Computer Networks and the Internet

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Sept. 06, 2005

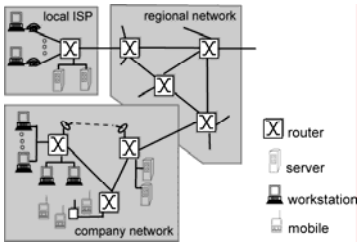
Summary of Presentation Material of Prof. Jim Kurose

Contents

1. What is the Internet?:

1.1 A Nut's and Bolts Description

- End Hosts : Server, Workstation, PC, Mobile, Appliances.
- Application programs
- Router, Communication link
- Protocols



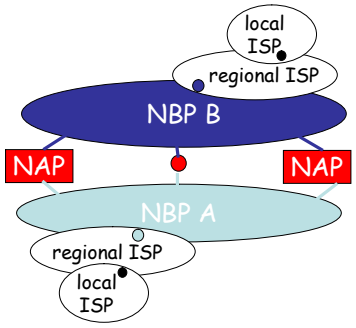
- Run protocols (TCP, IP, HTTP, FTP) that control sending and receiving.
- Internet Standard
  - RFC: Request for Comments
  - IETF: Internet Engineering Task Force
- Internet Service Provider (ISP)

1.2 A Service Description

- communication infrastructure enables distributed applications:
  - WWW, email, games, e-commerce, database., voting, file sharing
- communication services provided:
  - connectionless
  - connection-oriented

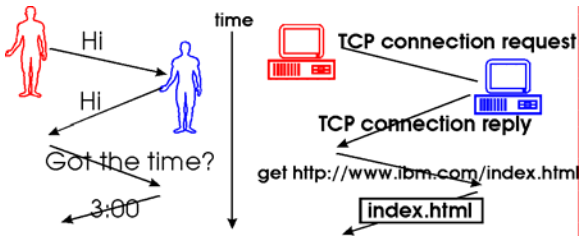
1.3 Internet Structure

- Network of networks
- Roughly hierarchical
- National/international backbone providers (NBP)
  - AT&T, Sprint, IBM, UUNet,...
  - Interconnect with each other privately, or at public Network Access Point (NAPs)
- Regional ISPs
  - Connect into NBPs
- Local ISP, Company
  - Connect into regional ISPs



2. What is protocol?

- Protocols define format, order of messages sent and received among network entities, and actions taken on message transmission, receipt



Human Protocol

Computer Network Protocol

3. Network Structure

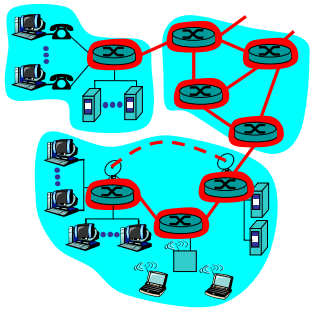
- Network Edge
  - Application programs and Hosts (Workstation, Server, Appliances, ...)
  - Hosts runs application program
    - Client/Server Model (WWW, email, FTP, ...)
    - Peer-to-Peer Model (Gnutella, KazaA, Soribada, ...)
- Network Core
  - Routers
  - Network of networks

3.1 Network Edge

- End system programs use the services of the Internet
  - Connection-oriented service
    - TCP (Transmission Control Protocol): reliable, in-order, flow control, congestion control
    - WWW (HTTP), File Transfer (FTP), Remote Login (Telnet), Email (SMTP)
  - Connectionless service
    - UDP (User Datagram Protocol): unreliable, no flow control, no congestion control
    - Streaming Media, Teleconferencing, Internet Telephony.

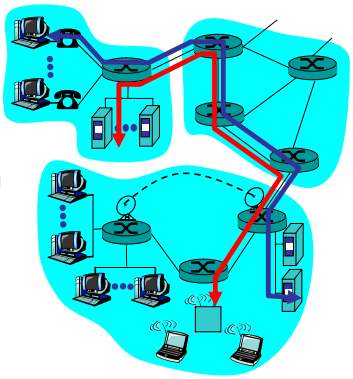
3.2 The Network Core

- Mesh of interconnected routers
- The fundamental question: how is data transferred through net?
  - Circuit Switching
  - Packet Switching

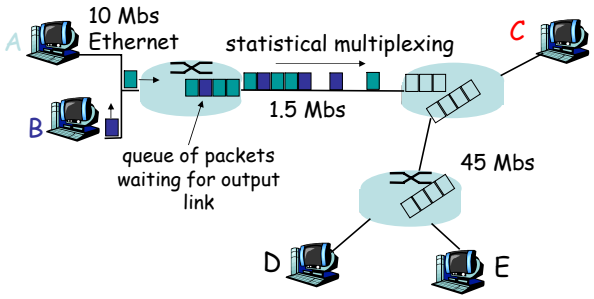


3.2.1 Circuit Switching

- dedicated circuit per call: telephone net
- End-end resources reserved for "call"
  - link bandwidth, switch capacity
  - dedicated resources: no sharing
  - circuit-like (guaranteed) performance
  - call setup required
- TDMA (Time Division Multiple Access), FDMA (Frequency Division Multiple Access)



3.2.2 Packet Switching (Internet)



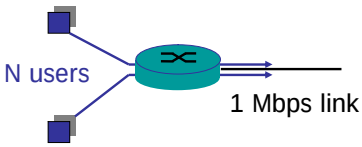
- each end-end data stream divided into *packets*
  - user A, B packets *share* network resources
  - each packet can use full link bandwidth
  - resources used *as needed*

- Resource contention:
  - aggregate resource demand can exceed amount available
  - congestion: packets queue, wait for link use
  - store and forward: packets move one hop at a time
    - transmit over link
    - wait turn at next link

3.2.3 Packet Switching vs. Circuit Switching

Packet switching allows more users to use network!

- 1 Mbit link
- each user:
  - 100Kbps when "active"
  - active 10% of time
- circuit-switching:
  - 10 users
- packet switching:
  - with 35 users, probability > 10 active less than .0004



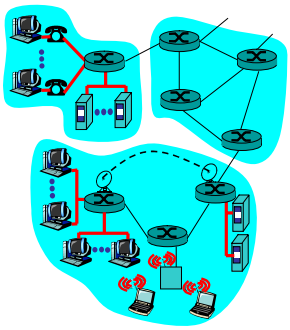
- Packet Switching is great for bursty data, but it needs mechanism for reliable data transfer and congestion control.
- How to provide circuit-like behavior?
  - Bandwidth Guarantees for Video/Audio Application
  - Still an unsolved problem (Chapter 6)

3.2.4 Packet Switched Networks: Routing

- datagram network:
  - *destination address* determines next hop
  - routes may change during session
  - analogy: driving, asking directions
- virtual circuit network:
  - each packet carries tag (virtual circuit ID), tag determines next hop
  - fixed path determined at *call setup time*, remains fixed thru call
  - routers maintain per-call state

3.3 Access Networks

- Residential Access Nets: Dialup, ISDN, Cable Modem, ADSL, VDSL
- Institutional Access Nets: Ethernet
- Mobile Access Nets: Wireless LAN

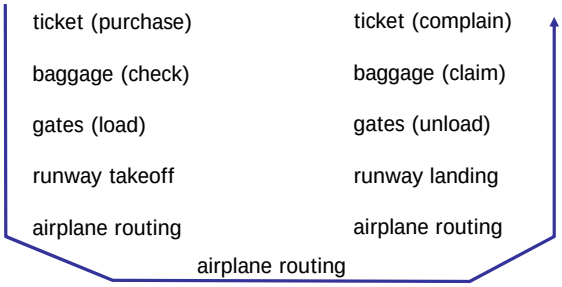


4. Layered Architecture

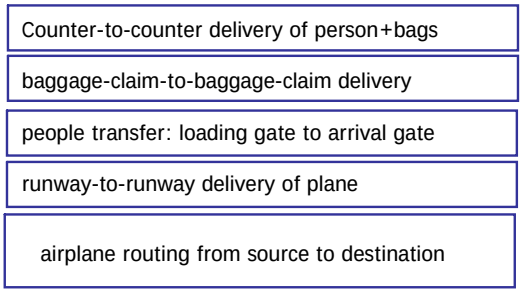
- Networks are complex!
- Dealing with complex systems:
  - explicit structure allows identification, relationship of complex system's pieces.
  - modularization eases maintenance, updating of system
    - change of implementation of layer's service transparent to rest of system
    - e.g., change in gate procedure doesn't affect rest of system
- Weak point?
  - Overhead: Long header, Message copy, Duplicated Job (Error Correction)

Layers: each layer implements a service
- via its own internal-layer actions
- relying on services provided by layer below

Organizing of air travel

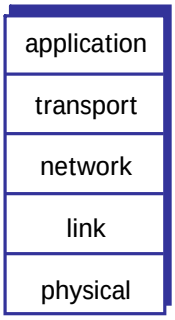


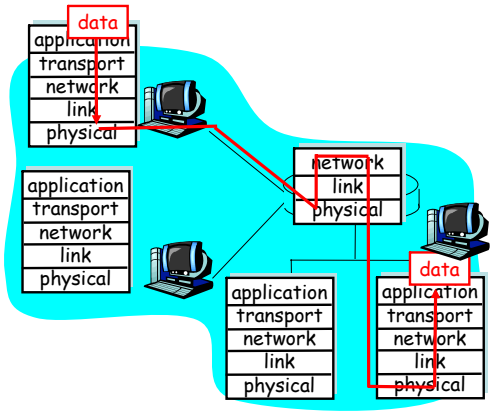
Layered Air Travel: Services



Internet protocol stack

- application: supporting network applications
  - ftp, smtp, http
- transport: application-application data transfer service
  - tcp, udp
- network: host-host data transfer service
  - ip, routing protocols
- link: data transfer service between neighboring network elements
  - ppp, ethernet
- physical: bits "on the wire"





Layering and Protocol Data Unit (PDU)