Overview

- Carrier Systems
  - DS-n
  - SONET
  - SDH
- Next: Virtual Circuit Systems
  - Frame Relay
  - ATM

The North American Digital Carrier System

- The Basic channel is a DS0 = 64kbps
- DS1 = 24 x DS0 plus framing = 1.544Mbps
- DS1C = 2 x DS1
- DS2 = 4 x DS1
- DS3 = 28 x DS1

European Digital Carrier

- Basic channel: DS0 = 64kbps
- E1 = 30 x DS0 + 2 x 64kbps for signaling = 2.048Mbps
- No signaling embedded in the user channels.
What does a "raw" T1 Signal Look Like (AMI coding)?

The T1 Frame (D4 Format)

- 8000 frames per second
- 0.125 msec per frame
- Channel 1: bits 1 to 8
- Channel 2: bits 9 to 16
- Channel 3: bits 17 to 24
- Channel 24: bits 183 to 192
- Framing Bit: bit 193

Signaling in a T1

- At the T1 level
- "Superframe" signaling uses groups of 12 T1 frames to create timing and signaling patterns
- "Extended Superframe" signaling uses 24 T1 frames to create timing, error detection, and signaling capabilities

SF and ESF Signaling

Superframe Signaling (Sequence of 12 framing bits):

```
100011011100
```

Extended Superframe (Sequence of 24 framing bits):

```
DD0DDDDC1DC0DC1DC0DC1DC0
```
In-Band Channel-Associated Signaling

- Inside each channel
- Voice channels use signaling bits to indicate on-hook and off-hook conditions
- Data channels may include signaling bits and bits that enforce the “1”s density

Robbed-Bit Signaling

Frame Bit 1 2 3 4 5 6 7 8 9 10 11 12
1 v v v v v v v v v v v v
2 v v v v v v v v v v v v
3 v v v v v v v v v v v v
4 v v v v v v v v v v v v
5 v v v v v v v v v v v v
6 v v v v v v v v v v v v
7 v v v v v v v v v v v v
8 v v v v v v v v v v v v
9 v v v v v v v v v v v v
10 v v v v v v v v v v v v
11 v v v v v v v v v v v v
12 v v v v v v v v v v v v

SONET

<table>
<thead>
<tr>
<th>Electrical Signal</th>
<th>The-North-End</th>
<th>The-South-End</th>
<th>Capacity</th>
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<tbody>
<tr>
<td>STS-1</td>
<td>OC-12</td>
<td>OC-12</td>
<td>155.520 Mbps</td>
</tr>
<tr>
<td>STS-1c</td>
<td>OC-1</td>
<td>OC-12</td>
<td>155.520 Mbps</td>
</tr>
<tr>
<td>STS-63</td>
<td>OC-4</td>
<td>OC-12</td>
<td>155.520 Mbps</td>
</tr>
<tr>
<td>STS-64</td>
<td>OC-4</td>
<td>OC-12</td>
<td>155.520 Mbps</td>
</tr>
<tr>
<td>STS-192</td>
<td>OC-4</td>
<td>OC-12</td>
<td>155.520 Mbps</td>
</tr>
<tr>
<td>STS-16 × 256</td>
<td>OC-4</td>
<td>OC-12</td>
<td>155.520 Mbps</td>
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<tr>
<td>STS-192c</td>
<td>OC-4</td>
<td>OC-12</td>
<td>155.520 Mbps</td>
</tr>
<tr>
<td>STS-192c × 2</td>
<td>OC-4</td>
<td>OC-12</td>
<td>155.520 Mbps</td>
</tr>
</tbody>
</table>

SONET Structure

From Bates, Voice and Data Communications Handbook
SONET notes

- Tributaries
- Payload pointers permit “floating” in case of clock drift
- Drop and Insert Support
- Ring Architecture

SDH

<table>
<thead>
<tr>
<th>Electrical Rate</th>
<th>Optical Rate</th>
<th>Speed</th>
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<tbody>
<tr>
<td>STS-1</td>
<td>STS-1</td>
<td>155.52 Mbps</td>
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<tr>
<td>STS-2</td>
<td>STS-2</td>
<td>622.08 Mbps</td>
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<td>STS-3</td>
<td>STS-3</td>
<td>2488.32 Mbps</td>
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<td>STS-4</td>
<td>STS-4</td>
<td>9953.28 Mbps</td>
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<td>STS-24</td>
<td>STS-24</td>
<td>1.44 Gbps</td>
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<tr>
<td>STS-16</td>
<td>STS-16</td>
<td>2.06 Gbps</td>
</tr>
<tr>
<td>STS-64</td>
<td>STS-64</td>
<td>15.36 Gbps</td>
</tr>
</tbody>
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SDH Frame