The Internet

Lecture 24

Based in part on material from "Computer Networks: A Systems Approach" by Larry Peterson & Bruce Davie

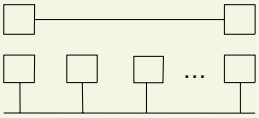
CS 638 Web Programming

Overview

- Basic concepts
- Organization
- TCP/IP
- DNS

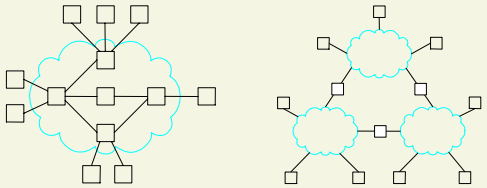
Network building blocks

- Nodes: PC, special-purpose hardware…
  - hosts (PCs, cell phones, toasters, etc.)
  - routers (and switches, bridges, hubs, etc.)
- Links: coax cable, optical fiber, wireless …
  - point-to-point
  - multiple access



Nodes + links = networks

- A network can be defined recursively as...
  - two or more nodes connected by a link, or
  - two or more networks connected by nodes

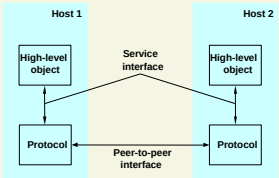


Packets (a.k.a. messages, datagrams, frames)

- A bundle of data consisting of a header and a body
  - Header: data used by network (e.g. destination address)
  - Body or payload: user data (e.g. an image)
- Similar to a letter or package traveling through the postal network
  - The header is the envelope, the body is the content
- How packets are used
  - Sent from one network node to a neighboring node
  - At intermediate nodes stored, processed and re-sent
  - Move from source to destination using intermediate nodes

Protocols

- A protocol is a module that performs a given function by processing traffic at multiple network nodes
  - Protocols are the building blocks of a network architecture
- Each protocol object has two different interfaces
  - *service interface*: operations on this protocol
  - *peer-to-peer interface*: messages exchanged with peer (format of messages and behavior)



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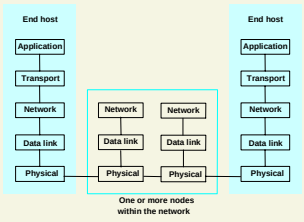
Layering

- Modularization makes it possible to build and maintain large and complex systems
  - Relies on use of abstractions to hide complexity
- Layering – form of modularization used by computer networks
  - Each layer uses the services of the layer below it
- Different abstractions at each layer
  - Simpler abstractions at lower layers
  - Complex powerful abstractions at higher layers

Internet Architecture

- Higher layer protocols typically defined by IETF (Internet Engineering Task force)
- Lower layer protocols often defined by IEEE (Institute of Electrical and Electronics Engineers)

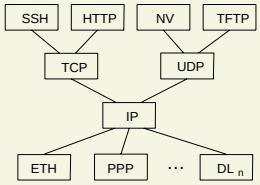


Layers of Internet architecture

1. Physical layer specifies how electromagnetic signals are interpreted as bits, standardizes wires
   - Examples: coaxial cable, twisted pair cable, connectors
2. Data link layer enables neighboring nodes to exchange messages (delimiting frames, error detection, deciding who sends next, etc.)
   - Examples: Ehternet, 802.11 (wireless)
3. Network layer enables the sending of messages between any pair of nodes connected to the Internet (addressing, fragmentation, etc.)
   - Only example: IP (Internet Protocol)
4. Transport layer provides abstractions such as a byte stream (reliable, in-order delivery of data)
   - Examples: TCP, UDP
5. Application layer interacts with user to initiate data transfers
   - Example applications: browser, media player, email client
   - Examples of application layer protocols: HTTP, SMTP

Hourglass Design

- Single protocol at network level ensures packets will get from source to destination while allowing for flexibility



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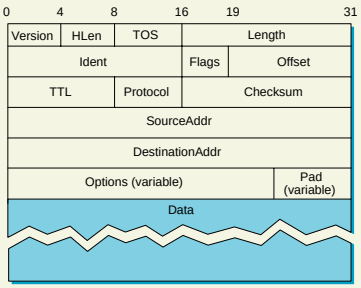
The Internet Protocol

- IP implements best effort end to end datagram delivery service
  - Packets may be lost or re-ordered
- All computers in the Internet use IP (version 4)
- Store and forward handling of packets
- Forwarding: routers decide which way to send a packet based on its destination IP address
  - Uses local database of networks called forwarding table
  - Forwarding tables configured statically or built dynamically by routing protocols

IP Packet format



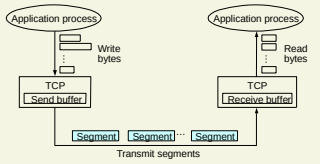
Addressing

- IP Address: 4byte-string that identifies a node
  - usually unique (some exceptions)
  - dotted decimal notation: 128.92.54.32
- Each endhost in the Internet has its own IP address
  - NAT (network address translation) breaks this rule
  - Address can be assigned statically (usually for servers) or dynamically (usually for clients)
  - Dynamically assigned IP address is temporary and may be re-used by another computer
  - Special “localhost” address 127.0.0.1 used by each computer to reach itself (e.g. debug web apps in VS2005)

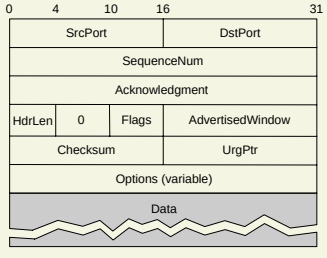
TCP (Transmission Control Protocol)

- TCP is most widely used transport protocol
  - Web, Peer-to-peer, email, ssh, etc.
- A two way, reliable, byte stream protocol
  - Achieves reliability by re-sending lost packets
  - Keeps buffer for re-ordering packets when needed
- Also implements port numbers which allow multiple services and applications to run on the same computer
- Closely tied to the Internet Protocol (IP)
  - TCP segments carried inside IP packets (encapsulation)

TCP operation



TCP segment format



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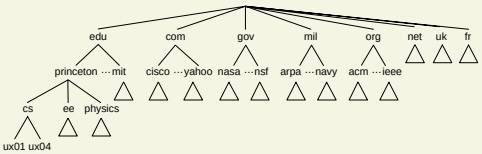
Domain Name System

- Main role is to allow the use of user-friendly names for referring to network hosts: maps names to IP addresses
- Each organization runs a few name servers
  - DNS servers of various organizations communicate with each other
- DNS servers have two roles
  - Help the computers from within the organization find the correct mapping from names to IP addresses for computers in other organizations
  - Tell the rest of the world about the mappings from names to IP addresses for the computers within the organization

Hierarchy of names

- Hierarchical name space for Internet objects



- Names are read from right to left separated by periods
  - Each suffix in a domain name is a domain

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wail.cs.wisc.edu, cs.wisc.edu, wisc.edu, edu
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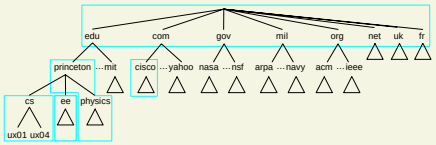
Name Servers

- Partition hierarchy into *zones* (administrative authorities)



- Typically one organization in charge of one zone
  - Authority for sub-domains typically delegated to another (sub)organization (e.g. university to department)
  - It is possible for an organization to handle multiple domains (e.g. web hosting companies)

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