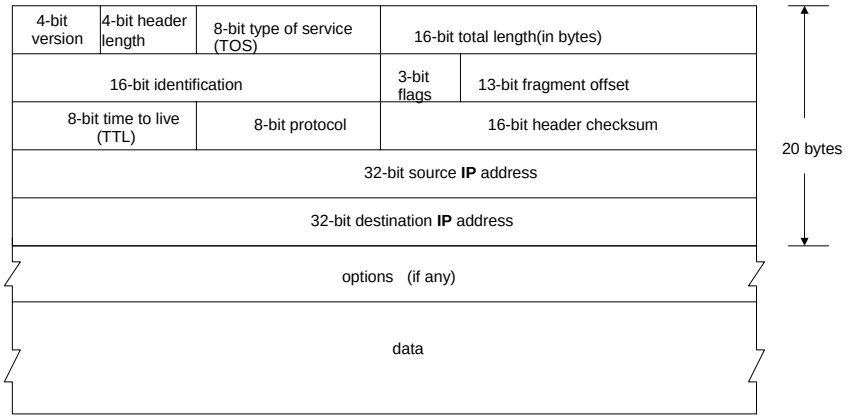
Chapter 3:
IP: INTERNET PROTOCOL

IP: Internet Protocol

- **Introduction**
  - Unreliable
  - Connectionless
- **IP header**
- **IP routing**
- **Subnetting**

IP Header



Recommended Values for TOS Field

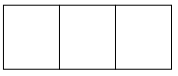
Application	Minimize delay	Maximize throughput	Maximize reliability	Minimize monetary cost	Hex value
Telnet/Rlogin	1	0	0	0	0X10
FTP					
control	1	0	0	0	0X10
data	0	1	0	0	0X08
any bulk data	0	1	0	0	0X08
TFTP	1	0	0	0	0X10
SMTP					
command phase	1	0	0	0	0X10
data phase	0	1	0	0	0x08
DNS					
UDP query	1	0	0	0	0X10
TCP query	0	0	0	0	0X00
zone transfer	0	1	0	0	0X08
ICMP					
error	0	0	0	0	0X00
query	0	0	0	0	0X00
any IGP	0	0	1	0	0X04
SMNP	0	0	1	0	0X04
BOOTP	0	0	0	0	0X00
NNTP	0	0	0	1	0X02

TOS Precedence Field

- **Precedence**
  - 111: Network Control
  - 110: Internetwork Control
  - 101: CRITIC/ECP
  - 100: Flash Override
  - 011: Flash
  - 010: Immediate
  - 001: Priority
  - 000: Routine

3-Bit Flag Field

- **Bit 0:**
  - reserved, must be zero
- **Bit 1:**
  - 0 = may fragment, 1 = cannot fragment
- **Bit 2:**
  - 0 = last fragment, 1 = more fragment



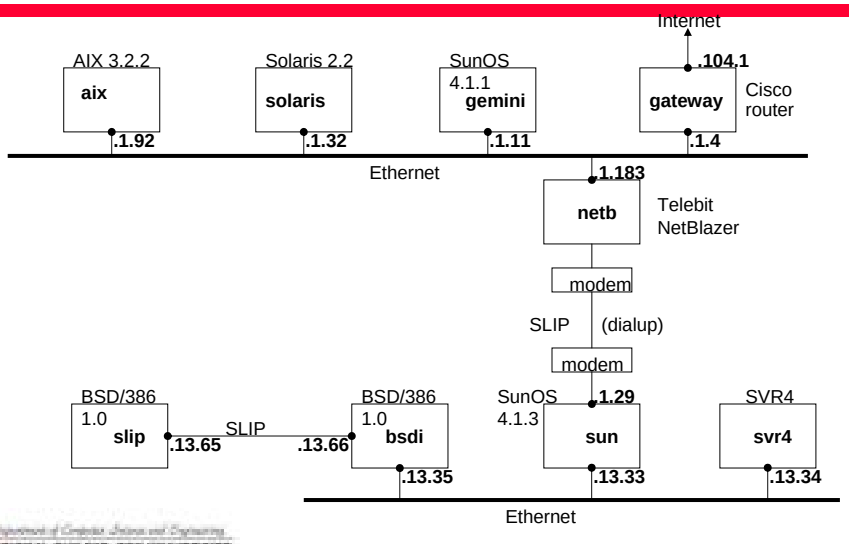
Routing Table

- **Destination IP address**
- **IP address of a *next-hop router* or the IP address of a directly connected network.**
- **Flags**
  - Specifies whether the destination IP address is the address of a network or the address of a host.
  - Say whether the next-hop router field is really a next-hop router or a directly connected interface.
- **Specification of which network interface the datagram should be passed to for transmissions.**

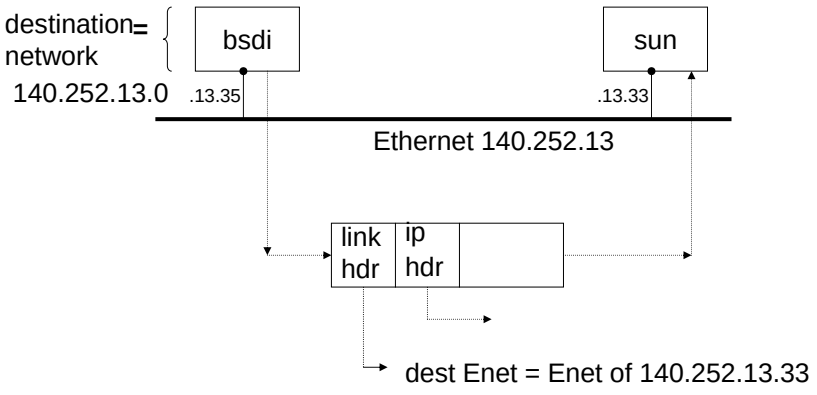
IP Routing Actions

- **Search the routing table for an entry that matches the complete destination IP address (matching network ID and host ID).**
- **Search the routing table for an entry that matches just the destination network ID.**
- **Search the routing table for an entry labeled "default".**
- **Remarks:**
  - A complete matching host address is searched for before a matching network ID.
  - Another fundamental feature of IP routing:
    - Only to specify a route to a network, rather than specifying a route to every host.

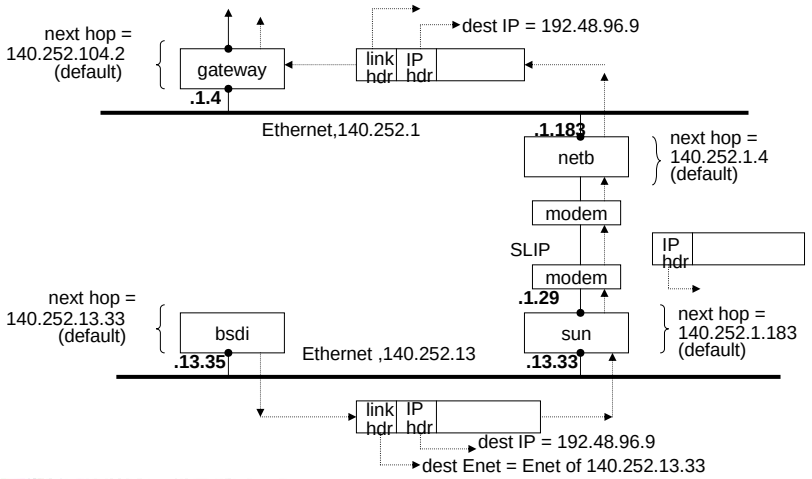
Network Topology



Delivery of IP Datagram from *bsdi* to *sun*

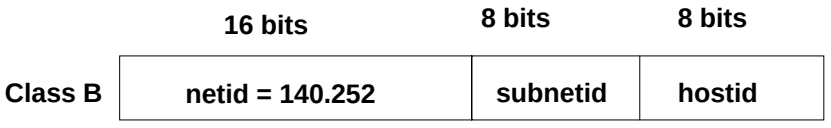


Path from *bsdi* to *ftp.uu.net* (192.48.96.9)

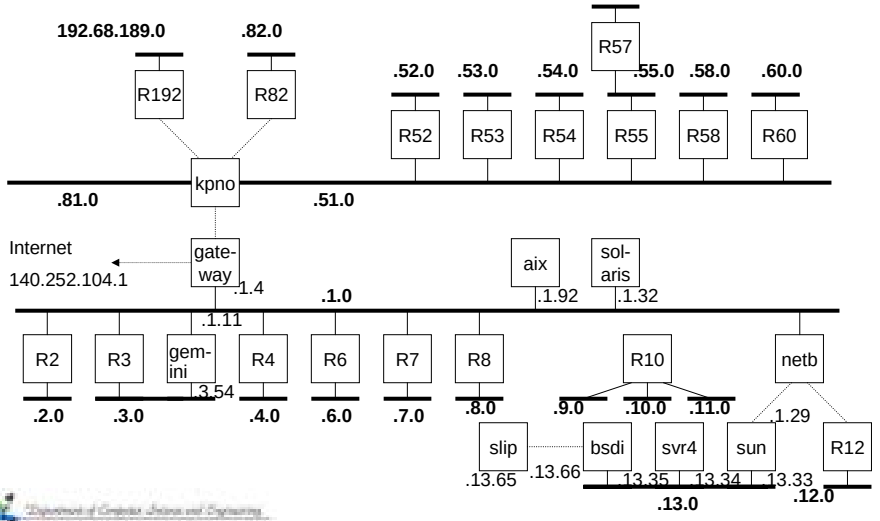


Subnetting a Class B Address

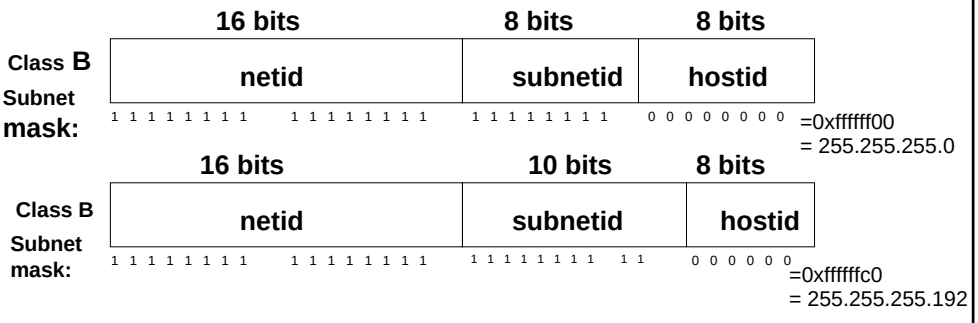
- The host ID portion is divided into a subnet ID and a host ID.
- The subnet boundary for a class A or class B address is ***NOT*** necessary on a byte boundary.
- Subnetting hides the detail of internal network organization to external routers.
- Comparing 30 class C addresses to a single class B address with 30 subnets:
  - Subnetting reduces the size of the Internet's routing tables.
- Subnetting is not transparent to routers within the subnet.



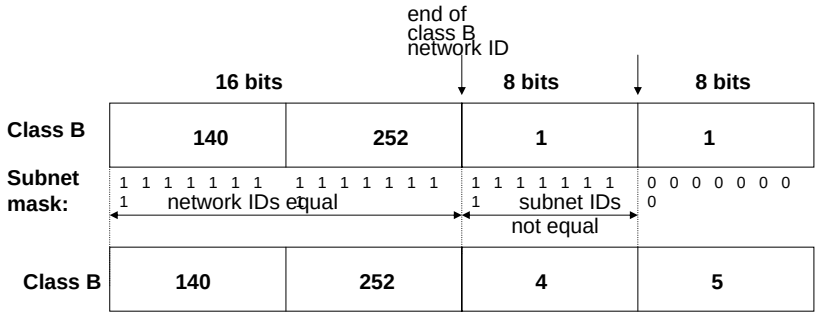
Example of Subnetting (140.252 Subnets)



Subnet Mask



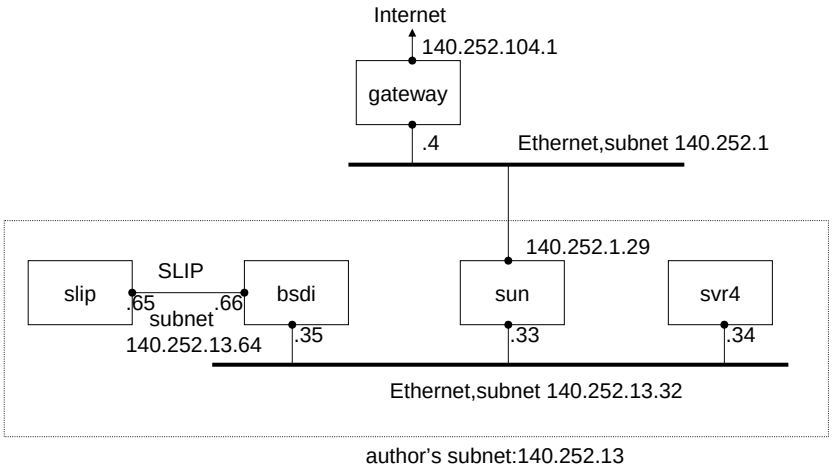
Comparison of Two Class B Addresses



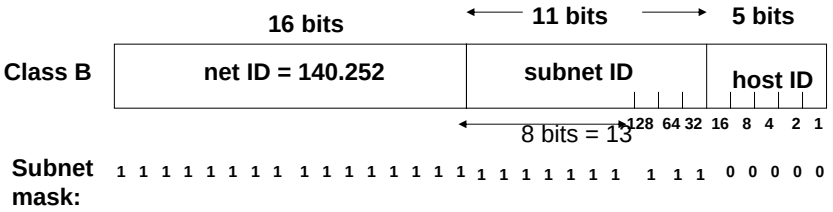
Special Case IP Addresses

IP address			Can appears as		Description
net ID	subnet ID	host ID	source ?	destination?	
0		0	OK	never	this host on this net (see restrictions below)
0		hostid	OK	never	Specified host on this net (see restrictions below)
127		anything	OK	OK	loopback address (Section 2.7)
-1		-1	never	OK	
netid		-1	never	OK	
netid	subnetid	-1	never	OK	
netid	-1	-1	never	OK	

A Subnet Example



Variable-Length Subnet



IP Addresses on Textbook

Host	IP address	Subnet mask	Net ID / Subnet ID	Host ID	Comment
sun	140.252.1.29 140.252.13.33	255.255.255.0 255.255.255.254	140.252.1 140.252.13.32	29 1	on subnet 1 on author's Ethernet
svr4	140.252.13.34	255.255.255.224	140.252.13.32	2	
bsdi	140.252.13.35 140.252.13.66	255.255.255.224 255.255.255.224	140.252.13.32 140.252.13.64	3 2	on Ethernet point-to-point
slip	140.252.13.65	255.255.255.224	140.252.13.64	1	point-to-point
	140.252.13.63	255.255.255.224	140.252.13.32	32	broadcast addr on Ethernet

3 Problems with IP

- Over half of all Class B addresses have already been allocated.
- 32-bit IP addresses in general are inadequate for the predicted long-term growth of the Internet.
- Routing structure is not hierarchical, but flat, requiring one routing table entry per network.

Solutions

- **SIP, the Simple Internet Protocol.**
  - 64-bit IP address and a different header format
- **PIP.**
- **TUBA, “TCP and UDP with Bigger Addresses”**
- **TP/IX: RFC 1475.**