COMT 220

Carrier Systems, Multiplexing
Carrier Systems
General Overview
Carrier Systems

 Aggregate Signal

4kHz

4kHz

4kHz

4kHz

4kHz
Analog Carrier

4kHz

4kHz

4kHz

4kHz

4kHz

20 kHz

16-20kHz
12-16kHz
8-12kHz
4-8kHz
0-4kHz
Digital Carrier

4kHz codec 64kbps
4kHz codec 64kbps
4kHz codec 64kbps
4kHz codec 64kbps
4kHz codec 64kbps
320kbps
Digital Carrier Hierarchy
The US 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
The SONET Hierarchy

- Synchronous Optical Network
- STS-n is the electrical standard, OC-n the optical one
- Basic channel STS-1 = about 52Mbps
- OC-3 = about 155Mbps
- OC-12 = about 600Mbps
- OC-48 = about 2500Mbps, etc.
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.
T1 Service:
A Carrier System Applied to End-User Demand
Definitions

• T1 and DS1 are synonymous
• To the end-user, a T1 represents either
  – a digital transmission path of 1.536Mbits/sec,
  – or 24 “channels”, with each channel capable of carrying a voice call or digital data up to 56kbits/sec.
  – Channels are 64kbits/sec “wide”, more about that later…
Market Environment

• Typical uses for the T1
  – Voice trunks (ACDs)
  – Small Business Internet Access
  – Next higher speed after ISDN

• T1 is a “mature” market with established manufacturers; growth is modest.
Voice Applications

24 Voice Trunks

PBX

Channel Bank

T1 Facility
Data/Hybrid Applications

Video Conference

LAN Router

Voice

CSU/DSU

T1 Facility
Trends

• T1 facilities will continue to be in widespread use.
• T1 is being used to carry “Frame Relay” data traffic.
• The next step after T1 (possibly multiple ones) is DS3=45Mbit/sec private lines and ATM (Asynchronous Transfer Mode) networks over SONET.
Synchronous Transmission

Data: 1 1 1 0 0 1 1 1 1 1

Timing:

Transmit:

Receive:

Timing:

What if:
What does a “raw” T1 Signal
A “channelized” T1

• A “Frame” consists of 8 bits for each channel, strung one after the other
  – 8 bits/channel times 24 channels = 192 bits

• One “Framing Bit” is added to each frame
  – Total frame length is 193 bits

• 8000 frames are sent per second
  – 8000 times 193 = 1,544,000
The T1 Frame (D4 Format)

- Channel 1: bits 1 to 8
- Channel 2: bits 9 to 16
- Channel 3: bits 17 to 24
- Channel 24: bits 185 to 192

8000 frames per second
0.125 msec per frame

Framing Bit: bit 193

8000 frames per second
0.125 msec per frame
Restrictions on the T1 signal

• In the bit stream, there must never be more than 15 consecutive “0”s.
• Over short periods of time, there must be at least 12.5% “1”s in the signal.
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):
1000110111100

Extended Superframe (Sequence of 24 framing bits):
DCD0DCD0DCD1DCD0DCD1DCD1
Signaling in a T1 cont…

• 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.
# Voice Channel Signaling

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\(A\)

\(B\)
CSU - Channel Service Unit

• Interface between the customer and the carrier circuit.
• Regenerates the signal
• Provides or recovers timing
• Passes a T1 signal (DS1-X) to the customer equipment
DSU - Data Service Unit

- Receives a T1 signal from the CSU
- Converts the signal to a “short-haul” interface format
  - RS-232
  - V.35
  - RS-422
- Can access and “break out” individual channels.
MUX - the Multiplexer

• Combines numerous voice and data input streams into a T1
• May use the 24-channel format
• Often uses proprietary channel assignments
DCS - Digital Cross-Connect

• Used by carriers and large end-users
• Electronically connects T1s to each other, or
• Connects channels from one T1 to channels in another T1.