

Chapter 1: roadmap

1.1 what *is* the Internet?

1.2 network edge

- end systems, access networks, links

1.3 network core

- packet switching, circuit switching, network structure

1.4 delay, loss, throughput in networks

1.5 protocol layers, service models

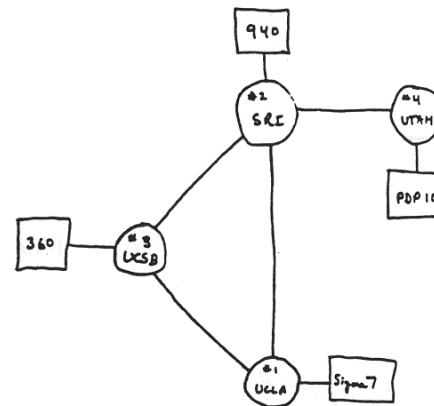
1.6 networks under attack: security

1.7 history

Internet history

1961-1972: Early packet-switching principles

- ❖ **1961:** Kleinrock - queueing theory shows effectiveness of packet-switching
- ❖ **1964:** Baran - packet-switching in military nets
- ❖ **1967:** ARPAnet conceived by Advanced Research Projects Agency
- ❖ **1969:** first ARPAnet node operational
- ❖ **1972:**
 - ARPAnet public demo
 - NCP (Network Control Protocol) first host-host protocol
 - first e-mail program
 - ARPAnet has 15 nodes



THE ARPA NETWORK

Internet history

1972-1980: Internetworking, new and proprietary nets

- ❖ **1970:** ALOHAnet satellite network in Hawaii
- ❖ **1974:** Cerf and Kahn - architecture for interconnecting networks
- ❖ **1976:** Ethernet at Xerox PARC
- ❖ **late 70's:** proprietary architectures: DECnet, SNA, XNA
- ❖ **late 70's:** switching fixed length packets (ATM precursor)
- ❖ **1979:** ARPAnet has 200 nodes

Cerf and Kahn's internetworking principles:

- minimalism, autonomy - no internal changes required to interconnect networks
- best effort service model
- stateless routers
- decentralized control

define today's Internet
architecture

Internet history

1980-1990: new protocols, a proliferation of networks

- ❖ 1983: deployment of TCP/IP
- ❖ 1982: smtp e-mail protocol defined
- ❖ 1983: DNS defined for name-to-IP-address translation
- ❖ 1985: ftp protocol defined
- ❖ 1988: TCP congestion control
- ❖ new national networks: Csnnet, BITnet, NSFnet, Minitel
- ❖ 100,000 hosts connected to confederation of networks

Internet history

1990, 2000's: commercialization, the Web, new apps

- ❖ early 1990's: ARPAnet decommissioned
- ❖ 1991: NSF lifts restrictions on commercial use of NSFnet (decommissioned, 1995)
- ❖ early 1990s: Web
 - hypertext [Bush 1945, Nelson 1960's]
 - HTML, HTTP: Berners-Lee
 - 1994: Mosaic, later Netscape
 - late 1990's: commercialization of the Web

late 1990's – 2000's:

- ❖ more killer apps: instant messaging, P2P file sharing
- ❖ network security to forefront
- ❖ est. 50 million host, 100 million+ users
- ❖ backbone links running at Gbps

Internet history

2005-present

- ❖ ~750 million hosts
 - Smartphones and tablets
- ❖ Aggressive deployment of broadband access
- ❖ Increasing ubiquity of high-speed wireless access
- ❖ Emergence of online social networks:
 - Facebook: soon one billion users
- ❖ Service providers (Google, Microsoft) create their own networks
 - Bypass Internet, providing “instantaneous” access to search, email, etc.
- ❖ E-commerce, universities, enterprises running their services in “cloud” (eg, Amazon EC2)



2015 SPRING SEMESTER

CNCE461: COMMUNICATION NETWORKS

통신네트워크

(2. Application Layer)

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Chapter 2: outline

2.1 principles of
network
applications

2.2 Web and HTTP

2.3 FTP

2.4 electronic mail

- SMTP, POP3,
IMAP

2.5 DNS

2.6 P2P applications

2.7 socket
programming
with UDP and TCP

Chapter 2: application layer

our goals:

- ❖ conceptual, implementation aspects of network application protocols
 - transport-layer service models
 - client-server paradigm
 - peer-to-peer paradigm
- ❖ learn about protocols by examining popular application-level protocols
 - HTTP
 - FTP
 - SMTP / POP3 / IMAP
 - DNS
- ❖ creating network applications
 - socket API

Some network apps

- ❖ e-mail
- ❖ web
- ❖ text messaging
- ❖ remote login
- ❖ P2P file sharing
- ❖ multi-user network games
- ❖ streaming stored video (YouTube, Hulu, Netflix)
- ❖ voice over IP (e.g., Skype)
- ❖ real-time video conferencing
- ❖ social networking
- ❖ search
- ❖ ...
- ❖ ...

Application architectures

possible structure of applications:

- ❖ client-server
- ❖ peer-to-peer (P2P)

Processes communicating

process: program running within a host

- ❖ within same host, two processes communicate using **inter-process communication** (defined by OS)
- ❖ processes in different hosts communicate by exchanging **messages**

clients, servers

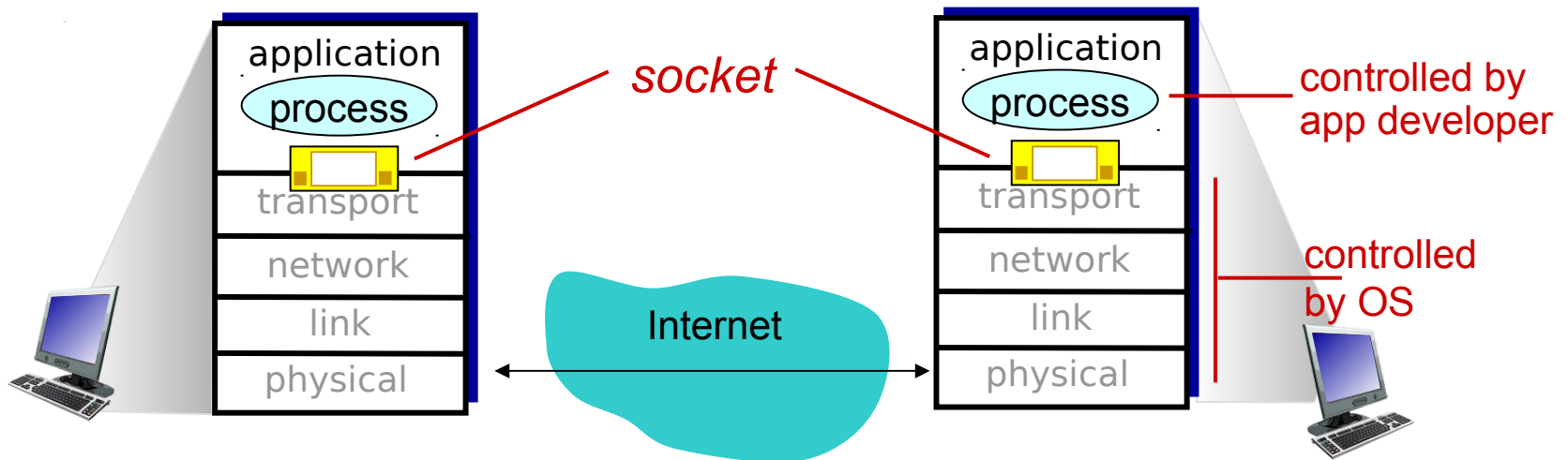
client process: process that initiates communication

server process: process that waits to be contacted

- ❖ aside: applications with P2P architectures have client processes & server processes

Sockets

- ❖ process sends/receives messages to/from its **socket**
- ❖ socket analogous to door
 - sending process shoves message out door
 - sending process relies on transport infrastructure on other side of door to deliver message to socket at receiving process



What transport service does an app need?

data integrity

- ❖ some apps (e.g., file transfer, web transactions) require 100% reliable data transfer
- ❖ other apps (e.g., audio) can tolerate some loss

timing

- ❖ some apps (e.g., Internet telephony, interactive games) require low delay to be “effective”

throughput

- ❖ some apps (e.g., multimedia) require minimum amount of throughput to be “effective”
- ❖ other apps (“elastic apps”) make use of whatever throughput they get

security

- ❖ encryption, data integrity, ...

Transport service requirements: common apps

application	data loss	throughput	time sensitive
file transfer	no loss	elastic	no
e-mail	no loss	elastic	no
Web documents	no loss	elastic	no
real-time audio/video	loss-tolerant	audio: 5kbps-1Mbps video: 10kbps-5Mbps	yes, 100's msec
stored audio/video	loss-tolerant	same as above	yes, few secs
interactive games	loss-tolerant	few kbps up	yes, 100's msec
text messaging	no loss	elastic	yes and no