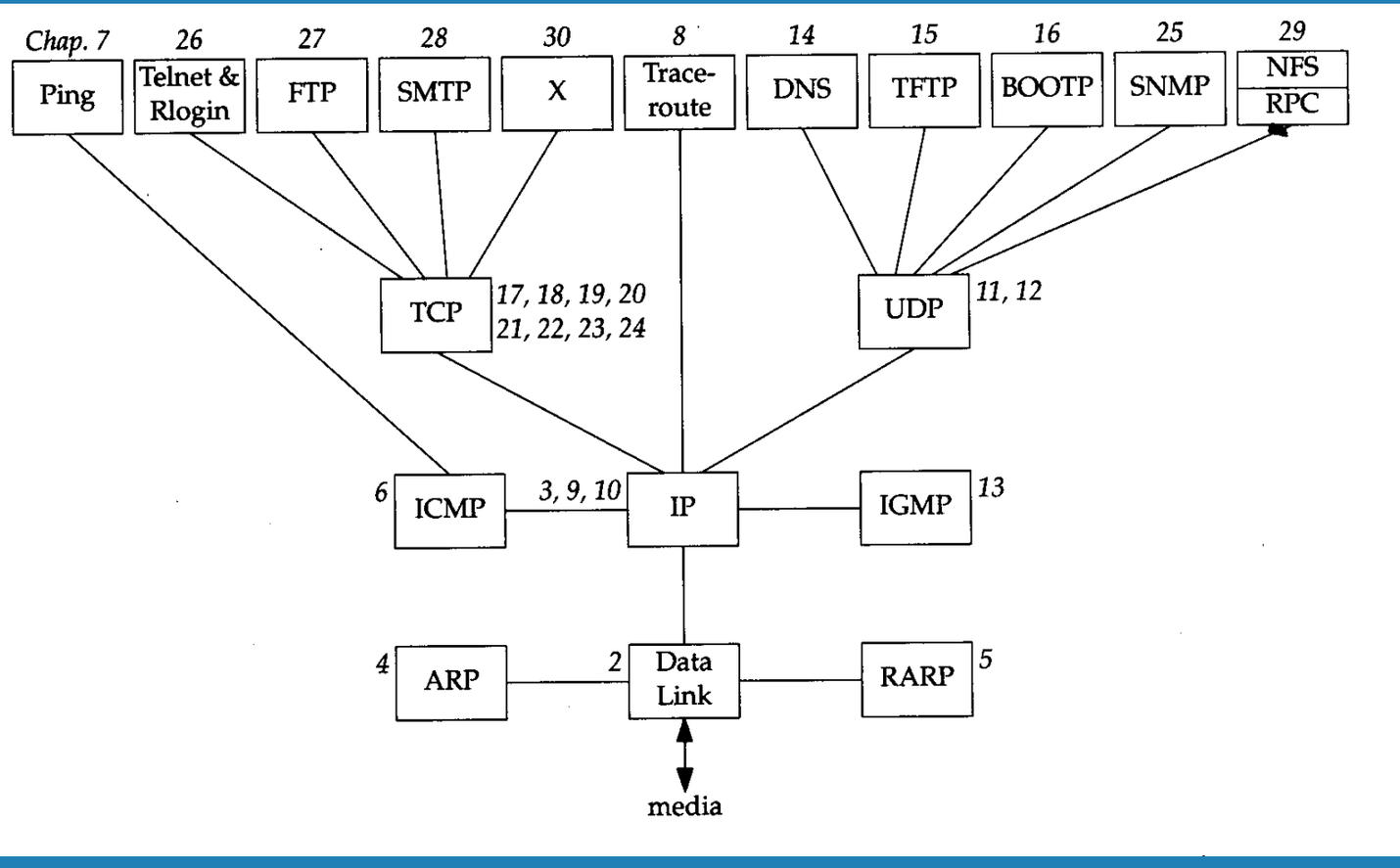
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SMTP
X
Trace-route
DNS
TFTP
BOOTP
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21, 22, 23, 24
UDP
11, 12
6
ICMP
3, 9, 10
IP
IGMP
13
4
ARP
2
Data Link
RARP
5
media

Layering

- Client/Server Model
- Routers/Gateways
- Multihomed

TCP/IP Overview

- Addressing
- The Domain Name System
- Demultiplexing
- Implementations (BSD4.4)

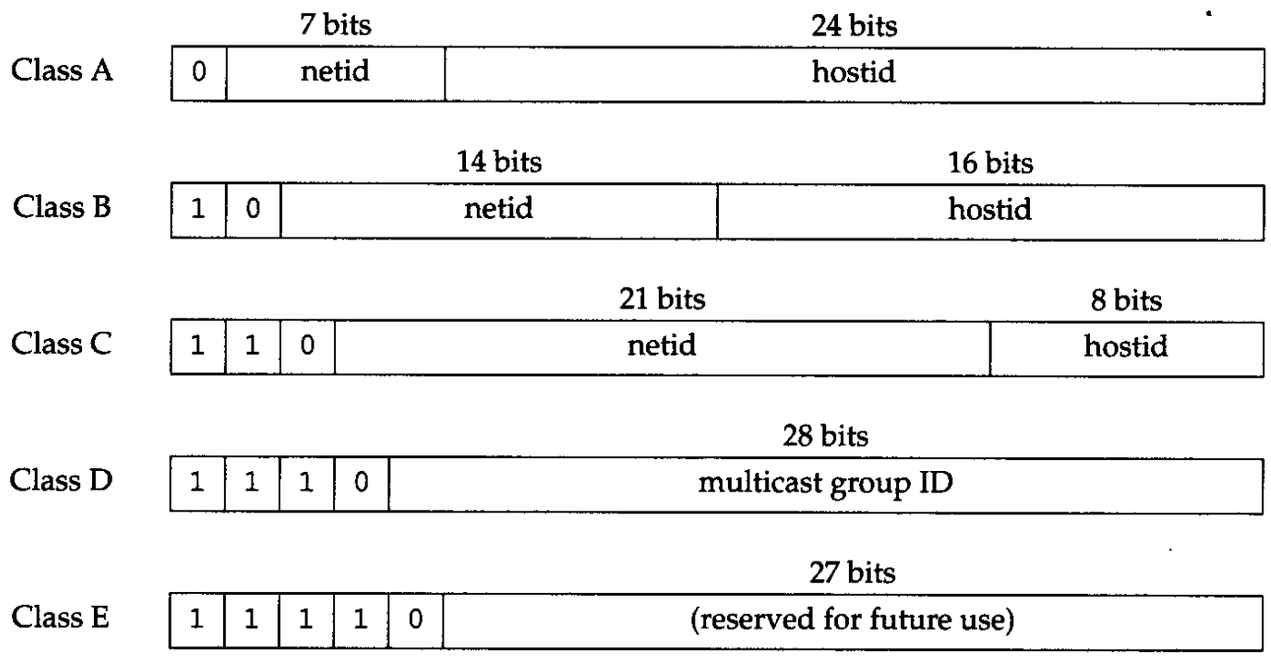


Figure 1.5 The five different classes of Internet addresses.

Class	Range
A	**0**.0.0.0 to **127**.255.255.255
B	**128**.0.0.0 to **191**.255.255.255
C	**192**.0.0.0 to **223**.255.255.255
D	**224**.0.0.0 to **239**.255.255.255
E	**240**.0.0.0 to **247**.255.255.255

Figure 1.6 Ranges for different classes of IP addresses.

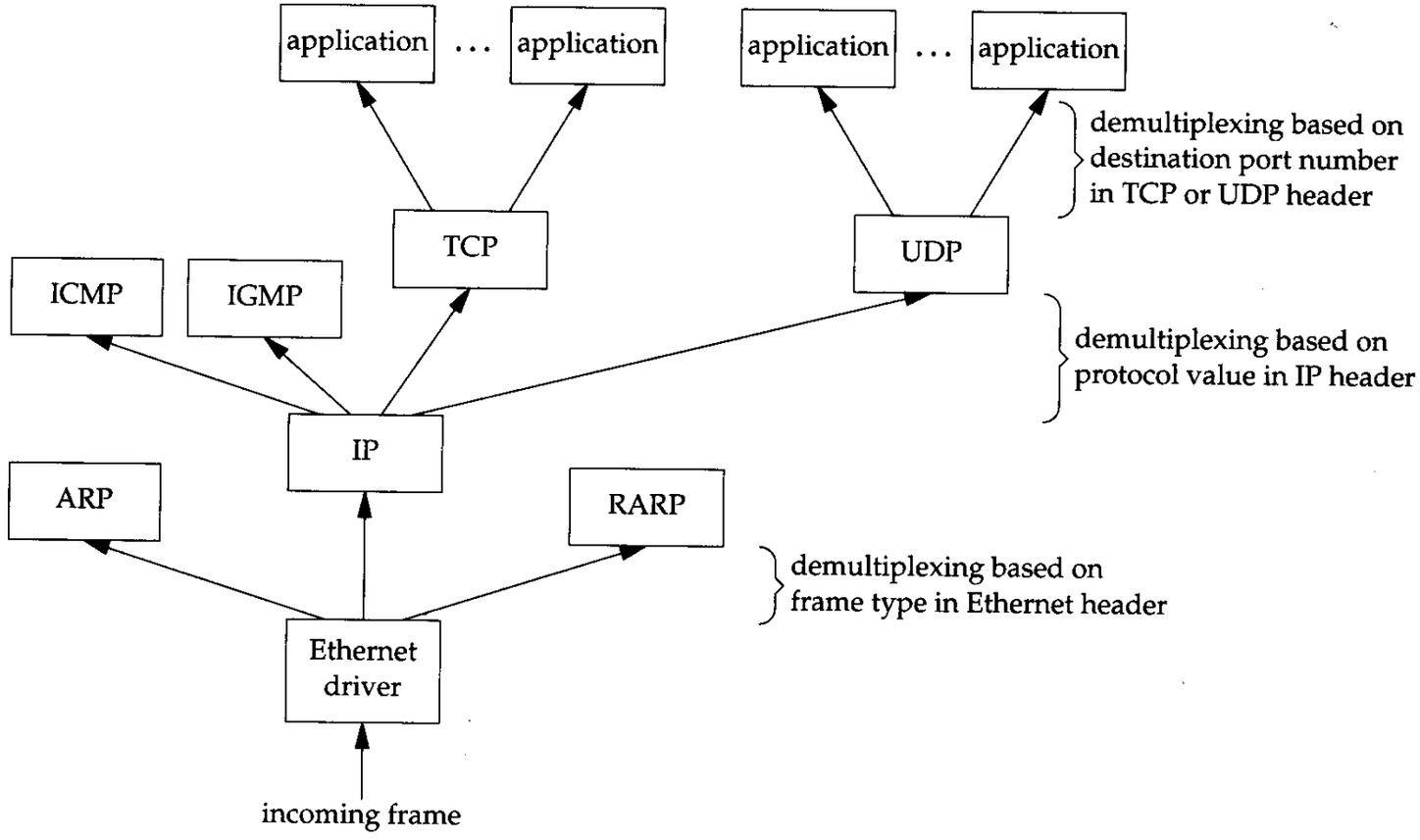


Figure 1.8 The demultiplexing of a received Ethernet frame.

Demultiplexing

- Allows multiple applications to use one network point of entry
- How do we know what port to use?
  => “well-known” ports

“Well-Known” Ports

- On UNIX: look in /etc/services
- Ports 1 - 1023 require superuser/Administrator access to assign (For authentication purposes)
- RFC 1700 provides Internet standard

Request For Comments (RFC)

- Official standards of the Internet Community
- Usually the best place to start
- http://www.pmg.lcs.mit.edu/rfc.html
- E-mail to rfc-info@ISI.EDU

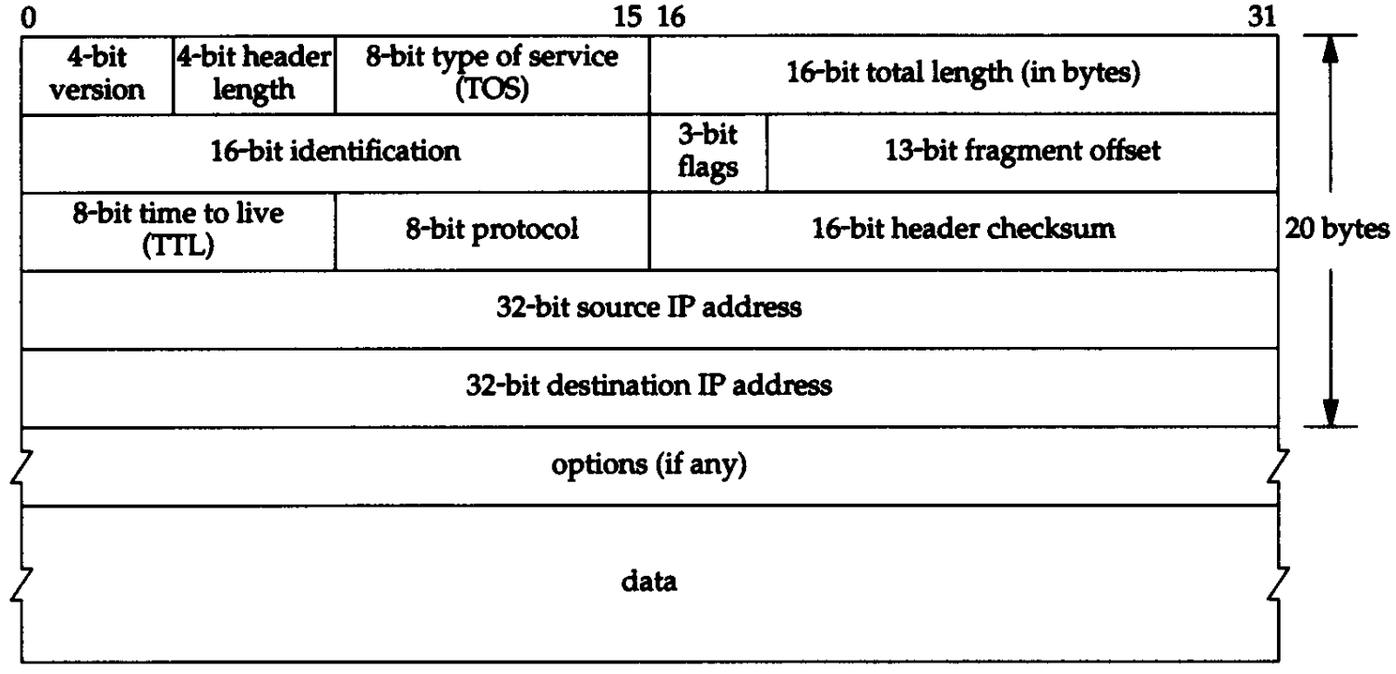
RFCs (cont)

- Also available in ASCII form from ISI (http://info.internet.isi.edu/1/in-notes)
- Published by Internet Engineering Task Force (IETF)

Important RFCs

- Assigned #s RFC: 1700
- Official Protocol Standards: 2200
- Host Requirements: 1122, 2181
- Router Requirements: 1812

IP Header


0
15 16
31
4-bit version
4-bit header length
8-bit type of service (TOS)
16-bit total length (in bytes)
16-bit identification
3-bit flags
13-bit fragment offset
8-bit time to live (TTL)
8-bit protocol
16-bit header checksum
20 bytes
32-bit source IP address
32-bit destination IP address
options (if any)
data

Endian

- Network byte order calls for the MSByte to be sent first. This is referred to as “Big Endian”
- RISC processors commonly used by Macs and UNIX are big endian
- Intel processors use “little endian” and must convert headers and data to network byte order before transmission

IP Header Fields

- Version is either 4 (0100) or 6 (0110)
- Header Length is # of 32-bit words in header including any options
  - 4 bits => Max header size is 60 bytes
  - Normal value is 5 (no options)
- Type of Service is not generally used. (Usually zero)

IP Header Fields (cont)

- Total Length is the total length of the IP packet in bytes
  - Compute length of data using hdr length
  - 16 bits => Max size of IP datagram is 65,535 bytes
  - Most link layers will fragment
  - Necessary with padded link layer frames

IP Header Fields (cont)

- The Identification field generally increments one for each datagram sent
- Used to reassemble fragmented IP packets
- Fragmentation options are provided by the three flag bits
  - First bit is reserved for future use
  - Second bit “on” (1) indicates “Don’t Fragment”
  - Third bit “off” (0) means last fragment

IP Header Fields (cont)

- The TTL field limits the lifetime of the datagram by restricting the number of routers it can pass through
- The protocol field is used for demultiplexing
- The header checksum is a 16-bit one's complement of the sum of each 16 bit segment in the header

IP Header Fields (cont)

- Source and Destination addresses
- Options:
  - security and handling: Specifically used with DoD applications to pass classification level of data (see RFC 1108)
  - record route
  - source routing

IP Routing

- From the host's perspective:
  - If the destination is directly connected (on the same LAN), send the datagram directly to the destination
  - Otherwise send the datagram to the router

IP Routing (cont)

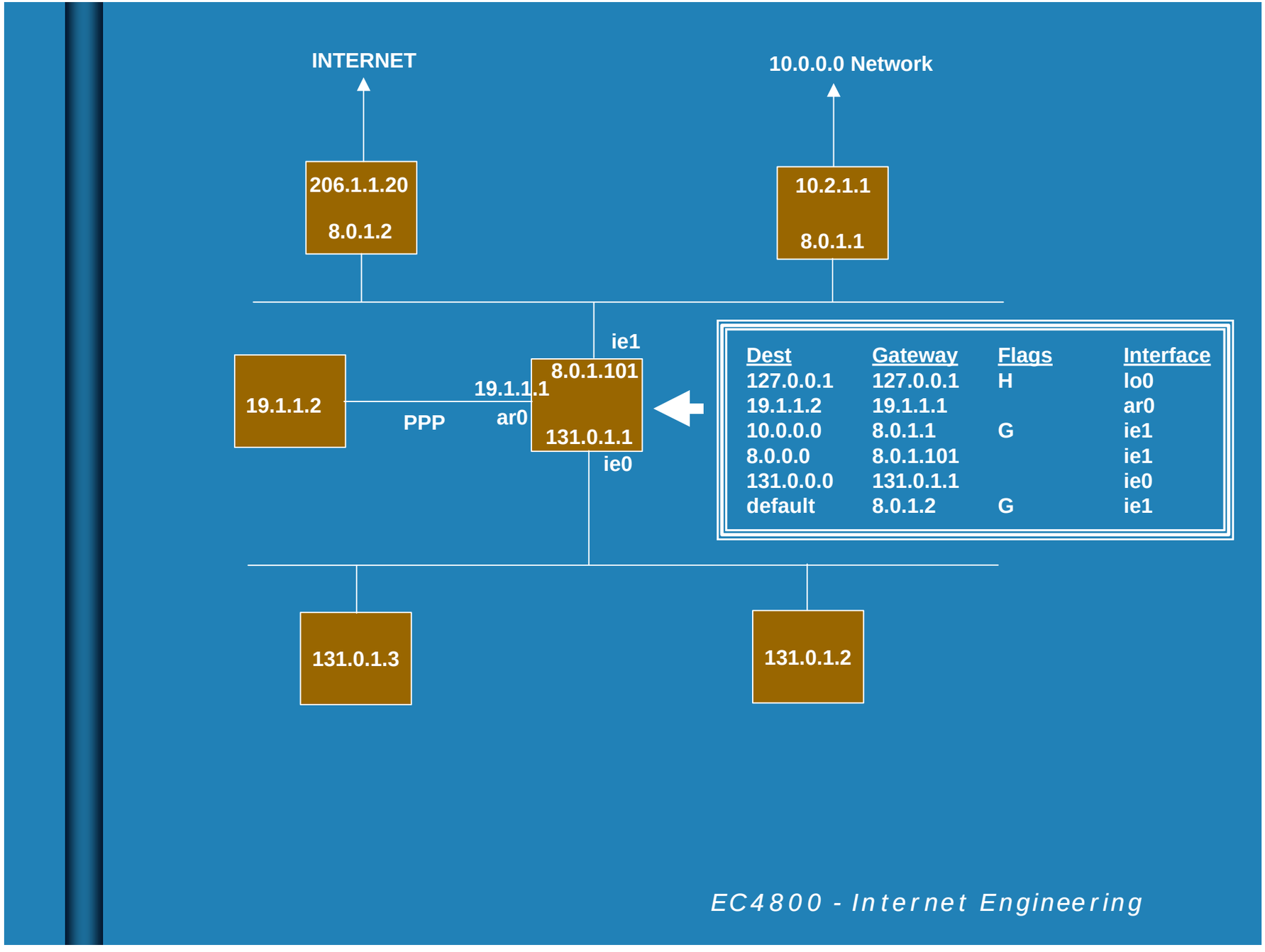
- Routers use a routing table to determine where next to send
- Routing table consists of:
  - Destination host or network address
  - IP address of “next-hop” router
  - Flags that specify what the next-hop router is (e.g. - a host, a router) and if it’s up
  - The interface to transmit out

IP Routing (cont)

- Routing table lookup is performed for each packet generated
- Implies router performance is due in large part to efficiency of lookup algorithm
- No router knows the complete route to the destination

IP Routing Algorithm

- 1. Look for an exact match of incoming IP address within routing table
- 2. Search routing table for a matching network ID
- 3. Search the routing table for a “default” entry
- 4. Return a “host/network unreachable” ICMP packet.


INTERNET
10.0.0.0 Network
206.1.1.20
8.0.1.2
10.2.1.1
8.0.1.1
ie1
8.0.1.101
19.1.1.2
19.1.1.1
PPP
ar0
131.0.1.1
ie0
131.0.1.3
131.0.1.2
Dest Gateway Flags Interface
127.0.0.1 127.0.0.1 H lo0
19.1.1.2 19.1.1.1 ar0
10.0.0.0 8.0.1.1 G ie1
8.0.0.0 8.0.1.101 ie1
131.0.0.0 131.0.1.1 ie0
default 8.0.1.2 G ie1

Subnet Addressing

- Divides the host ID of and IP address into a subnet ID and a host ID
- Not restricted to 8-bit boundary although a common practice
- EC currently 131.120.20.0
- Moving to range of 131.120.96.1 - 131.120.111.255

Subnet Masks

- Allows a host to know whether the destination is:
  - on its own subnet,
  - on a different subnet in its own AS
  - on a different network
- Subnet mask identifies where the boundary is between subnet ID and host ID