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| CS 4/54201 Computer Communication Network | Kent State University Dept. of Computer Science www.mcs.kent.edu/~javed/class-NET06F/ |
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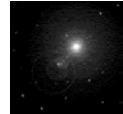
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|  | A Course on Networking and Computer Communication |
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Internet Protocol

3

Class Mechanics

- Submit Homework#3 on Wed Nov 18th

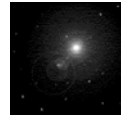


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Internet Protocol

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

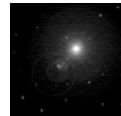
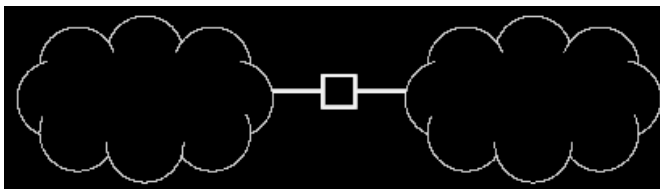


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The Main Hardware Component

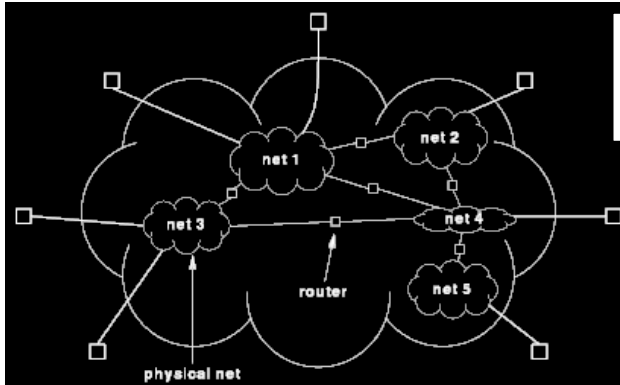
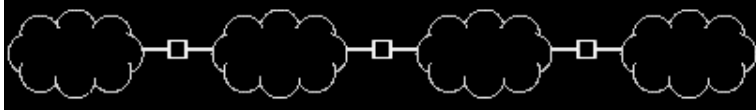
- **Routers:**
 - like bridge connects two network.
 - Performs filtered frame forwarding.
 - But, also understands packet format.
 - Two sides can be two technologies.



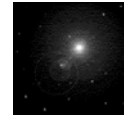
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Internet Architecture



Why Routers are Bridge like, but not Switch like?



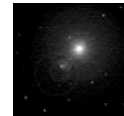
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Protocols for Internetworking

- 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 5 million computers across more than 82 countries.

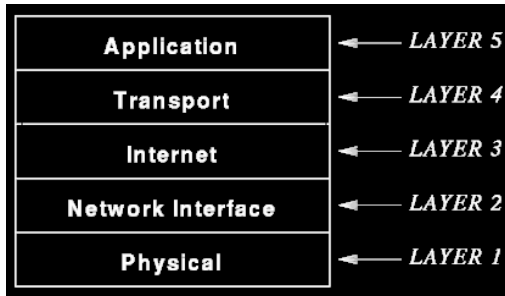


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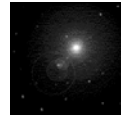
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TCP/IP Protocol Stack



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

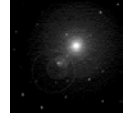


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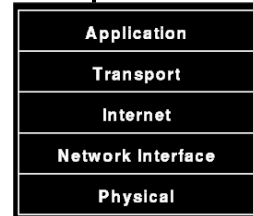
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IP4

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



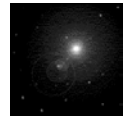
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IP Addressing Scheme

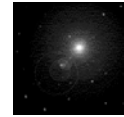
- To achieve an illusion of single network, all computers, despite their differences in physical technology, are assigned a **software address**.
- In this abstraction, each host in internet is assigned an unique 32 bit address called IP address.



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IP Addressing Format



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IP address
= Network number + host number

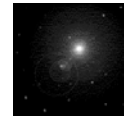


If n bits are for network than how many networks can be there?

How many hosts can be in those networks?

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IP Addressing Classes



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

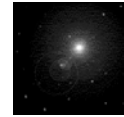
| | bits | 0 | 1 | 2 | 3 | 4 | 8 | 16 | 24 | 31 | |
|----------------|------|---|--------|--------|--------|-------------------------|--------|--------|--------|----|--|
| Class A | | 0 | prefix | | | | suffix | | | | |
| Class B | | 1 | 0 | prefix | | | | suffix | | | |
| Class C | | 1 | 1 | 0 | prefix | | | | suffix | | |
| Class D | | 1 | 1 | 1 | 0 | multicast address | | | | | |
| Class E | | 1 | 1 | 1 | 1 | reserved for future use | | | | | |

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Dotted Decimal Notation

| 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 |

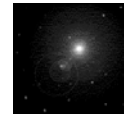


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Network Sizes

| 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 |

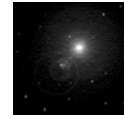


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Address Management

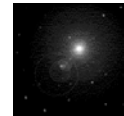
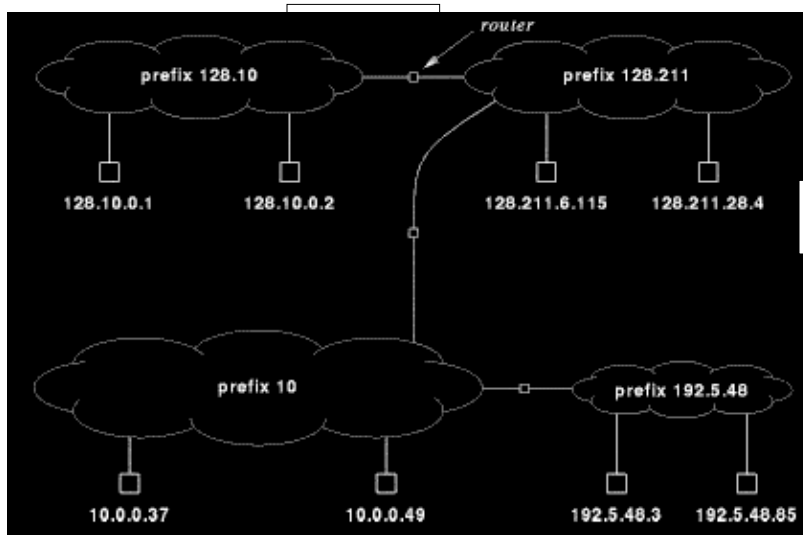
- IANA (Internet Assigned Number Authority) assigns network numbers or blocks of network numbers to ISPs.
- Big ISPs further distribute the network numbers to smaller ISPs connected to them.
- Network administrators assigns the host numbers to individual computers.



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An Example Private TCP/IP Network



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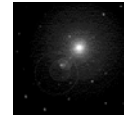
Can you determine
the network classes?

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Special Addresses

- Network Address
 - Never appears as the destination in an IP packet.
- Direct Broadcast
 - All computer in the logical network.
- Limited Broadcast
 - All computers in physical network
- This computer
 - used during booting.
- Loopback
 - used for testing.

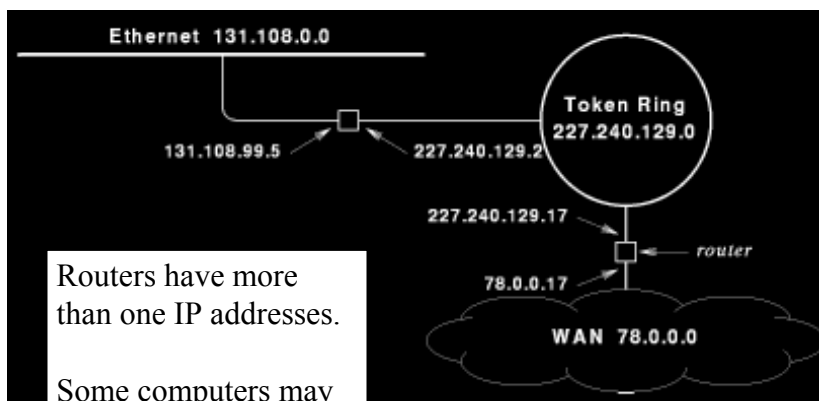
| Prefix | Suffix | Type Of Address | Purpose |
|---------|--------|--------------------|----------------------------|
| all-0s | all-0s | this computer | used during bootstrap |
| network | all-0s | network | identifies a network |
| network | all-1s | directed broadcast | broadcast on specified net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



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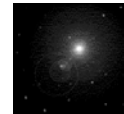
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Router Addresses



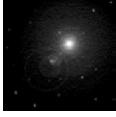
Routers have more than one IP addresses.

Some computers may also be in more than one networks.



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COMPUTER COMMUNICATION NETWORK

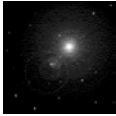
- IP- Internet Protocol
 - Addressing Scheme
 - Address Resolution
 - Datagram Forwarding
 - Encapsulation, Fragmentation & Reassembly
- TCP- Transmission Control Protocol
 - Connection startup & shutdown
 - Reliability: ordering, missing data handling

| |
|-------------------|
| Application |
| Transport |
| Internet |
| Network Interface |
| Physical |

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How Data is Forwarded?

- To create an illusion of large uniform network software works with IP addresses. It puts data into packet and specifies the IP address of the destination.
- TCP/IP software in each host (or router) looks into the destination address and decides the next-hop. This next hop is also IP address.
- Unfortunately, IP addresses are virtual and cannot be used to reach the next-hop across a physical network.
- A frame sent across a physical network must have a physical address.

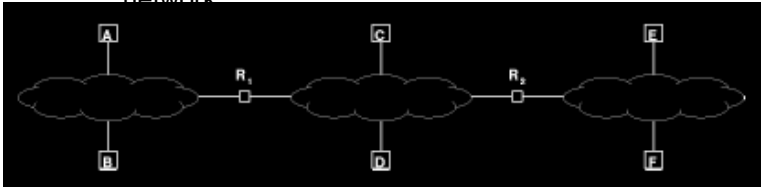


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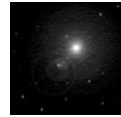
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Address Resolution

- Translation from IP address to hosts physical address is known as address resolution.
- Address resolution is always local to a physical network



A to B: Protocol Software resolves B's address.
A to D: Protocol Software on A determines R1 is the next hop's IP address. A resolves R1's address.
Protocol Software on R2 resolves D's address.

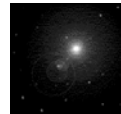


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Address Resolution Techniques

- Depends on Physical Network Technology.
- Three main types:
 - Table Lookup
 - Closed form Computation
 - Message Exchange



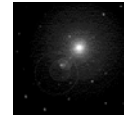
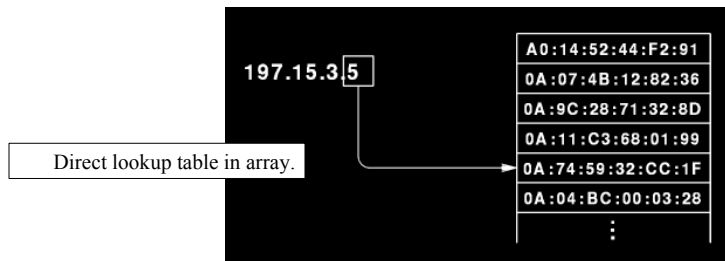
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AR by Table Lookup

| IP Address | Hardware Address |
|------------|-------------------|
| 197.15.3.2 | 0A:07:4B:12:82:36 |
| 197.15.3.3 | 0A:9C:28:71:32:8D |
| 197.15.3.4 | 0A:11:C3:68:01:99 |
| 197.15.3.5 | 0A:74:59:32:CC:1F |
| 197.15.3.6 | 0A:04:BC:00:03:28 |
| 197.15.3.7 | 0A:77:81:0E:52:FA |

Address binding table.



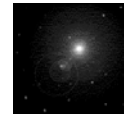
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AR with Message Exchange

- Send a request for physical address.
 - Broadcast to all
 - Send to designated server.
 - Broadcast to designated servers.
- Receive message with physical address.
 - The actual owner of the IP address or the server replies.

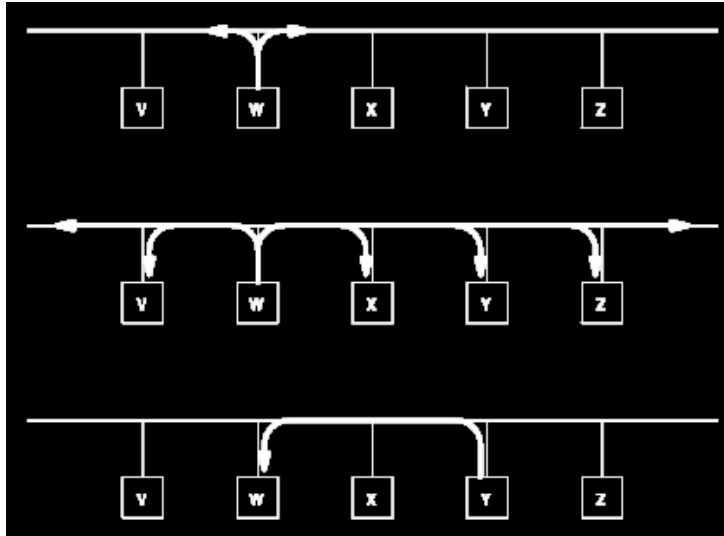
TCP/IP can use any of the three methods. However, to guarantee that all computers agree on the exact format and meaning of messages the suit includes ARP.



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ARP Message Delivery



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ARP Message Format

- ARP protocol is general and can handle any-to-any translation.



IP to Ethernet ARP message format

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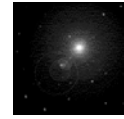
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Sending ARP Message

- Encapsulation (in Ethernet Frame)



| | | | | |
|-------------------------------|-----------|-------------------------------|----|----|
| 0 | 8 | 16 | 24 | 31 |
| HARDWARE ADDRESS TYPE | | PROTOCOL ADDRESS TYPE | | |
| HADDR LEN | PADDR LEN | OPERATION | | |
| SENDER HADDR (first 4 octets) | | | | |
| SENDER HADDR (last 2 octets) | | SENDER PADDR (first 2 octets) | | |
| SENDER PADDR (last 2 octets) | | TARGET HADDR (first 2 octets) | | |
| TARGET HADDR (last 4 octets) | | | | |
| TARGET PADDR (all 4 octets) | | | | |

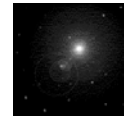


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Caching ARP Address

- 1 communication = 3 messages (2 ARPs)
- Caching is done:
 - but only in memory.
 - ARP maintains a small memory
 - Entries are deleted if not used for more than 20 min.
 - For new address oldest is removed.

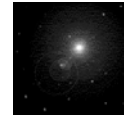


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Processing ARP message

- ARP specifies the following actions for the receiver of ARP messages:
 - Extract senders address binding. Update own cache only if it is there.
 - Check the OPERATION field. Request or response?
 - If response, (the receiver must be the target), add the entry.
 - If request, check TARGET PAADR, if this is the target send ARP response.
 - Reverse sender & target fields. Insert own physical address in SENDER HADDR.
 - After sending, if the receiver is target, add the senders binding in own cache.



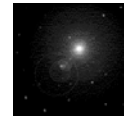
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Why broadcast receivers don't record the senders binding?

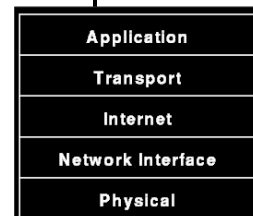
Why only target receivers record it?

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