29 V5 interface:** A general term for the family of V interfaces for connection of ANs to the LE, e.g. a V5.1 interface or a V5.2 interface.

## 4 Electrical and physical interface requirements

The V5.1 interface consists of a single 2048 kbit/s interface as defined in ITU-T G.703 [1] and ITU-T G.704 and ITU-T G.706 [2].

The interface may use any standard transmission system [1], [2] that is designed to transport 2048 kbit/s signals. The interface shall conform to the electrical (optical) and format requirements appropriate for the selected structure.

NOTE – The remainder of this Recommendation is based on 2048 kbit/s electrical interface specifications.

The electrical and physical characteristics of the interface shall conform to ITU-T G.703 [1], 2048 kbit/s case.

Two interface presentation alternatives are defined in ITU-T G.703 [1]: the balanced interface pair type and the coaxial type. According to the two alternatives of interface applications shown in Figure 1, it is left to the network operator to request the interface presentation required.

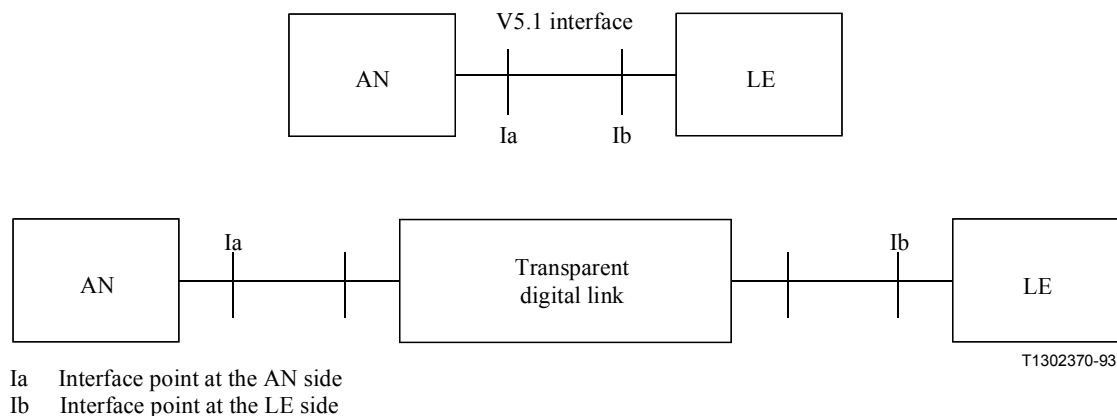


**Figure 1/G.964 – V5.1 application with and without transparent digital link**

The tolerance to jitter of interface inputs shall conform to the requirements for low-Q clock recovery according to ITU-T G.823 [7]. Interface outputs shall conform with the requirements for high-Q clock recovery according to ITU-T G.823 [7] even with tolerable input jitter according to low-Q clock recovery, i.e. a jitter reduction capability is required in the frequency area between high-Q and low-Q cut-off frequencies for the jitter transfer. This requirement supports independence of the interface implementation from application in networks using different clock recovery Q-factors as well as with an additional digital link to increase the range of the interface.

## 5 Procedural interface requirements

The functional and procedural requirements of the interface shall conform to ITU-T G.704 and ITU-T G.706 [2], 2048 kbit/s case. The CRC-4 (CRC) procedure specified in ITU-T G.704 and ITU-T G.706 [2] shall be applied including the CRC error reporting using bit E in the CRC-multiframe.

## 6 Services and architecture aspects and requirements

The following services shall be supported by the V5.1 interface specification. It is however not intended by this specification to restrict any implementation of ANs or LEs supporting the full set or a subset of the services listed in this Recommendation.

### 6.1 On-demand services

On-demand services pass through the V5.1 interface. Two types are supported:

#### 6.1.1 PSTN

- a) *Single customer*
  - with DTMF or line state signalling;
  - with or without supplementary services.
- b) *PABXs*
  - with or without DDI;
  - with DTMF or line state signalling;
  - with or without supplementary services.

The protocol elements specified in this Recommendation can be combined in a flexible manner to support dedicated PSTN applications except those using data over voice methods.

#### 6.1.2 ISDN basic access

With NT1 as integral part of the AN, or as a separate equipment supporting transmission systems described in ITU-T G.961 and conforming to ITU-T G.960 [4],

- for the support of multipoint layer 1, passive bus configuration at the coincident S- and T-reference point;
- for the support of NT2 (e.g. ISDN PABX), connected at T-reference point.

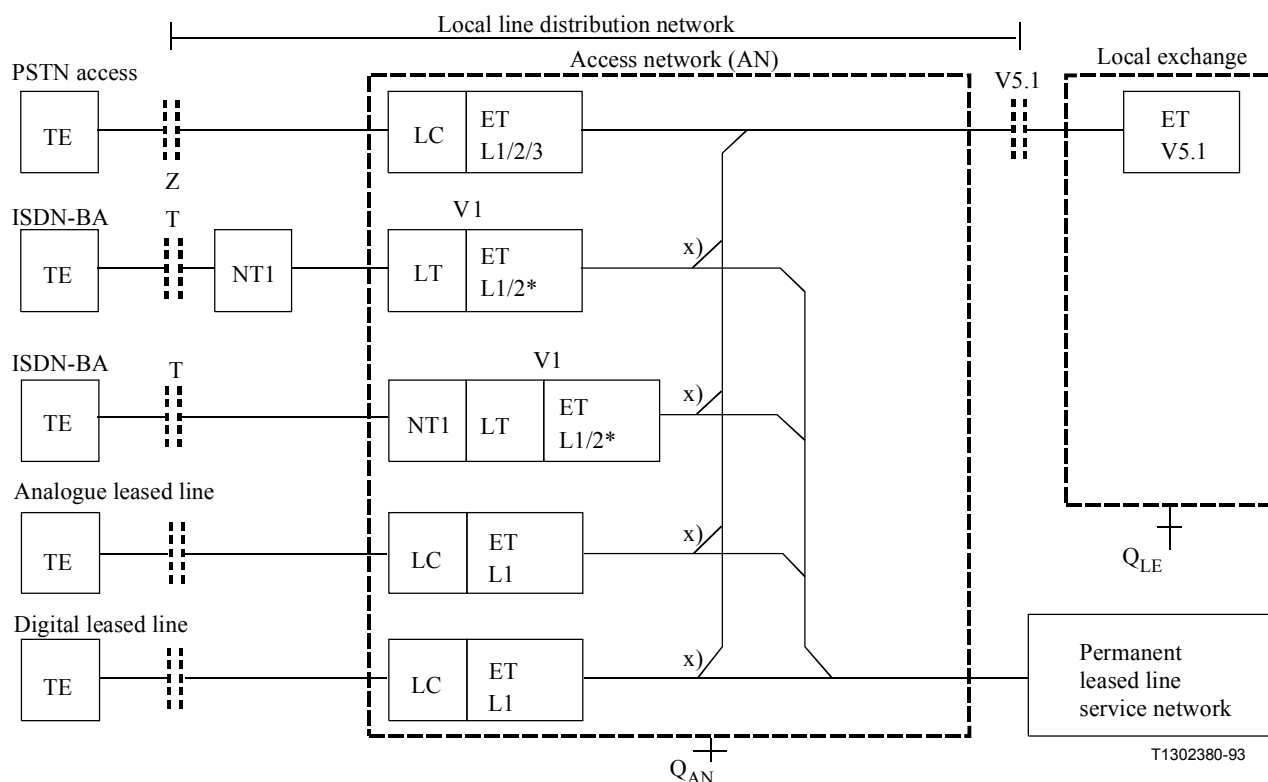
There shall be no restriction for teleservices or bearer services using B-channels as well as supplementary services for the ISDN access. Packet mode services through D-channel and Packet-data in B-channel shall also be supported.

Bit rates lower than 64 kbit/s are not supported directly. They are seen as user applications within a 64 kbit/s B-channel.

One or both B-channel may be used for permanent leased line service or semi-permanent leased line service; see 6.2 and 6.3.

## 6.2 Permanent Line (PL) capability

The PL capability uses one or both B-channels of an ISDN basic access. The PL B-channel bypasses the LE as shown in Figure 2. For further information on their effect on the V5.1 interface, see Annex A.



x) The selection of channels and the service allocation is part of the provisioning.

NOTE – The asterisk indicates that layer 2 is only partially terminated in the AN.

**Figure 2/G.964 – Architecture of V5.1 interface from a service point of view**

## 6.3 Semi-permanent leased line

Semi-permanent leased lines pass through the V5.1 interface. For further information on their effect on the V5.1 interface, see Annex A.

Three types of semi-permanent leased line service are shown in Figure 2.

- use of one or both B-channels of an ISDN basic access;
- analogue leased line without outband signalling;
- digital leased line(s) without outband signalling.

The requirements and procedures for the support of the semi-permanent leased line service are covered by the requirements and procedures defined in this Recommendation.

## 6.4 Permanent leased line services

Permanent leased line services, provided by the AN, bypass the LE. The interfaces may be analogue or digital.

Digital leased line service may be supplied by ISDN basic access. This capability (Permanent Leased Line on ISDN basic access) uses one or both B-channels.

When the whole access is used for PLL (two B-channels and D-channel), the service is entirely provided by the AN and has no effect on the V5.1 interface; there are no requirements or procedures covered by this Recommendation.

When one or two B-channels are used (leaving the D-channel for switched service), the LE and AN share the same user port. For further information on their effect on the V5.1 interface, see Annex A.

Provisions have been made in the user port control procedure for the support of this capability (see 14.1). This capability is called Permanent Line capability.

## 7 Control and provisioning

### 7.1 Control principles

#### 7.1.1 General requirements and assumptions

Based on Figure 3, the following general requirements have been identified for the ISDN basic access port. They shall be relevant for PSTN ports as well if not stated otherwise:

- 1) The responsibility for call control resides in the LE (i.e. the AN may have no knowledge of the call state during normal operation of the V5.1 interface).
- 2) The access management in the AN and the service management in the LE each maintain their FSMs and protocol entities and communicate over the V5.1 interface.

FSMs are required for each user port and for the 2048 kbit/s interface as well as protocol entities for the layer 2 links, in both the AN and in the LE (see Figure 4 for clarification and clause 14 for the definition of the FSMs, protocol entities and the layer 3 protocol). The information provided from the individual FSM or protocol entity to the management shall be used to decide on the appropriate action towards other FSMs and protocol entities, the call control function and the operation system. For further information, some basic assumptions are provided in Annex C.

- 3) Port blocking request, for non-urgent port maintenance via the Q-interface of the AN, can only be granted by the LE (i.e. blocking request should not interfere with on-going calls, calls being set up or cleared down or semi-permanent connections).
- 4) Urgent port maintenance requested via the Q-interface of the AN shall be indicated to the LE irrespective of the state in the LE (i.e. "immediate blocking" effective immediately, but new state to be synchronized with the LE).
- 5) Detected layer 1 failures related to a user port shall result in immediate blocking (for both ISDN and PSTN).

There may be anomalies and defects which may degrade the service but do not result in a total loss of service and thus do not result in the generation of an immediate blocking message. Such anomalies or defects affecting PSTN service may impact the PSTN protocol, for instance through the negative acknowledgement of a request message, but shall not affect the port FSM.

- 6) It is required that detected anomalies and other events are reported to the associated management and logged.

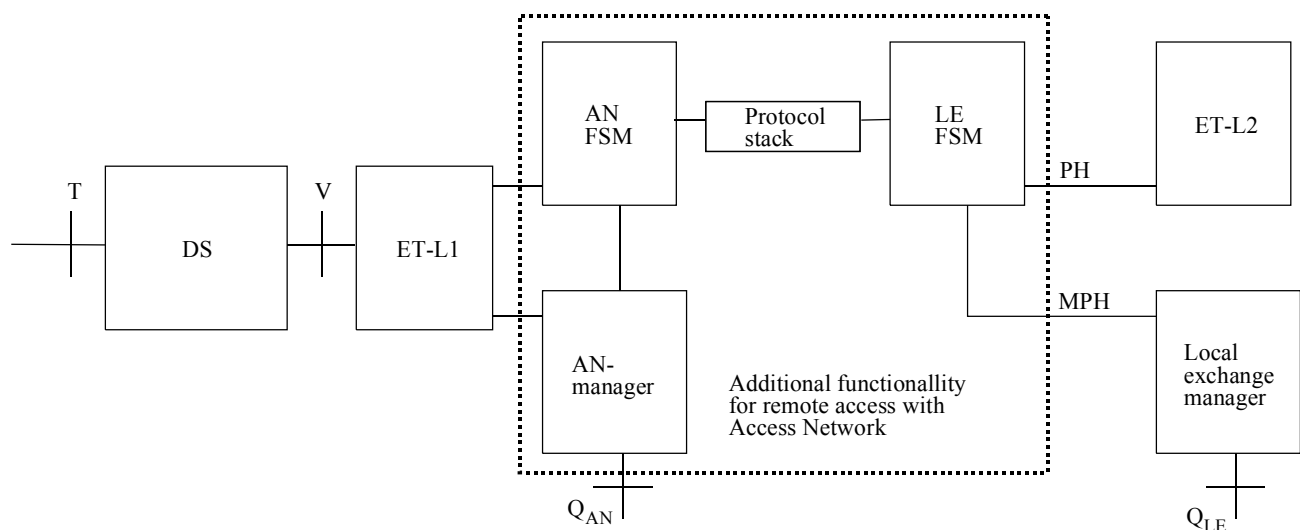
- 7) When a port is blocked, originating calls are not possible and terminating calls shall be treated by the LE as if the port is out of service according to the national protocol.
- 8) The LE must know the transmission quality level related to user ports via "grading" messages from the AN to the LE which do not affect the port status FSMs. These messages contain grading information to be registered by the LE. The LE may use this information to decide whether a requested service should be delivered or not.

This requirement is only relevant to an ISDN port with NT1 which lies outside the AN. The performance between user port and V5.1 interface shall not be impacted unduly by a reduced performance due to bit errors occurring on AN internal links. This shall be excluded by in-service monitoring and blocking of AN internal links from service in case of reduced error performance.

- 9) Loopback shall only be applied when a port is in the blocked state. This function is under the control of the AN.

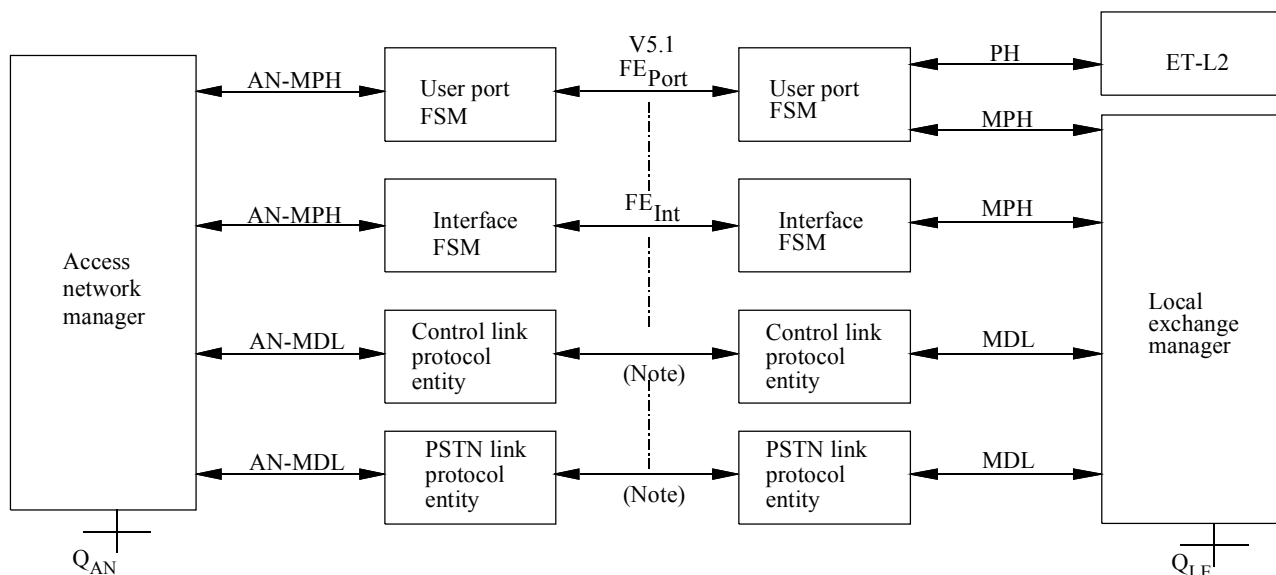
The execution of failure localization within the AN and the user port is the responsibility of the AN. Active testing which interferes with the service under the responsibility of the LE shall not be carried out until the port is blocked (FSM in blocked condition) by the LE.

- 10) There shall be a mechanism to identify individual V5 interfaces, and the labels of their current and new provisioning variants. The provisioning variant is a unique label of a complete provisioning data set applied via the Q-interfaces (see 14.5).



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**Figure 3/G.964 – ISDN user port functional model**



NOTE – Refer to 10.4.

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**Figure 4/G.964 – Layer 1 and layer 2 FSM functional model**

## 7.1.2 Control of ISDN user port for the PL capability

### 7.1.2.1 Statements and assumptions

- 1) The PL capability supported by an AN in the V5.1-interface configuration is an additional feature at an ISDN user-network interface which cannot be supported by an access connected directly to an LE.
- 2) The PL capability may as an option use one or both B-channels on a user port, that are not provisioned in the AN and LE to carry on-demand services. Permanent activation of the access is required.
- 3) The LE is responsible for on-demand services, as well as for the permanent activation of the access during normal operational conditions of the user port. When the user port is to be blocked (from AN or LE, or in case of a V5-interface problem), the AN takes responsibility for this permanent activation. Partial activation (just the access digital section) is an AN-only function, and hence outside the scope of this Recommendation.

### 7.1.2.2 ISDN and PL capability

The PL capability does not use the D-channel, according to the definition given in 6.2.

The currently defined ISDN service over the basic access (ITU-T G.960 [4]), delivered to an ISDN user port at an AN shall be the same as for direct access connections to the LE.

For an AN, no impact on an ISDN on-demand service can be accepted from any service (e.g. PLL service) that uses one or both of the B-channels for other than on-demand service.

The LE will not be aware of the AN-provisioned permanent (or partial) activation, and treat the user port as if normal activation procedures apply; the AN will override the LE's request for de activation.

### 7.1.2.3 Decoupling of AN and LE FSM

As a consequence of the PL capability sharing the same user port with on-demand services, the two user port FSMs in the AN and LE need to be decoupled when in the "non-operational" states. This allows for the activation of the access under the control of the AN to maintain the PL capability until

both sides change to an operational state and the LE takes over the responsibility for activation control (refer to 14.1, which defines the relevant procedures in the AN).

## **7.2 Provisioning strategy and requirements**

### **7.2.1 General**

Provisioning is one of many aspects to control functions. It has been separated from the other control requirements because provisioning shall be performed through the Q-interfaces of the AN and the LE and is therefore not directly relevant to the V5.1-interface specification. Only those provisioning aspects having at least conceptual or indirect implication to the interface definition are defined below.

### **7.2.2 Provisioning requirements**

- 1) The association of bearer channels to user ports at the AN and LE shall be provisioned. In case where an AN equipment has only a single 2048 kbit/s interface, the equipment may have a pre-defined association of bearer channels to user ports. As a principle the same applies to the allocation of an EFaddr to an ISDN user port or a L3addr to a PSTN user port. Further exceptions from this principle, however, may be defined in the AN specification.
- 2) All data for provisioning, including modification and cessation, shall be handled by the relevant Q-interface. Data for provisioning shall be consistent with the splitting of control functionality between the LE and the AN. This includes data related to the user interface (for example line circuit parameters) and the signalling protocol (for both the LE and the user interfaces).

The TMN function has the responsibility of ensuring that the configuration of the LE and of the AN are compatible, and there is no impact on the V5.1-interface specification. This includes provisioning of PL capability which are multiplexed onto an ISDN user port.

- 3) Changing the provisioning (re-provisioning) shall only be applied when the relevant user port is in the non-operational state in order not to interfere with on-going calls or calls being set up or cleared down.
- 4) The AN may support ports and services which are not associated with the V5.1 interface. These ports or services shall not impact the operability of ports associated with the V5.1 interface.
- 5) A single AN may have multiple V5.1 interfaces. The association of user ports with different V5.1 interfaces shall be performed through provisioning. The V5.1 interface does not support a change of association between user ports and the V5.1 interfaces on a call-by-call basis.

The control of the association between user ports and V5.1 interfaces shall be performed via the Q-interface, not over the V5.1 interface.

- 6) Information flow for inventory and auditing functions shall be via the Q-interfaces, not the V5.1 interface.
- 7) AN shall be provisioned to support tributary line and user port testing in addition to the other related control functions which were previously LE functions.
- 8) Provisioning includes installation testing of the AN carried out prior to its connection to the LE. AN testing, including tributary line and user port tests, is initiated by the Q-interface and can be used to check the AN during this phase.
- 9) Re-provisioning of a V5 interface can be synchronized by the use of the interface ID and the provisioning variant protocol elements of the common control protocol. Fields shall be provided for this labelling by the V5-interface protocol, but the TMN function is responsible for the content of these fields and the consistency of the provisioning data set. Reference is

made to 14.5, describing the re-provisioning procedures, to the control protocol specification in 14.4 as well as to Annex C.

- 10) If there is no PSTN protocol provisioned, all the requirements and procedures related to the PSTN protocol and the PSTN data link are invalid.

Reference is made to Annex A which describes the assumptions and requirements for the application of permanent and semi-permanent leased lines relevant to the V5.1-interface concept, as well as to Annex F concerning upgrading aspects.

## 8 Protocol architecture and multiplexing structure

### 8.1 Functional description

The functional description is illustrated in Figure 5. The following functional requirements are defined:

- *Bearer channels* – To provide the bidirectional transmission capability for allocated B-channels from basic access user ports or PCM encoded 64 kbit/s channels from PSTN user ports.
- *ISDN D-channel information* – To provide the bidirectional transmission capability for D-channel information from basic access user ports (including Ds-, p- and f-type data).
- *PSTN signalling information* – To provide the bidirectional transmission capability for signalling information of PSTN user ports.
- *Control of user ports* – To provide the bidirectional transmission capability to carry the status and control of each individual user port.
- *Control of the 2048 kbit/s link* – Frame alignment, multiframe alignment, alarm indication and CRC information of the 2048 kbit/s.
- *Control of layer 2 links* – To provide bidirectional communication capability to carry control and PSTN signalling information.
- *Control for the support of common functions* – To provide synchronized application of provisioning data and restart capability.
- *Timing* – To provide the necessary timing information for bit transmission, octet identification and frame synchronization. This information may also be used for the synchronization of LE and AN for synchronous operation. There are however various other methods possible to establish synchronous operation therefore the method used may depend on the network operator's requirement and is outside the scope of this Recommendation.

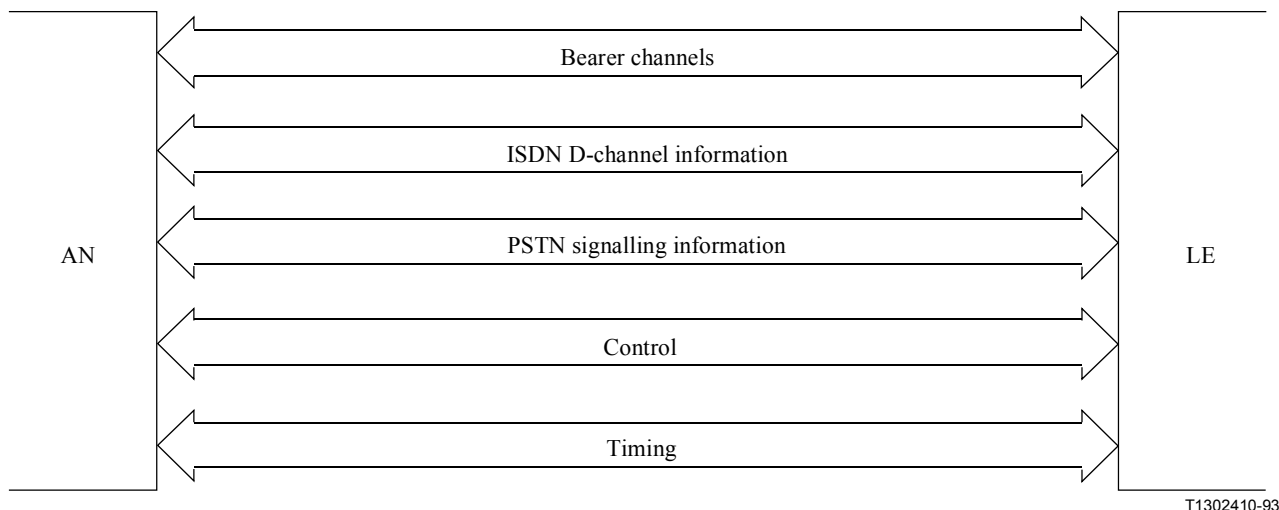
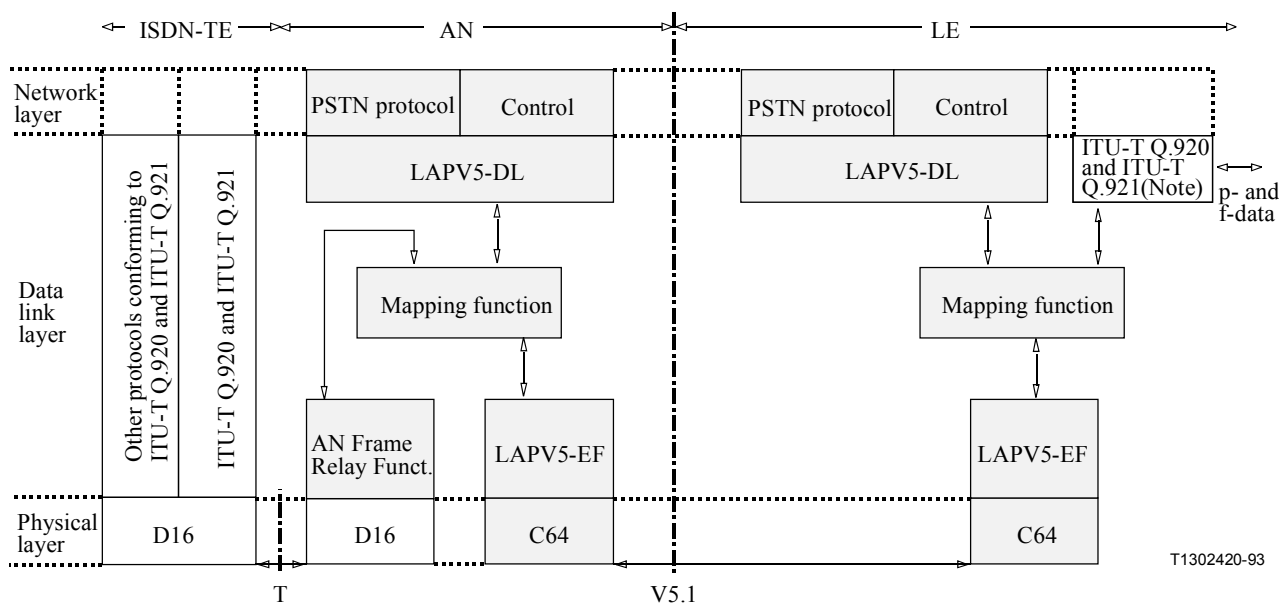


**Figure 5/G.964 – Functional description of V5.1 interface**

## 8.2 Protocol requirements for PSTN and ISDN

Figure 6 shows the protocol architecture in a simplified form. The functions specified in this Recommendation are shaded. They are defined in the following clauses:

- Envelope function sublayer of LAPV5 (LAPV5-EF): Clause 9,
- Data link sublayer of LAPV5 (LAPV5-DL): Clause 10,
- Frame relaying sublayer of the AN (AN-FR): Clause 11,
- Sublayer-to-sublayer communication and mapping function: Clause 12,
- PSTN signalling protocol specification and layer 3 multiplexing: Clause 13,
- Control protocol: Clause 14.



NOTE – Except those functions terminated in the AN Frame Relay function in the AN.

**Figure 6/G.964 – Protocol architecture**

The ISDN D-channel information shall be multiplexed at layer 2 and frame relayed over the V5.1 interface. The capability to separate p-type and f-type data from s-type signalling data onto different communication channels shall be supported by the AN and the LE, but it shall be possible to carry them on a single communication channel as a traffic engineering option, which requires that this can be provisioned (see also 8.4).

An overview of frame formats used in the V5.1 interface can be found in Annex E.

The protocol specification for PSTN ports is based on the following:

- The analogue PSTN signalling information shall be transported over the V5.1 interface using the layer 3 messages of the V5-PSTN protocol.
- Signalling information shall be multiplexed at layer 3 and carried over a single layer 2 data link.
- Only the LE shall have knowledge about the PSTN services under operational condition of the V5.1 interface.
- DTMF senders, receivers, tone generators and announcements shall be located in the LE.

NOTE – DTMF senders, receivers, tone generators and announcements may also be present in the AN, e.g. for:

- line maintenance (via the Q-interface);
- emergency call handling in case of V5.1-interface failures; the required facilities shall only be activated for long-term failures. This function is optional.

Emergency call handling is outside the scope of this Recommendation.

### 8.3 Time slots

According to clauses 4 and 5 there shall be only one 2048 kbit/s link on a V5.1 interface and layer 1 of the V5.1 interface is structured according to ITU-T G.704 and ITU-T G.706 [2]. Time slots 1 to 31 of the 2048 kbit/s link shall be used for channels allocated by provisioning:

- time slots which carry ISDN and PSTN bearer channels;
- communication channels which carry ISDN D-channel information, PSTN signalling information and control information.

### 8.4 Time slot allocation for communication channels

If only PSTN user ports are supported, the capability for one or two communications channels shall be provided. When two communication channels are provided, they shall be assigned by provisioning.

If either ISDN user ports or ISDN and PSTN user ports are supported, the capability for one, two or three communications channels shall be provided. When more than one communication channel is provided, they shall be assigned by provisioning.

If only one communication channel is allocated, then it shall be time slot 16 (C-channel 1).

If two communications channels are allocated, then they shall be time slots 15 and 16 (C-channel 2 and 1 respectively).

If all three communications channels are allocated, then they shall be time slots 15, 16 and 31 (C-channel 2, 1 and 3 respectively).

The following types of data have been defined which shall be conveyed over the V5.1 interface as communication paths:

- a) p-type data – This is ISDN D-channel data with SAPI 16.
- b) f-type data – This is ISDN D-channel data with SAPI = 32 to 62.

- c) Ds-type – This is ISDN D-channel signalling type data with SAPI not equal to any of those above (see Note 1).
- d) PSTN – This is PSTN signalling information.
- e) Control – This is control information data.

NOTE 1 – It has been identified that services using previously reserved SAPIs may be provided in the future. Giving a default allocation at least allows earlier implementations of V5.1 to transport these D-channel signalling types across the AN although their future data type allocation may be changed.

The control communication path shall always be allocated to C-channel 1. The other communication paths shall be allocated to any C-channel by provisioning. Ds-type data shall be kept within a single C-channel. The same applies for PSTN.

P-type data from an ISDN user port shall be placed in a single C-channel. F-type data from an ISDN user port shall be placed in a single C-channel. Both p-type data and f-type data from an ISDN user port may be placed in the same C-channel or split over different C-channels. P-type and f-type data with different EFaddr may be split into different communication paths which shall be conveyed over different C-channels, following the rules above.

NOTE 2 – p-type data and f-type data may also be routed by the AN through the leased line service network by provisioning. There is no impact to the V5.1-interface specification.

## 8.5 Layer 2 sublayering and multiplexing on communication channels

The protocol specification and procedures are based upon the LAPD protocol and procedures defined in ITU-T Q.920 and ITU-T Q.921 [5] to allow for flexibility in multiplexing the different information streams into the communication channels. This protocol is defined in clauses 9, 10 and 11.

The LAPV5 is subdivided into an Enveloping Function sublayer (LAPV5-EF) and a Data Link sublayer (LAPV5-DL).

The layer 2 function of the AN shall additionally contain the AN frame relay sublayer for the support of ISDN D-channel information.

The sublayer-to-sublayer communication within the layer 2 shall be controlled by the mapping function which is defined in clause 12.

## 8.6 Layer 3 multiplexing

The signalling information for PSTN user ports is multiplexed at layer 3 and carried via one layer 2 data link over the V5.1 interface. Similarly, control information is multiplexed at layer 3 and carried via the control layer 2 data link over the V5.1 interface. Address information of the individual ports is contained in the layer 3 messages of the PSTN and control protocols. The specification of the layer 3 protocol for PSTN signalling is given in clause 13. The control protocol is defined in clause 14.

## 8.7 Congestion control

Three mechanisms for congestion control are available but all are based on existing mechanisms or those required for control of the user port.

### 8.7.1 Flow control end to end

The LE shall utilize existing flow control procedures at layer 2 of the user-network interface to regulate the traffic in the D-channel of the ISDN user port.

## 8.7.2 Congestion control on the V5.1 interface

No additional flow control procedure has been identified necessary in the V5.1 protocol. Overload should be prevented by traffic engineering.

## 8.7.3 Blocking of ISDN user ports at layer 2

Blocking for the ISDN D-channels may be required in case of a terminal failure causing overload in the protocol multiplexer and overflow of buffers. Control functionalities shall be used by the LE to request from the AN to discard all layer 2 frames from an individual ISDN user port (see also 14.1, primitives MPH-DB and MPH-DU as well as FE207 and FE208). The user port stays in the access activated state (AN2.2) to enable periodic D-channel unblocking by the LE management to verify the persistence of the problem.

## 8.7.4 Flow control using LAPV5-DL mechanisms

LAPV5-DL provides flow control mechanisms. Details are defined in 10.4.

NOTE – LAPV5-DL, as specified in clause 10, provides flow control mechanisms for the V5 data links using, e.g., RNR or RR frames. These procedures may also be used to control the flow of V5 messages at layer 3. This means that if one side is not able to receive V5 messages at layer 3, this should be indicated to the peer side via the existing mechanisms at layer 2 (i.e. via RNR frames).

Furthermore, if the peer layer 2 entity indicates via existing mechanisms at layer 2 that the peer side is currently in an overload situation, layer 3 shall not initiate the sending of new V5 messages, but wait until the overload situation has disappeared. This implies that the re-transmission timers shall not be started until the overload situation has disappeared.

The above mechanisms require coordination between layer 2 and layer 3 via system management.

# 9 Envelope Function Sublayer of LAPV5 (LAPV5-EF)

## 9.1 Frame structure for peer-to-peer communication

### 9.1.1 General

All envelope function peer-to-peer exchanges of information between the AN and the LE shall be in frames conforming to the format shown in Figure 7.

| 8                         | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Octet |
|---------------------------|---|---|---|---|---|---|---|-------|
| Flag                      |   |   |   |   |   |   |   | 1     |
| 0                         | 1 | 1 | 1 | 1 | 1 | 1 | 0 |       |
| Envelope function address |   |   |   |   |   |   |   | 2     |
| Envelope function address |   |   |   |   |   |   |   | 3     |
| Information               |   |   |   |   |   |   |   |       |
| FCS                       |   |   |   |   |   |   |   | N-2   |
| FCS                       |   |   |   |   |   |   |   | N-1   |
| Flag                      |   |   |   |   |   |   |   | N     |
| 0                         | 1 | 1 | 1 | 1 | 1 | 1 | 0 |       |

Figure 7/G.964 – Frame structure supported by the envelope function

### 9.1.2 Flag sequence

The definition and use of the flags shall be as in 2.2/Q.921 [5].

### 9.1.3 Interframe time fill

Contiguous flags shall be transmitted when no layer 2 frames have to be sent. Flag monitoring is not required at the receiving side of the data link connection to detect an anomalous condition or failure.

NOTE – It is left to the implementor of the equipment to implement the flag monitoring for consistency reasons with the data link monitoring procedures defined for the communications channels in the V5.2-interface specification.

### 9.1.4 Envelope function address field

The envelope function address field consists of two octets. The format of the address field is defined in 9.2.1.

### 9.1.5 Envelope information field

The envelope information field of a frame follows the envelope function address field and precedes the frame check sequence field. The contents of the envelope information field shall consist of an integral number of octets.

The default value for the maximum number of octets in the envelope information field shall be 533 octets. The minimum envelope information field size shall be 3 octets.

NOTE – Because of the relaying provided by the LAPV5-EF, this function has to apply even to frames considered as "too long frames" but not to "unbounded frames" (frames which are not properly bounded by flags).

A layer 2 frame is considered unbounded if two times the longest permissible frame plus two octets are received without flag (closing flag) detection. So, an unbounded frame will consist of a sequence of 538 ( $2 \times 268 + 2$ ) octets.

Unbounded frames are considered as invalid frames and discarded by LAPV5-EF (see 9.1.8).

Consequently, the maximum permissible size of a "too long frame" shall be 537 octets.

Considering that LAPV5-EF relays frames without the six octets corresponding to the opening flag, closing flag, Envelope Function Address and FCS fields, the maximum sequence of octets to be accommodated by the envelope for relaying will be 531 ( $537 - 6$ ) octets.

That leads to the conclusion that the default maximum value for the information field of the envelope is 531 octets.

### 9.1.6 Transparency

The definition and use of transparency shall be as in 2.6/Q.921 [5].

### 9.1.7 Frame check sequence (FCS)

The definition and use of the FCS shall be as in 2.7/Q.921 [5].

### 9.1.8 Format convention

The definition of format and numbering conventions shall be as in 2.8/Q.921 [5].

### 9.1.9 Invalid frames

An invalid frame shall be a frame which:

- a) does not conform to 9.1.4; or
- b) has fewer than five octets between the address field and the closing flag; or
- c) does not consist of an integral number of octets prior to binary ZERO bit insertion or following binary ZERO bit extraction; or
- d) contains a frame check sequence error; or

- e) contains an address field with size not equal to two octets; or
- f) contains an Envelope Function address (EFaddr) which is not supported by the receiver.

Invalid frames shall be discarded without notification to the sender. No action shall be taken on receipt of invalid frames.

### 9.1.10 Frame aborts

The definition of and the reaction to frame aborts shall be as in 2.10/Q.921 [5].

## 9.2 Format of fields for data link envelope peer-to-peer communication

### 9.2.1 Envelope function address field format

The length of the address field shall be 2 octets. The address field format is defined in Figure 8. It contains the address extension bits (EA) and the (EFaddr). The second bit of the first octet shall be set to binary ZERO and the receiving side shall treat it as don't care.

|                |   |   |   |   |   |   |         |       |
|----------------|---|---|---|---|---|---|---------|-------|
| 8              | 7 | 6 | 5 | 4 | 3 | 2 | 1       | Octet |
| EFaddr         |   |   |   |   |   | 0 | EA<br>0 | 1     |
| EFaddr (lower) |   |   |   |   |   |   | EA<br>1 | 2     |

**Figure 8/G.964 – Envelope address field format**

### 9.2.2 Address field variables

#### 9.2.2.1 Address field extension bit (EA)

The definition and use of the EA shall be as in 3.3.1/Q.921 [5].

#### 9.2.2.2 EFaddr

The EFaddr shall be a 13-bit number. The range from 0 to 8175 shall be used to uniquely identify an ISDN user port within the V5 interface.

Values 8176 up to 8191 are reserved and shall be used to identify a point at which data link layer services are provided by the V5 layer 2 entity to a layer 3. These values of EFaddr shall be equal to the corresponding V5DLaddr as defined in 10.3.2.3.

## 10 Data link sublayer of LAPV5 (LAPV5-DL)

### 10.1 Frame structure for peer-to-peer communication

#### 10.1.1 General

All data link sublayer peer-to-peer exchanges of information between the AN and the LE shall be in frames conforming to the formats defined in Figure 9. Two format types are shown:

- format A for frames without information field; and
- format B for frames containing an information field.

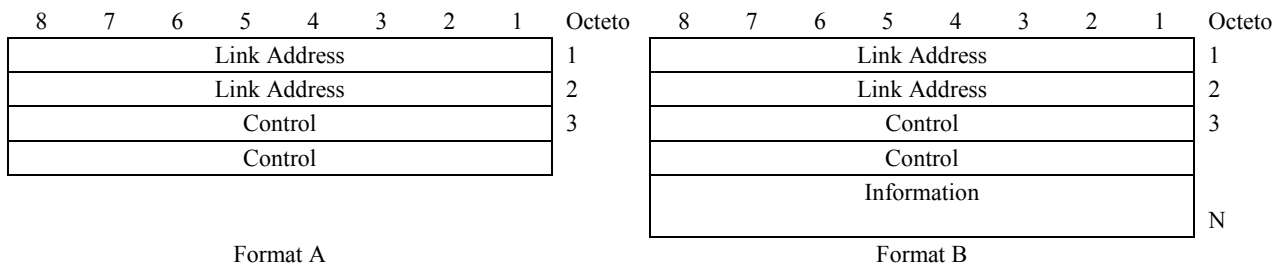


**Figure 9/G.964 – Data link sublayer frame formats**

### 10.1.2 Link address field

The link address field consists of two octets. The format of the link address field is defined in 10.3.1.

### 10.1.3 Control field

The definition of the control field shall be as in 2.4/Q.921 [5].

### 10.1.4 Information field

The information field of a frame, when present, follows the control field. The contents of the information field shall consist of an integer number of octets. The maximum number of octets in the information field shall be 260.

### 10.1.5 Format convention

The definition of format and numbering conventions shall be as in 2.8/Q.921 [5].

## 10.2 Invalid frames

An invalid frame shall be a frame which:

- a) has fewer than four octets if it contains sequence numbers and fewer than three octets if it does not contain sequence numbers; or
- b) contains a link address field whose size is not equal to two octets; or
- c) contains a V5-Data Link address (V5DLaddr) which is not supported by the receiver.

Invalid frames shall be discarded without notification to the sender. No action shall be taken as the result of that frame.

## 10.3 Elements of procedures and formats of fields for data link sublayer peer-to-peer communication

### 10.3.1 Link address field format

The length of the address field shall be 2 octets. The link address field format is defined in Figure 10. It contains extension bits, the command/response bit (C/R) and the V5DLaddr.

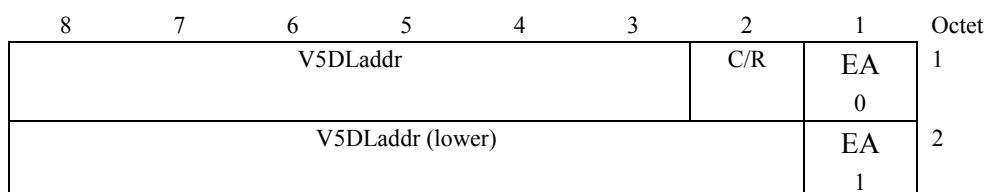


**Figure 10/G.964 – Link address field format**

### 10.3.2 Link address field variables

#### 10.3.2.1 Address field extension bit (EA)

The definition and use of the EA shall be as in 3.3.1/Q.921 [5].

#### 10.3.2.2 Command/Response field bit

The definition and use of the C/R bit shall be as in 3.3.2/Q.921 [5].

#### 10.3.2.3 V5DLaddr

The V5DLaddr shall be a 13-bit number. Values in the range of 0 up to 8175 shall not be used to identify a layer 3 protocol entity, because that range is used for identifying ISDN user ports.

Defined values of the V5DLaddr are given in Table 1.

**Table 1/G.964 – Coding of V5DL address values**

| Bits |   |   |   |   |   |     |    |                  |
|------|---|---|---|---|---|-----|----|------------------|
| 8    | 7 | 6 | 5 | 4 | 3 | 2   | 1  |                  |
| 1    | 1 | 1 | 1 | 1 | 1 | C/R | EA | Octet 1          |
| 1    | 1 | 1 | 0 | 0 | 0 | 0   | EA | Octet 2          |
| 1    | 1 | 1 | 0 | 0 | 0 | 1   | EA | PSTN signalling  |
| 1    | 1 | 1 | 0 | 0 | 0 | 1   | EA | Control protocol |

### 10.3.3 Control field formats

The definition and use of the control field shall be as in 3.4/Q.921 [5].

### 10.3.4 Control field parameters and associated state variables

The definition and use shall be as in 3.5/Q.921 [5].

### 10.3.5 Frame types

The definition and use of frame types shall be as in 3.6/Q.921 [5].

## 10.4 Definition of the peer-to-peer procedures of the data link sublayer

### 10.4.1 General

The purpose of the Link Access Procedure for the Control-channel or PSTN-signalling-channel is to convey information between layer 3 in the LE and corresponding peer entities in the AN.

Communications between the data link layer and adjacent layers, and between the data link layer and the system management are accomplished by means of primitives.

Primitives represent, in an abstract way, the logical exchange of information and control between the data link layer and adjacent layers, and between the data link layer and the system management.

The Link Access Procedures for the Control-channel or PSTN-signalling-channel are based on the point-to-point Link Access Procedures on the D-channel (LAPD) specified in ITU-T Q.920 and ITU-T Q.921 [5].

Figure 11 shows the functional model of the data link layer and the relevant primitives. From the repertoire of primitives defined in 4.1/Q.921 [5], the following subset shall also be used for the LAPV5-DL peer-to-peer communication procedures:

- PH-DATA (request, indication);
- MDL-ERROR indication;
- DL-DATA (request, indication).

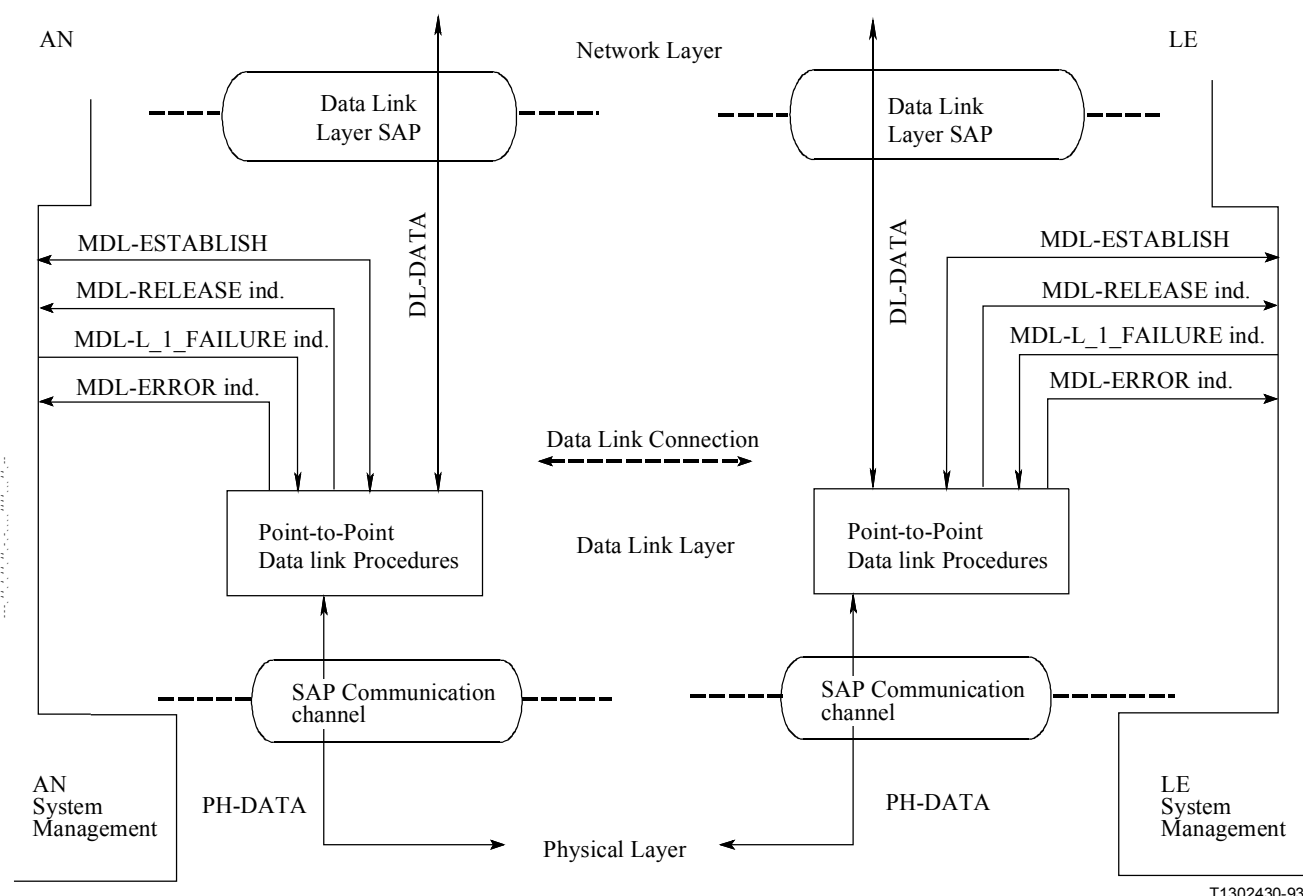


**Figure 11/G.964 – Functional model of the data link layer management**

The establishment and release of data links shall be the responsibility of the system management (see Annex C). Therefore, in addition to the above listed primitives the following new primitives shall be used:

- MDL-ESTABLISH (request, confirmation, indication);
- MDL-RELEASE indication;
- MDL-LAYER\_1\_FAILURE-indication.

The MDL-ESTABLISH primitives are used to request, indicate and confirm the outcome of the procedures for establishing multiple frame operation. The MDL-RELEASE primitives are used to indicate the outcome of the procedures for terminating multiple frame operation.

The information about the condition of the physical layer (MDU-LAYER\_1\_FAILURE-indication) is provided by the FSM of the 2048 kbit/s interface as defined in 14.3 and is available for the system management in the LE and AN. Thus, no activation/deactivation procedures or primitives are required. As a consequence, between layer 1 and layer 2 only PH-DATA primitives shall be issued. No

MPH primitives are used (MPH-ACTIVATION, MPH-DEACTIVATION, MPH-INFORMATION). For system management procedures, see Annex C.

Clause 10.4.11 specifies the state transition tables related to the procedures defined in this clause.

For the LAPV5-DL peer-to-peer communication procedures only the multiframe acknowledged information transfer shall be used. Unacknowledged information transfer and connection management entity information transfer as defined in ITU-T Q.921 [5] are not used.

The elements of procedure (frame types) which apply shall be:

- SABME-command;
- UA-response;
- DM-response;
- RR-command/response;
- RNR-command/response;
- REJ-command/response;
- I-command.

NOTE – The DISC-command as well as the FRMR-response is neither generated nor is expected to be received.

#### **10.4.2 Procedure for the use of the P/F-bit**

The procedure for the use shall be as defined in 5.1/Q.921 [5].

#### **10.4.3 Terminal Endpoint Identifier (TEI) management procedures**

Since the Data Link Connection Identifier for the Control- and PSTN-signalling-links are fixed, no TEI management procedures shall be applied. Therefore, the states 1-4 in Annex B/Q.921 [5] (i.e. TEI unassigned, Establish awaiting TEI, Assign awaiting TEI, and TEI assigned) shall be replaced by a single state called LINK-NOT-ESTABLISHED (state 9).

#### **10.4.4 Automatic negotiation of data link layer parameters**

Automatic negotiation of data link layer parameters shall not be used. The data link layer parameters as specified in 10.4.9 shall be used.

#### **10.4.5 Procedures for establishment and release of multiple frame operation**

##### **10.4.5.1 Establishment of multiple frame operation**

Extended multiple frame operation (modulo 128 sequencing) shall be used.

##### **10.4.5.1.1 General**

These procedures shall be used to establish multiple frame operation between the LE and a corresponding entity in the AN.

The system management shall request establishment of the multiple frame operation by the use of the MDL-ESTABLISH request primitive. This procedure shall also be applied after initialization of the interface or recovery of layer 1 from failure condition indicated by MPH-AI. Re-establishment shall also be initiated as a result of the data link layer procedures defined in 10.4.7. All frames other than unnumbered frame formats received during the establishment procedures shall be ignored.

##### **10.4.5.1.2 Establishment procedures**

A data link entity shall initiate a request for the multiple frame operation to be set by transmitting the SABME command. All existing exception conditions shall be cleared, the retransmission counter

shall be reset, and timer T200 shall then be started (timer T200 is defined in 5.9.1/Q.921 [5]). All mode setting commands shall be transmitted with the P-bit set to binary ONE.

System management initiated establishment procedures imply the discard of all outstanding DL-DATA request primitives and all I frames in queue.

A data link layer entity receiving an SABME command, if it is able to enter the multiple-frame-established state, shall:

- respond with an UA response with the F-bit set to the same binary value as the P-bit in the received SABME command;
- set V(S), V(R) and V(A) to binary ZERO;
- enter the multiple-frame-established state and inform system management using the MDL-ESTABLISH indication primitive;
- clear all existing exception conditions;
- clear any existing peer receiver busy condition; and
- start timer T203 (timer T203 is defined in 5.9.8/Q.921 [5]).

If the data link layer entity is unable to enter the multiple-frame-established state, it shall ignore the SABME command.

Upon reception of the UA response with the F-bit set to binary ONE, the originator of the SABME command shall:

- reset timer T200;
- start timer T203;
- set V(S), V(R), and V(A) to binary ZERO; and
- enter the multiple-frame-established state and inform system management using the MDL-ESTABLISH confirm primitive.

Upon reception of a DM response with the F-bit set to binary ONE, the originator of the SABME command shall indicate this to system management by means of the MDL-RELEASE indication primitive, and reset timer T200. It shall then enter the link-not-established state. DM responses with the F-bit set to binary ZERO shall be ignored in this case.

#### **10.4.5.1.3 Procedure on expiry of timer T200**

If timer T200 expires before the UA or DM response with F-bit set to binary ONE is received, the data link layer entity shall:

- retransmit the SABME command as above;
- restart T200; and
- increment the retransmission counter.

After retransmission of the SABME command N200 times, the data link layer entity shall indicate this to system management by means of the MDL-RELEASE indication and MDL-ERROR indication primitives and enter the link-not-established state, after discarding all outstanding DL-DATA request primitives and all I frames in queue.

The value of N200 is defined in 5.9.2/Q.921 [5].

#### **10.4.5.2 Information transfer**

Having either transmitted the UA response to a received SABME command or received the UA response to a transmitted SABME command, I frames and supervisory frames shall be transmitted and received according to the procedures described in 5.6/Q.921 [5].

If an SABME command is received while in the multiple-frame-established state, the data link layer entity shall invoke the re-establishment procedure described in 5.7/Q.921 [5].

### **10.4.5.3 Termination of multiple frame operation**

In the case of persistent layer 1 failure, the system management shall inform the data link layer entity by MDL-LAYER\_1\_FAILURE indication which then shall discard all I queues and deliver to the system management an MDL-RELEASE indication primitive. If timers T200 or T203 are running, they shall be stopped.

### **10.4.5.4 Link-not-established state**

While in the link-not-established state:

- on receipt of an SABME command, the procedures defined in 10.4.5.1 shall be followed;
- on receipt of an unsolicited DM response with the F-bit set to binary ZERO, the data link layer entity shall, if it is able to, initiate the establishment procedures by the transmission of the SABME (see 10.4.5.1.2); otherwise, the DM shall be ignored;
- on receipt of any unsolicited UA response, an MDL-ERROR indication primitive shall be issued; and
- all other frame types shall be discarded.

### **10.4.5.5 Collision of unnumbered commands and responses**

#### **10.4.5.5.1 Identical transmitted and received commands**

If the transmitted and received unnumbered commands (SABME) are the same, the data link layer entities shall send UA response at the earliest possible opportunity. The indicated state shall be entered after receiving the UA response. The data link layer entity shall notify system management by means of the appropriate confirm primitive.

#### **10.4.5.5.2 Different transmitted and received commands**

Since the only unnumbered command, which may be used for the peer-to-peer procedures of the data link sublayer, is the SABME command, a collision of different transmitted and received unnumbered commands cannot occur. The corresponding clause 5.5.5.2/Q.921 [5] is not applicable.

#### **10.4.5.6 Unsolicited DM response and SABME command**

When a DM response with the F-bit set to binary ONE is received by a data link layer entity, a collision between a transmitted SABME command and the unsolicited DM response may have occurred.

In order to avoid misinterpretation of the DM response received, a data link layer entity shall always send its SABME command with the P-bit set to binary ONE.

A DM response with the F-bit set to binary ZERO colliding with an SABME command shall be ignored.

### **10.4.6 Procedures for information transfer in multiple frame operation**

Procedures for information transfer in multiple frame operation shall be as defined in 5.6/Q.921 [5].

The DISC command shall neither be generated nor expected to be received.

## 10.4.7 Re-establishment of multiple frame operation

### 10.4.7.1 Criteria for re-establishment

The criteria for re-establishing the multiple frame mode of operation are defined in this clause by the following conditions:

- the receipt, while in the multiple frame mode of operation, of a SABME;
- the receipt of an MDL-ESTABLISH request primitive from the system management (see 10.4.5.1.1);
- the occurrence of N200 retransmission failures while in the timer recovery condition (see 5.5.1.1/Q.921 [5]);
- the occurrence of a frame rejection condition as identified in 5.8.5/Q.921 [5];
- the receipt, while in the multiple frame mode of operation, of an unsolicited DM response with the F-bit set to binary ZERO (see 5.8.7/Q.921 [5]);
- the receipt, while in the timer-recovery condition, of a DM response with the F-bit set to binary ZERO.

### 10.4.7.2 Procedures

In all re-establishment situations, the data link layer entity shall follow the procedures defined in 10.4.5.1. All locally generated conditions for re-establishment will cause the retransmission of the SABME.

In the case of data link layer and peer initiated re-establishment, the data link layer entity shall also:

- issue an MDL-ERROR indication primitive to the system management; and
- if  $V(S) > V(A)$  prior to re-establishment, issue an MDL-ESTABLISH indication primitive to the system management, and discard all I queues.

In case of system management initiated re-establishment, or if an MDL-ESTABLISH request primitive occurs pending re-establishment, the MDL-ESTABLISH confirm primitive shall be used.

## 10.4.8 Exception condition reporting and recovery

Exception condition reporting and recovery shall be as defined in 5.8/Q.921 [5]. The TEI-assigned state in ITU-T Q.920 and ITU-T Q.921 [5] is replaced by the link-not-established state.

### 10.4.9 List of system parameters

The values of the following parameters defined in 5.9/Q.921 [5], shall be:

- timer T200 (1 s);
- maximum number of retransmissions N200 (3);
- maximum number of octets in an information field N201 (260);
- timer T203 (10 s).

The maximum number (k) of sequentially numbered I frames that may be outstanding (that is unacknowledged) at any time shall be 7.

NOTE – This value of k is in line with the value for signalling data on a 64 kbit/s D-channel according to 5.9/Q.921 [5].

## 10.4.10 Data link monitor function

### 10.4.10.1 General

The procedural elements defined in 10.4 allow for the supervision of the data link layer resource. This clause defines the procedures which shall be used to provide this supervision function at the LE and AN side.

### 10.4.10.2 Data link layer supervision in the multiple-frame-established state

The procedure is based on supervisory command frames (RR command, RNR command) and timer T203, and operates in the multiple-frame-established state as follows.

If there are no frames being exchanged on the data link connection (neither new nor outstanding I frames, nor supervisory frames with a P-bit set to binary ONE), there is no means to detect a faulty data link connection condition. Timer T203 represents the maximum time allowed without frames being exchanged.

If timer T203 expires, a supervisory command with a P-bit set to binary ONE is transmitted. Such a procedure is protected against transmission errors by making use of the normal timer T200 procedure including retransmission count and N200 attempts.

### 10.4.10.3 Connection verification procedures

The connection verification procedures shall be as defined in 5.10.3/Q.921 [5].

## 10.4.11 PSTN and control data link FSM and requirements

This clause specifies the state transition table of the point-to-point procedures of the data link layer for the PSTN and control.

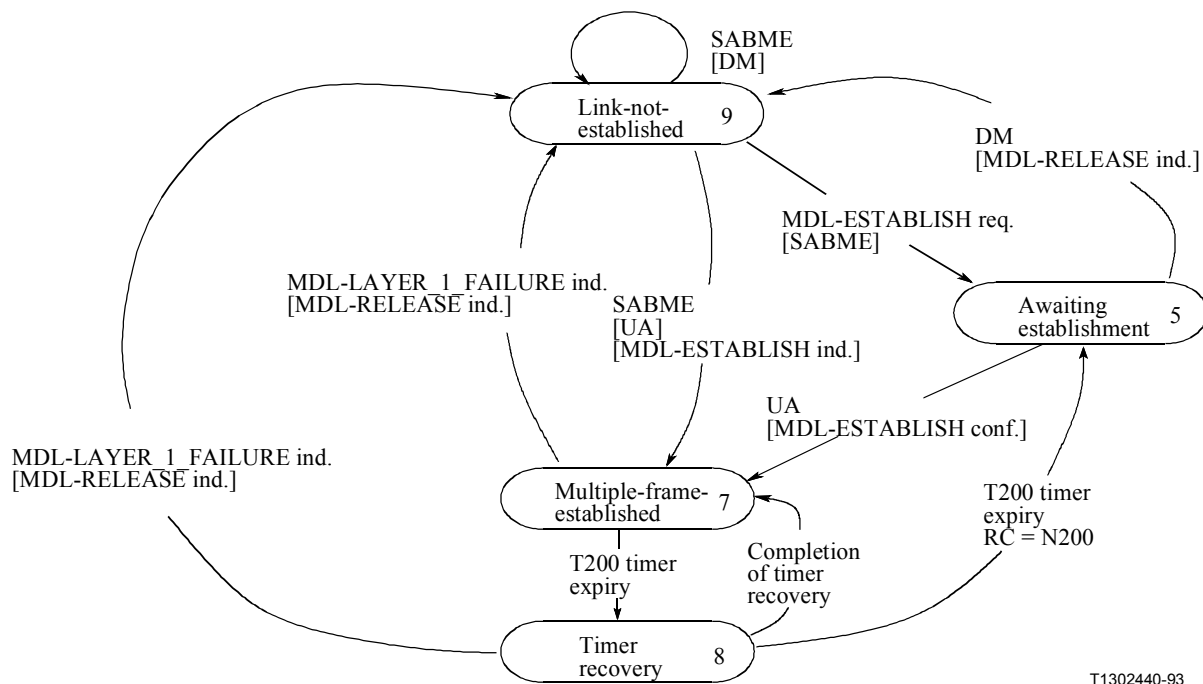
### 10.4.11.1 General

The state transition table defined in this clause is based on the peer-to-peer procedures of the data link sublayer, as defined in 10.4.1 to 10.4.10, which result in the following four basic states and the related transmitter and receiver conditions.

- State 5 Awaiting-establishment
- State 7 Multiple-frame-established
- State 8 Timer-recovery
- State 9 Link-not-established

The state transition tables shall be derived from the existing LAPD state transition tables included in Annex D/Q.921 [5]. Thus, the same numbering was used for states 5, 7 and 8. The new state defined in 10.4.3 (Link-not-established) is state 9.

Figure 12 gives an overview of the states and the typical transitions. This overview is incomplete, and serves only as an introduction to the state transition tables.



NOTE – Not all transitions are included.

**Figure 12/G.964 – Overview of the states of the data link FSM**

#### 10.4.11.2 Data link FSM

The requirements and specifications in this clause are relevant for both the AN and LE because of the symmetry of the interface functions.

The state transition table relinquishes to any partitioning of the procedures. It is conceptual and does not prevent a designer from partitioning in his implementation. Moreover, all the processes related to primitive procedures, the management of queues and the exchange of information between adjacent layers are conceptual, not visible from outside of the system and would not impose any constraints on the implementation.

The four basic states apply to both the transmitter and the receiver within one data link layer entity. However, some of the conditions are confined to the transmitter (e.g. "peer receiver busy"), whilst some are confined to the receiver (e.g. "REJ recovery"). This implies, if the concept of non-partitioning is adopted, that each transmitter condition has to be combined with each receiver condition resulting in composite states. This state transition table comprises 19 composite states representing the four basic states and the related combinations of transmitter and receiver conditions.

Events are defined as follows:

- a) primitives;
- b) repertoire of frames to be received
  - unnumbered frames (SABME, UA, DM);
  - supervisory frames (RR, REJ, RNR);
  - information frame (I);
- c) internal events (servicing of queues, expiry of timers, receiver busy condition).

The actions to be taken when an event occurs whilst in a specific state comprise:

- i) transition to another state;

- ii) peer-to-peer frame to be transmitted;
- iii) primitives to be issued;
- iv) timer actions;
- v) retry counters;
- vi) state variables;
- vii) P/F bit setting;
- viii) discarding contents of queues.

Tables D.1/Q.921 to D.3/Q.921 define the data link layer FSM with the modifications given below.

Changes to Tables D.1/Q.921 to D.3/Q.921 shall be as follows:

- Replace basic state name TEI-ASSIGNED state (state 4) by LINK-NOT-ESTABLISHED state number 9.
- Replace all the transitions to state 4 (TEI-ASSIGNED state) by transitions to state 9 (LINK-NOT-ESTABLISHED).
- Replace the event "Persistent Deactivation" by "MDL-LAYER\_1\_FAILURE indication".
- Replace all "DL-ESTABLISH" and "DL-RELEASE" primitives by "MDL-ESTABLISH" and "MDL-RELEASE" primitives.
- Delete the following event rows:
  - "DL-RELEASE Request";
  - "DL-UNIT DATA Request";
  - "UI FRAME IN QUEUE";
  - "MDL-ASSIGN Request";
  - "MDL-REMOVE Request";
  - "MDL-ERROR Response";
  - "DISC P = 1";
  - "DISC P = 0";
  - "UI command";
  - all rows related to "FRMR response";
  - "DISC incorrect length";
  - "FRMR incorrect length";
- In Table D.1/Q.921, delete columns related to state numbers 1, 2, 3, 5.2 and 6.
- In Table D.1/Q.921, in row "SABME P = 1, UNABLE TO ENTER STATE 7.0", under column "TEI ASSIGNED", replace the action "TX DM F = 1" with "-" (No action, no state change).

## 11 AN frame relay sublayer

### 11.1 General

The AN executes an AN frame relay function, which means that the customer's D-channel data link layer protocol is not fully terminated. The AN only performs the following core procedures in its relay process:

- frame delimiting, alignment and transparency;
- frame multiplexing/demultiplexing using the ISDN layer 2 address field according to 8.5;

- inspection of the frame to ensure that it consists of an integral number of octets prior to binary ZERO bit insertion or following binary ZERO bit extraction;
- inspection of the frame that it is neither unbounded nor too short;
- insertion of HDLC flags if no layer 2 frames have to be sent;
- detection of transmission errors.

Valid frames incoming from an ISDN access shall be multiplexed onto an allocated V5-communication channel on the basis of the ISDN layer 2 frame address, after adding the EFaddr related to the frame's user port of origin. The definition of invalid frames from the ISDN user port is given below.

Valid frames incoming from the LE shall be demultiplexed and relayed to the relevant user port after EFaddr removal. Invalid frames shall be detected and handled by the LAPV5-EF function.

## 11.2 Invalid frames

The AN-FR shall discard, without notification to the sender, invalid frames received from an ISDN user port.

An invalid frame shall be a frame which:

- a) is not properly bounded by two flags, i.e. longer than 533 octets; or
- b) has fewer than five octets between flags; or
- c) does not consist of an integral number of octets prior to binary ZERO bit insertion or following binary ZERO bit extraction; or
- d) contains a frame check sequence error; or
- e) contains a single octet address field.

## 11.3 Detailed description of the AN frame relay function

The main function of the AN concerning ISDN protocol handling is to add in the AN to LE direction the EFaddr and to remove this number in the AN to customer direction as defined in this clause. Figure 13 shows the frame relaying function in the AN.

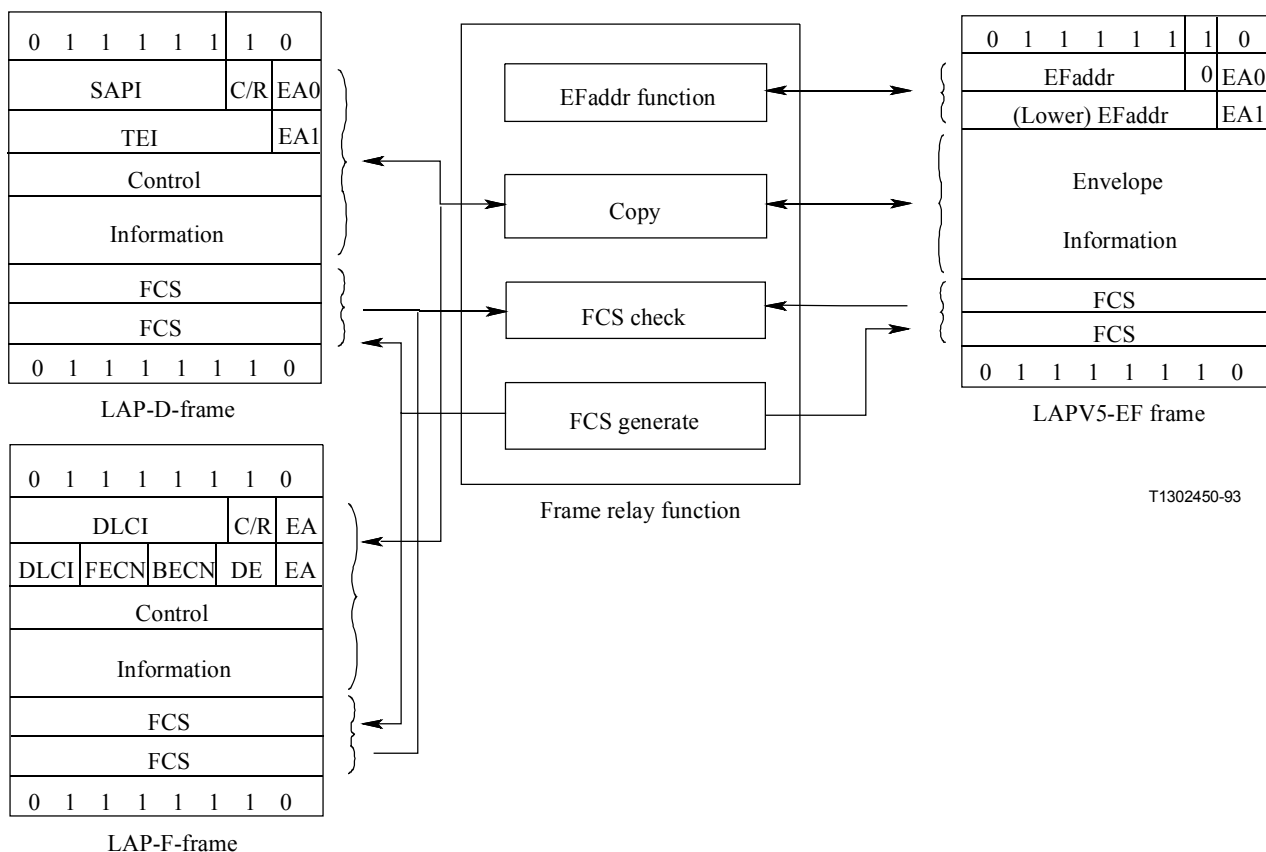


**Figure 13/G.964 – The frame relaying function in the AN**

### 11.3.1 Frame received from LE

- receive EFaddr and envelope information field from the mapping function in accordance with 12.4;
- determine ISDN user port with EFaddr using provisioning data;
- create frame with opening flag;
- copy the envelope information field after the flag;
- generate the frame check sequence;
- add closing flag.

### 11.3.2 Frame received from ISDN user port

- check for valid frame;
- remove flags and FCS;
- retrieve allocated EFaddr from provisioning data;
- pass EFaddr and processed frame to mapping function in accordance with 12.3.

## 12 Sublayer-to-sublayer communication and mapping function

### 12.1 LAPV5-EF to LAPV5-DL communication

When frames are received by the LAPV5-EF sublayer from the LE, and if the V5DLaddr lies within the range reserved for sublayer peer-to-peer data as defined in 10.3.2.3, the envelope information field shall be passed to the LAPV5-DL sublayer.

## 12.2 LAPV5-DL to LAPV5-EF communication

The data link sublayer requests the envelope function to transmit data link sublayer peer-to-peer data with a given EFaddr, which shall be set equal to the V5DLaddr. The data link sublayer frame (see Figure 9) shall be mapped into the envelope information field of the envelope function of the communications channel selected in accordance with 8.4.

## 12.3 AN-FR to LAPV5-EF communication

D-channel frames received from ISDN user ports shall be passed after processing by the AN frame relay function of the AN (see clause 11) to the envelope function for transmission on the V5 interface. The EFaddr associated with the port is passed as a parameter. The processed frame shall be mapped into the envelope information field of the envelope function of the communications channel selected in accordance with 8.4.

## 12.4 LAPV5-EF to AN-FR communication

When frames are received by the LAPV5-EF sublayer from the LE, and if the V5DLaddr lies within the range reserved for ISDN user port identification as defined in 9.2.2.2, the envelope information field and the EFaddr shall be passed to the AN frame relay function for additional processing and transmission towards the ISDN user port.

# 13 PSTN signalling protocol specification and layer 3 multiplexing

## 13.1 General

### 13.1.1 Introduction

The PSTN protocol on the V5.1 interface is basically a stimulus protocol; i.e. it does not control the call procedures in the AN; it rather transfers information about the analogue line state over the V5.1 interface. The V5.1-PSTN protocol shall be used in conjunction with the national protocol entity in the LE (see Figure 14). The national protocol entity in the LE, which is used for customer lines which are connected directly to the LE, will also be used to control calls on customer lines which are connected via the V5.1 interface. For time-critical sequences it is also required to extract certain signalling sequences (e.g. compelled sequences) from the national protocol entity into an "AN part" of the national protocol entity. However, the V5.1-PSTN protocol has a relatively small functional part which is concerned with path set-up, release of the path on the V5.1 interface, call collision resolution on the V5.1 interface and handling of new calls in case of overload conditions in the LE. The majority of line signals will not be interpreted by the V5.1-PSTN protocol, but simply transferred transparently between the user port in the AN and national protocol entity in the LE.

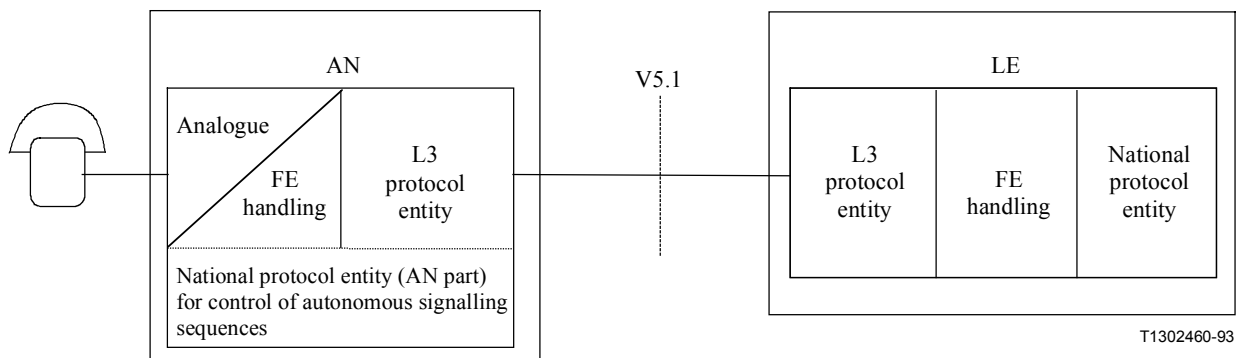


Figure 14/G.964 – PSTN user port functional model

### 13.1.2 Separation of responsibilities

The LE shall be responsible for providing the service (call control, supplementary services). DTMF senders, receivers, tone generators and announcements shall be located in the LE. This implies that address information using DTMF shall be carried transparently between user port and LE whereas line state signalling shall be interpreted in the AN and then carried over the V5.1 interface by means of layer 3 messages.

The LE shall be responsible for preventing situations where messages exchanged at a high rate between AN and LE due to unavailability of resources in the LE (e.g. ESTABLISH – DISCONNECT – ESTABLISH message sequences in an originating PSTN call).

It shall be the responsibility of the AN to handle access specific parameters related to the protocol such as recognition times of analogue signals, duration, voltage and frequency of meter pulses, ringing current or the specific details of a signalling sequence (AN part of the national protocol entity). These parameters shall be set either in hardware, software or in data. In the latter case this data shall be pre-defined but some of the data may be overruled by "protocol parameter" messages via the V5.1 interface for a call.

For time-critical responses to customer signalling it is necessary for the AN to respond autonomously. This shall be explicitly required for ring trip and dial tone suppression. There may be other time-critical responses required in national PSTN protocols which shall be defined in the national PSTN protocol mapping specification.

For time-critical signalling sequences (e.g. autonomous seizure acknowledge for ground start PBXs) it shall also be necessary for the AN to control the time-critical part of the signalling sequence autonomously. In this case, the autonomous signalling sequence shall be triggered by the national protocol entity in the LE. After executing the autonomous signalling sequence, the AN may return a response to the LE.

The protocol definition is provided in clause 13. Annex B provides additional information for the use of the information elements to define the national PSTN protocol mapping.

### 13.1.3 National specific PSTN signal information elements

This Recommendation gives the complete set of PSTN signalling information elements that may be sent over a V5.1 interface in order to cope with all the national PSTN protocols identified to date. It is unlikely that the full set of PSTN signal information elements will be required by any network provider and therefore it is not expected that the full set will be utilized over any individual V5.1 interface. Optionally, an equipment may support more PSTN signal information elements than required by a particular network provider. In this case, only those PSTN signal information elements required in order to correctly support that particular national PSTN protocol shall appear on the interface.

It will be the responsibility of the individual equipment providers to ensure that their equipment contains at least the ability to recognize and utilize the correct PSTN signal information elements for the national PSTN protocols to be supported by the local network provider.

It shall be the responsibility of the equipment providers to ensure that the PSTN signal information elements are provided in accordance with the national PSTN protocols.

PSTN signal information elements not required for the required national PSTN protocol shall be treated as unrecognized information elements as specified under 13.5.2.7, if they occur.

The full set of PSTN messages, information elements, and coding, may not be required to support a specific national protocol. Only those PSTN messages, information elements, and coding that apply to the protocol shall be used over the V5.1 interface.

## **13.2 PSTN protocol entity definition**

### **13.2.1 Definition of PSTN path states and explanation**

#### **13.2.1.1 Path states in the AN [AN(PSTN)]**

##### **Out of service state (AN0)**

This state shall be entered when the restart procedure has been initiated by the system management and is applicable to all PSTN ports simultaneously.

##### **Null state (AN1)**

The port is inactive and there is no call in progress. This shall be the rest state for the port interface. When the PSTN protocol entity in the AN returns to the NULL state, it must be capable to detect and report a (may be already present) subscriber seizure.

##### **Path initiated by AN state (AN2)**

A seizure has been detected within the AN and an ESTABLISH message has been sent to the LE. The AN is now waiting for an ESTABLISH\_ACK back from the LE. In the event of no response from the LE, for example in the case of an LE overload, the ESTABLISH message will be repeated at a low repetition rate (Timer T1).

Call collision resolution shall be achieved by the AN and LE during this phase of the call.

##### **Path abort request state (AN3)**

ESTABLISH message was sent to the LE but no ESTABLISH\_ACK has yet been received. The subscriber has released (e.g. on-hook). This state shall be used to regulate the number of ESTABLISH messages that may be sent to the possibly overloaded LE, if the port is seized again. After a guard period the AN will go back to the NULL state.

##### **Line information state (AN4)**

This state shall only be entered into whilst a line information from the PSTN port is being processed by the LE. This state may only be entered from the NULL state and may exit to NULL state either the OUT OF SERVICE state or the PORT BLOCKED state only.

##### **Path active state (AN5)**

The active state shall be the state during which normal PSTN signalling functions are active for that port. During this state a user may proceed with call establishment, communication or call clearing.

##### **Port blocked state (AN6)**

This state can be entered from any state. Once entered, the only state that the port may proceed to shall be the NULL state when the port is again available for service.

Once the blocked state has been entered all call activity for that port shall be halted and the port may be deactivated, e.g. power down.

##### **Disconnect request state (AN7)**

The AN requests the LE to disconnect the path. This state shall be exited when the LE has successfully acknowledged the DISCONNECT. If this does not happen, the maintenance entity shall be informed.

### 13.2.1.2 Path states in the LE [LE(PSTN)]

#### Out of service state (LE0)

This state shall be entered when the restart procedure has been initiated by the system management and is applicable to all PSTN ports simultaneously.

#### Null state (LE1)

The port is inactive and there is no call in progress. This shall be the rest state for the port interface.

#### Path initiated by LE state (LE2)

The port is seized. The LE has sent an ESTABLISH message to the AN. Call collision resolution shall be achieved by the AN and the LE during this phase of the call.

#### Path initiated by AN state (LE3)

The AN has sent an ESTABLISH message to the LE and is waiting for an ESTABLISH\_ACK. Call collision resolution shall be achieved by the AN and the LE during this phase of the call.

#### Path active state (LE4)

The active state shall be the state during which normal PSTN signalling functions are active for that port. During this state a user may proceed with call establishment, communication or call clearing.

#### Path Disconnect request state (LE5)

The LE requested the AN to release the path. This state shall be exited when the AN has successfully acknowledged the DISCONNECT. If this does not happen, the maintenance entity shall be informed.

#### Port blocked state (LE6)

This state can be entered from any state. Once entered, the only state that the interface may proceed to shall be the NULL state when the port is again available for service.

Once the blocked state has been entered all call activity for that port shall be halted.

### 13.2.2 Definition of PSTN protocol primitives, messages and timers

Tables 2 and 3 define the primitives, messages and timers used for the PSTN state transitions in Tables 29 to 32.

The PSTN FE primitives are to be used either inside the AN between the PSTN protocol entity and the user port or inside the LE between the PSTN protocol entity and the National Protocol entity.

Refer to B.13 for further information about the FE primitives used in the AN and LE.

**Table 2/G.964 – Primitives, messages and timers used in the AN(PSTN) FSM**

|                                                                                                                                                   | Direction         | Description                                                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------------------------------------------------------------------------------------------------------------------------|
| FE-line_information                                                                                                                               | PSTN_AN ← SUB     | The subscriber line status has changed.                                                                                   |
| FE-line_signal                                                                                                                                    | PSTN_AN ↔ SUB     | The subscriber has applied an electrical condition to the port or change the electrical condition of the subscriber port. |
| FE-subscriber_release<br>(e.g. on-hook)                                                                                                           | PSTN_AN ← SUB     | The subscriber indicates release during initiation of the PSTN path.                                                      |
| FE-subscriber_seizure<br>(e.g. off-hook)                                                                                                          | PSTN_AN ← SUB     | Subscriber wishes to originate a PSTN path.                                                                               |
| DISCONNECT                                                                                                                                        | PSTN_AN ↔ PSTN_LE | Initiation of clearing the path.                                                                                          |
| DISCONNECT COMPLETE                                                                                                                               | PSTN_AN ↔ PSTN_LE | Positive response to path clearing.                                                                                       |
| ESTABLISH                                                                                                                                         | PSTN_AN ↔ PSTN_LE | Initiation of PSTN path.                                                                                                  |
| ESTABLISH ACK                                                                                                                                     | PSTN_AN ↔ PSTN_LE | Positive response to PSTN path initiation.                                                                                |
| PROTOCOL PARAMETER<br>SIGNAL                                                                                                                      | PSTN_AN ← PSTN_LE | A request to change a PSTN port parameter.                                                                                |
|                                                                                                                                                   | PSTN_AN ↔ PSTN_LE | An electrical condition described in a message.                                                                           |
| SIGNAL ACK                                                                                                                                        | PSTN_AN ↔ PSTN_LE | Acknowledgement of sent/received signal messages.                                                                         |
| STATUS ENQUIRY                                                                                                                                    | PSTN_AN ← PSTN_LE | Request of PSTN port status.                                                                                              |
| STATUS                                                                                                                                            | PSTN_AN → PSTN_LE | Report of PSTN port status.                                                                                               |
| Time-out T1/T2                                                                                                                                    | AN internal       | Timer T1 or T2 has expired.                                                                                               |
| Time-out T3                                                                                                                                       | AN internal       | Timer T3 has expired.                                                                                                     |
| Time-out Tr                                                                                                                                       | AN internal       | Timer Tr has expired.                                                                                                     |
| Time-out Tt                                                                                                                                       | AN internal       | Timer Tt has expired.                                                                                                     |
| MDU-CONTROL<br>(port blocked)                                                                                                                     | PSTN_AN ← SYS     | The AN system management indicates to block the subscriber port in the AN.                                                |
| MDU-CONTROL<br>(port unblocked)                                                                                                                   | PSTN_AN ← SYS     | The AN system management indicates to unblock the subscriber port in the AN.                                              |
| MDU-CONTROL<br>(restart request)                                                                                                                  | PSTN_AN ← SYS     | The AN system management requests a restart of the PSTN protocol entity.                                                  |
| MDU-CONTROL<br>(restart ack)                                                                                                                      | PSTN_AN → SYS     | Positive response to restart request.                                                                                     |
| MDU-error indication                                                                                                                              | PSTN_AN → SYS     | Indication of error condition in AN.                                                                                      |
| SUB      Subscriber port<br>SYS      AN system management<br>PSTN_AN   PSTN protocol entity in the AN<br>PSTN_LE   PSTN protocol entity in the LE |                   |                                                                                                                           |

.....

**Table 3/G.964 – Primitives, messages and timers used in the LE(PSTN) FSM**

|                                 | Direction         | Description                                                                                              |
|---------------------------------|-------------------|----------------------------------------------------------------------------------------------------------|
| FE-disconnect_request           | PSTN_LE ← NAT     | The national protocol requests clearing of the PSTN path.                                                |
| FE-disconnect_complete_request  | PSTN_LE ← NAT     | The national protocol requests that an acknowledgement of line-information is sent.                      |
| FE-establish_acknowledge        | PSTN_LE ← NAT     | Positive response from the national protocol to request for a PSTN path.                                 |
| FE-establish_request            | PSTN_LE ← NAT     | The national protocol requests establishment of a PSTN path.                                             |
| FE-line_signal_request          | PSTN_LE ← NAT     | The national protocol requests an electrical condition to be applied to the subscriber's port in the AN. |
| FE-protocol_parameter_request   | PSTN_LE ← NAT     | The national protocol requests that a PSTN protocol parameter is changed.                                |
| FE-disc._complete_ind.          | PSTN_LE → NAT     | Indication that the PSTN path has been cleared completely.                                               |
| FE-establish_indication         | PSTN_LE → NAT     | Report of a request to initiate a PSTN path.                                                             |
| FE-establish_ack_ind.           | PSTN_LE → NAT     | Positive response to a request to initiate a PSTN path.                                                  |
| FE-line_signal_indication       | PSTN_LE → NAT     | Report that the electrical conditions have changed at the subscriber's port in the AN.                   |
| DISCONNECT                      | PSTN_LE ↔ PSTN_AN | Initiation of clearing the PSTN path.                                                                    |
| DISCONNECT COMPLETE             | PSTN_LE ↔ PSTN_AN | Positive response to a path clearing.                                                                    |
| ESTABLISH                       | PSTN_LE ↔ PSTN_AN | Initiation of PSTN path.                                                                                 |
| ESTABLISH ACK                   | PSTN_LE ↔ PSTN_AN | Positive response to path initiation.                                                                    |
| SIGNAL                          | PSTN_LE ↔ PSTN_AN | An electrical condition described in a message.                                                          |
| SIGNAL ACK                      | PSTN_LE ↔ PSTN_AN | Acknowledgement of sent/received signal messages.                                                        |
| STATUS                          | PSTN_LE ← PSTN_AN | Report of PSTN status.                                                                                   |
| STATUS ENQUIRY                  | PSTN_LE → PSTN_AN | A request for a report of PSTN port state.                                                               |
| PROTOCOL PARAMETER              | PSTN_LE → PSTN_AN | A request to change a PSTN port parameter.                                                               |
| Time-out T1                     | LE internal       | Timer T1 has expired.                                                                                    |
| Time-out T3                     | LE internal       | Timer T3 has expired.                                                                                    |
| Time-out T4                     | LE internal       | Timer T4 has expired.                                                                                    |
| Time-out Tr                     | LE internal       | Timer Tr has expired.                                                                                    |
| Time-out Tt                     | LE internal       | Timer Tt has expired.                                                                                    |
| MDU-CONTROL<br>(port blocked)   | PSTN_LE ← SYS     | The LE system management indicates to block a PSTN port in the LE.                                       |
| MDU-CONTROL<br>(port unblocked) | PSTN_LE ← SYS     | The LE system management indicates to unblock a PSTN port in the LE.                                     |

**Table 3/G.964 – Primitives, messages and timers used in the LE(PSTN) FSM**

|                                                                                                                                                     | Direction     | Description                                                                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----------------------------------------------------------------------------|
| MDU-CONTROL<br>(restart request)                                                                                                                    | PSTN_LE ← SYS | The LE system management requests a restart of the PSTN protocol entity.    |
| MDU-CONTROL<br>(restart complete)                                                                                                                   | PSTN_LE ← SYS | The LE system management indicates that the restart procedure is completed. |
| MDU-CONTROL<br>(restart ack)                                                                                                                        | PSTN_LE → SYS | Positive response to a restart request.                                     |
| MDU-error indication                                                                                                                                | PSTN_LE → SYS | Indication of error condition at the LE.                                    |
| NAT      National Protocol<br>SYS      LE system management<br>PSTN_AN   PSTN protocol entity in the AN<br>PSTN_LE   PSTN protocol entity in the LE |               |                                                                             |

### 13.3 PSTN protocol message definition and content

A complete set of messages for the PSTN protocol is given in Table 4.

**Table 4/G.964 – Messages for PSTN protocol control**

| Message type        | Reference<br>(clause) |
|---------------------|-----------------------|
| ESTABLISH           | 13.3.1                |
| ESTABLISH ACK       | 13.3.2                |
| SIGNAL              | 13.3.3                |
| SIGNAL ACK          | 13.3.4                |
| STATUS              | 13.3.5                |
| STATUS ENQUIRY      | 13.3.6                |
| DISCONNECT          | 13.3.7                |
| DISCONNECT COMPLETE | 13.3.8                |
| PROTOCOL PARAMETER  | 13.3.9                |

In the following subclauses the different messages are specified, highlighting the functional definition and information content (i.e. semantics) of each message. Each definition includes:

- a) a brief description of the message, direction and use;
- b) a table listing the information elements in the order of their appearance in the message (same relative order for all message types). For each information element the table indicates:
  - 1) the clause of this Recommendation describing the information element;
  - 2) the direction in which it may be sent, i.e. AN to LE, LE to AN, or both;
  - 3) whether inclusion is mandatory ("M"), optional ("O") or conditional ("C");
  - 4) the length of the information element in octets.

Refer to Annex B for further information about the FE primitives used in the AN and LE.

NOTE – The inclusion status of a PSTN Protocol IE may be changed in the national PSTN protocol mapping specification from optional (O) to conditional (C) if the optional IE shall be considered as mandatory in the relevant national PSTN protocol. The presence conditions for these IEs shall be defined in the national PSTN protocol mapping specification.

### 13.3.1 ESTABLISH

The ESTABLISH message (see Table 5) shall be used as an indication of either an originating or terminating path request.

**Table 5/G.964 – ESTABLISH message content**

Message type: ESTABLISH

Direction: Both

| Information element                                                                      | Reference (clause) | Direction | Type | Length |
|------------------------------------------------------------------------------------------|--------------------|-----------|------|--------|
| Protocol discriminator                                                                   | 13.4.2             | Both      | M    | 1      |
| L3 address                                                                               | 13.4.3             | Both      | M    | 2      |
| Message type                                                                             | 13.4.4             | Both      | M    | 1      |
| Line-information                                                                         | 13.4.6.2           | AN to LE  | C    | 1      |
| Autonomous-signalling-sequence                                                           | 13.4.6.4           | LE to AN  | C    | 1      |
| Cadenced-ringing                                                                         | 13.4.7.2           | LE to AN  | C    | 3      |
| Pulsed-signal                                                                            | 13.4.7.3           | LE to AN  | C    | 3 to 5 |
| Steady-signal                                                                            | 13.4.7.4           | Both      | C    | 3      |
| NOTE – Only one of the conditional information elements may be contained in the message. |                    |           |      |        |

### 13.3.2 ESTABLISH ACK

The ESTABLISH ACK message (see Table 6) shall be used to acknowledge that the requested action has been performed by the entity. Reference is made to B.10 concerning a special procedure for the cases where a signal information element was contained in the ESTABLISH message.