

University of British Columbia

Cpsc 527 Advanced Computer Networks

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The World Connected

Information and Organization

- Instructor: Dr. Son Vuong
 - ◆ Email: vuong@cs.ubc.ca
 - ◆ Office Hours: M, W: 1-2 pm
- References:
 - ◆ Research reports/papers and protocol standard documents.
 - ◆ "Computer Networks," A. **Tanenbaum** – 4th Ed., Prentice Hall (2003)
 - ◆ "Data and Computer Communications," W. **Stallings** - 8th Ed. (2006)
 - ◆ Computer Networks and Internets (5th Edition), D. **Comer**, Prentice Hall (2008)
 - ◆ "Computer Networking: A Top Down Approach Featuring the Internet," Jim **Kurose** & Keith **Ross**, 4th Ed., Addison Wesley, 2007

Text and Workload

□ Tentative Course Load and Evaluation:

- ◆ 1 Project (50%)
- ◆ 1 Presentation (15%)
- ◆ Short Quizzes (25%)
- ◆ 1 Assignment (10%)
- ◆ Class Participation (Bonus 5%)

- Use of **BlueCT** (on Laptop) for interactive participation and learning

Cpsc 527 Outline

(*) Review

- **The Internet and TCP/IP** (including IPv6, Multicasting, ATM congestion control) (*)
- **Next-Generation Internet:** QoS, Scheduling, MPLS, IntServ, DiffServ, RSVP
- **Distributed multimedia systems:** Compression, RTP/RTSP, **VoIP**
- **P2P Networks and Grid Computing**
- **P2P Video-on-demand streaming (BitVampire)**
- **Network security** (Intrusions, VPN, IPSec, VoIP security)

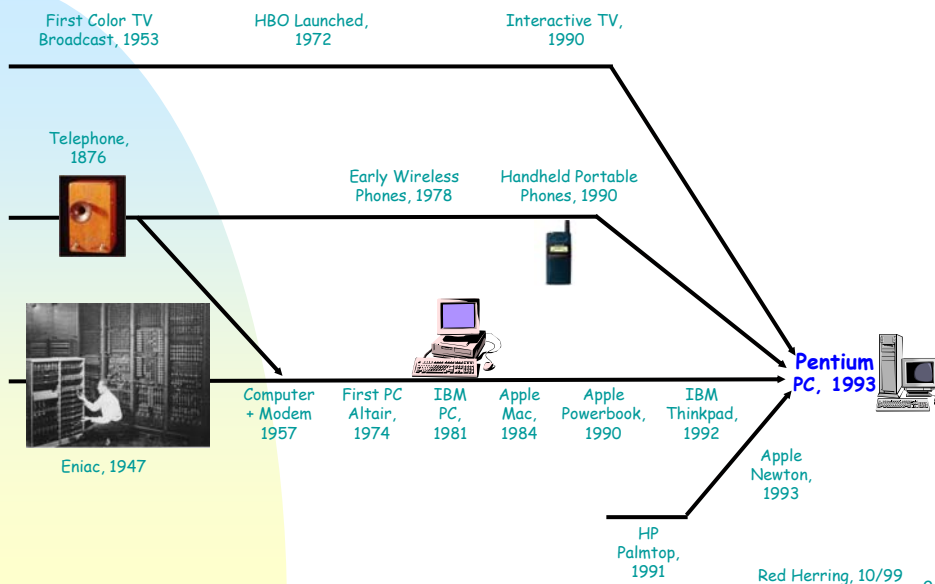
Other hot topics (if time permits):

- **Mobile (wireless) communications** (Mobile-IP, 802.11abg, Cellular, PAN - Bluetooth, Satellites)
- **Mobile intelligent agents** (Wave/NEMO)
- **Network management**, SNMPv2, RMON2, etc.

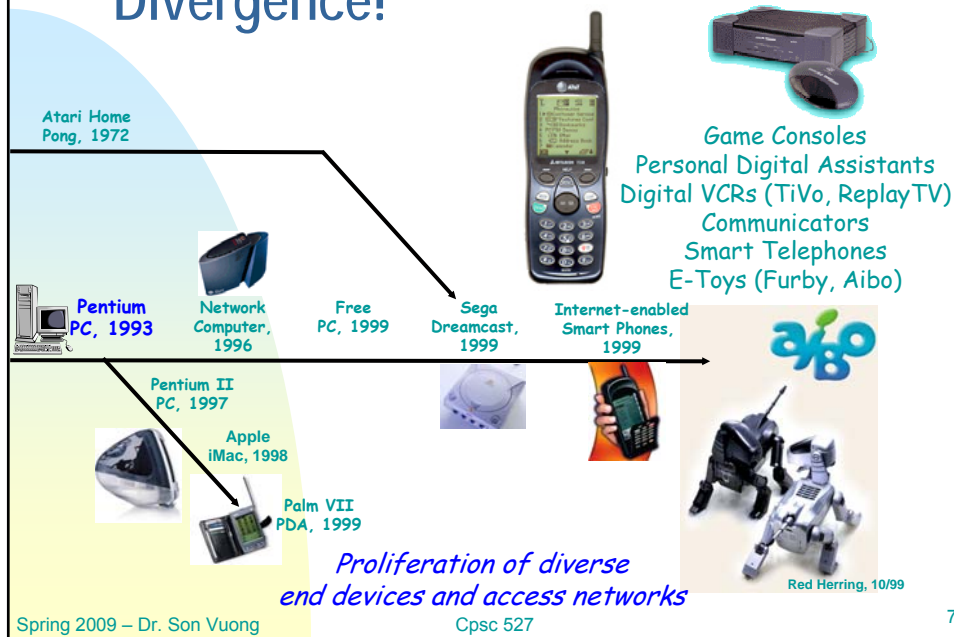
Review

- ❑ Overview - Protocol and Service
- ❑ Internet Protocol Architecture
- ❑ IPv4/IPv6, TCP
- ❑ Other Internet Protocols

Convergence?



Divergence!



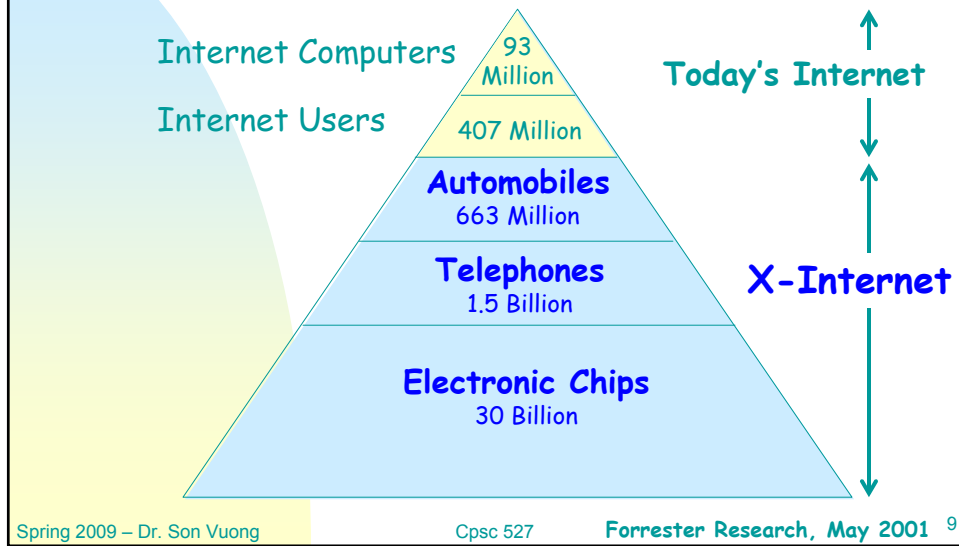
The Shape of Things to Come



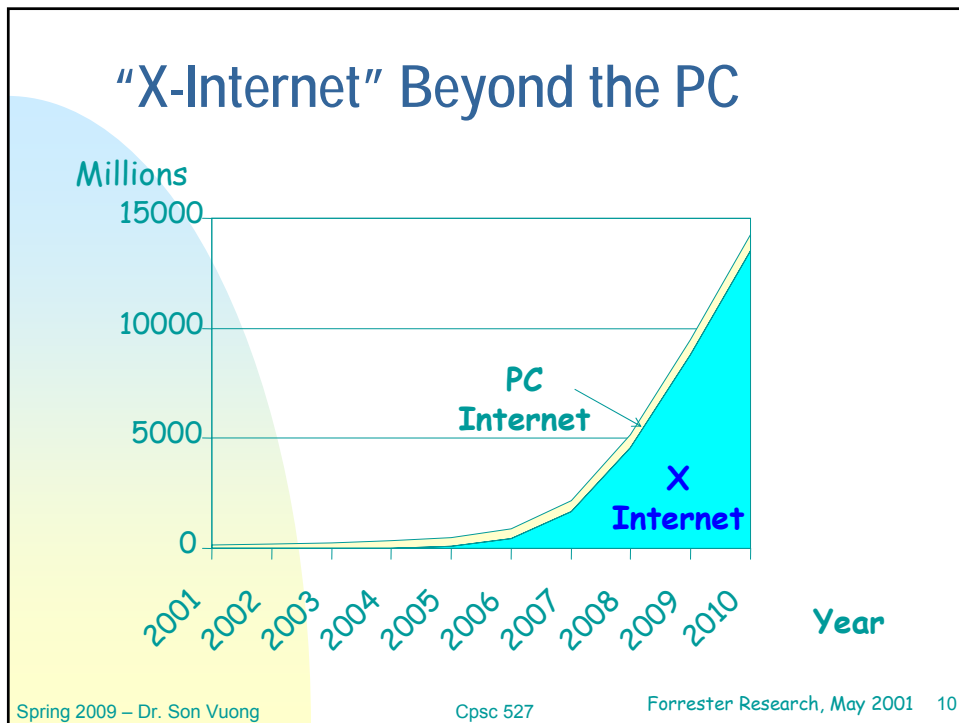
Toyota Pod Concept Car

- ◆ Co-designed with Sony
- ◆ Detects driver's skill level and adjust suspension
- ◆ Detects driver's mood (pulse rate, perspiration), compensates for road rage and incorporates a mood meter (happy vs. angry face)
- ◆ Inter-pod wireless LAN to communicate intentions between vehicles, such as passing
- ◆ Individual entertainment stations for each passenger

"X-Internet" Beyond the PC



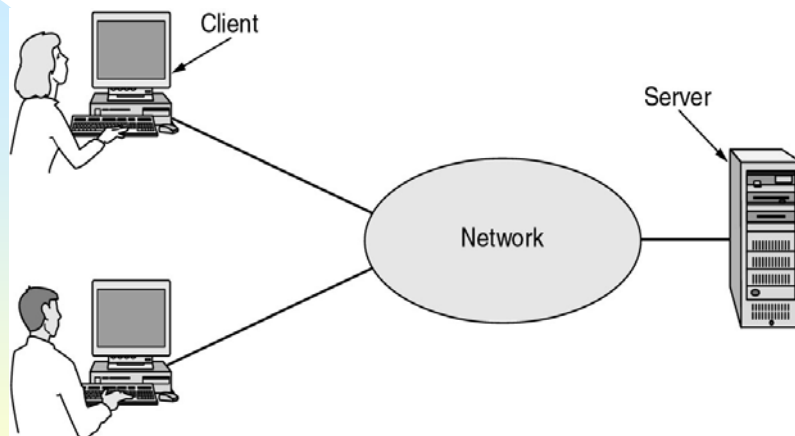
"X-Internet" Beyond the PC



Uses of Computer Networks

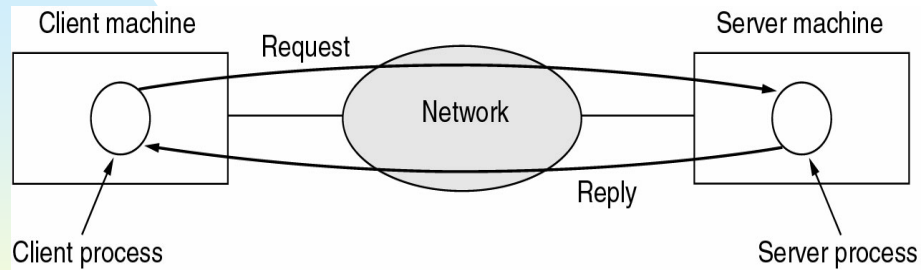
- Business Applications
- Home Applications
- Mobile Users
- Social Issues

Business Applications of Networks



□ A network with two clients and one server.

Business Applications of Networks (2)



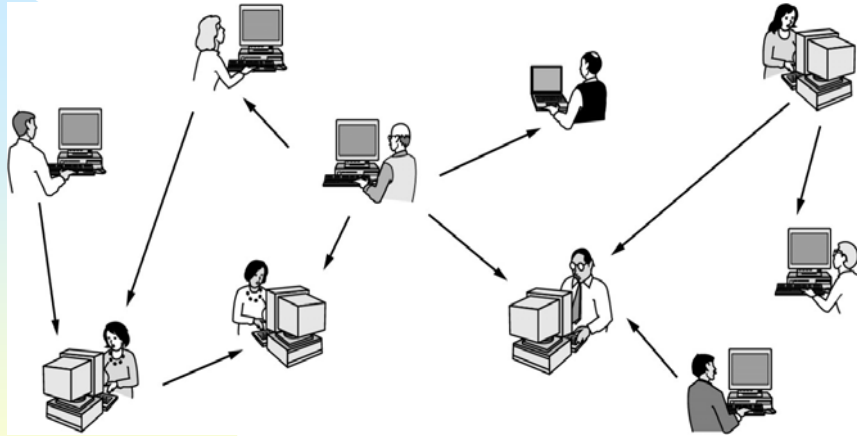
- The client-server model involves requests and replies.

Home Network Applications

- Access to remote information
- Person-to-person communication
- Interactive entertainment
- Electronic commerce

**** Home Gateway Initiative (HGI)**

Home Network Applications (2)

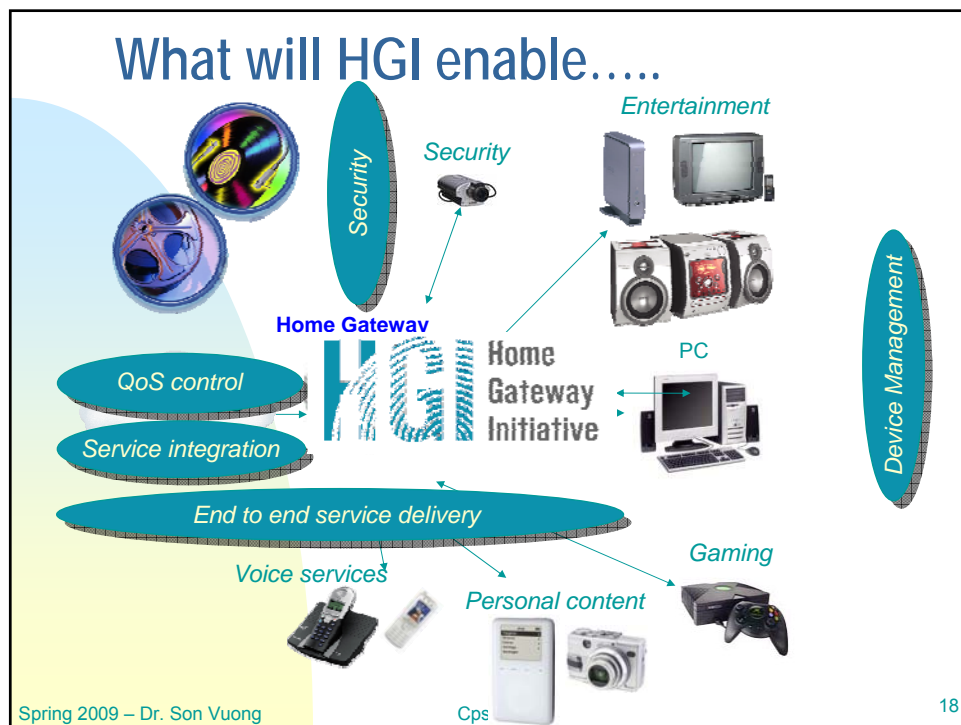
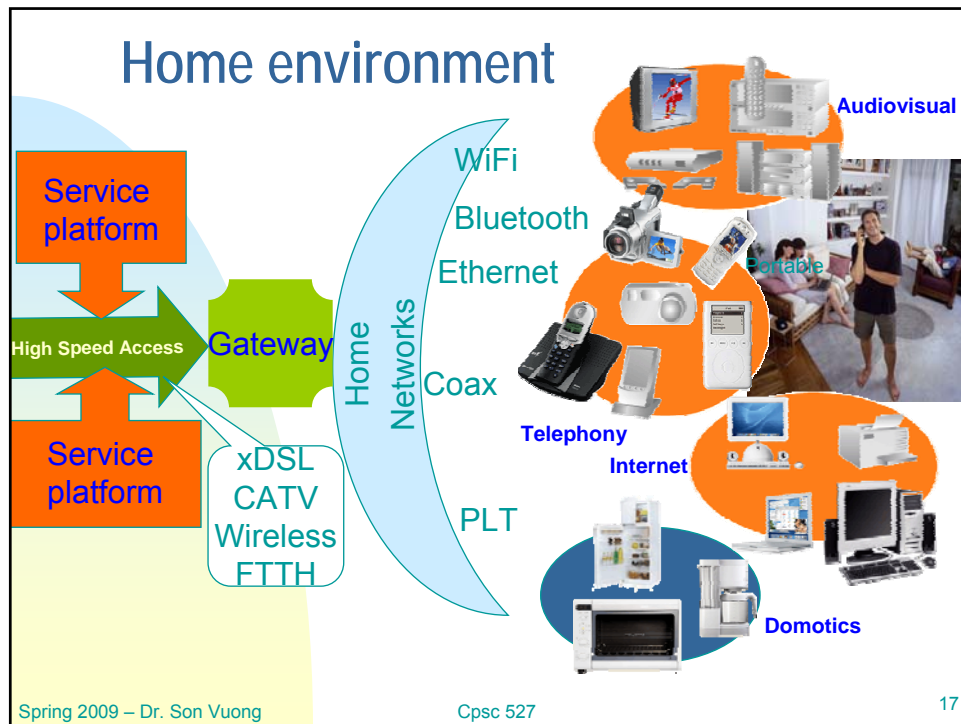


In peer-to-peer system there are no fixed clients and servers.

Home Network Applications (3)

Tag	Full name	Example
B2C	Business-to-consumer	Ordering books on-line
B2B	Business-to-business	Car manufacturer ordering tires from supplier
G2C	Government-to-consumer	Government distributing tax forms electronically
C2C	Consumer-to-consumer	Auctioning second-hand products on-line
P2P	Peer-to-peer	File sharing

Some forms of e-commerce.



Mobile Network Users

Wireless	Mobile	Applications
No	No	Desktop computers in offices
No	Yes	A notebook computer used in a hotel room
Yes	No	Networks in older, unwired buildings
Yes	Yes	Portable office; PDA for store inventory

Combinations of wireless networks and mobile computing.

Classification of Networks

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	
100 m	Building	Local area network
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

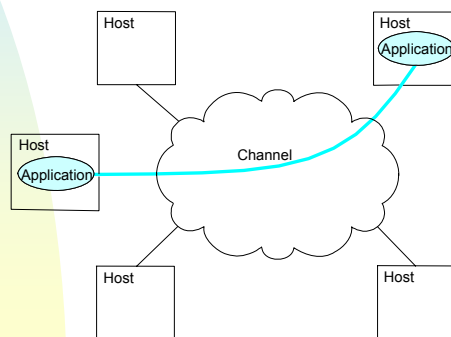
Classification of interconnected processors by scale.

Network Perspective

- ❑ Network users: services that their applications need, e.g., guarantee that each message it sends will be delivered without error within a certain amount of time
- ❑ Network designers: cost-effective design e.g., that network resources are efficiently utilized and fairly allocated to different users
- ❑ Network providers: system that is easy to administer and manage e.g., that faults can be easily isolated and it is easy to account for usage

Inter-Process Communication

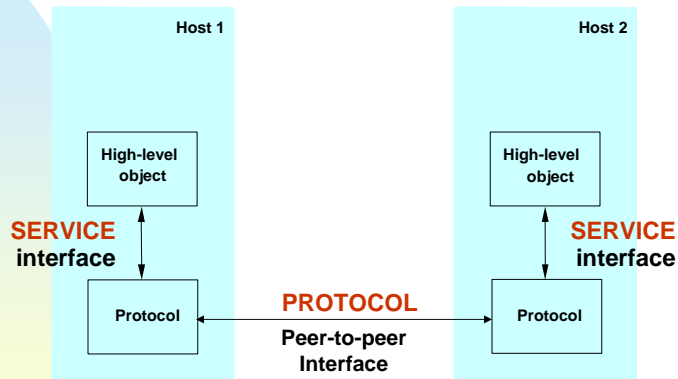
- ❑ Turn host-to-host connectivity into process-to-process communication.
- ❑ Fill gap between what applications expect and what the underlying technology provides.

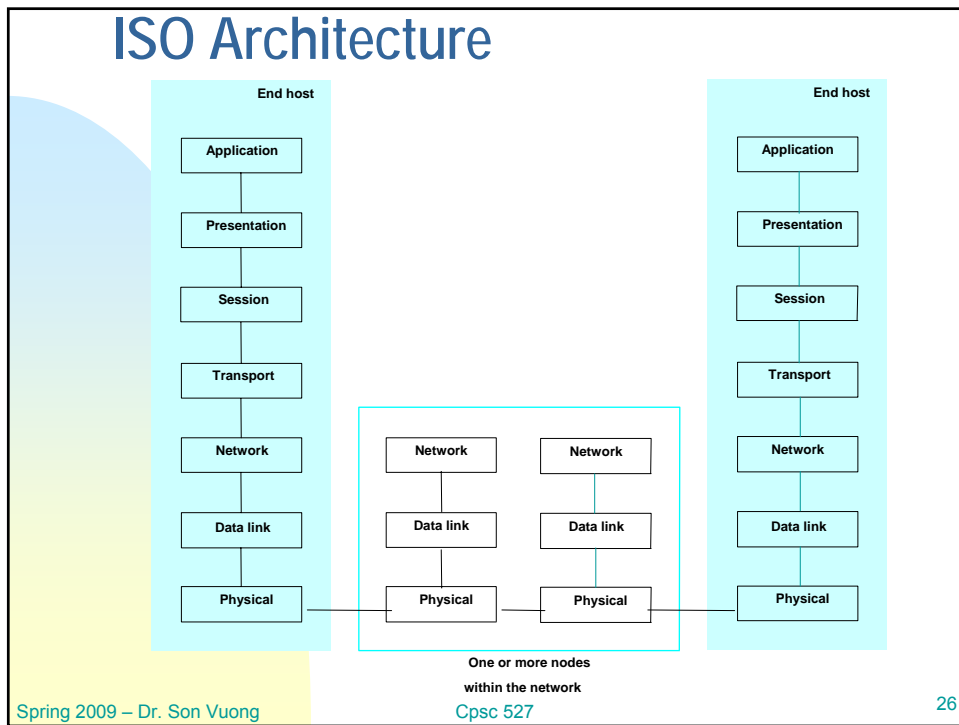
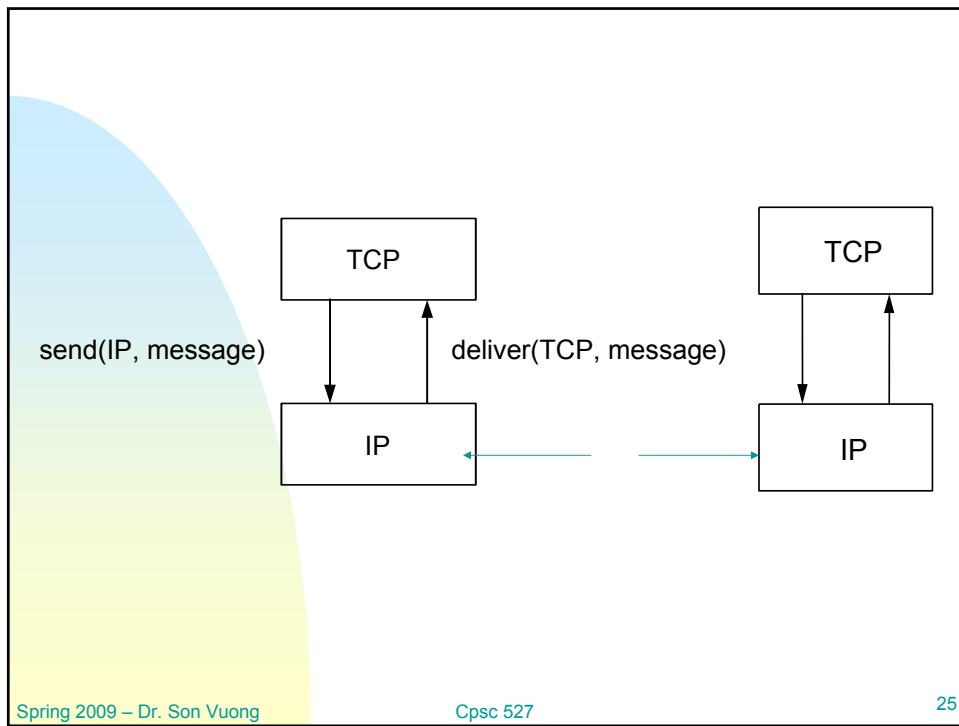


IPC Abstractions

- Request/Reply (responsive traffic)
 - ◆ distributed file systems
 - ◆ digital libraries (web)
- Stream-Based (non-responsive traffic)
 - ◆ video: sequence of frames
 - ☞ 1/4 NTSC = 352x240 pixels (CIF/SIF)
 - ☞ $(352 \times 240 \times 24)/8 = 247.5\text{KB} = 2\text{ Mbits}$
 - ☞ 30 fps = 7500KBps = 60Mbps
 - ◆ video applications
 - ☞ on-demand video
 - ☞ video conferencing

Interfaces (Protocol and Service)





TCP/IP Reference Model

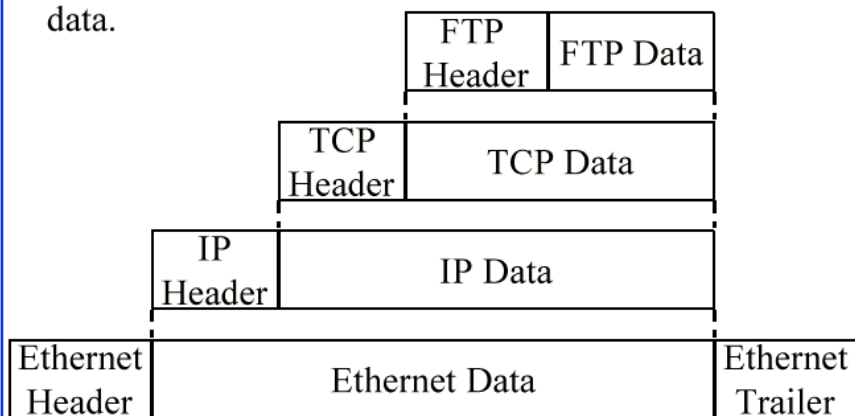
□ TCP = Transport Control Protocol

□ IP = Internet Protocol (Routing)

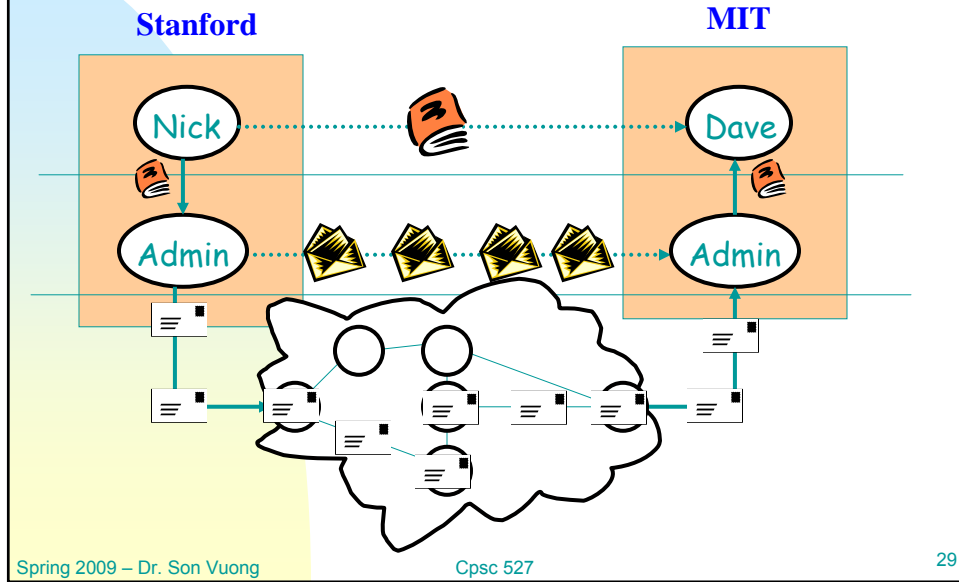
TCP/IP Ref Model	TCP/IP Protocols				OSI Ref Model
Application	FTP	Telnet	HTTP		Application
Transport	TCP		UDP		Presentation
Internetwork	IP				Session
Host to Network	Ethernet	Packet Radio	Point-to-Point		Transport
					Network
					Datalink
					Physical

Layered Packet Format

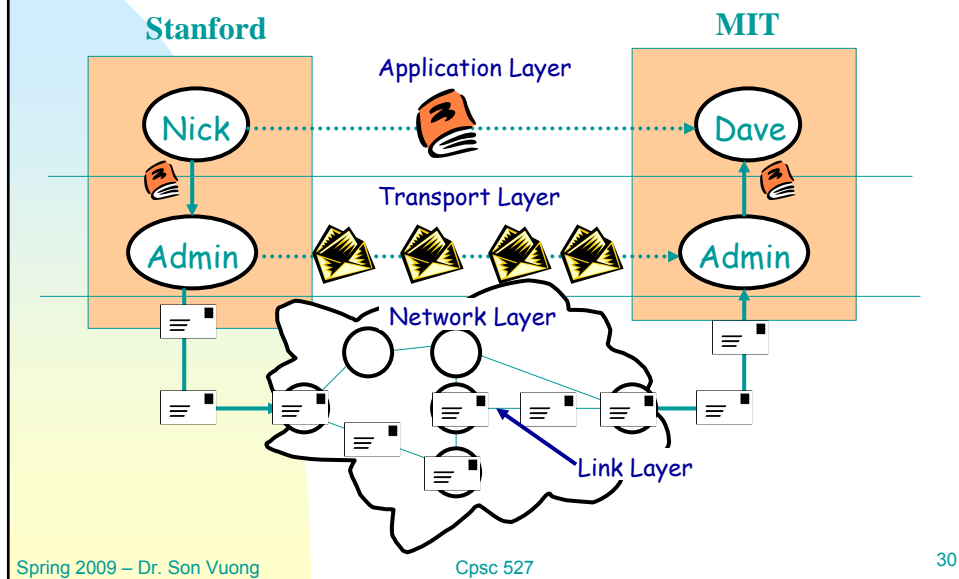
□ Nth layer control info is passed as N-1th layer data.



The Mail System



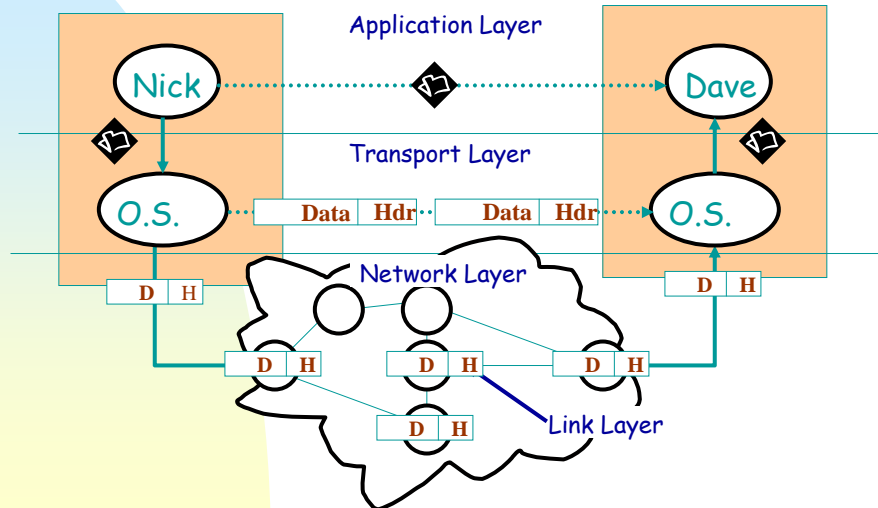
The Mail System (Cont)



The Internet

Leland.Stanford.edu

Athena.MIT.edu

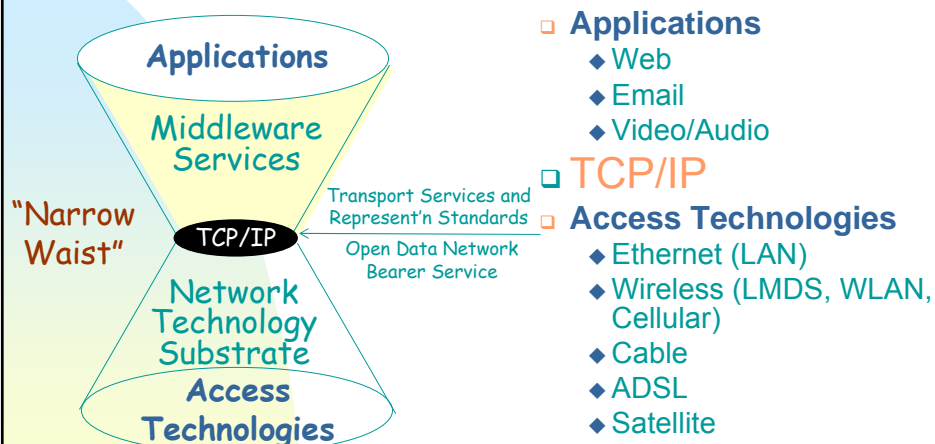


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What is the Internet? "It's the TCP/IP Protocol Stack"



Where is the next "narrow waist"?

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Lect 1 Peer Instruction Question 1.0 – Characteristics of Current Internet

What are **the characteristics of current Internet** ?

- A. No time guarantee for delivery
- B. No guarantee of delivery in sequence or at all
- C. Each packet is individually routed
- D. Best effort service
- E. All of the above
- F. None of the above

Characteristics of the Internet

- ❑ Each packet is individually routed.
- ❑ No time guarantee for delivery.
- ❑ No guarantee of delivery in sequence or at all.
 - ◆ Things get lost
 - ◆ Acknowledgements
 - ◆ Retransmission
 - How to determine when to retransmit? Timeout?
 - Need local copies of contents of each packet.
 - How long to keep each copy?
 - What if an acknowledgement is lost?
 - No guarantee of integrity of data.
 - Packets can be fragmented.
 - Packets may be duplicated

Layering in the Internet

□ Transport Layer

- ◆ Provides reliable, in-sequence delivery of data from end-to-end on behalf of application.

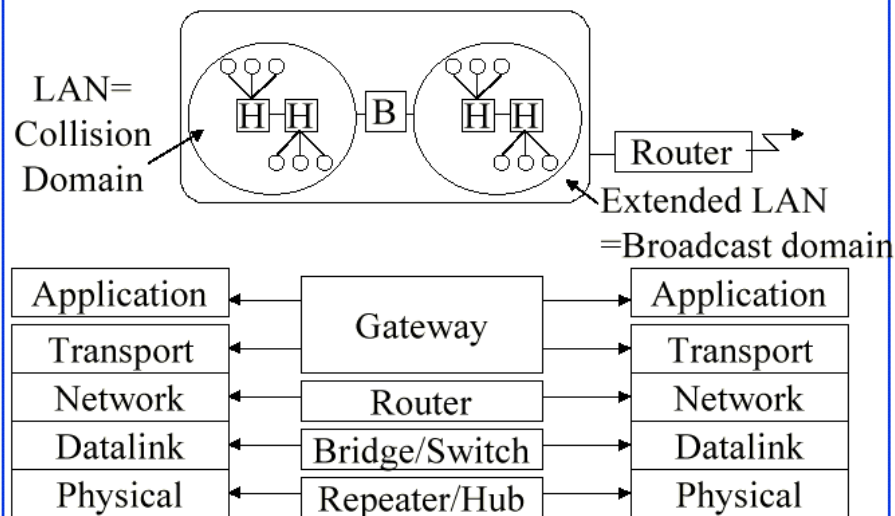
□ Network Layer

- ◆ Provides “best-effort”, but unreliable, delivery of datagrams.

□ Link Layer

- ◆ Carries data over (usually) point-to-point links between hosts and routers; or between routers and routers.

Interconnection Devices



Interconnection Devices

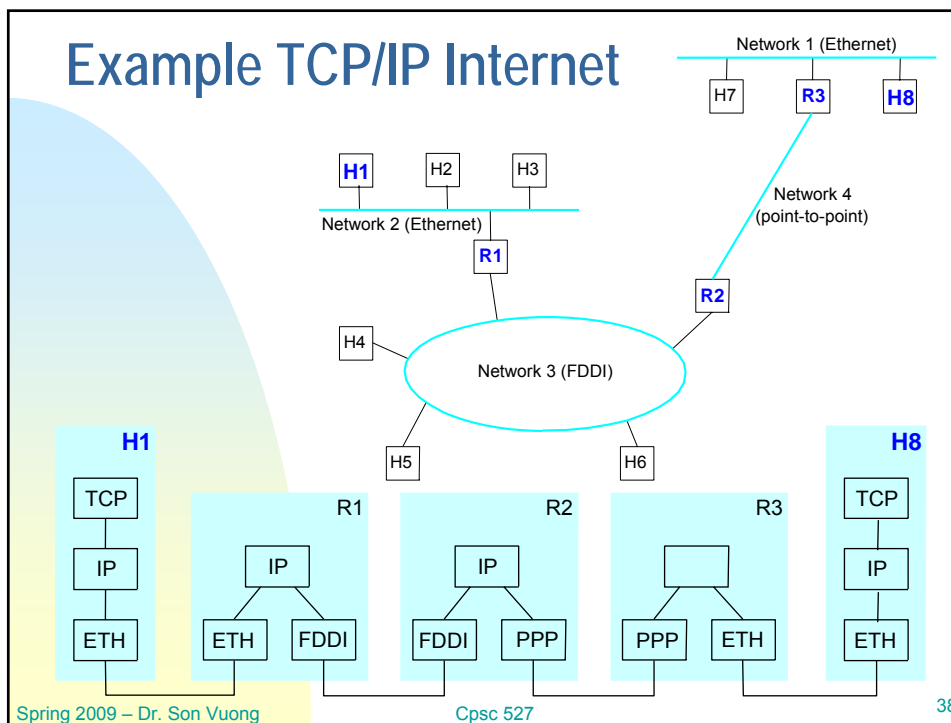
- ❑ **Repeater:** PHY device that restores data and collision signals
- ❑ **Hub:** Multiport repeater + fault detection and recovery
- ❑ **Bridge:** Datalink layer device connecting two or more collision domains. MAC multicasts are propagated throughout “extended LAN.”
- ❑ **Router:** Network layer device. IP, IPX, AppleTalk. Does not propagate MAC multicasts.
- ❑ **Switch:** Multiport bridge with parallel paths
These are functions. Packaging varies.

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Example TCP/IP Internet



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Summary

- ❑ ISO/OSI reference model has seven layers.
- ❑ TCP/IP Protocol suite has four layers.
- ❑ Interconnection devices: Gateway, Router, Switch/Bridge, Hub/Repeater
- ❑ Next lecture: IPv4-v6
- ❑ Then: TCP

Lect 1 Peer Instruction Question 1.1 – Hub and Switch

- ❑ What are the differences between a **hub** and a **switch**?
- A. Layer: physical layer (repeater), link layer
- B. Buffering: yes/no
- C. Intelligence: with/out CSMA/CD
- D. Collision domain: single vs multiple
- E. Forwarding: flooding vs self-learning
- F. Plug-and-play: yes/no

Lect 1 Peer Instruction Question 1.1 – Hub and Switch - Answer

<u>hub</u>	<u>switch</u>
□ <u>Layer:</u> physical layer (repeater)	link layer
□ <u>Buffering:</u> no	yes
□ <u>Intelligence:</u> no CSMA/CD	CSMA/CD
□ <u>Collision domain:</u> single	multiple
□ <u>Forwarding:</u> flooding	self-learning
□ <u>Plug-and-play:</u> yes	yes

Ethernet CSMA/CD algorithm

1. Adaptor receives datagram from net layer & creates frame
2. If adapter senses channel idle, it starts to transmit frame. If it senses channel busy, waits until channel idle and then transmits
3. If adapter transmits entire frame without detecting another transmission, the adapter is done with frame !
4. If adapter detects another transmission while transmitting, aborts and sends jam signal
5. After aborting, adapter enters **exponential backoff**: after the m th collision, adapter chooses a K at random from $\{0, 1, 2, \dots, 2^m - 1\}$. Adapter waits $K \cdot 512$ bit times and returns to Step 2

Ethernet's CSMA/CD (more)

Jam Signal: make sure all other transmitters are aware of collision; 48 bits

Bit time: .1 microsec for 10 Mbps Ethernet ;
for $K=1023$, wait time is about 50 msec

See/interact with Java applet on AWL Web site: highly recommended !

Exponential Backoff:

- **Goal:** adapt retransmission attempts to estimated current load
 - ◆ heavy load: random wait will be longer
- **first collision:** choose K from $\{0,1\}$; delay is $K \cdot 512$ bit transmission times
- **after second collision:** choose K from $\{0,1,2,3\}$...
- **after ten collisions,** choose K from $\{0,1,2,3,4,\dots,1023\}$

Lect 7 (Ch. 5). Peer Instruction Question 7.1 – Bin Exp Backoff

In CSMA/CD, after the 5th collision, what is the probability that a node chooses $K=4$?

Answer:

A:1/8 B:1/16 C:1/32 D:1/64 E: none

Lect 7 (Ch. 5). Peer Instruction Answer 7.1 – Bin Exp Backoff

In CSMA/CD, after the 5th collision, what is the probability that a node chooses K=4?

Answer:

CSMA/CD uses binary exponential backoff.

After the 5th collision, the adapter chooses any K from {0, 1, 2, ..., 31 = $2^{**}5 - 1$ }

The probability that it chooses K= 4 is 1/32.

A:1/8 B:1/16 C:1/32 D:1/64 E: none

Efficiency of Ethernet (CSMA/CD)

□ Efficiency = $\frac{1}{(1 + 5.4 \alpha)}$

where $\alpha = t_{\text{prop}} / t_{\text{trans}} = (L/c) / (F/R) = LR/cF$
(L: cable length, c: prop speed, R: rate, F: frame size)

□ Derivation:

Efficiency = $\frac{t_{\text{trans}}}{(t_{\text{trans}} + t_{\text{contention}})}$

$T_{\text{contention}} = t_{\text{slot}} N_{\text{slots}} = (2 t_{\text{prop}}) (e) = 2e T = 5.4 T$

$N_{\text{slots}} = 1/\text{Prob (some station acquires channel in the slot)} = e$

CSMA/CD efficiency

- T_{prop} = max prop between 2 nodes in LAN
- t_{trans} = time to transmit max-size frame

$$\text{Efficiency} = \frac{1}{1 + 5t_{prop} / t_{trans}}$$

- Efficiency goes to 1 as t_{prop} goes to 0
- Goes to 1 as t_{trans} goes to infinity
- Much better than ALOHA, but still decentralized, simple, and cheap