

## INTRODUCTION

### What is a computer network?

Components of a computer network:

- host devices (PCs, servers, laptops, handhelds)
- routers & switches (IP router, Ethernet switch)
- links (wired, wireless)
- protocols (IP, TCP, CSMA/CD, CSMA/CA, RIP, BGP)
- applications (network services)
- humans and bots

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, CDMA or TDMA air interface
  - what about USB and FireWire?
- NIC firmware: software side of NIC
- device driver: part of OS
  - fast and slow interrupt handlers
- ARP, RARP: OS
  - NICs have two names (48 vs. 32 bits): translation
- IP: OS
  - hosts, routers, cell phones
  - global networking glue

- OSPF, RIP, BGP: IP protocols running at routers
  - OSPF, RIP: within organizations (intra-domain)
  - BGP: global Internet (inter-domain)
- TCP, UDP: OS
  - transport protocols: host OS
- DNS, HTTP, SMTP, SNMP: application layer
- ssh, web browser, P2P (BitTorrent), YouTube, Facebook: application layer
- humans, bots (web crawlers, network monitors, DDoS)
  - protocols: span many layers—low to high

What layers are important?

- 1970s: lower layers and hardware
- 1980s: lower and higher layers
- 1990s: higher layers
- 21st century: lower and higher layers, and hardware
  - driving force: wireless networks
  - forces us to understand lower layers

Where it's at today:

- handheld, mobile devices
- merging of data, telephone, entertainment, etc.
  - Voice, data, video, GPS, RFID, TV, music, . . .
  - old traditional boundaries fading

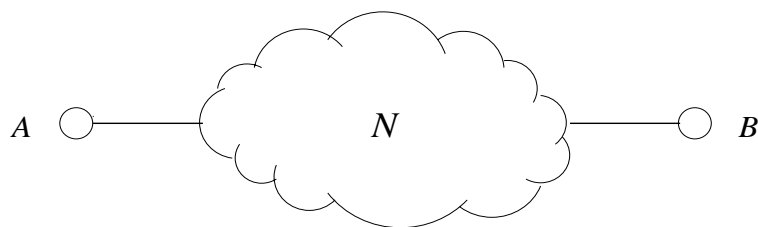
- freed-up wireless spectra
  - digital TV and radio (analog gone)
  - UHF frequencies available for networking
  - e.g., super WiFi

Sound technical grounding: ever more important

Computer networks: enable communication

Simplest instance of communication problem:

given two hosts  $A$ ,  $B$  connected by some network  $N$ , facilitate transmission of information between  $A$  &  $B$ .



Network  $N$  can take many forms.

What are the necessary capabilities of  $A$ ,  $B$ , and  $N$ ?

→ functional requirements

## Information abstraction

- representation as objects (e.g., files, real-time video)
  - high-level representation
- bytes & bits
  - digital form
  - low-level representation
- signals over physical media (e.g., electromagnetic waves)
  - analog or digital form
  - dominant today: analog transmission
  - 1980s: square waves were in vogue

Minimal functionality required of  $A$ ,  $B$

- encoding of information
- decoding of information
  - data representation & translation
  - convention  $A$  and  $B$  agree upon
  - preparation step before physical (wired or wireless) transmission

Example:

- little endian vs. big endian
  - mundane but necessary
- length of message (if variable-length allowed)
  - fixed-length is less common
  - maximum length cap imposed
  - not necessarily enforced
- payload type: needed for demultiplexing



Additional functionalities may be required depending on properties of network  $N$

- information corruption: bits flip
  - called bit error rate (BER)
  - $10^{-9}$  for fiber optic cable
  - $10^{-6}$  or higher for wireless
- information loss: packet drop at routers and hosts
  - if buffer full
- information delay: like toll booth, airport
  - bad for voice, real-time video, games
- information security
  - protect against eavesdropping: confidentiality
  - protect against ID theft: authentication
  - protect against tampering: integrity
- etc.

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

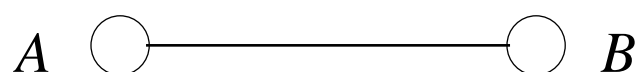
- point-to-point link
- multi-access link
- internetwork

Network medium may be

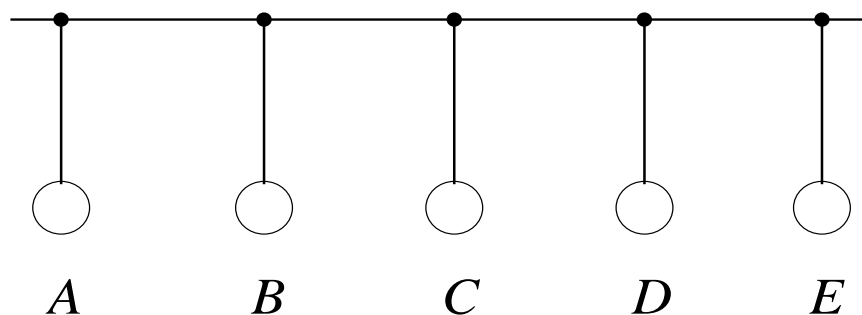
- wired
- wireless

Host (e.g., node, station, router) may be

- stationary
- mobile

*Point-to-point link*

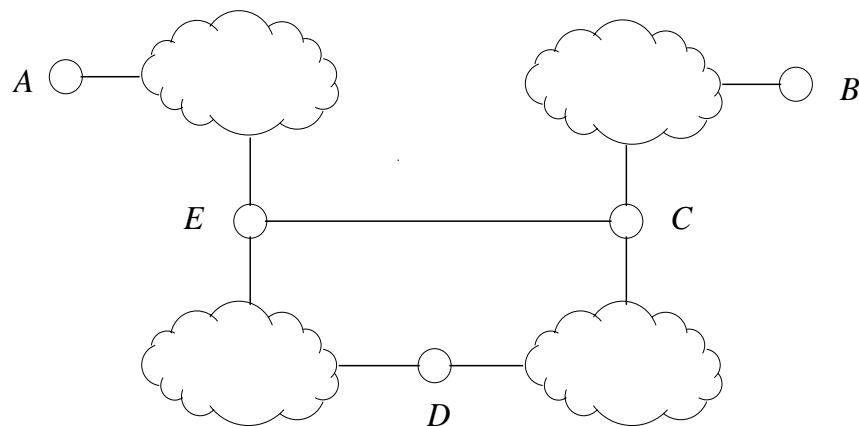
- various wired cables
  - copper and fiber of different quality or grade
- wireless medium
  - line of sight
  - directional antennas
  - e.g., building-to-building, infrared TV remote
- no addressing (i.e., names) necessary
  - special case

*Multi-access link*

- bus (e.g., old Ethernet)
- wireless media
  - omni-directional antennas
  - wireless LANs
- broadcast: everyone can hear everything
  - for application to hear everything: NIC is set to *promiscuous* mode
- addressing (i.e., naming) necessary
  - “From” and “To”

- multi-user access control: who gets to use when
  - multi-access link: shared resource
  - myriad of LAN technologies and protocols
  - computer motherboard: bus arbitration
  - Ethernet CSMA/CD, WLAN CSMA/CA
  - cellular TDMA, FDMA, CDMA
  - WLAN/WiMax/cellular SDMA/MIMO

## 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 fast 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
  - geographical distinction is secondary
  - often go hand-in-hand
  - counter example?