

Example Networks and the Physical Layer

CS158a

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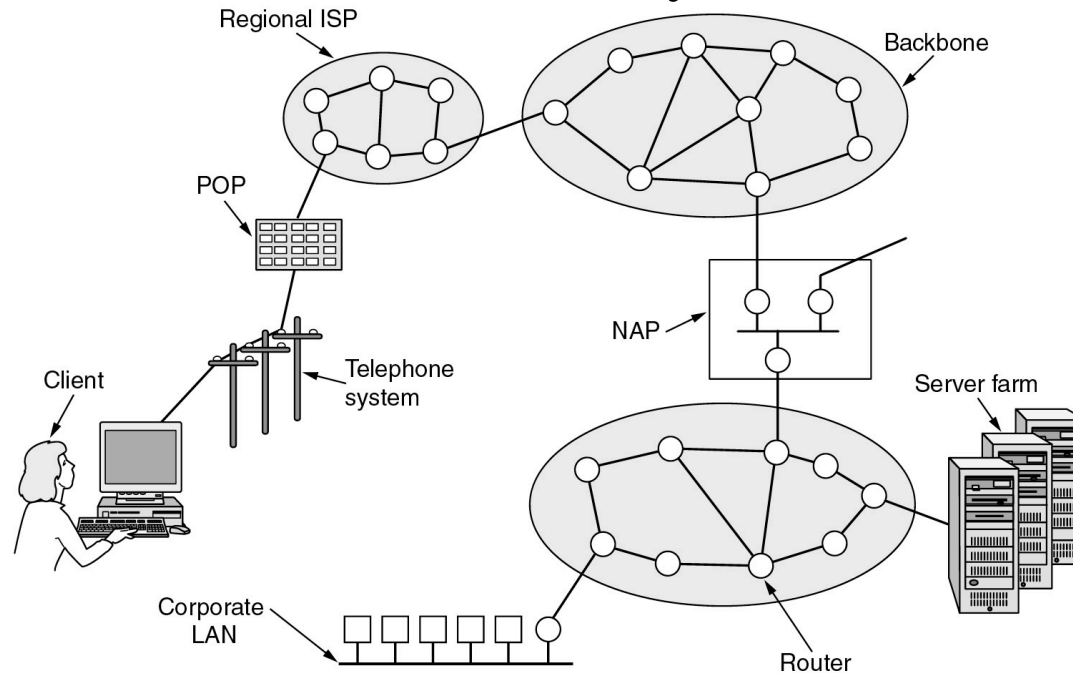
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Outline

- Example Networks
- The Physical Layer

Architecture of the Internet

- Last day, we looked at two network which led up to the internet: ARPANET and NSFNET.
- When the government got out of networking business, it awarded contracts to four different providers to establish **Network Access Points** in SF, Chicago, Washington, and NJ.
- Every operator that wants to provide backbone service to the NSF regional network has to be able to connect to all the NAPs.
- A picture of what the internet today in the US looks like is:



Connection-Oriented Networks: X.25 and Frame Relay

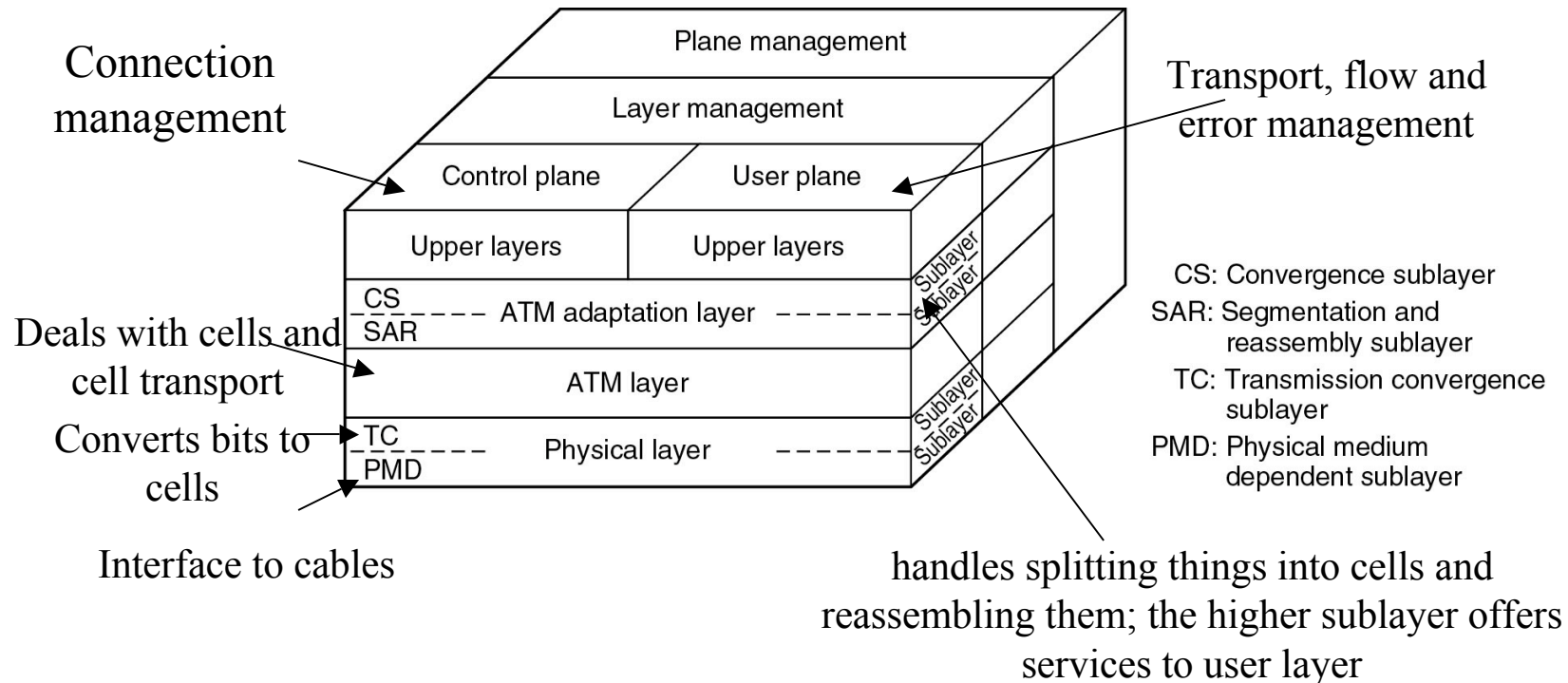
- The telephone companies were big proponents of connection-oriented networks because: (1) it is easier to guarantee quality of service, and (2) it is easier to do billing.
- They created a connection oriented network called X.25 in the 1970s
- To use X.25, a machine first established a connection to a remote machine (placed a telephone call).
- The connection was given a connection number and this was used in data transfer packets. This was needed as it was possible to open multiple connections at the same time.
- A packet consisted of a 3 byte header together with 128 bytes of data.
- The header was split into a 12-bit connection number, a packet sequence number, an acknowledgement number, and a few extra bits.
- Although moderately successful X.25 was replaced in the 1980s by a new kind of network called **frame relay**. This was a connection oriented network with no-error or flow control.
- It had properties similar to a wide area LAN and was used in businesses to connect multiple offices of a company that were geographically separated.
- It is still sometimes used.

ATM

- Asynchronous Transfer Mode (ATM) is another kind of connection-oriented network.
- It is often used for internal transport with the telephone system
- To start a connection a set-up packet is sent through the network from source to target.
- As this happens the routers add entries to their tables to reserve resources for this connection. (Sometime path called a **virtual circuit**.)
- ATM also supports **permanent virtual circuits**.
- An ATM packet is called a **cell**.
- Each cell consists 5 header bytes and 48 data bytes.
- Cell routing is done in hardware so faster. This is possible because of the fixed cell size.
- All cells follow the same route to the destination.
- ATM operates at 155.52 Mbps and 622 Mbps and networks are organized like WANs with lines and switches.

ATM Reference Model

- ATM has a 3D Reference Model distinct from OSI and TCP/IP



Ethernet

- Developed at Xerox based on work on wireless networks to connect computers in Hawaii (ALOHANET).
- ALOHANET had two radio channels one for upstream and one for downstream.
- The goal was to connect a terminal and a computer so downstream never would have a conflict, but upstream might. In the case of a conflict, the terminal would notice no acknowledgement and send again.
- Ethernet uses a **multidrop cable**.
- It initially ran at 2.94Mbps but was quickly scaled up to faster speed. 10, 100, and 1000Mbps
- If a computer notices line in use waits.
- If two try to use line at same time, each waits a random time and tries again.

Wireless LANS:802.11

- The IEEE 802.11 group is responsible for trying to come with standards for wireless LANs.
- The standard works in two modes: (1) in the presense of a base station (aka **access point**); (2) in an **ad-hoc network** mode between pairs of machines.
- It also had to be compatible with Ethernet.
- This was non-trivial. With Ethernet each machine is always connected to the same machines on the multidrop cable.
- For wireless, different machines might be within range of different machine radios and base stations.
- One also has the issue that radio waves reflect so one might see the same signal multiple ways. (**multipath fading**)
- Another problem is that a lot of software is not aware of mobility. For instance, a word processor might expect its printer list to always be available.
- A last problem is how to hand off between base stations.
- The 802.11 committee came up with a standard in 1997 that ran a 2Mbps. It immediately spawned several further standards 802.11a, 802.11b, 802.11g and n.

Basis For Data Communication

- We will now begin to talk about the physical layer.
- It is responsible for mechanical, electrical, and timing interfaces to the network.
- To begin information can be transmitted on wires by varying some physical property such as voltage or current.
- We model this property as a function of time $f(t)$ and consider how to analyze this function.

Fourier Analysis

- Jean-Baptiste Fourier developed a way to study periodic functions using sines and cosines.
- Given a function $g(t)$ with period T we try to write it as:

$$g(t) = \frac{1}{2}c + \sum_{n=1}^{\infty} a_n \sin(2\pi nft) + \sum_{n=1}^{\infty} b_n \cos(2\pi nft)$$

- Here $f = 1/T$, a_n and b_n are the amplitudes for the n **harmonic** and c is a constant.
- To compute these coefficients we can use the formulas

$$a_n = \frac{2}{T} \int_0^T g(t) \sin(2\pi nft) dt, \quad b_n = \frac{2}{T} \int_0^T g(t) \cos(2\pi nft) dt, \quad \text{and} \quad c = \frac{2}{T} \int_0^T g(t) dt$$

Bandwidth Limited Signals

- Suppose we want to send a ASCII “b”.
- This consists of the string 01100010
- We need some way to create this voltage profile.
- So we build it up using the first few terms of the fourier series until we match it closely enough so it can be recognized at the other end.
- Some power will be lost in the transmission of the signal
- Transmission facilities drop different frequency components differently. (**Attenuation**)
- The range of frequencies which can be transmitted without too much attenuation is called the **bandwidth**.
- Phone lines have a bandwidth of about 1Mhz, but the phone company artificially has a filter to limit frequencies above 3100Hz. (**Voice grade line**).
- This means if the bit rate is b bits/sec then to send 8 bits take $8/b$ seconds. The bit frequency is thus $b/8$ Hz. So to send 8 bits on a voice grade line the highest harmonic that can be used is $3000/(b/8) = 24000/b$
- So at $b=9600$ bps, get at most up to the 3 harmonic.