Exhibit D

Packet Switching Evolution from Narrowband to Broadband ISDN

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- packet length supervision
- packet size negotiation
- throughput class negotiation (that is, definition of the speed of data transmission)
- transit delay negotiation
- packet sequence numbering
- window size negotiation (the window size is the number of packets or frames that the sender can transmit without receiving an acknowledgment from the receiver)
- packet retransmission
- setup of point-to-multipoint paths for example, from several terminals to one host computer
- error correction (the correction of bit errors in case they were detected by the redundancy mechanisms)
- buffering (storing) of packet or frames
- flow control (the technique used to match the speed between sender and receiver, implemented by introducing windows)
- congestion control, executed by warning previous nodes in the network that packet traffic has to be decreased during a certain (variable) duration

2.4. DATALINK LAYER PROTOCOLS

The ISDN needs two link-access (layer 2) protocols to establish a link between two users. A link is not yet a full call; it is a switched transmission medium that, at certain points in the network, contains circuits to control errors, sequence of data elements, and so on.

LAPD

The first part of the link has to be setup with circuit-switching techniques. The protocol to be used, therefore, has been specially designed for ISDN and is called LAPD (link access protocol D). This protocol is specified by CCITT in recommendation Q.921. It uses the D channel to send information and is based on the LAPB protocol in terms of principles used, frame structure, and so on (see further below).

The subscriber's D channel is used for several purposes. Each basic access (BA) can be connected to up to eight physical terminals. These terminals can be telephones, circuit-switching devices, or packet-switching devices. The signaling information sent by those terminals is multiplexed on the D channel. The LAPD protocol has to ensure that those different types of signaling can be distinguished by the exchange. To do this the LAPD employs a two–part address consisting of a terminal endpoint identifier (TEI), which is the address that indicates which of the up to eight physical terminals (or more than eight if the eight physical terminals represent more logical terminals) has initiated the call;

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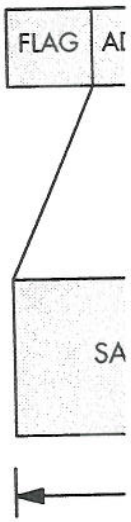

Figure 2.19 A

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and the service access point identifier (SAPI), which indicates the type of traffic that is used. The TEI and SAPI are found in the address field of the frame (see Figure 2.19).

The C/R bit in the address field identifies the frame as going in the transmit direction (bit = 0) or in the receive direction (bit = 1). The SAPI can have 64 different values, but not all are used. Those defined are as follows :

- 0 for call-control procedures, in which case the information in the frame contains signaling data to setup the call
- 1 for packet mode communication using Q.931 call-control procedures (for example, frame mode bearer service, or FMBS)
- 16 for packet mode communication using X.25 layer 3 call-control procedures
- 63 for management data, in which case the information in the frame contains data that is used by the network for operation and maintenance purposes

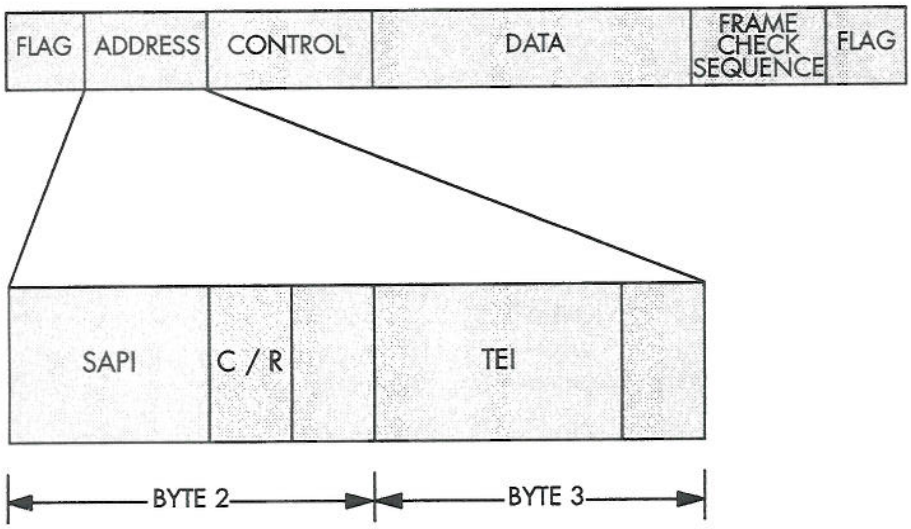


Figure 2.19 Address field of an LAPD frame.

The TEI can have 128 values. Number 127 is reserved for broadcast datalink connections, the other values are for point-to-point connections. The values 0 - 63 can be allocated by the user, the values 64 - 126 are allocated by the network.

LAPB

After the link between the subscriber and the packet-switching module is established by using the LAPD protocol, the X.25 call set up can begin. For this the LAPB (link access

Second, in the case of permanent virtual circuit procedures, layers 1 and 2 must be permanently active, and the B channel has to be established at subscription time. (Some networks may offer PVCs by using on-demand connections.) The terminal selection and identification is also fixed at subscription time. Call establishment and call termination are not applicable. Data transfer is executed following X.25 packet layer data transfer procedures.

3.3.3.2. ISDN Virtual Call (VC) and Permanent Virtual Circuit (PVC) Bearer Services Provided on the D Channel of the Basic Access and Primary Rate Access

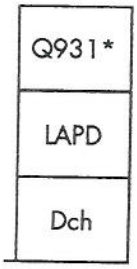
These services are generally available on point–to–multipoint (for example, passive bus) and point–to–point ISDN access arrangements. These packet mode bearer services allow users (terminals) in a point–to–point communication configuration to communicate via the ISDN using X.25 encoding, by means of procedures over a D channel in both directions continuously and simultaneously for the duration of a call. User classes 8 – 10 as specified in CCITT Recommendation X.1 can be supported on the basic access (D channel at 16 kbit/s), use of class 11 may be available if the primary rate access (D channel at 64 kbit/s) is offered.

Provision and Withdrawal

These services are provided on a subscription basis:

- *General subscription to the D channel packet service.* Some networks may not require specific subscription to the packet service because it may be offered to all ISDN subscriptions. X.31 requires the terminals to be identified by means of E.164 numbers.
- *Subscription to a standard service profile.* The following standard user service profile is defined to be applicable to users who are not registered in the network against any specific user's service profile applied at subscription time. Support of the OSI Network layer service is a general requirement of this standard service profile.

  - single link procedure, modulo 128
  - standard basic packet sequence numbering (modulo 8)
  - incoming and outgoing calls allowed
  - two two–way logical channels
  - default maximum packet length: 128 octets
  - default window size: 2
  - fast select acceptance facility
  - default throughput class: A (9600 bit/s)
  - throughput class negotiation facility available
  - transit delay negotiation allowed



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Normal procedures

Subscription to the multiple subscriber number (MSN) or direct dialing in (DDI) supplementary services may be required for terminal selecting purposes. Virtual call and permanent virtual circuit procedures can be invoked and operated concurrently by a given terminal.

Virtual Call Procedures.

Layer 1 may be permanently active but is normally activated on demand by the DTE or the packet handler. For primary rate access (PRA) layer 1 is permanently active. All packet information is conveyed in logical links identified by SAPI = 16. Each terminal has its own logical link (SAPI = 16) identified by TEI value. Three different methods of layer 2 activation can be identified:

1. Method 1: Semipermanent layer 2. Logical links between the DTE and the network (packet handler) are activated at subscription time by an operator command. The network keeps the data link layer in the activated state.
2. Method 2: On-demand layer 2 with fixed TEI values, also call PLL (permanent logical link). The TEI of the terminal is assigned at subscription time (known by the network); that is, manual TEI assignment is used. The activation of a logical link is initiated either by the DTE or the network depending on the direction of the first virtual call. No Q.931 procedures are used. The data link is setup by using out-of-band signaling, as shown in Figure 3.21.

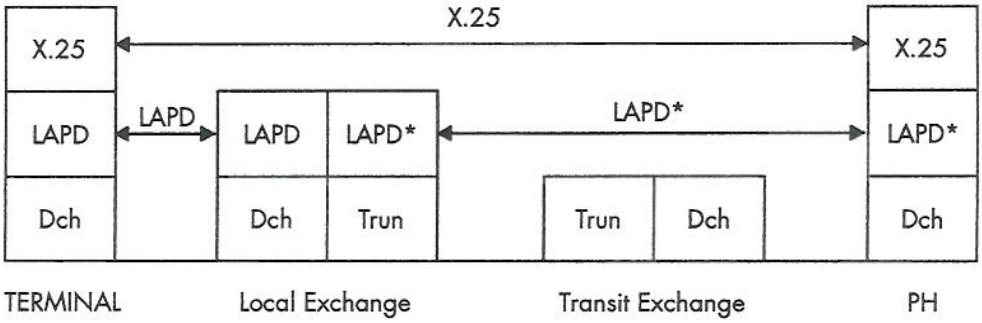

Figure 3.21 Protocol stack (data + outband signaling plane).

3. Method 3: On-demand layer 2 with dynamic TEI allocation. This method is restricted to one logical link in the case of point–to–point access arrangements.

The activation of a logical link is initiated either by the DTE or the network, depending on the direction of the first virtual call. In the case of incoming calls (network to user), Q.931 call-offering procedure (conditional notification class) may be used to interrogate the layer 2 address (TEI) to be used for the call.

Terminal Interface Identification (Network to Terminal)

This description deals only with a single user-network interface supporting multiple logical links. Users can operate several packet terminals in their in–house installation. In general, an ISDN number is used to identify a user access. In addition, the multiple subscriber number facility may be used, there by allowing users to allocate a specific ISDN number to a given terminal or terminal adapter.

Successive incoming calls to the same ISDN number will be directly multiplexed on an already established logical link, irrespective of information contained in the X.25 called-address extension facility field. However, in the case of no notification class, the packet handler could make use of this information to identify a specific logical link (see Annex G of Recommendation X.25). This would be a nonstandard use of a facility intended to support the OSI network service and would remain a network option.

In addition to these methods, additional digits from the X.121 numbering scheme can be allocated to a user, as described in CEPT Recommendation T/CD 08–03.

Terminal Interface Identification (Terminal to Network)

In the case of dynamic assignment of TEIs and use of MSN or X.121 subaddresses, the terminal identity is derived from the first call request after successful activation of layer 2. In this case the terminal must provide its identity immediately after layer 2 activation otherwise a call to the terminal may not be successful.

Call Establishment

Q.931 procedures may be used to notify the user of incoming calls. X.25 packet layer procedures are operated on an active logical link. A call is established over the whole network, as shown in Figure 3.22. In this example, terminals A and B use the same D channel and each have their own packet data link. Terminal A also has a signaling data link that the subscriber can use to establish an extra data link on demand. The packet data links are switched in the local exchange and multiplexed into 64 kb/s channels (called Bd channels) toward the packet handler (PH). An X.25 call runs between applications of terminals B and C.

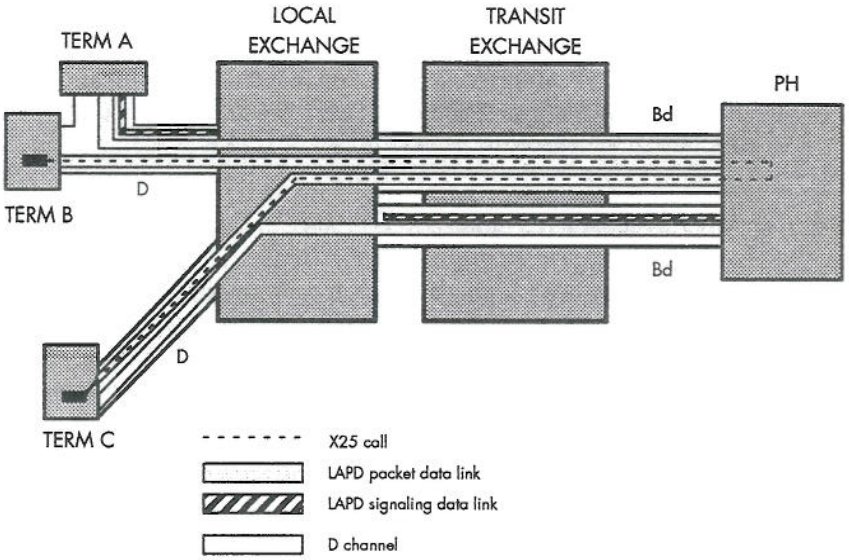

Figure 3.22 Call between D channels.

For data transfer and call termination, X.25 packet layer procedures apply. The terminal or network should deactivate layer 2 after clearing the last VC unless layer 2 is semipermanent or follow-on calls are expected. Layer 1 should be deactivated (from the network side) if it is not needed by other services. However, it has to remain active for semipermanent layer 2. (Note: Primary rate access (PRA) has no defined deactivated state.)

Permanent Virtual Circuit Procedures

Layer 1 must be permanently active, and Layer 2 must be permanently available. Terminal selection and identification are fixed at subscription time. Call establishment and termination are not applicable. Data transfer follows X.25 packet layer data transfer procedures.

3.3.4. Signalin

3.3.4.1. Signal

Incoming Calls

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2. X.31 Case
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Bd Channel Es

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Outgoing Calls

Bb Channel Es

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