Fundamentals of Networks

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- What is a Network?

  - A collection of devices (aka nodes) interconnected by different types of links, which allow devices to communicate at a distance in order to support diverse applications
  - Devices:

    * End systems or terminal nodes: computer (desktop, laptop), cell-phone, tablet, car, sensor, and virtually almost anything
    * Intermediate nodes: modem, repeater, hub, switch, router, base station, etc.
  - Links:

    * Wired links: fiber, copper, etc.
    * Wireless links: electromagnetic waves (radio, microwave, terahertz band, infra-red, etc.), acoustic waves (ultra-sounds), etc.
  - Applications:

    * E-mail, instant messaging, web browsing, multimedia streaming, etc.

- A wireless sensor network

  - Many applications:

    * Military applications: battlefield surveillance, nuclear, biological, and chemical attack prevention, etc.
    * Environmental applications: tracking birds, smart irrigation, earth monitoring, etc.
    * Health applications: health telemonitoring, drug administration tracking, etc.

- Network Types (classified by size):

  - PAN (Personal Area Networks) — Bluetooth, USB, etc.

* Range of a person
- LAN (Local Area Networks) — WiFi, Ethernet, etc.
    * Range of a single building: a home, office, or factory
- MAN (Metropolitan Area Networks) — WiMax, cable, etc.
    * Range of a city
- WAN (Wide Area Networks) — Cellular, landline telephone, etc.
    * Range of an entire country or continent
- Satellite

- Thus, the internet is a "network of networks"

  - Billions of connected computing devices:
    * Hosts = end systems
    * Running network applications at Internet's "edge"
  - Packet switches: forward packets (chunks of data)
    * Routers, switches, etc.
  - Communication links
    * Fiber, copper, radio, satellite
    * Transmission rate: link capacity (bps)
  - Networks
    * Managed by organization
  - Interconnected ISPs (Internet Service Providers)

- Protocols are everywhere

  - Control sending, receiving of messages
  - Examples: HTTP (Web), streaming video, Skype, TCP, IP, WiFi, 4G, 5G, Ethernet

- Internet Standardization

  - IETF: Internet Engineering Task Force
    * RFC: Request for Comments
  - IEEE: Institute of Electrical and Electronics Engineers
    * IEEE 802.3, IEEE 802.11

- Infrastructure that provides services to applications:

- Web, streaming video, multimedia teleconferencing, e-mail, games, e-commerce, social media, interconnected appliances

- Provides programming interface to distributed applications:

  - "Hooks" allowing sending/receiving applications "connect" to, use Internet transport service
  - Provides service options, analogous to postal service

- Protocols

  - For humans, an example is language (we have phonetics, grammar, etc.)
  - All communication activity in Internet governed by protocols
  - Sample definition: Protocols define the format, order of messages sent and received among network entities, and actions taken on message transmission and receipt.

- A closer look at internet structure:

  - Edge of the network:
    * Hosts: clients and servers
    * Servers often in data centers
  - Access networks:
    * Wired, wireless communication links
  - Network core:
    * Interconnected routers
    * Network of networks

- Physical Media

  - Bit: unit of information that is carried by the signal that propagates between transmitter and receiver
  - Physical link: what lies between transmitter and receiver
  - Types of media:
    * Guided media: signals propagate solid media (e.g. copper, fiber, coaxial)
      · Twisted pair (TP) — Two insulated copper wires twisted together in a helical form (The signals are usually carried as the difference in voltage between the two wires in the pair to increase robustness against noise).
      · Coaxial cable — Two concentric cooper conductors, with bidirectional capabilities. Longer distances at higher data transmission rates than twisted pairs. A broadband system; that is, multiple frequency channels on cable.

· Fiber optic cable — Glass fiber carrying light pulses, each pulse a bit. High-speed operation, with point-to-point transmissions ranging from 10's-100's Gbps. Very low error rate because it is immune to electromagnetic noise, with repeaters spaced far apart. Downside: expensive and fragile

∗ Unguided media: signals propagate freely (no physical wire, like a radio)

· Signal can be carried in different ways — electromagnetic waves (most commonly used), acoustic waves (typically underwater), magnetic-induction (e.g. Near Field Communications)

· Propagation environment effects — reflection, obstruction by objects, interference