Introduction

What is a computer network?

Components of a computer network:

- hosts (PCs, laptops, handhelds)
- routers & switches (IP router, Ethernet switch)
- links (wired, wireless)
- protocols (IP, TCP, CSMA/CD, CSMA/CA)
- applications (network services)
- humans and service agents

Hosts, routers & links form the *hardware* side.

Protocols & applications form the *software* side.

Protocols can be viewed as the "glue" that binds everything else together.

Protocol example: low to high layer

- NIC (network interface card): hardware

  → e.g., Ethernet card, WLAN card

  → what about USB and FireWire?

- device driver: part of OS
- ARP, RARP: OS

  → NICs have two names (48 vs. 32 bits): translation

- IP: OS

  → even your cell phone speaks IP

  → ubiquitous, integrated

- TCP, UDP: OS
- OSPF, BGP, HTTP: application layer
- ssh, web browser, P2P (BitTorrent), other (YouTube): application layer

  ⟶ protocol: multi-layered glue

What layers are important?

- 1970s: lower layers and hardware
- 1980s: lower and higher layers
- 1990s: higher layers
- today: lower and higher layers, and hardware

  → especially lower layers

Where it's at:

- handheld, mobile devices
- merging of data, telephone, entertainment, etc.

  → GPS, RFID, music, TV, . . .
- wireless

  → e.g., focus of Silicon Valley

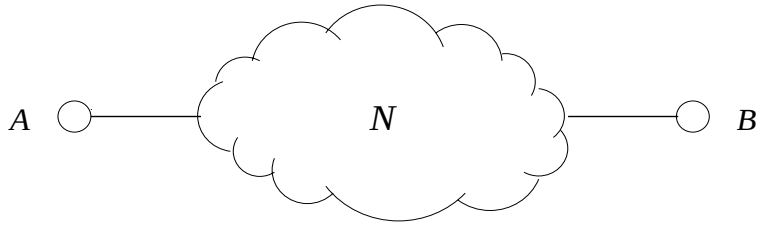
  ⟶ sound technical grounding: ever more important

  ⟶ where do YouTube, KaZaA, Skype fit in?

Computer networks: enable communication

Simplest instance of communication/networking problem:

> Given two devices (hosts) A, B interconnected by some network N, facilitate communication of information between A & B.



Information abstraction

- representation as objects (e.g., files, real-time video)
- bytes & bits

  $\rightarrow$ digital form
- signals over physical media (e.g., electromagnetic waves)

  $\rightarrow$ analog form

Minimal functionality required of A, B

- encoding of information
- decoding of information

$\longrightarrow$ data representation & translation

Additional functionalities may be required depending on properties of network N

- information corruption: bits flip

  $\rightarrow$ called bit error rate (BER)

  $\rightarrow 10^{-9}$ for fiber optic cable

  $\rightarrow 10^{-3}$ or higher for wireless

- information loss: packet drop at routers and hosts
- information delay: like toll booth, airport
- information security

Network N connecting two or more nodes can be of three types:

- point-to-point links
- multi-access links
- internetworks

Network medium may be

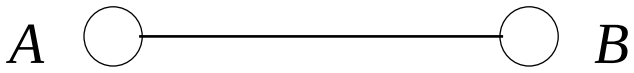
- wired
- wireless

Node (e.g., hosts, routers) may be

- stationary
- mobile

  $\rightarrow$ cell phones/PDAs, laptops, routers(?)

Point-to-point links



- various "cables"

  → copper, fiber, wireless

- line of sight wireless communication

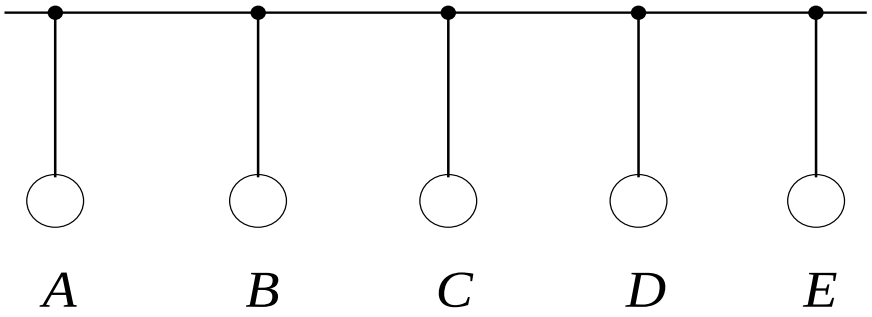
  → directional antennas

  → wireless LAN?

- no addressing (i.e., names) necessary

  → special case

Multi-access links



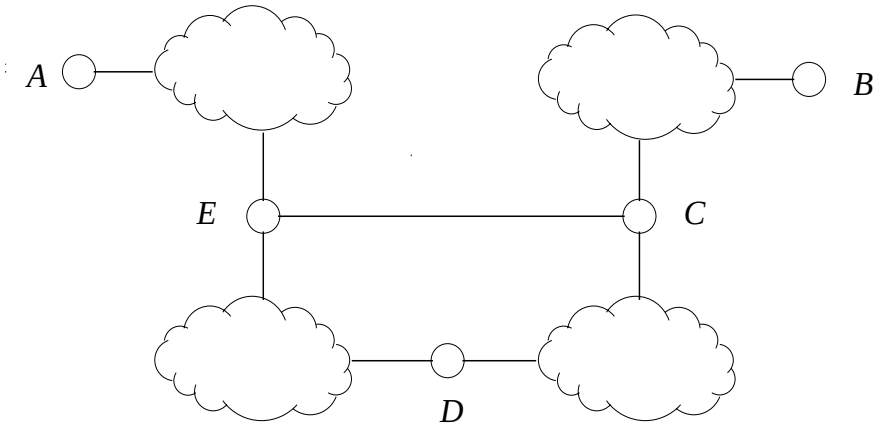
- bus (e.g., old Ethernet)
- wireless media

  → omni-directional antennas (wireless Ethernet)
- broadcast (everyone can hear everything)

  → for application to hear everything: set NIC to *promiscuous* mode
- access control: i.e., bus arbitration

  → resolve contention and recover from interference
- addressing (i.e., naming) necessary

Internetwork



- recursive definition

  → point-to-point and multi-access: internetwork

  → composition of one or more internetworks

- addressing necessary
- path selection between sender/receiver: routing
- how much to send: congestion control
- protocol translation: internetworking
- location management: e.g., Mobile IP

LAN (local area network) vs. WAN (wide area network) distinction:

- LAN: point-to-point, multi-access
- WAN: internetwork

  $\longrightarrow$ geographical distinction is secondary

  $\longrightarrow$ often go hand-in-hand

  $\longrightarrow$ counter example?

Myriad of different LAN technologies co-existing in a WAN. For example:

- Fast Ethernet (100 Mbps)
- Gigabit Ethernet (1000 Mbps); 10 GigE

  → Purdue CS backbone: 10 Gbps

  → AT&T (tier-1 provider)?
- WLAN (54 or 11 Mbps)
- FDDI (Fiber Distributed Data Interface), 100 Mbps
- SONET
- modem/DSL (cable and dial-up)
- ATM

Keep in mind:

⟶ WAN is a collection of LANs

⟶ ultimately: everything happens at LANs

Each LAN, in general, speaks a different language.

⟶ message format

⟶ behavioral: protocol

Internetworking solves this problem by translating everything to IP . . .

⟶ technical definition of **I**nternet

. . . and from IP back to LAN languages

But:

⟶ IP is not necessary

⟶ e.g., large systems of layer 2 (LAN) switches

⟶ trend: L2 (70s & 80s) → IP (90s) → L2 (today)

⟶ IP remains global software glue

Remark on addresses:

Communicating entities are *processes* residing on nodes A and B running some operating system (e.g., Linux, Windows, MacOS).

Thus an *address* must also identify which process a message is destined for on a host.

$\longrightarrow$ e.g., port number abstraction

$\longrightarrow$ at least a tuple (host address, port number)

Can your PC or laptop have more than one host address?