Terminology

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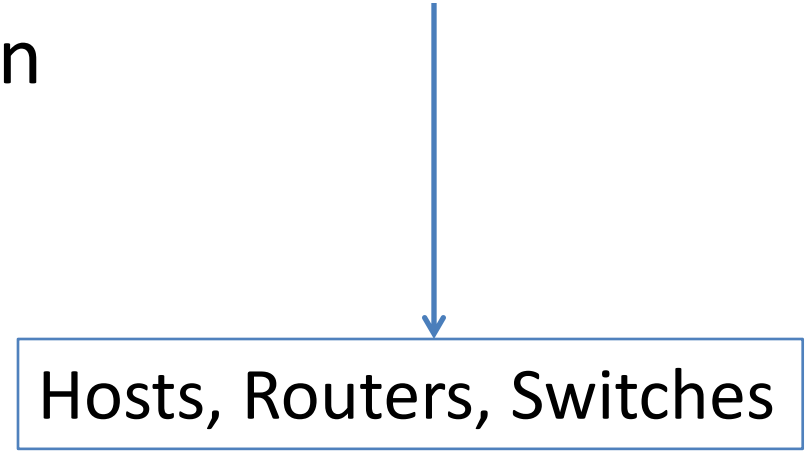
Computer Network

- Infrastructure that permits computing devices to exchange information



Hosts/ End Systems

- Servers, Desktops, Laptops, Smart-phones etc
- Typically owned by users (of computer network)

Server Rack

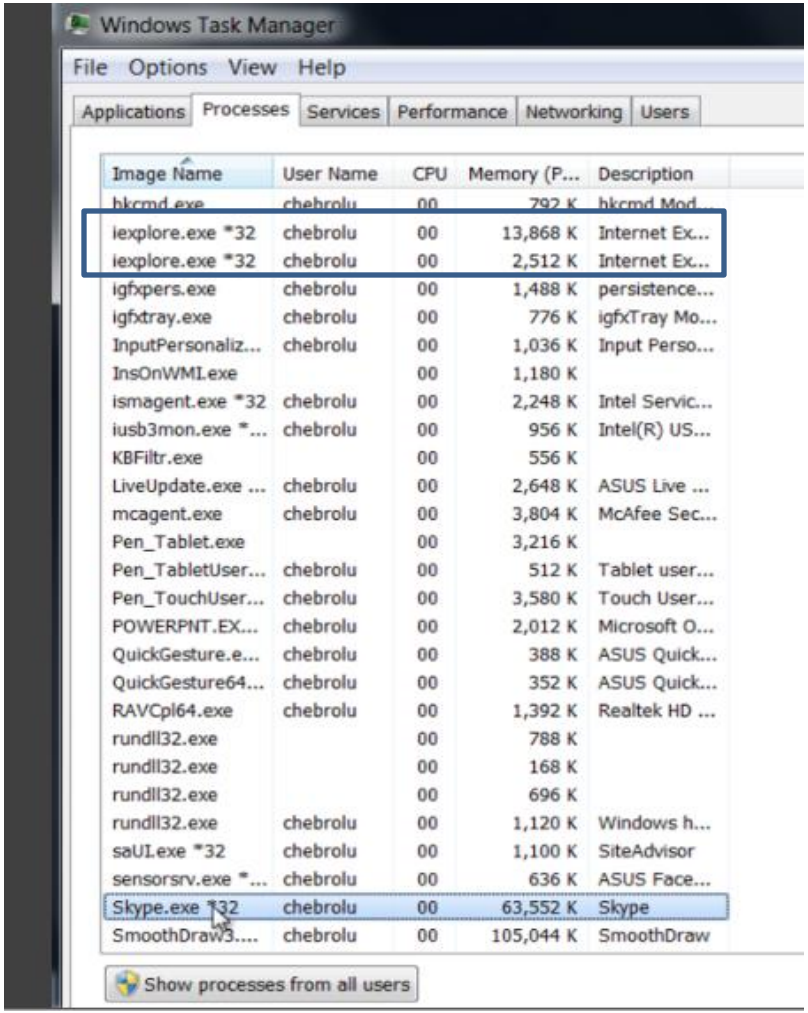
Desktop

Laptop

Smartphone

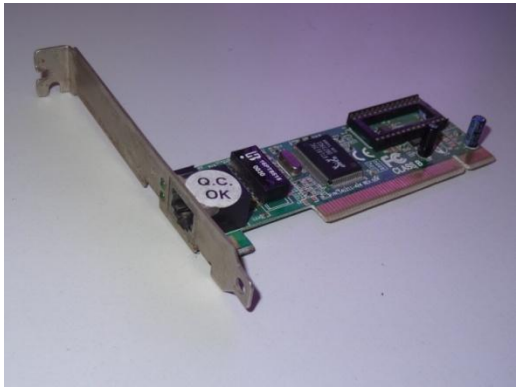
Process

- A “running” program in a host
  - E.g. Chrome, Internet Explorer, Skype etc
  - Generate/Receive/Process “messages/data” for communication

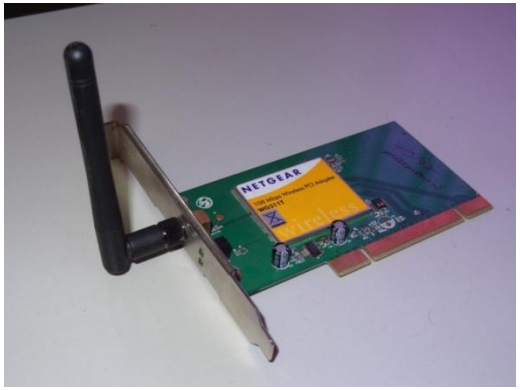


Network Adaptor

- Other names
  - Network Interface card
  - Network Interface controller
- Hardware that connect a device to a network



Ethernet Adaptor



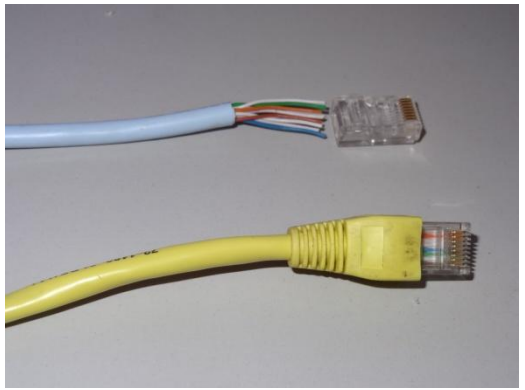
802.11 Wireless Adaptor

Communication Links

- Physical media that interconnects computing devices
  - Co-axial cable, fiber-optics, Twister-pair, Air (Wireless)

Co-axial (Cable TV/Antenna)

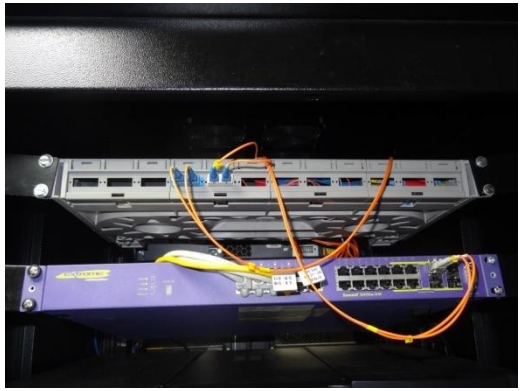
Fiber



Twisted-Pair (Ethernet)

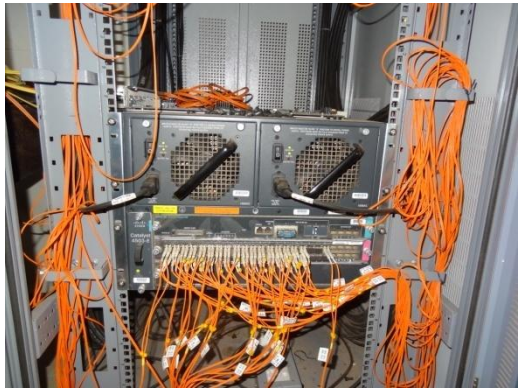
Switches / Gateways / Routers

- Interconnect Networks (which are made up of hosts and links)
- Forward Data/Messages



Switch

Switch



Router

Node

- Any computing device attached to a network
  - End Systems/Hosts, Routers, Switches etc

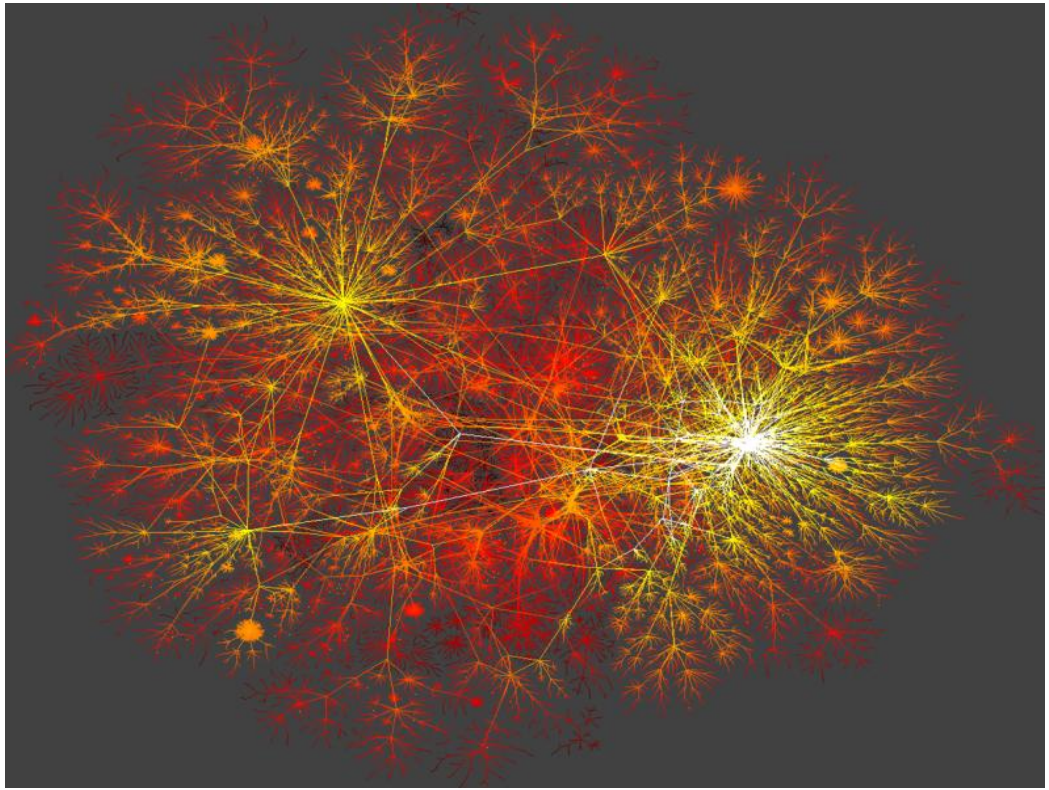
Internet

- A network of networks, a worldwide computer network

A snapshot of
Internet connectivity

Selected backbone
ISPs are color coded

Reference:
K.C. Claffy
(www.caida.org)



Internet Service Provider (ISP)

- Organization that provides access to Internet
- National: Reliance, Tata
- International: AT&T, Sprint

Types of Network

Distance	Type of Network	Example	Technology
1-10m	Personal Area Network (PAN)	Wireless Network between Computer, mouse, keyboard	Bluetooth, 802.15.4
10m-1km	Local Area Network (LAN)	Room/Building/ Campus	Ethernet, 802.11
1-10km	Metropolitan Area Network (MAN)	City wide	Cable TV, 802.16
100-1000km	Wide Area Network (WAN)	Country/ Continent	All types
1000km-10000km	Internet	World-wide	All types
>50000km	Inter-planetary Internet	Across Planets	?

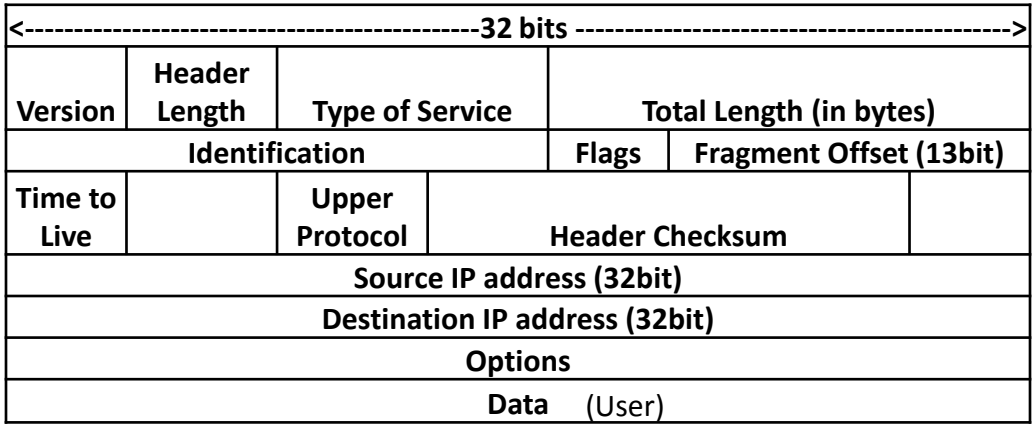
Protocol

- Defines format and rules for exchange of messages
  - What to send: Format
  - When to send & How to act : Rules
- E.g. TCP, IP, CSMA/CD (Ethernet)

Packet

- Block of data exchanged between nodes/processes
  - Expressed in bits (b) or bytes (B)
  - Eg: 1000B = 8000b = 1KB
- Two parts
  - User data (also called payload, generated by user)
    - Eg. Portion of email, Web page etc
  - Control data (added by protocol)
    - E.g. Sequence number, Address etc

IP Packet


<----------32 bits ---------->
Version
Header Length
Type of Service
Total Length (in bytes)
Identification
Flags
Fragment Offset (13bit)
Time to Live
Upper Protocol
Header Checksum
Source IP address (32bit)
Destination IP address (32bit)
Options
Data (User)

Address

- Byte string that identifies a node
  - Eg. 125.12.11.100 (IP address)
  - Eg. 00:06:5B:BD:9A:C2 (MAC address)

Performance Metrics

- Measure performance of a protocol, technology
- Defined based on requirement, application scenario etc

Throughput

- Also called Bandwidth or Data-Rate
  - Bandwidth may also mean spectrum, expressed in Hertz (need to interpret it based on context)
- Rate of data transfer
  - Measured in Mbps, Kbps (less often in MBps, KBps)

Latency/Delay

- Delay experienced by a packet/message from source to destination (one way delay)
- Round trip time: source-destination-source
- Measured in us (micro-second), ms, s
- Made up of
  - Processing, Transmission, Propagation and Queuing

Transmission: How long it takes to push all the bits of a packet into the medium (wire, fiber, air).

Propagation: How long it takes for a single bit to travel from sender to receiver through the medium.

Latency/Delay

- Processing: Time to inspect the packet
  - Examine headers, check for errors
- Queuing: waiting time in a queue (E.g. at routers)
- Transmission: Time to transmit the packet
  - size (of packet or message in bits)/Data-Rate
- Propagation: distance/speed of light
  - Speed of light: $2.3 * 10^8$ ms/s in cable; $2 * 10^8$ m/s in fiber; $3 * 10^8$ m/s in vacuum
- Total Latency = processing + queuing + transmission +propagation

Error/Loss

- Causes:
  - Limited storage space (memory) at switches
  - Noise in the physical media
- Often measured as a probability
  - Eg. 0.1 or 10% loss (on average one out of every 10 packets are lost)