Internet Protocol (IP): Addressing and Forwarding
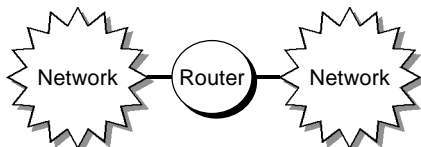
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Overview

❑ **Internetworking**
❑ **IP Address format**
❑ **IP data forwarding**
Ref: RFC 791, Chap 1, 3

Internetworking

❑ **Internetwork = Collection of networks**
Connected via routers

Network — Router — Network

Internet = Virtual Network
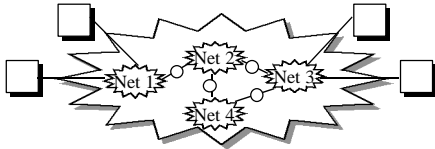❑ **Any computer can talk to any other computer**

Fig 13.3

How does IP forwarding work ?

❑ **A)** *Source & Destination in same network (fig 3.3 in text)*

  ❑ Recognize that destination IP address is on same network. [1]

  ❑ Find the destination LAN address. [2]

  ❑ Send IP packet encapsulated in LAN frame directly to the destination LAN address.

    ❑ Encapsulation => source/destination IP addresses don't change

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IP forwarding (contd)

❑ **B)** *Source & Destination in different networks (fig 3.4 in text)*

  ❑ Recognize that destination IP address is not on same network. [1]

  ❑ Look up destination IP address in a (routing) table to find a match, called the next hop router IP address.

  ❑ Send packet encapsulated in a LAN frame to the LAN address corresponding to the IP address of the next-hop router. [2]

Addressing & Resolution

- *[1] How to find if destination is in the same network ?*
  - **IP address = network ID + host ID.** *Source and destination network IDs match => same network*
  - **Splitting address into multiple parts is called hierarchical addressing**
- *[2]: How to find the LAN address corresponding to an IP address ?*
  - **Address Resolution Problem.**
  - **Solution: ARP, RARP (next chapter)**

Route Table Lookup

- **Intermediate routers lookup only the destination network-ID,**
  - **Deliver datagrams to next-hop and finally to destination network, not to host directly**
  - **Hierarchical forwarding: routing tables scale.**

Net 1 — R1 — Net 2 — R2 — Net 3 — R3 — Net 4

Table at R2:

Destination	Next Hop
Net 1	Forward to R1
Net 2	Deliver Direct
Net 3	Deliver Direct
Net 4	Forward to R3

IP Address Formats

- Class A:

0 Network	Host
1 7	24 bits

- Class B:

10 Network	Host
2 14	16 bits

- Class C:

110 Network	Host
3 21	8 bits

- Class D:

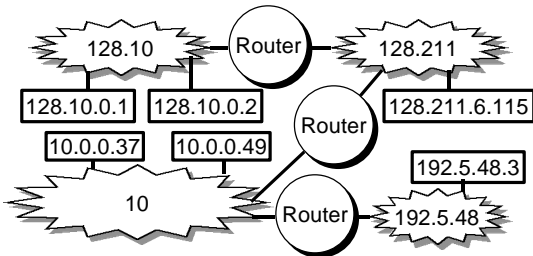| 1110 Multicast Group addresses |
|---|
| 4   28   bits |

- Class E: Reserved.

Router   Router

Dotted Decimal Notation

❑ **Binary: 11000000 00000101 00110000
00000011
Hex Colon: C0:05:30:03
Dotted Decimal: 192.5.48.3**

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

Also see fig 1.6, 1.7 in text

An Addressing Example

128.10 Router 128.211

128.10.0.1 128.10.0.2 Router 128.211.6.115

10.0.0.37 10.0.0.49

192.5.48.3

10 Router 192.5.48

❑ **All hosts on a network have the same
network prefix (I.e. network ID)**

Some special IP addresses

❑ **All-0s ⇒ This computer**
❑ **All-1s ⇒ All hosts on this net (*limited
broadcast*: *don't forward out of this net*)**

❑ **All-0 *host suffix* ⇒ Network Address ('*0*' means
'*this*')**
❑ **All-1 *host suffix* ⇒ All hosts on the destination
net (directed broadcast).**

❑ **127.*.*.* ⇒ Loopback through IP layer**
❑ **Further classification in fig 3.9 of text**

Subnet Addressing

❑ **Classful addressing inefficient: Everyone wants class B addresses**

❑ **Can we split class A, B addresses spaces and accommodate more networks ?**

  ❑ **Need another level of hierarchy. Defined by "subnet mask" (eg: fig 3.5)**

  ❑ **External routers send to "network" specified by the "network ID" and have smaller routing tables**

Subnet Addressing (Contd)

❑ **Internal routers & hosts use subnet mask to identify "subnet ID" and route packets between "subnets" within the "network".**

❑ **Eg: Mask: 255.255.255.0 => subnet ID = 8 bits with upto 62 hosts/subnet**

❑ **Route table lookup:**

  ❑ **IF ((Mask[i] & Destination Addr) = = Destination[i])**
    Forward to **NextHop[i]**

Route Table Lookup: Example

30.0.0.7	40.0.0.8	128.1.0.9
30.0.0.0	40.0.0.0	128.1.0.0	192.4.0.0
40.0.0.7	128.1.0.8	192.4.10.9
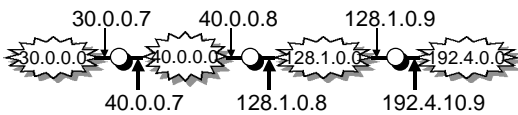
Destination	Mask	Next Hop
30.0.0.0	255.0.0.0	40.0.0.7
40.0.0.0	255.0.0.0	Deliver direct
128.1.0.0	255.255.0.0	Deliver direct
192.4.10.0	255.255.255.0	128.1.0.9

Summary

□ **Addressing:**

□ **Unique IP address per interface**

□ **Classful (A,B,C) => address allocation not efficient**

□ **Hierarchical => smaller routing tables**

□ **Provision for broadcast, multicast, loopback addresses**

□ **Subnet masks allow "subnets" within a "network" => improved address allocation efficiency**

□ **Problem: Host moves between networks => IP address changes.**

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Summary (contd)

□ **Forwarding:**

□ **Simple *"next-hop"* forwarding.**

□ **Last hop forwards directly to destination**

□ ***Best-effort delivery :* No error reporting. Delay, out-of-order, corruption, and loss possible => problem of higher layers!**

□ **Forwarding vs routing: Routing tables setup by separate algorithm (s)**

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UNIX networking commands

*Section 1, tools and commands. (* denotes most relevant)*

□ **telnet   telnet (1)   - user interface to a remote system using the TELNET protocol**

□ **ftp   ftp (1)   - file transfer program**

□ **tftp   tftp (1)   - trivial file transfer program**

□ ***ifconfig   ifconfig (1m)   - configure network interface parameters**

□ **in.rdisc   in.rdisc (1m)   - network router discovery daemon**

□ ***in.routed   in.routed (1m) - network routing daemon**

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UNIX Networking commands

- ❏ *netstat   netstat (1m)   - show network status
- ❏ *ping   ping (1m)   - send ICMP
  ECHO_REQUEST packets to network hosts
- ❏ snoop   snoop (1m)   - capture and inspect
  network packets
- ❏ nslookup   nslookup (1m) - query name servers
  interactively
- ❏ *tcpdump   tcpdump (1)   - dump traffic on a
  network
- ❏ *route   route (1m)   - manually manipulate the
  routing tables
- ❏ in.named   in.named (1m) - Internet domain name
  server

UNIX networking commands

- ❏ in.tftpd   in.tftpd (1m) - Internet Trivial File
  Transfer Protocol server
- ❏ tftpd   in.tftpd (1m) - Internet Trivial File
  Transfer Protocol server
- ❏ whois   whois (1)   - Internet user name
  directory service
- ❏ *inetd   inetd (1m)   - Internet services daemon
- ❏ *arp   arp (1m)   - address resolution display
  and control

*Section 4, related configuration files (All are pretty
  relevant)*

- ❏ netconfig   netconfig (4)   - network configuration
  database

UNIX Networking commands

- ❏ netmasks   netmasks (4)   - network mask
  database
- ❏ networks   networks (4)   - network name
  database
- ❏ routing   routing (4)   - system support for packet
  network routing
- ❏ services   services (4)   - Internet services and
  aliases
- ❏ protocols   protocols (4) - protocol name database
- ❏ inetd.conf   inetd.conf (4) - Internet servers
  database
- ❏ nsswitch.conf nsswitch.conf (4) - configuration file
  for the name service switch

UNIX Networking commands

❑ **bootparams: bootparams (4) - boot parameter data base**

Section 7, protocol description. (All are pretty relevant)

❑ ***ICMP icmp (7p) - Internet Control Message Protocol**

❑ ***IP   ip (7p)   - Internet Protocol**

❑ ***TCP   tcp (7p)   - Internet Transmission Control Protocol**

❑ ***UDP   udp (7p)   - Internet User Datagram Protocol**

❑ ***if_tcp   if_tcp (7p)   - general properties of Internet Protocol network interfaces**

❑ ***inet   inet (7p)   - Internet protocol family**

❑ ***arp   arp (7p)   - Address Resolution Protocol**