Public Switched Telephone Network

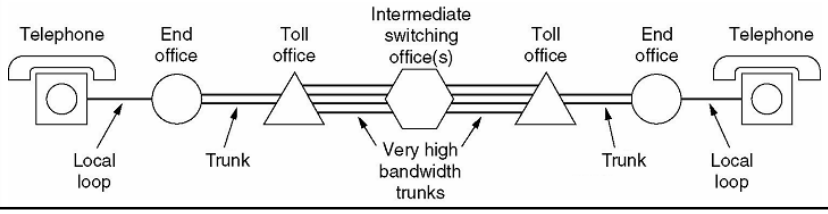
- Introduction
- Local loops
  - Modems, DSL, Wireless
- Trunk Lines
  - FDM, WDM
  - TDM, SONET/SDH
- Switching Offices
  - Circuit switching, Packet switching

Introduction

- Largest _____
- Designed for _____ using _____with a _____
- Uses: Transmission of _____

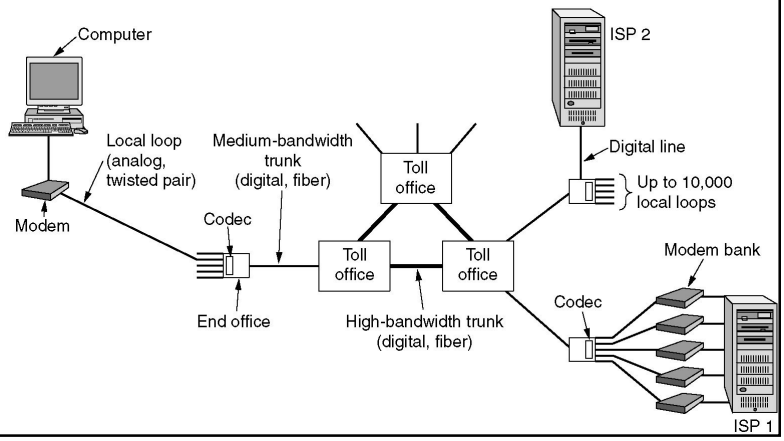
PSTN components

- Local loop: _____
  - Normally CAT 3 cables
- Trunk lines: _____
  - Digital _____
- Switching offices _____



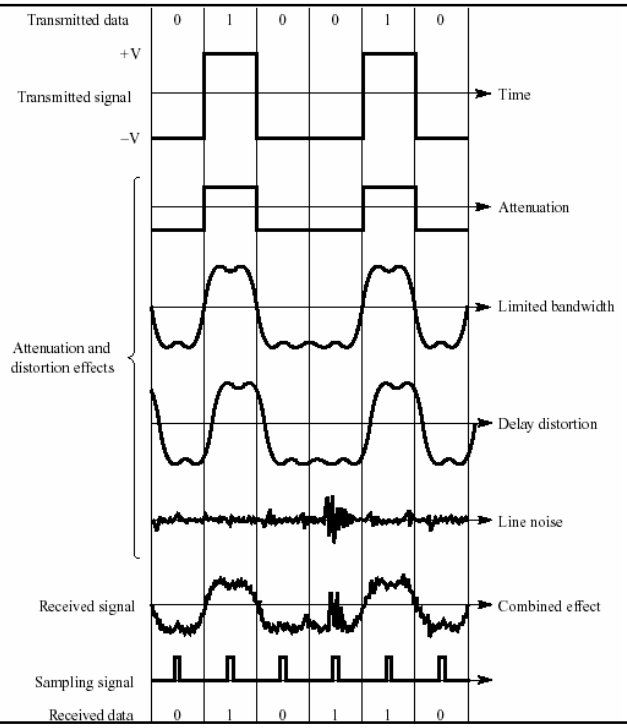
Data on the Local Loop

1. D/A _____
2. A/D _____



Signal Degradation

- Attenuation: _____
  - Decibels/km
- Distortion
  - Fourier components _____
- Noise
  - Thermal _____
  - Crosstalk _____
  - Impulse _____

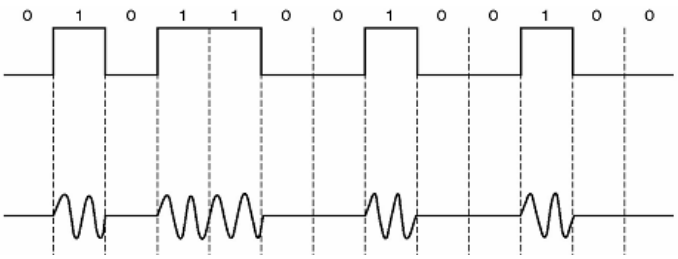


Digital Signal problems

- Avoid a wide frequency range
  - Why? _____
    _____
- Digital Signals _____
  _____
  - Baseband: _____
- Broadband _____
  - Signal modulated onto _____
  - 3 methods of modulation…

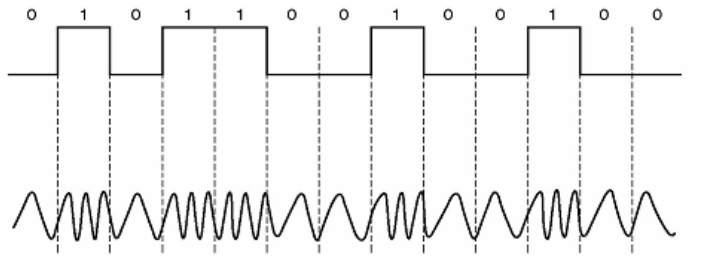
1. Amplitude Modulation

- Two different amplitudes
  - 0 _____
  - 1 _____



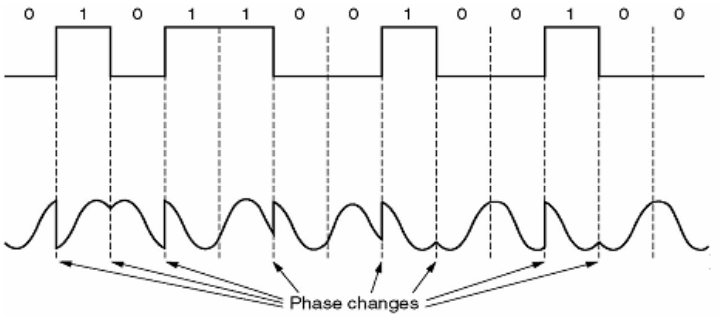
2. Frequency Shift Keying

- Two different tones
  - 0 _____
  - 1 _____



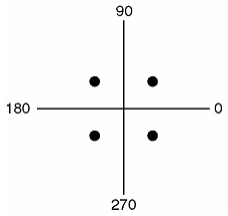
3. Phase Modulation

- Different phase shifts
  - 0→1 _____
  - 1→0 _____
  - 0→0 & 1→1 _____



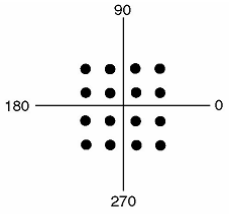
Modems

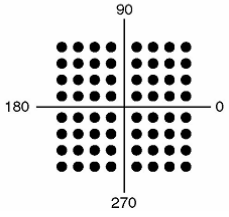
- Given 3.1KHz how often should we sample?
  - _____
- But the medium is not perfect…
  - Most modems sample _____
  - One symbol per baud…
  - How can we increase the bits per symbol?
    - QPSK: _____
      _____



QAM _____

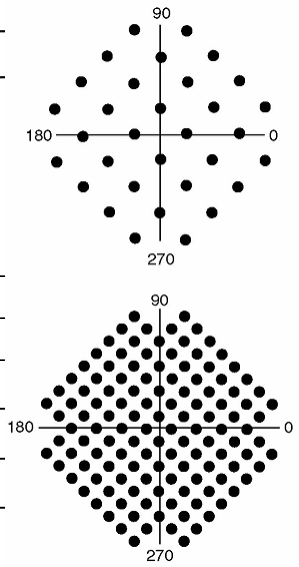
- Most modems _____
- Combination of _____
  _____
- Constellation diagram…
- QAM-16
  - Bits: _____
  - Data rate: _____
- QAM-64
  - Bits: _____
  - Data rate: _____





Real Modems

- Risk of Error _____
  _____
- Trellis Code Modulation
  - E.g. Using parity bits
  - V.32
    - Points _____
    - Error bits _____
    - Data Rate _____
  - V.32 bis _____
  - V.34 _____
  - V.34 bis _____



Some modem issues

- Compress the data? _____
- Choosing a speed:_____
  - Test the line _____
- Direction of traffic _____
- Why no more than 33,600bps?
  - _____

V.90 modems

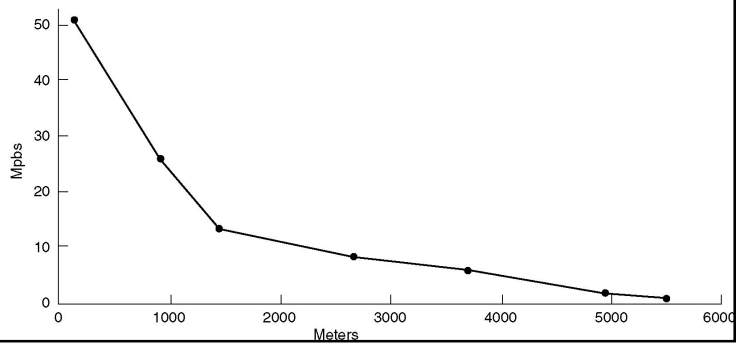
- Digital connection to ISP
  - Theoretical max data rate _____
  - Bandwidth _____
  - Max samples _____
  - Bits per symbol _____
  - Data Rate _____
- V.90
  - Data rate _____
- V.92
  - Data rate _____
  - Set up time _____

DSL concept

- Goals
  - Work on _____
  - No affect on _____
  - Much faster
  - Always on
- Changes
  - In the end office: _____
    _____
  - In the home: _____
    _____

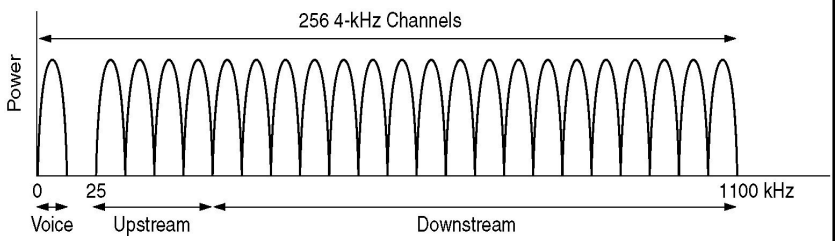
DSL Limitations

- Capacity of line related to
  - Length: _____
  - Quality: _____
  - Bundling: _____



DMT _____

- 0 – POTS _____
- 1-5 – _____
- 6-255 – _____
  - 125-125 _____
  - 218-32 _____

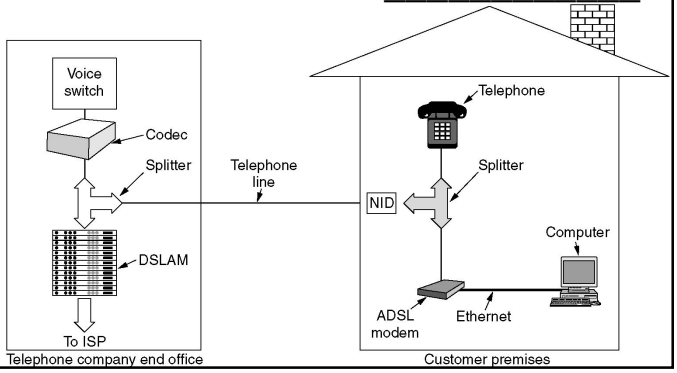


ADSL Speeds

- ADSL standard
  - Up to _____
  - Standard service _____
  - Premium service _____
- Modulation
  - Similar to _____
  - QAM is used _____
  - 218 channels => _____
  - Line quality _____

DSL Configuration

- Splitter _____
- DSLAM _____
- NID _____
- Splitter _____
- ADSL modem _____
- Ethernet_____

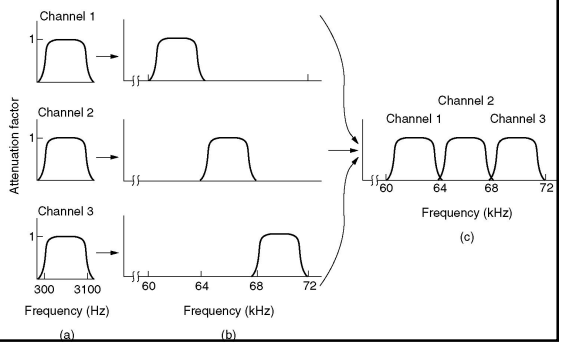


Trunk lines

- Cost of installation _____
  _____
  - Hence there has always been an interest in sharing/multiplexing lines.
- Two Categories:
  - FDM _____
  - TDM _____

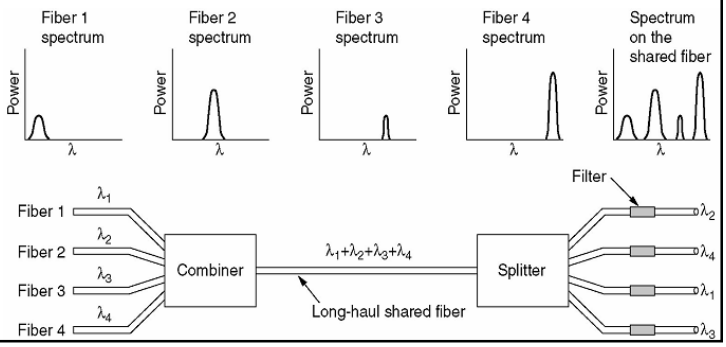
FDM

- Channels
  - 3.1KHz for _____
  - 4.0KHz to provide _____
  - Raise to a _____
  - Combine…



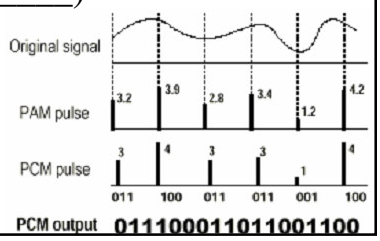
WDM

- FDM @ higher frequencies
- Speed:
  - 2001: _____
  - Limit: _____



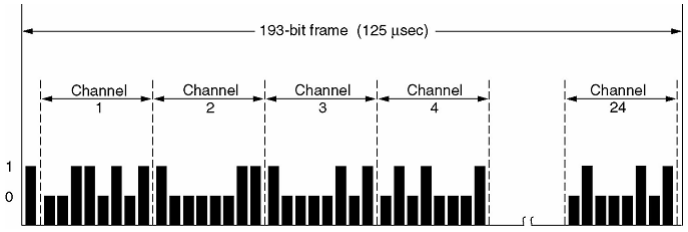
TDM – PCM

- Allow each channel _____
  _____
  - Only possible for digital data
- To recreate a 4 kHz voice channel
  - Need 8000 samples/sec
  - First the signal is sampled (using PAM _____)
  - Then it is quantised
    - PCM → bits per sample



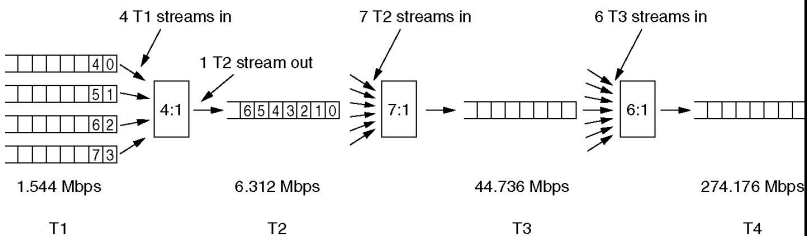
TDM – T1 / E1

- 193 bits/257 bits every 125µsec
  - Framing: First bit _____
    - Frame slips: _____
  - Data & Signaling (24/32 channels)
    - 7 bits _____
    - Common channel signaling _____
    - Channel associated signaling _____



TDM – Multiplexing streams

- T1 streams
  - T2 = _____
  - T3 = _____
  - T4 = _____



- CCITT streams
  - Multiplexed _____
  - 2.048 (32), 8.848 (128), 34.304 (512), 139.364 (2048), 565.148 (8192)

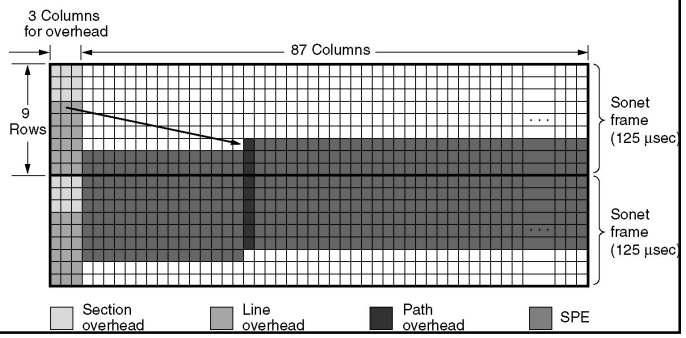
SONET/SDH

- Optical TDM
  - SONET: _____
  - SDH: _____
- Synchronous transmission: _____
  _____

SONET		SDH	Data rate (Mbps)		
Electrical	Optical	Optical	Gross	SPE	User
STS-1	OC-1		51.84	50.112	49.536
STS-3	OC-3	STM-1	155.52	150.336	148.608
STS-9	OC-9	STM-3	466.56	451.008	445.824
STS-12	OC-12	STM-4	622.08	601.344	594.432
STS-18	OC-18	STM-6	933.12	902.016	891.648
STS-24	OC-24	STM-8	1244.16	1202.688	1188.864
STS-36	OC-36	STM-12	1866.24	1804.032	1783.296
STS-48	OC-48	STM-16	2488.32	2405.376	2377.728
STS-192	OC-192	STM-64	9953.28	9621.504	9510.912

SONET/SDH

- STS-1
  - 810 bytes (9 rows * 90 columns) frames
  - Section & Line overheads
  - Data
    - SPE: _____

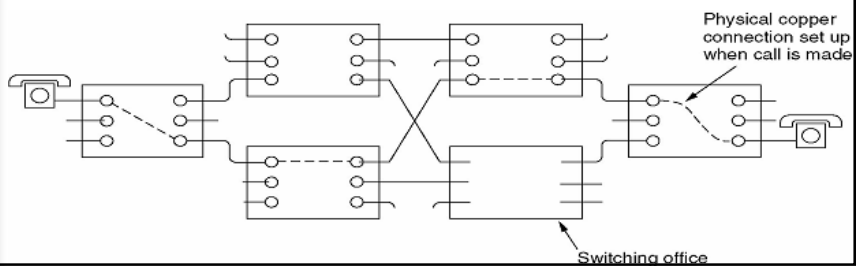


Switching

- Categories
  - Circuit Switching
  - Packet Switching

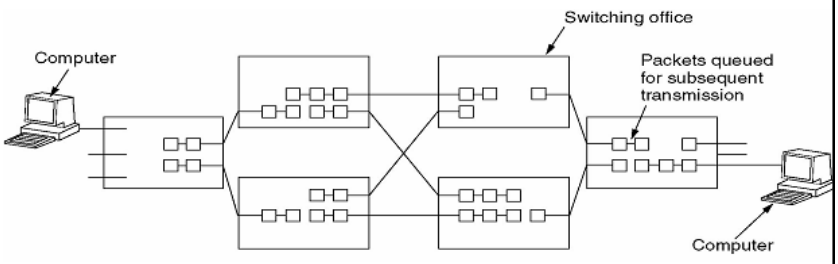
Circuit Switching

- Create a path
  - Physical _____
  - Conceptual _____
- Path setup _____



Packet Switching

- Send packets
  - Routers
  - Store & Forward



Circuit vs. Packet Switching

Item	Circuit-switched	Packet-switched
Call setup	Required	Not needed
Dedicated physical path	Yes	No
Each packet follows the same route	Yes	No
Packets arrive in order	Yes	No
Is a switch crash fatal	Yes	No
Bandwidth available	Fixed	Dynamic
When can congestion occur	At setup time	On every packet
Potentially wasted bandwidth	Yes	No
Store-and-forward transmission	No	Yes
Transparency	Yes	No
Charging	Per minute	Per packet