CS 4/55231
Internet Engineering

Kent State University
Dept. of Computer Science

LECT-6

INTERNET SYSTEM

NETWORK SOFTWARE

- Protocols & Layers
- Internetworking
- IP/TCP

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Protocols

- All parties involved in a communication must agree on a set of rules to be used when exchanging messages. Diplomats call it protocol.
- Tom Merill:
  - connected two computers (Lincoln Lab's TX-2 and the SDC-Q-32 at Santa Monica) with a 2000 bps crude modem, which he called an automatic dialer, and was able to send message back and forth.
  - Merill set up a procedure for grouping characters into messages, sending them across links, and checking to see if message has arrived. If not, message was retransmitted.
  - Merill called his procedure Protocol.

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Protocols Suits & Layering

- Making communication happen is complex.
- Thus instead of having a single giant protocol taking care of everything, it is better if the communication problems can be divided into small pieces each focused on a small manageable sub-problem.

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Layering Approach

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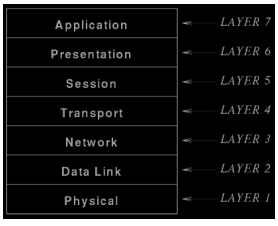

Seven layer OSI model

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Layering Approach

Seven layer OSI model

- Physical:
  - example RS-232 specs.
- Data Link:
  - frame generation, byte stuffing, checksum etc.
- Network:
  - addressing, forwarding.
- Transport:
  - reliable transfer.
- Session:
  - login, secury, etc.
- Presentation:
  - data translation, representation.
- Application:

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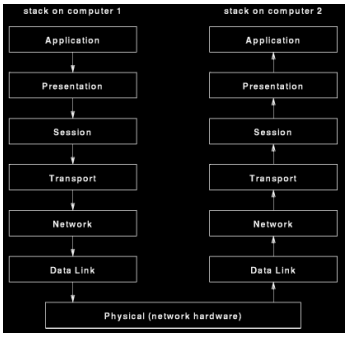
Protocol Stack



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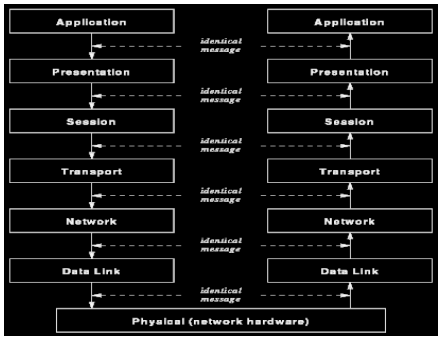
Stack-to-Stack Communication



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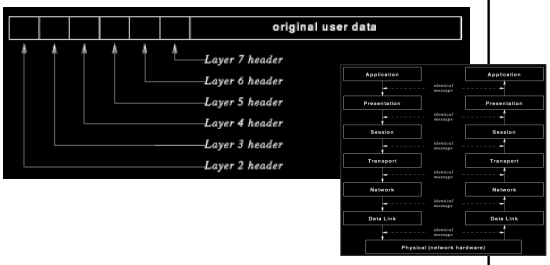
Nested Headers



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Some Important Protocol Functions

- Sequencing Out-of-Order Packets
  - A connectionless protocol may route different packets to be routed through different paths.
  - How to handle?
    - Sender inserts a field called sequence number. Receiver maintains a buffer, if a new packet arrives inserts it in the buffer in right location. If all previous packets are there, it is delivered. If delivered, also checks for additional packets in buffer.
- Eliminate Duplicate Packets
  - Can duplication occur in CSMA/CD?
  - Combine with sequencing, check if it has already been received, or in the buffer discard it.

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Protocol Functions (contd..)

- Retransmission of Lost Packets
  - transmission error makes packet loss a part of digital communication.
  - Create some form of ACK/ buffer.
- Avoiding Replay
  - example: packet-3 of last transmission arrives late as a packet-3 of a later transmission, resulting in drop of the actual packet-3.
  - Solution: unique ID for each session.

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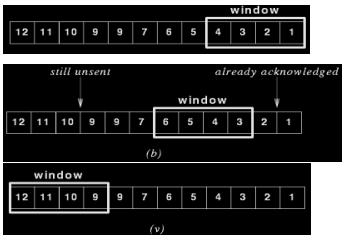
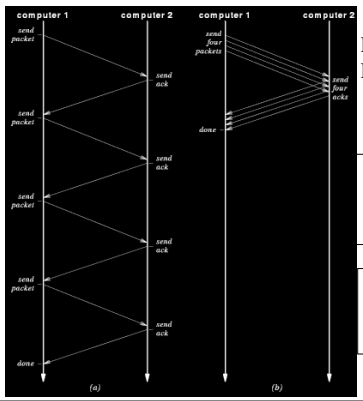
Flow Control to Prevent Data Overrun

- Computers do not operate all at same speed.
- Solution: Stop-and-go



- Stop-and-go can be inefficient.
- Allow more than 1 packet to be transmitted without wait for acknowledgement.

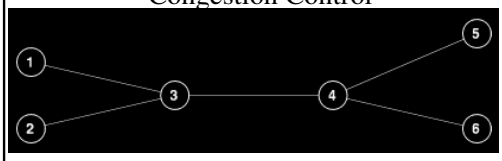
Efficiency & Flow Control



Stop-and-go can be inefficient.
Allow more than 1 packets to be transmitted without wait for acknowledgement.

- How much improvement?
- T_w=min (B, $T_{stop\text{-}and\text{-}go}$xW)

Congestion Control



- Let all the links are 1.5Mbps. What if 1 & 2 both are sending at 15 Mps rate?
- Solution:
  - Drop or delay packet
- Management:
  - Let the switch send back warning to senders.
    - Send back to sender, or mark in message via receiver.
  - Let senders count pocket loss and adjust.

Protocol Design

- A delicate task!
- Examples:
  - sequence number size big or small?
  - Congestion control or flow control?
  - Message size?

Vendor	Stack
Novell Corporation	Netware
Banyan System Corporation	VINES
Apple Computer Corporation	AppleTalk
Digital Equipment Corporation	DECNET
IBM	SNA
(many vendors)	TCP/IP

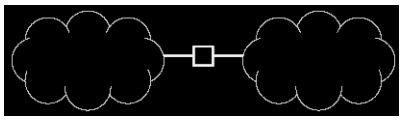
IP4

Internet Protocol

- Objective: Universal Service.
- Can we have one single network technology serving all?
- Why networks cannot communicate?
  - What are the two main sources of incompatibilty?
- What is **internet** and **Internet**?

The Main Hardware Component

- Routers:
  - like bridge connects two network.
  - Performs filtered frame forwarding.
  - But, also understands packet format.
  - Two sides can be two technologies.



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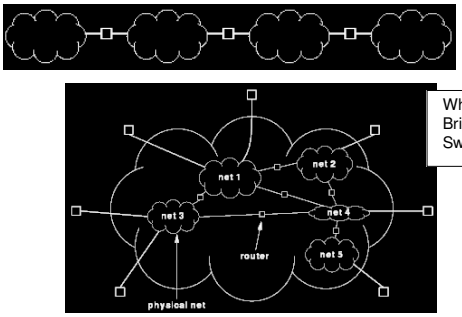
Internet Architecture



Why Routers are Bridge like, but not Switch like?

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Protocols for Internetworking

- A number of attempts were made to make internetworking possible. However, the most successful one is the protocol suit known as TCP/IP. Its development begun in the 1970s by DARPA.
- Now Internet connects more than 80 million computers across more than 107 countries.

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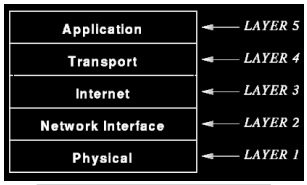
TCP/IP Protocol Stack



Host have all 5 layers.
How many layers routers need?

- Application
  - same as ISO
- Transport
  - reliability
- Internet
  - format consistency
  - routing
- NI
  - same as ISO
- Physical
  - same as ISO

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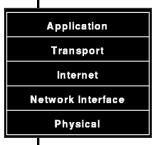
- IP- Internet Protocol
  - Global Addressing Scheme
  - Local Address Resolution
  - Datagram Forwarding
  - Encapsulation, Fragmentation & Reassembly
- TCP- Transmission Control Protocol
  - Connection startup & shutdown
  - Reliability: ordering, missing data handling



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IP Addressing Scheme

- To achieve an illusion of single network, all computers, despite their differences in physical technology, should have a uniform addressing scheme.
- This is done as a software address.
- In this abstraction, each host in internet is assigned an unique 32 bit address called IP address.

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IP Addressing Format

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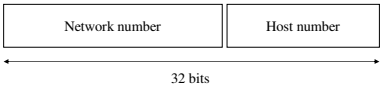
IP address
=
Network number + host number

If n bits are for network than how many networks can be there?

How many hosts can be in those networks?



The hierarchy allows host addresses to be assigned independently. What is the right allocation for bits for each part?

IP Addressing Classes

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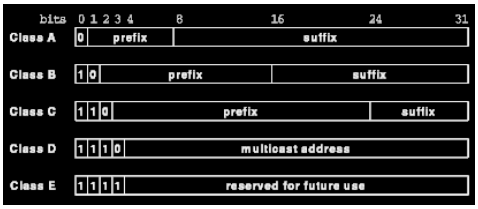
- IP divides the addresses into 5 classes to accommodate networks of varying sizes.



Class Computation

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First Four Bits Of Address	Table Index (in decimal)	Class of Address
0000	0	A
0001	1	A
0010	2	A
0011	3	A
0100	4	A
0101	5	A
0110	6	A
0111	7	A
1000	8	B
1001	9	B
1010	10	B
1011	11	B
1100	12	C
1101	13	C
1110	14	D
1111	15	E

- Determination of address class is crucial. Generally a machine reads 4 leading bits and determined the class from a table.

Dotted Decimal Notation

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32-bit Binary Number	Equivalent Dotted Decimal
10000001 00110100 00000110 00000000	129 . 52 . 6 . 0
11000000 00000101 00110000 00000011	192 . 5 . 48 . 3
00001010 00000010 00000000 00100101	10 . 2 . 0 . 37
10000000 00001010 00000010 00000011	128 . 10 . 2 . 3
10000000 10000000 11111111 00000000	128 . 128 . 255 . 0

Class	Range of Values
A	0 through 127
B	128 through 191
C	192 through 223
D	224 through 239
E	240 through 255

Network Sizes

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Address Class	Bits In Prefix	Maximum Number of Networks	Bits In Suffix	Maximum Number Of Hosts Per Network
A	7	128	24	16777216
B	14	16384	16	65536
C	21	2097152	8	256

Address Management

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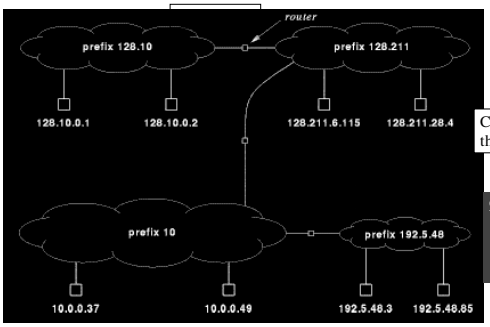
- IANA assigns network numbers or blocks of network numbers to ISPs.
- Big ISPs further distribute the network numbers to smaller ISPs connected to them.
- Network administrators assigns the host numbers to individual computers.

An Example Private TCP/IP Network



Can you determine the network classes?

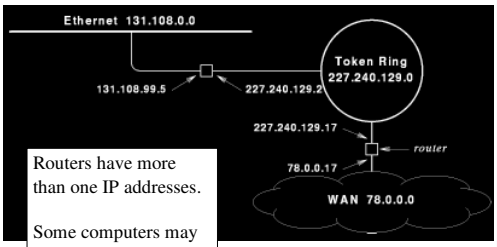
Class	Range of Values
A	0 through 127
B	128 through 191
C	192 through 223
D	224 through 239
E	240 through 255

Special Addresses

- Network Address (n.n.n.0, n.0.0.0, etc)
  - Never appears as the destination in an IP packet.
- Direct Broadcast (n.n.n.255, n.n.255.255, etc.)
  - All computer in the logical network.
- Limited Broadcast (255.255.255.255)
  - All computers in physical network
- This computer (0.0.0.0)
  - used during booting.
- Loopback (127.any)
  - used for testing.

Prefix	Suffix	Type Of Address	Purpose
all-0s	all-0s	this computer	used during bootstrap
network	all-0s	network	identifies a network
network	all-1s	directed broadcast	broadcast on specified net
all-1s	all-1s	limited broadcast	broadcast on local net
127	any	loopback	testing

Router Addresses



Routers have more than one IP addresses.

Some computers may also be in more than one networks.