Computer Networks I

Origins

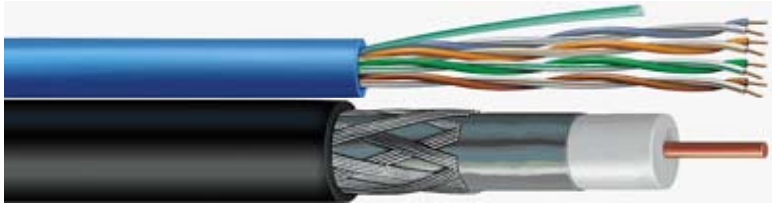
- US Department of *D*efense *A*dvanced *R*esearch *P*rojects *A*gency
  - Budget insufficient to provide computers for all scientists and engineers
  - 1960's: share specialized computers between groups
  - Challenges: How are computers to communicate? Want to achieve efficiency, not lose data.

Today

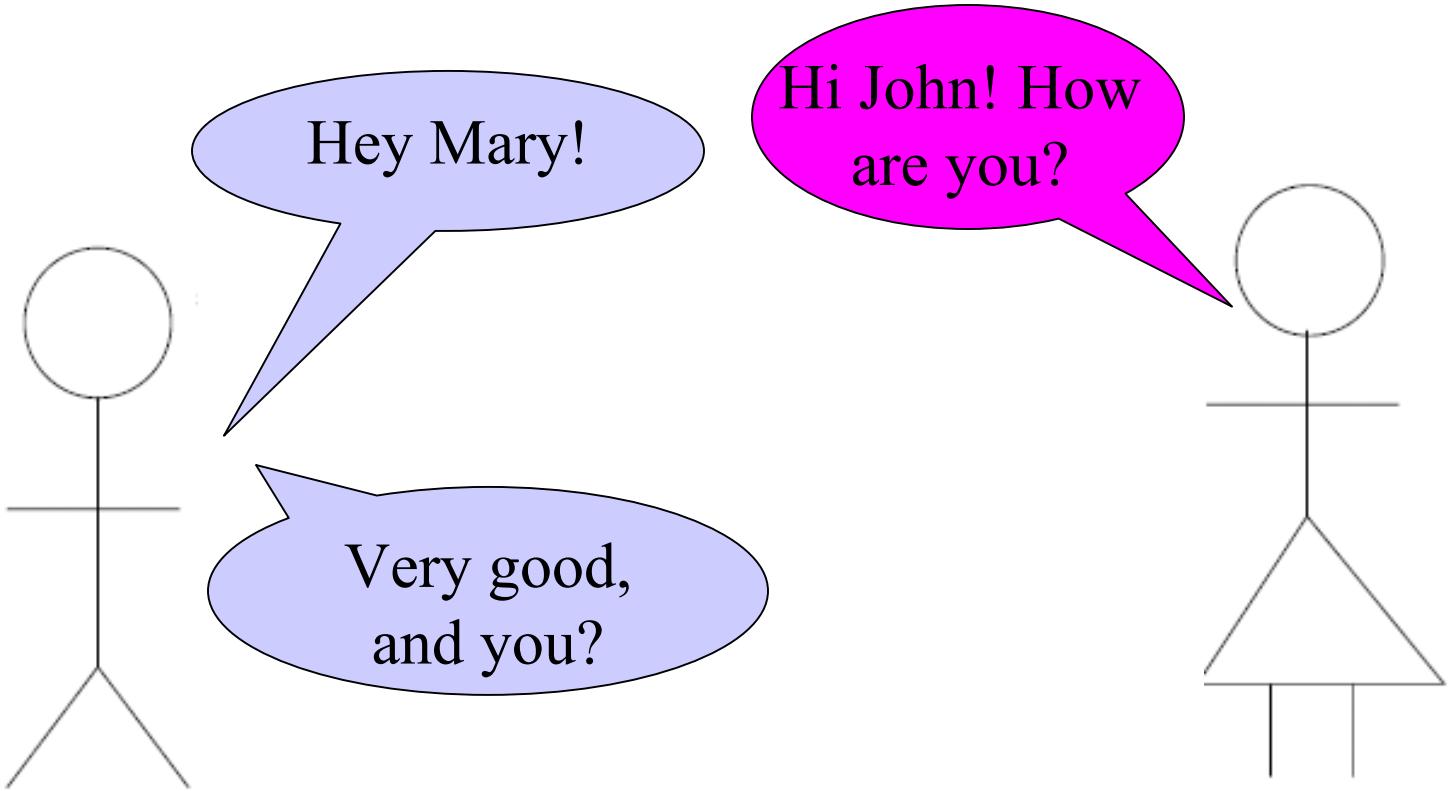
- Why use a computer network?
  - – Sharing of hardware resources (printers, scanner, etc.)
  - – Sharing of software resources (programs, files)
  - – Human-to-human communication (instant messaging, email)
  - – Distribute large complex tasks on several machines simultaneously (SETI*Search for Extraterrestrial Intelligence*@home)
  - – Play multi-player games

Message Transmission

- Transmission is a term used to represent the actual relaying of a message between a sender computer and a receiver computer
- Two main types of transmission media:
  - Wired transmission media
    - Twisted-pair cable
    - Coaxial (Cable TV) cable
    - Fiber-optic cable
  - Wireless transmission media
    - Radiowaves
    - Infrared waves



Communication Protocols



Communication Protocols

- Why was this communication successful?
  - Both people can hear and speak
  - Both people are speaking same language
  - Refers to the other by name
  - Shows willingness to communicate
  - Established a 'polite' communication pattern
  - Used special greeting words (eg. 'hey', 'hi')

Communication Protocols

- Humans abide by rules when they communicate:
  - We use the same frequency range
  - Languages are structured
  - Pattern: greet, talk, then listen, ...

- Computers must abide by strict rules to avoid communication problems

Communication Protocols

- A protocol is a set of rules that governs how computers have a "conversation"

- Eg. Protocol:
  - If a computer sends another computer a single bit set to '1', it is trying to reach that computer (ie. to see if it is awake/functional)
  - If a computer receives a single bit set to '1' from another computer, it sends it back a '0'-bit to indicate that it is awake/functional

Layered Communication

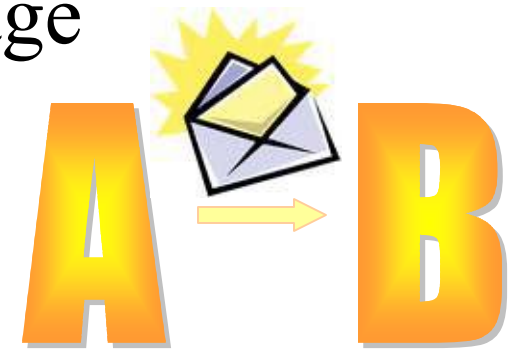
- Layers break the communication process into manageable chunks
- Each layer is independent of the other layers
  - changes made to protocols that effect one layer will not affect the other layers
- Each layer receives a message from the upper layer, and calls upon the services of the lower layer
- Effectively, layer *x* on one machine communicates with layer *x* on another machine.
- Each layer has protocols associated with the layer for specific purposes

Locating Computers on the Network – IP Address

- Suppose we have a simple network:
  - Each computer must have some unique id
  - Each computer could be identified by a unique IP address
  - Could be thought of as a street address
- Example: 192.168.10.123

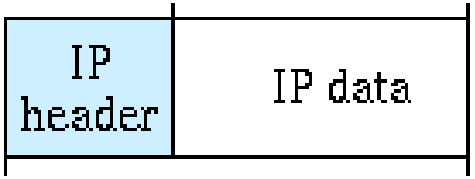
Sending Information

- Suppose we have computers A and B
- Computer A wants to send a message to computer B
- All computer A knows is B's IP address
- A "signs" all messages it sends with B's IP address
- All computers on the network get the messages, but only B reads them



Internet Protocol (IP)

- IP packet consists of an IP header and IP data
- IP header contains information such as source IP address, destination IP address, size of the IP data
- IP data contains any kind of data you want to transfer between two computers



Network layer

Internet Protocol

Unreliable:

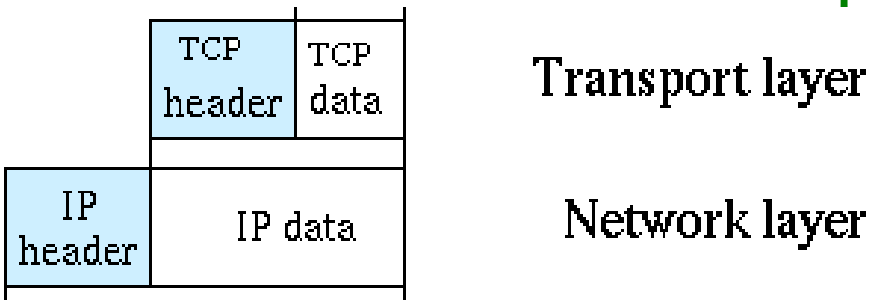
- data corruption
- duplicate arrival
- out of order (packet A may be sent before packet B, but B can arrive before A)
- lost or “dropped/discarded” packets
- Not very useful by itself

Transmission Control Protocol (TCP)

- For many forms of communication need reliability
- Need to know when communication has started and ended
- If a message is broken into multiple parts, once you get all the parts need to know how to put them back in order
- TCP solves all these problems

Transmission Control Protocol (TCP)

- TCP is a protocol constructed on top of IP



- Each TCP packet consists of TCP header and TCP data, similar to IP
- TCP header contains the source port, destination port, sequence number and acknowledgement (ACK) number

TCP ports

- If IP address is like a building number; port is like an apartment number
- If one wants to send data to a certain program running on a computer, the program needs to be listening for the data
- Information needs to be sent not only to the right computer (IP address) but to the right port on this computer

Three-Way Handshake

- Before communication can be started both ends must ensure that they have a stable connection and are ready to send and receive data : three-way handshake is a way of doing that
- Sent in the acknowledgement portion of the TCP header
  1. Initiator: SYN
  2. Receiver: SYN-ACK
  3. Initiator: ACK
- Once all three are sent and received, communication is established

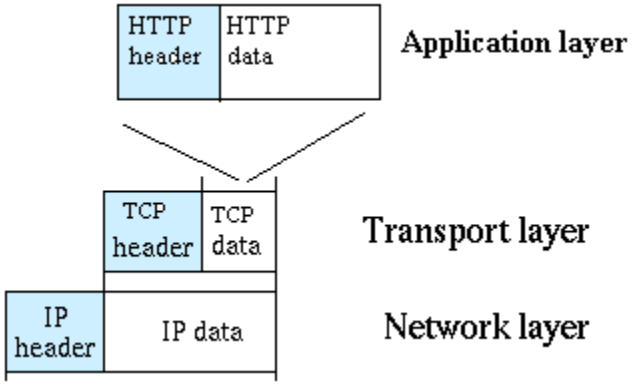
Sequence Numbers

- Recall that IP provides no guaranties on the order of packet delivery and TCP packets are stored in the IP packets
- Also part of the TCP header
- Used to reconstruct the complete message and to detect if any portions were not delivered
- Used to indicate to sender if something was not received and needs to be retransmitted

Example

HTTP

- Can TCP be further subdivided?
- Sure! TCP data portion can contain other packets, for example an HTTP packet



Is TCP good for everything

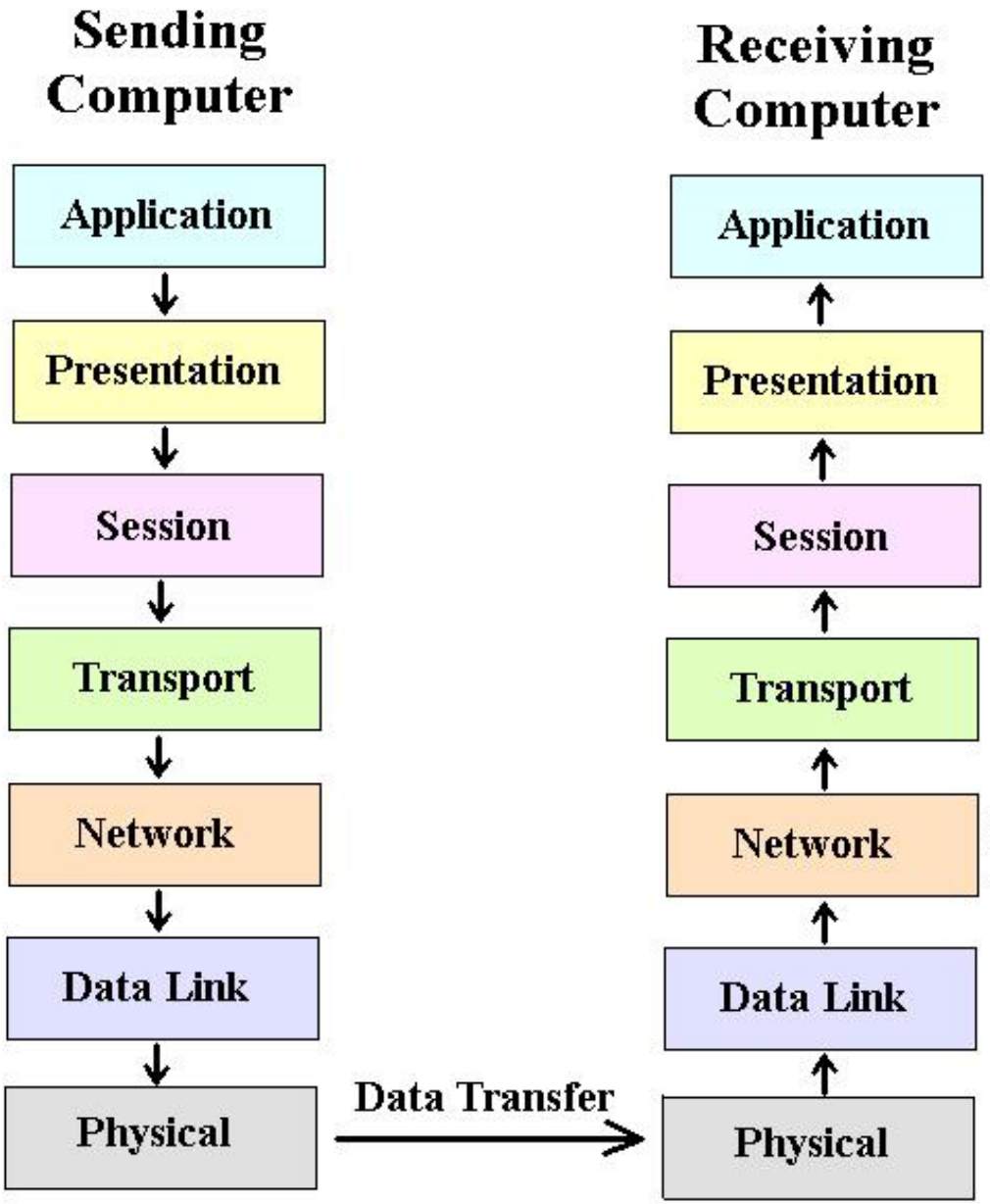
- TCP provides complete reliability, this is not always necessary, for example Voice over IP, if one sound out of a conversation is lost it will not affect understanding
- TCP communication has a big overhead, TCP header is relatively large and the receiving client is required to respond
- Need a lighter protocol

User Datagram Protocol (UDP)

- On the same level as TCP
- Of all the “interesting” information in the TCP header, UDP contains only the port number
- Is not reliable but very light and sufficient for certain types of applications
- Commonly used for streaming media (real time), online games, etc.

Open Systems Interconnection Reference Model (*OSI Model*) is a layered, abstract description for communications and computer network protocol design

1
2
3
4
5
6
7



Data Transfer

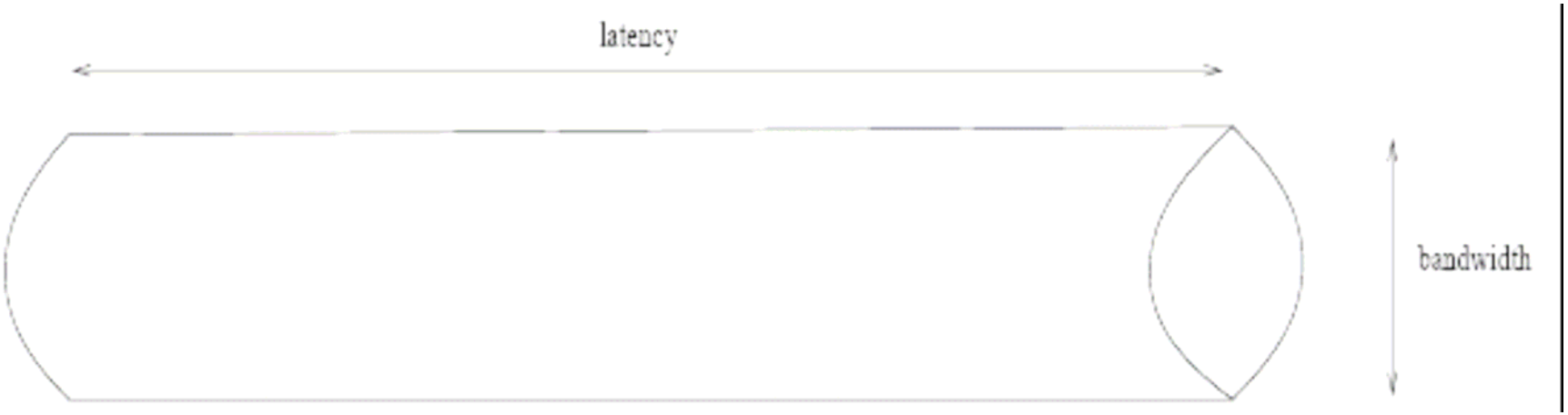
- For a transfer from host *x* to host *y*:
  - The size of the transfer is the total number of bits *b* transferred
  - The total time of the transfer is the total amount of time it took for the transfer

Network Performance

- The *latency* is the amount of time it takes a single bit of information to get from x to y.
- The *bandwidth* (*bps*) is the amount of information that can be sent per second
- The *optimal bandwidth* (b_{opt}) is the maximum bandwidth a link could ever achieve.
  - Videotron's high-speed optimal download bandwidth is 7 Mbps
  - Videotron's extreme plus high-speed optimal download bandwidth is 20 Mbps (as of 25/09/06)
- The *network efficiency* is the fraction b/b_{opt}

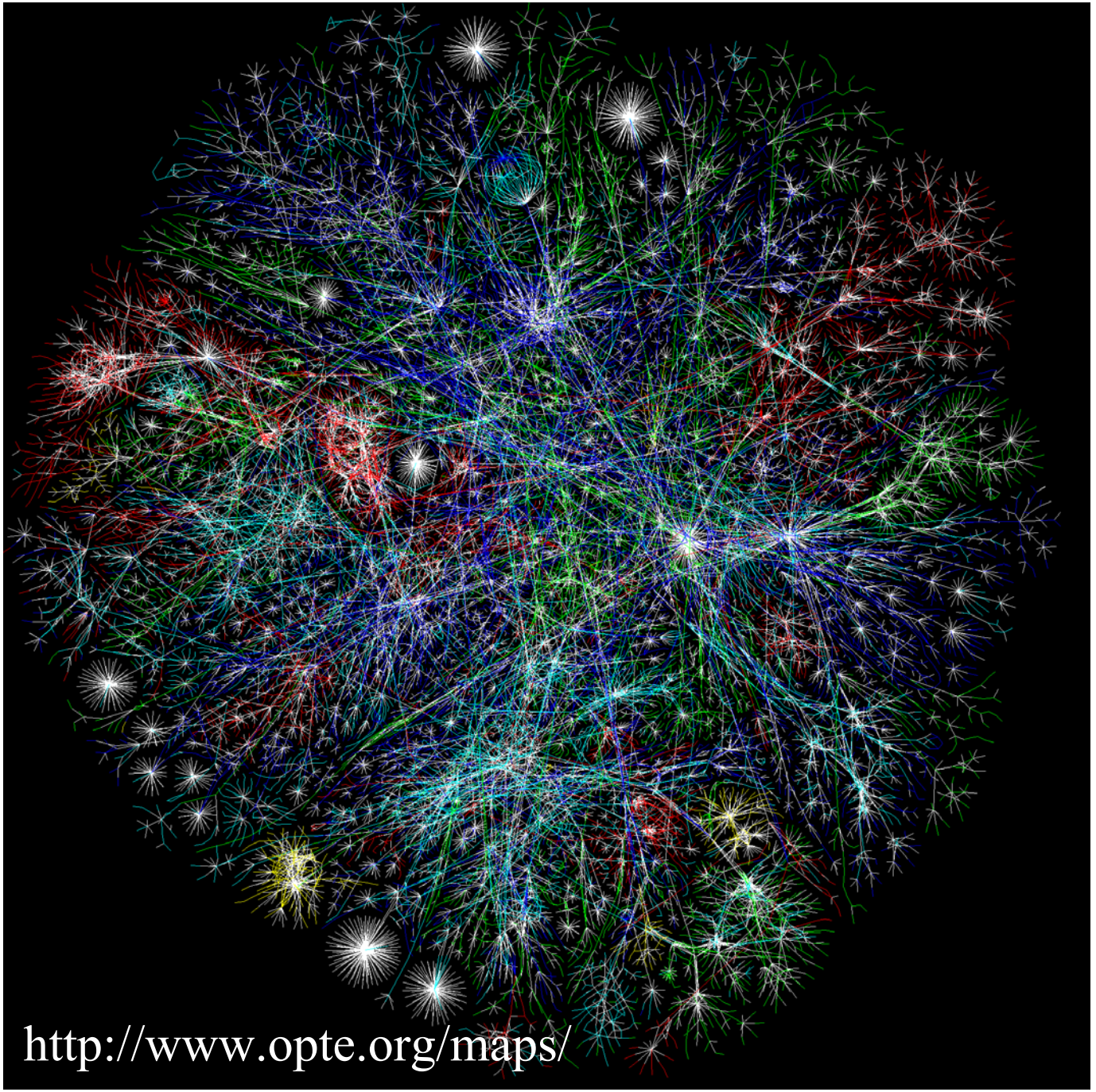
Data Transfer

- The latency is usually seen as the length of a pipe, while the bandwidth is seen as the width of the pipe.



Kinds of Networks:Geographically

- PAN (Personal Area Network)
- LAN (Local Area Network)
- MAN (Metropolitan Area Network)
- WAN (Wide Area Network)


http://www.opte.org/maps/