Chapter I: Introduction

UG3 Computer Communications & Networks (COMN)

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What’s the Internet: “nuts and bolts” view

- millions of connected computing devices:
  - *hosts = end systems*
  - running *network apps*

- *communication links*
  - fiber, copper, radio, satellite
  - transmission rate: *bandwidth*

- *Packet switches*: forward packets (chunks of data)
  - *routers* and *switches*
What’s the Internet: “nuts and bolts” view

- **Internet: “network of networks”**
  - Interconnected ISPs

- **Protocols** control sending, receiving of msgs
  - e.g., TCP, IP, HTTP, Skype, 802.11

- **Internet standards**
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force
What’s the Internet: a service view

• **Infrastructure that provides services to applications:**
  – Web, VoIP, email, games, e-commerce, social nets, …

• **provides programming interface to apps**
  – hooks that allow sending and receiving app programs to “connect” to Internet
  – provides service options, analogous to postal service
What’s a protocol?

**human protocols:**
- “what’s the time?”
- “I have a question”
- introductions

... specific msgs sent
... specific actions taken when msgs received, or other events

**network protocols:**
- machines rather than humans
- all communication activity in Internet governed by protocols

*protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt*
What’s a protocol?

A human protocol and a computer network protocol:

Human:
- Hi
- Hi
- Got the time?
- 2:00

Computer:
- TCP connection request
- TCP connection response
- <file>
A closer look at network structure:

- **network edge:**
  - hosts: clients and servers
  - servers often in data centers

- **access networks, physical media:** wired, wireless communication links

- **network core:**
  - interconnected routers
  - network of networks
Q: How to connect end systems to edge router?

- residential access nets
- institutional access networks (school, company)
- mobile access networks

keep in mind:

- bandwidth (bits per second) of access network?
- shared or dedicated?
Access net: digital subscriber line (DSL)

- **use** *existing* telephone line to central office DSLAM
  - data over DSL phone line goes to Internet
  - voice over DSL phone line goes to telephone net
- < 2.5 Mbps upstream transmission rate (typically < 1 Mbps)
- < 24 Mbps downstream transmission rate (typically < 10 Mbps)
Access net: cable network

frequency division multiplexing: different channels transmitted in different frequency bands
Access net: cable network

- **HFC: hybrid fiber coax**
  - asymmetric: up to 30Mbps downstream transmission rate, 2 Mbps upstream transmission rate

- **network** of cable, fiber attaches homes to ISP router
  - homes *share access network* to cable headend
  - unlike DSL, which has dedicated access to central office
Access net: home network

- **to/from headend or central office**
- **cable or DSL modem**
- **router, firewall, NAT**
- **wired Ethernet (100 Mbps)**
- **wireless access point (54 Mbps)**
- **wireless devices**

*often combined in single box*
Enterprise access networks (Ethernet)

- typically used in companies, universities, etc
  - 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates
  - today, end systems typically connect into Ethernet switch

institutional link to ISP (Internet)
institutional router
institutional mail, web servers
Wireless access networks

- shared wireless access network connects end system to router
  - via base station aka “access point”

**wireless LANs:**
- within building (100 ft)
- 802.11b/g (WiFi): 11, 54 Mbps transmission rate

**wide-area wireless access**
- provided by telco (cellular) operator, 10’ s km
- between 1 and 10 Mbps
- 3G, 4G: LTE
Host: sends packets of data

host sending function:
- takes application message
- breaks into smaller chunks, known as packets, of length $L$ bits
- transmits packet into access network at transmission rate $R$
  - link transmission rate, aka link capacity, aka link bandwidth

\[
\text{packet transmission delay} = \frac{L \text{ (bits)}}{R \text{ (bits/sec)}}
\]
Physical media

- **bit**: propagates between transmitter/receiver pairs
- **physical link**: what lies between transmitter & receiver
- **guided media**:  
  - signals propagate in solid media: copper, fiber, coax
- **unguided media**:  
  - signals propagate freely, e.g., radio

**twisted pair (TP)**

- two insulated copper wires
  - Category 5: 100 Mbps, 1 Gbps Ethernet
  - Category 6: 10Gbps
Physical media: coax, fiber

**coaxial cable:**
- two concentric copper conductors
- bidirectional
- broadband:
  - multiple channels on cable
  - HFC

**fiber optic cable:**
- glass fiber carrying light pulses, each pulse a bit
- high-speed operation:
  - high-speed point-to-point transmission (e.g., 10’ s-100’ s Gbps transmission rate)
- low error rate:
  - repeaters spaced far apart
  - immune to electromagnetic noise
Physical media: radio

radio link types:

- terrestrial microwave
  - e.g. up to 45 Mbps channels
- LAN (e.g., WiFi)
  - 11 Mbps, 54 Mbps
- wide-area (e.g., cellular)
  - 3G cellular: ~ few Mbps
- satellite
  - Kbps to 45 Mbps channel (or multiple smaller channels)
  - 270 msec end-end delay
  - geosynchronous versus low altitude

- signal carried in electromagnetic spectrum
- no physical “wire”
- Bidirectional
- propagation environment effects:
  - Reflection
  - obstruction by objects
  - interference