Objectives: Networks: Data Transfer and Challenges

refs: [O’H&Bryant, sect 12.1–12.3], [Tanenbaum, sect 8.4.1]

- to understand how packets get routed along a network
- to understand the details of IPv4 addressing and its consequences
- to know the steps of data transfer over the internet (from host to host)
- to appreciate current and future issues and challenges of the internet
Network Routing

- how does a packet of information get from the PC on my desk to a computer across the campus or across the world?
  - direct connections between the billions of computers is impractical! (as well as inefficient use of resources)
- a local area network (LAN) connects computers within an organization (within a building)
- the computer passing the packets back and forth between the LAN is called:
  - a gateway (from the perspective of other computers in the network), or
  - a router (from the perspective of the network engineer)
  - can be anything from an old i386-based Linux box to a $10K+ CISCO box
  - as well as forward packets, may filter (security) and log (pay-per-MB) them, and
    monitor the network
- thus the routing problem can be broken into two parts:
  - communication within the the local area (LAN)
  - communication between LANs (inter-network communication)
Address Structure and Routing Decisions

- (in IPv4) computers are addressed with a unique 32-bit number
- split into four 8-bit numbers (dotted-decimal notation), e.g.
  - cs.anu.edu.au: 150.203.164.35
  - www.anu.edu.au: 150.203.99.8
  - www.abc.net.au: 144.135.8.151
- the upper numbers addresses the network(s), the lower numbers (normally last) specifies the computer within the LAN
- how does a router know what to do with a packet?
- it makes a decision based upon the destination address of the packet and its given routing rules (tables)

example: packets for:
- 150.203.113.xx go out on link A
- 150.203.236.xx go out on link B
- 150.203.237.xx go out on link C
- other (sub)nets go out on link C
Data Transfer over the Internet

Host A

1. Data

2. Data PH FH1

3. Data PH FH1

4. Data PH FH1

LAN1 adapter

Protocol Software

Client

LAN1

Host B

5. Data PH FH2

6. Data PH FH2

7. Data PH FH2

8. Data

LAN2 adapter

Protocol Software

Server

LAN2

Router

LAN1 adapter

LAN1 adapter

Protocol software
Data Transfer over the Internet: Steps

1. client on host A invokes a (socket `send()`) system call

2. host A creates a LAN1 frame (extended packet) by appending IP header and LAN1 frame header to data

3. LAN1 adapter sends frame to network

4. router reads frame from its LAN1 adapter and passes it to protocol software

5. router determines how to route frame and appends new LAN2 frame header as required

6. router passes frame through its LAN2 adapter

7. host B’s LAN2 adapter reads frame and passes it to protocol software

8. protocol software on B strips off packet header and frame header and places data into server’s virtual address space

9. the data is collected upon a socket `recv()` system call
Hardware/Software Organisation of Internet Application

Internet client host

Client

TCP/IP

Network Adapter

System Interface (socket call)

Hardware Interface (interrupts)

User Code

Kernel Code

Hardware

Internet server host

Server

TCP/IP

Network Adapter

Global IP Internet
The Internet and WWW: Major Challenges

  - solutions: CIDR Hierarchical Addressing and Variable Length Subnet Masking and NAT
  - now having to adopt IPv6 (128-bit addresses) - especially for mobile devices

- internet routing remains an issue (e.g. distribution of info. on congestion / outage)

- security an increasing concern: denial-of-service and other forms of attacks

- how can a single web site deal with an intense period of (world-wide) demand?
  - e.g. 2014 World Cup Soccer site

- how can the (exponentially increasing) WWW be so efficiently searched? (Google)

- approaches are similar to that used in other computer systems
  - content delivery networks: virtualization (of URLs) and caching (e.g. AKAMAI)
  - precomputation (indexing) and parallelism (over and within queries)

- virtualization (of networks) also in the form of virtual private networks (VPNs)

- related topics: fairer & faster internet, Two Steps Toward a Terabit Internet

- the (near) future: semantic-based World Wide Web, Internet of Things