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- History
- Interfaces and protocol layers
- Reference points
- Addressing
Integrated Digital Networks

- Integrated ⇒ Both transmission and Switching
- Access was still analog

(a) Nonintegrated

(b) Integrated
Int. Service Digital Network

- Past: IDN = Integrated Digital Network
  ⇒ Standardized digital techniques for switching and transmission (T1 etc)
- 1980: ISDN ⇒ Integrated access to all services
  ⇒ Digital end-to-end (Digital subscriber loop)
- One set of interfaces for all services at multiple speeds
- Supports both circuit switching and packet switching
- Out-of-band signaling. Sophisticated network management and maintenance using Signaling System 7 (SS7)
- Layered protocol architecture
History

- 1968: Study Group D set by CCITT to study digital voice
- 1972: G.702 Integrated digital switching and transmission (IDN) concept
- 1976: Digital switching and signaling (SS7) spec
- 1980: G.705 - One page recommendation on ISDN
- 1992: Additional revisions
ISDN Architecture

non-switched
⇒ dedicated
⇒ Permanent

Subscriber Premises

TE - NT

User-Network signaling

ISDN Switch

>64 kbps nonswitched

>64 kbps switched

64 kbps ckt nonswitched

64 kbps ckt switched

X.25Packet switching

Frame Mode

CCS

User-Network signaling

Network

Possibly ATM

Subscriber or Provider
ISDN Channels

- B: 64 kbps for data or voice
- D: 16 or 64 kbps for signaling or packet switched data
- H: 384 kbps (H0), 1536 kbps (H11), 1920 kbps (H12)
ISDN Access Interfaces

- Basic Rate Interface (BRI): $2B + D = 2 \times 64 + 16$
  $= 144$ kbps (192 kbps total)

- Primary Rate Interface (PRI): For LANs or PBX
  - $23B + D = 23 \times 64 + 64 = 1.544$ Mbps
  - $30B + D = 30 \times 64 + 64 = 1.920$ Mbps $= 5H0+D$

E1 - 64 kbps Framing+mgmt
Other PRI Interfaces

- **PRI H0:**
  - $3H0 + D$ or $4H0 = 1.544$ Mbps
  - $5H0 + D = 2.048$ Mbps

- **PRI H1:**
  - One $H11$ in 1.544 Mbps
  - One $H12$ in 2.048 Mbps

- **PRI for Mixture of B and H0:**
  - 0 or 1 D and any combination of B and H0, e.g.,
    - $3H0 + 5B + D$ or $3H0 + 6B$ for 1.544 Mbps
Functional Groupings

- Terminal Equipment 1 (TE1): ISDN terminal
- Terminal Equipment 2 (TE2): Non-ISDN terminal, e.g., POT
- Terminal Adapter (TA): Allows non-ISDN devices on ISDN
- Network Termination 1 (NT1): Physical layer device. Separates user premises from phone company. Owned by user in USA. Owned by PTT in many countries.
- Network Termination 2 (NT2): OSI layers 2-3, e.g., PBX, LAN
- Network Termination 1,2 (NT12): NT1 + NT2
Functional Groupings

- **NT1:**
  - Physical and electrical terminal of ISDN at user
  - Isolates the user from the transmission technology of the subscriber loop
  - Line maintenance functions such as loop back testing and monitoring
  - Bit multiplexes various B and D channels
  - Supports multi-drop lines ⇒ Telephone, personal computer, and alarm on one NT1

- **NT2:** Digital PBX, LAN, Terminal controller
  Switching and concentration
**ISDN Reference Points**

- **Rate (R):** Between Non-ISDN and Terminal Adapter. Uses X or V series recommendations.
- **System (S):** Between ISDN equipment and NT2. Separates user equipment from switching equipment.
- **Terminal (T):** Between NT2 and NT1. Separates network from user.
- **User (U):** U interface not defined by ITU. Defined in North America since NT owned by user.
Protocol Reference Model

- Similar to OSI 7-layer model
- Separate user, control, and management planes
- Control = signaling
- Management = network diagnosis, maintenance, and operation

```
Physical Medium

Control  User

7
6
5
4
3
2
```

Management
### ISDN Protocols at UNI

<table>
<thead>
<tr>
<th>Layer</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>End-to-end user signaling</td>
</tr>
<tr>
<td>Presentation</td>
<td></td>
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<tr>
<td>Session</td>
<td></td>
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<tr>
<td>Transport</td>
<td></td>
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<tr>
<td>Network</td>
<td>Q.931</td>
</tr>
<tr>
<td>Datalink</td>
<td>LAPD</td>
</tr>
<tr>
<td>Physical</td>
<td>I.430 basic or I.431 Primary</td>
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<tr>
<td>Control</td>
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<tr>
<td>Packet</td>
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<td>Packet</td>
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<tr>
<td>Signaling</td>
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<tr>
<td>permanent</td>
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<tr>
<td>Switched</td>
<td></td>
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<tr>
<td>D Channel</td>
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<tr>
<td>B Channel</td>
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</tbody>
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LAPD

- Link Access Protocol for D Channel
- Similar to HDLC and LAPB
- X.25 packets are transmitted in LAPD frames
- LAPD used for signaling messages
Six types of services

- Circuit switched calls over a B or H channel
- Semi-permanent connections over a B or H channel
- Packet switched calls over a B or H channel
- Packet switched calls over a D channel
- Frame relay calls over a B or H channel
- Frame relay calls over a D channel
**ISDN Addressing**

- E.164 designed for ISDN allows up to 15 digits
  - Superset of E.163 for telephony (12 digits)
- Country code: 1 to 3 digits
- National Destination Code: Provider ID or Area code
- ISDN Address = ISDN number + ISDN subaddress

<table>
<thead>
<tr>
<th>Country Code</th>
<th>National Destination Code</th>
<th>ISDN Subscriber Number</th>
<th>ISDN Subaddress (Max 40 digits)</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

- National ISDN Number
- International ISDN Number (max 15 digits)
- ISDN Address (max 55 digits)
# Other Addressing Structures

- **X.121 Data Networks**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Country code</th>
<th>PDN code</th>
<th>Network term. number</th>
</tr>
</thead>
</table>

  **Data Network Identification Code**

<table>
<thead>
<tr>
<th>Data country code</th>
<th>National number</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>9</th>
<th>Country code</th>
<th>National significant number</th>
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</table>

  **E.163**

<table>
<thead>
<tr>
<th>8</th>
<th>Telex destination code</th>
<th>National telex number</th>
</tr>
</thead>
</table>

- **ISO 7498**

<table>
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<tr>
<th>Authority and format identifier</th>
<th>Initial domain identifier</th>
<th>Domain specific part</th>
</tr>
</thead>
</table>
Other Addressing (Cont.)

- IDI = Initial domain identifier
- DSP = Domain specific part
- AFI = Authority and format identifier (Six authorities):
  - Four ITU controlled: Packet-switched Data Networks (PSDN), Telex, Packet-switched Telephone Networks (PSTN), ISDN.
  - Two ISO Controlled:
    - ISO geographic domain: Assigned by countries
    - International organization domain, e.g., NATO.
  - AFI = 44 \(\oplus\) ISDN in decimal, 45 \(\oplus\) ISDN in binary
Summary

- B, D, and H channels
- BRI and PRI
- NT1, NT2, TE1, TE2, TA
- R, S, T, and U reference points
- Addressing, E.164, ISO
Homework

- Read Chapters 4, 5.1-5.5 of Stallings’ ISDN book
- Submit answers to Exercise 5.1