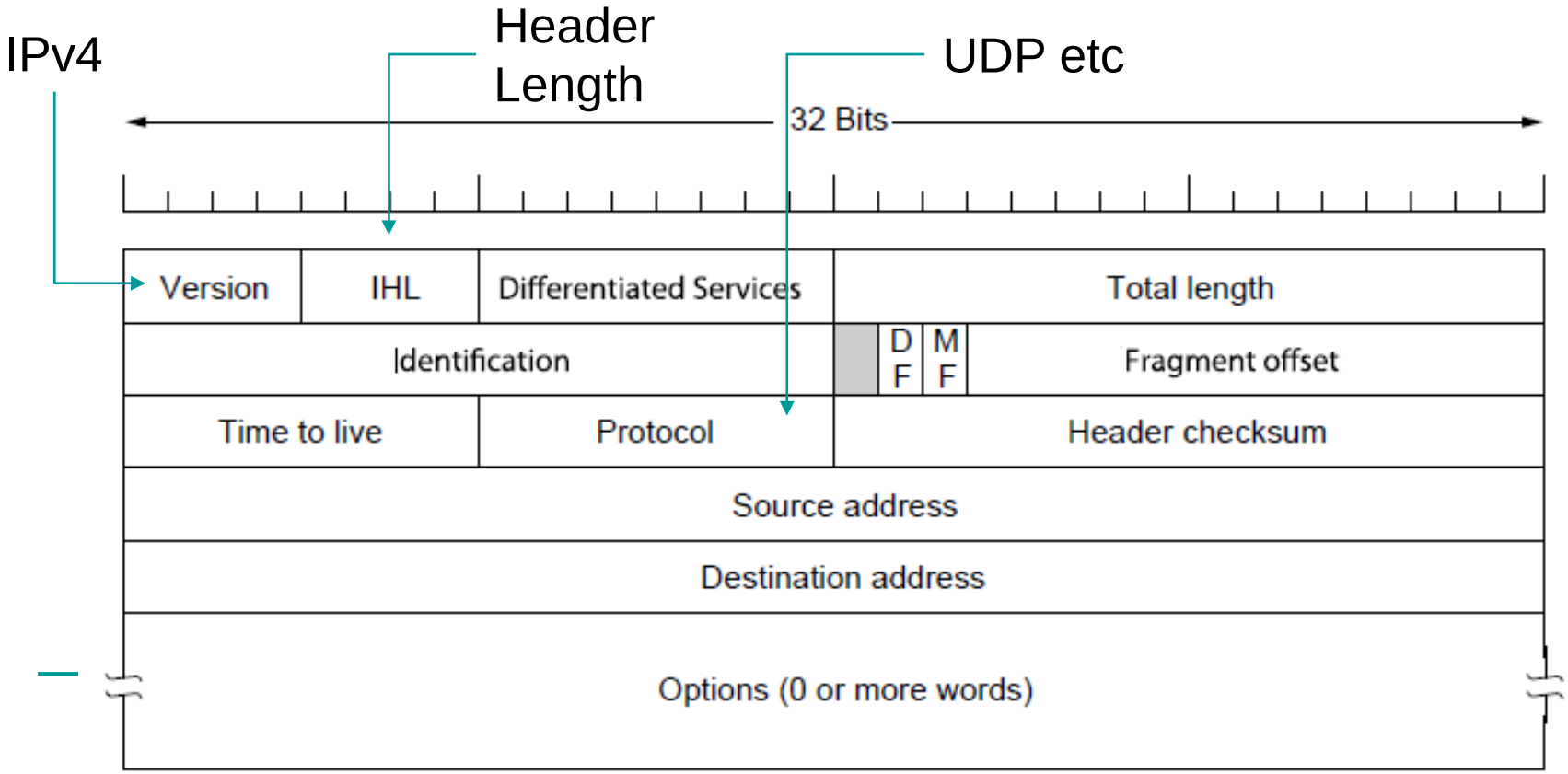
Week 5 – Network Layer (2)

COMP90007

Internet Technologies

IPv4 Datagram Structure (1)

- IPv4 (Internet Protocol) datagram consists of a header and payload
- IPv4 header is carried on all packets and has fields for the key parts of the protocol
- header is 20 byte fixed part + variable length optional part



IPv4 Datagram Structure (2)

- Version: IPv4 or IPv6
- IHL: Header Length – in 32-bit units, min 5 and max is 15
- Differentiated services: different classes of service
- Total Length: header and payload, maximum length 65535 bytes
- Identification: allows host to determine which datagram the new fragment belongs to - all fragments of same datagram have same ID
- DF: Don't Fragment
  - Now it is used as part of the process to discover the path MTU, which is the largest packet that can travel along a path without being fragmented
- MF: More Fragment - are there more or is this the last one ?

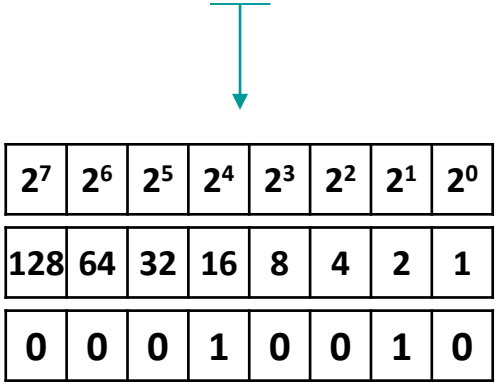
IPv4 Datagram Structure (3)

- Fragment offset: where in the datagram the current fragment belongs
- TTL: limits packet lifetimes - hops or seconds
- Protocol: TCP, UDP, others ...
- Header Checksum: verifies the header only
- Source Address: IP - host/network
- Destination Address: IP - host/network
- Options: e.g. security, strict vs loose source routing, record route, timestamp

IP Addresses (1)

- IP address (IPv4) is 32-bit long, written in dotted decimal notation

  128.18.3.11



2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
0	0	0	1	0	0	1	0

range: 0-255

- Addresses are **hierarchical** and can be allocated in **blocks**

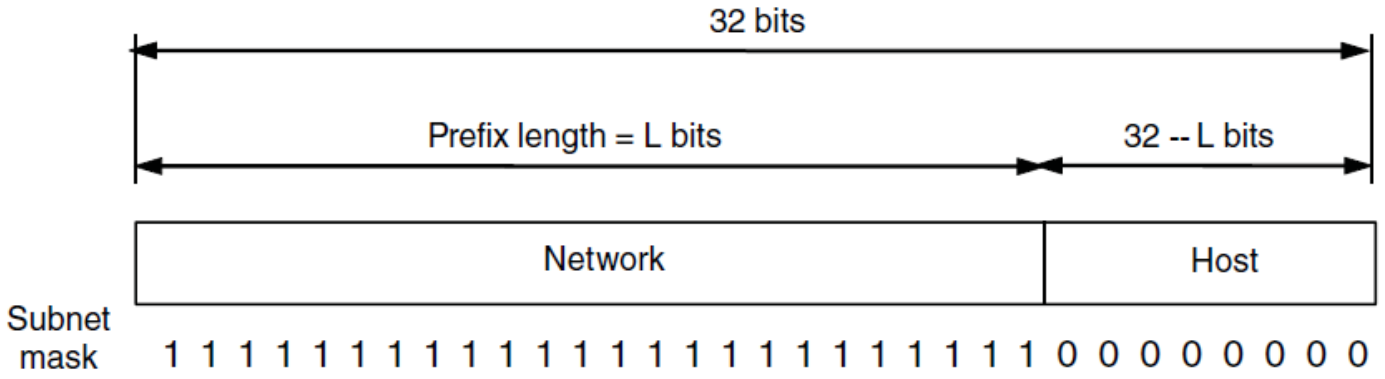
  e.g. 256 addresses in the block 128.18.3.0 – 128.18.3.255
- Overall IP allocation is managed by Internet Corporation for Assigned Names and Numbers (ICANN) by delegation to Internet Assigned Numbers Authority (IANA) and Regional Internet Registries (RIR's)

IP Addresses (2)

- network portion + host portion
- **Prefix:** determined by the network portion, all hosts on a single network has the same network portion.

  prefix is written as: lowest address/bit-length

  18.2.31.0/24, 18.2.0.0/16
- **Subnet mask**: all 1s in the network portion
- **Extract** prefix: ANDed the IP address with the subnet mask



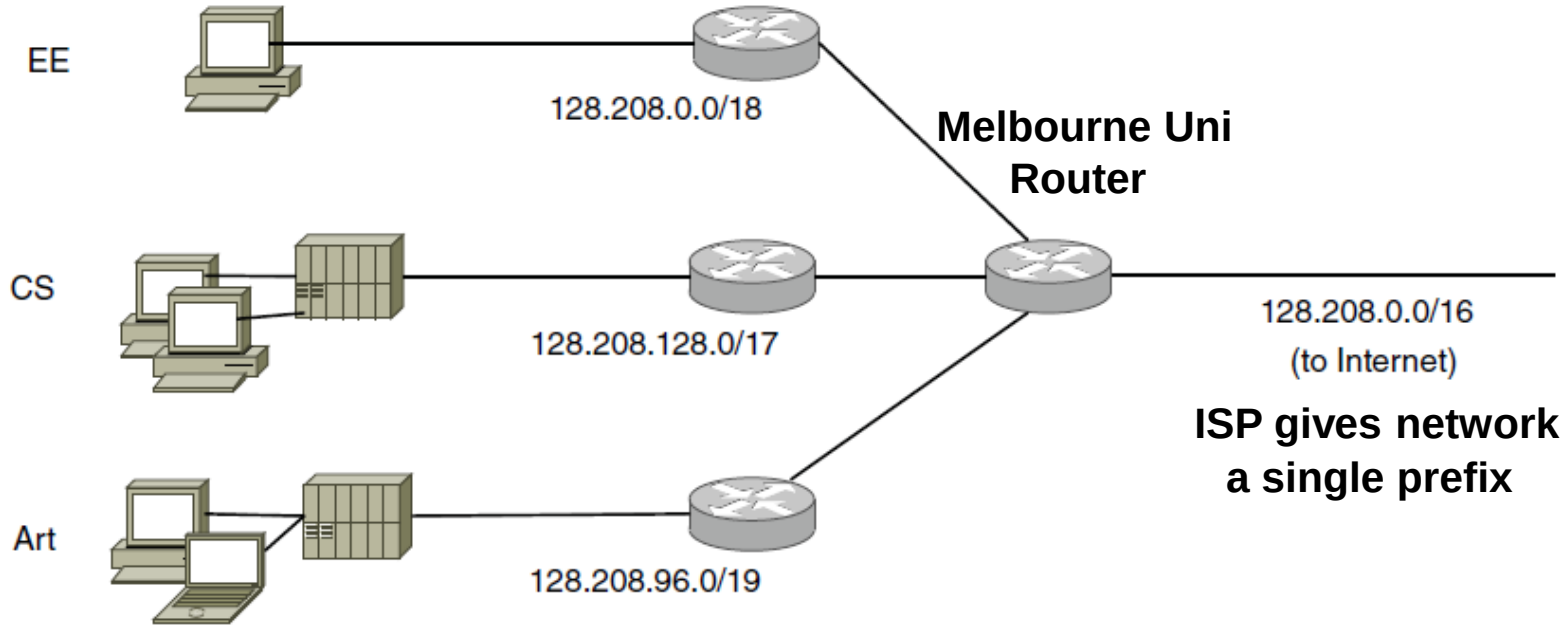
IP Addressing and Routing Tables

- Routing tables are typically built on a triplet:
  - IP Address
  - Subnet Mask
  - Outgoing Line (physical or virtual)
- Example: A row of a routing table:

Prefix Address	Subnet Mask	Interface
203.32.8.0	255.255.255.0	Eth 0

Subnets (1)

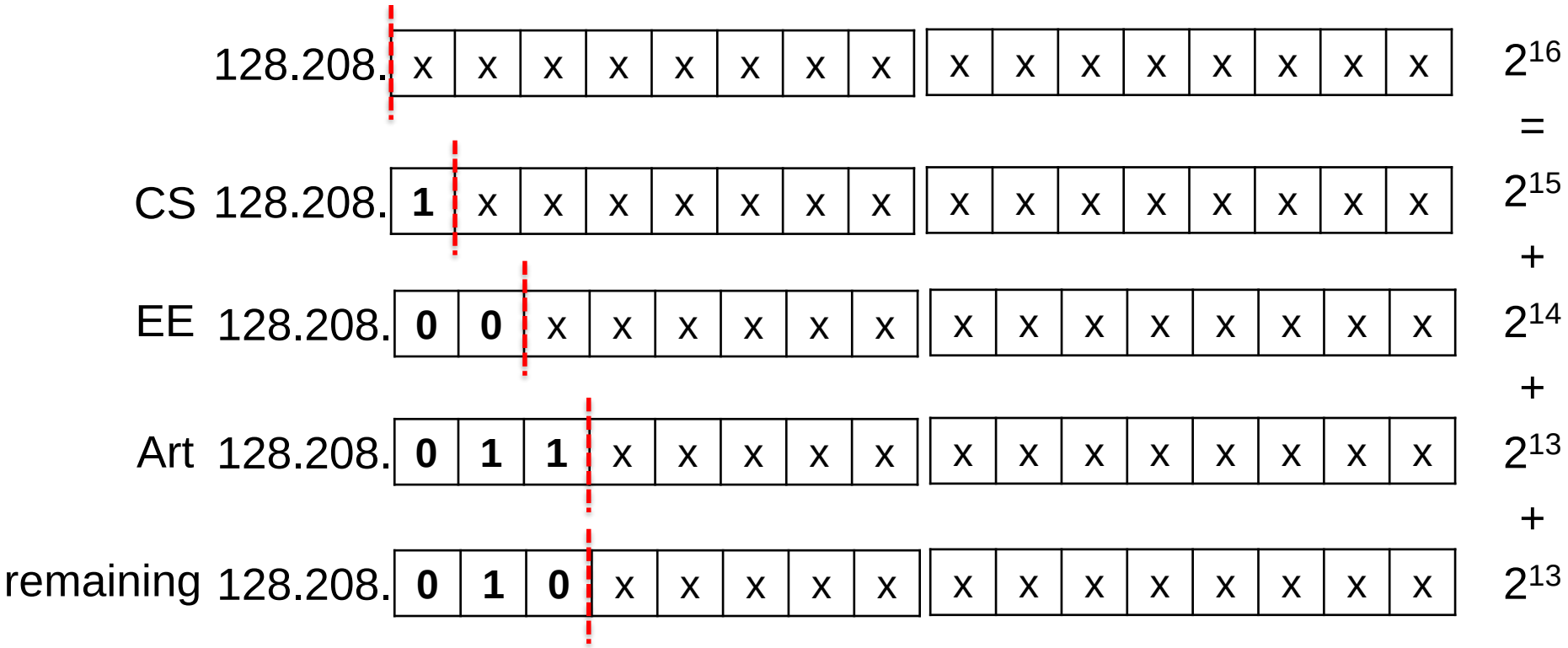
- Subnetting allows networks to be split into several parts for internal uses whilst acting like a single network for external use
- Looks like a single prefix outside the network



Network is divides into subnets internally

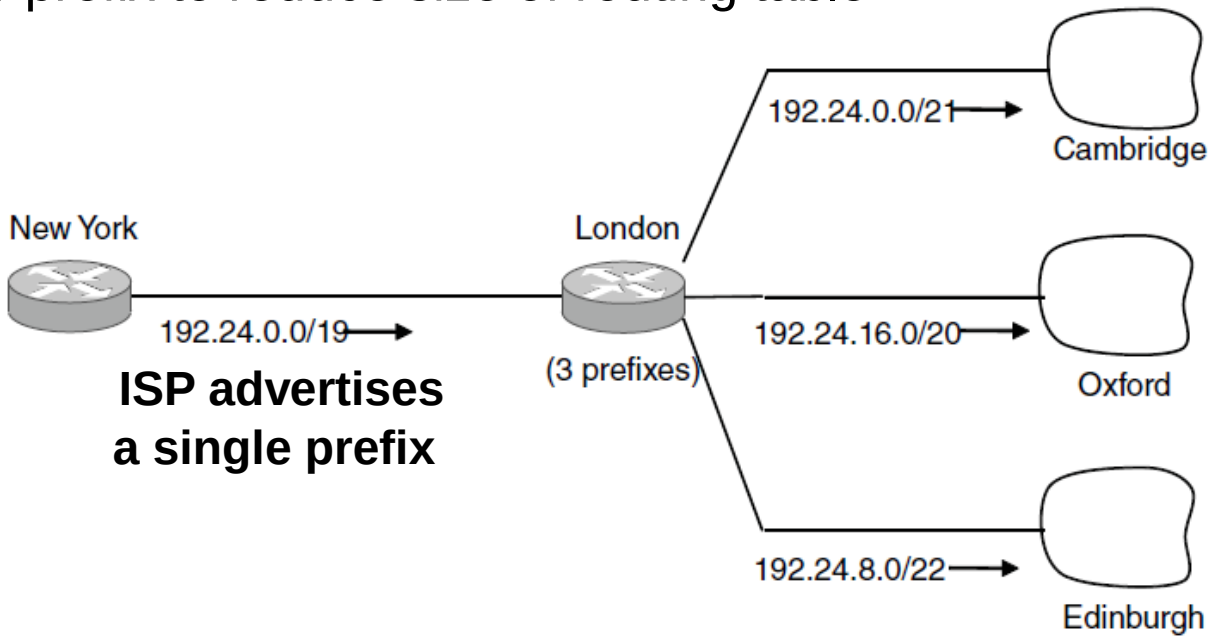
Subnets (2)

128.208.0.0/16 → number of addresses 2^{16}



Aggregation of IP Addresses

- Backbone router connecting networks around the world → 300k networks
- Search all outgoing lines for each incoming packet?
- Aggregation: process of joining multiple IP prefixes into a single larger prefix to reduce size of routing table



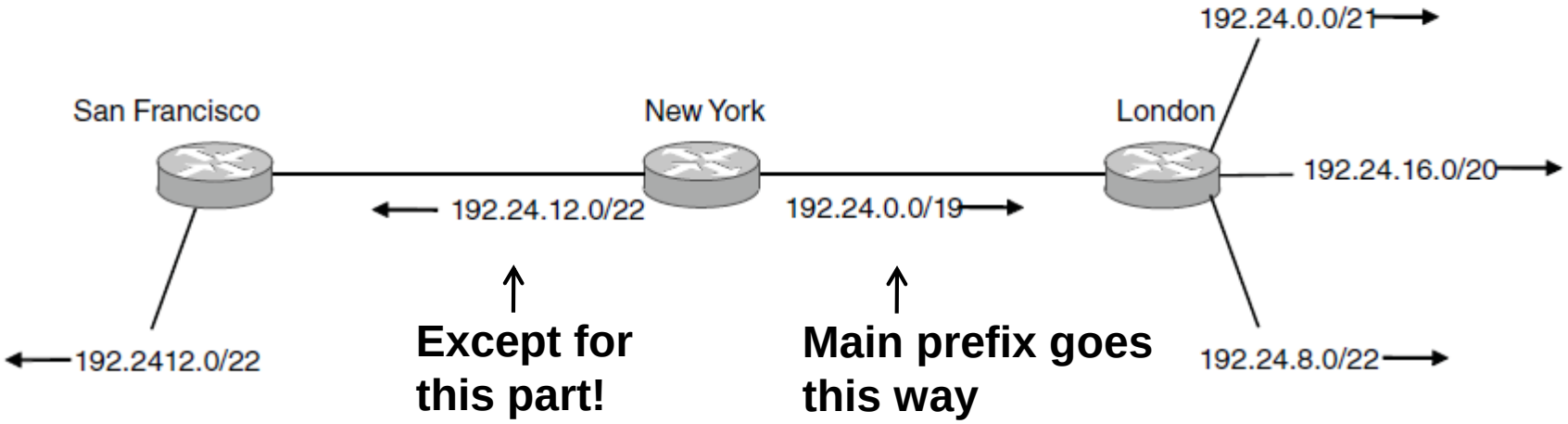
ISP customers have different prefixes

Longest Matching Prefix

- Packets are forwarded to the entry with the longest matching prefix or smallest address block
- Complicates forwarding but adds flexibility

  1) Check address whether matches the longest prefix → /22

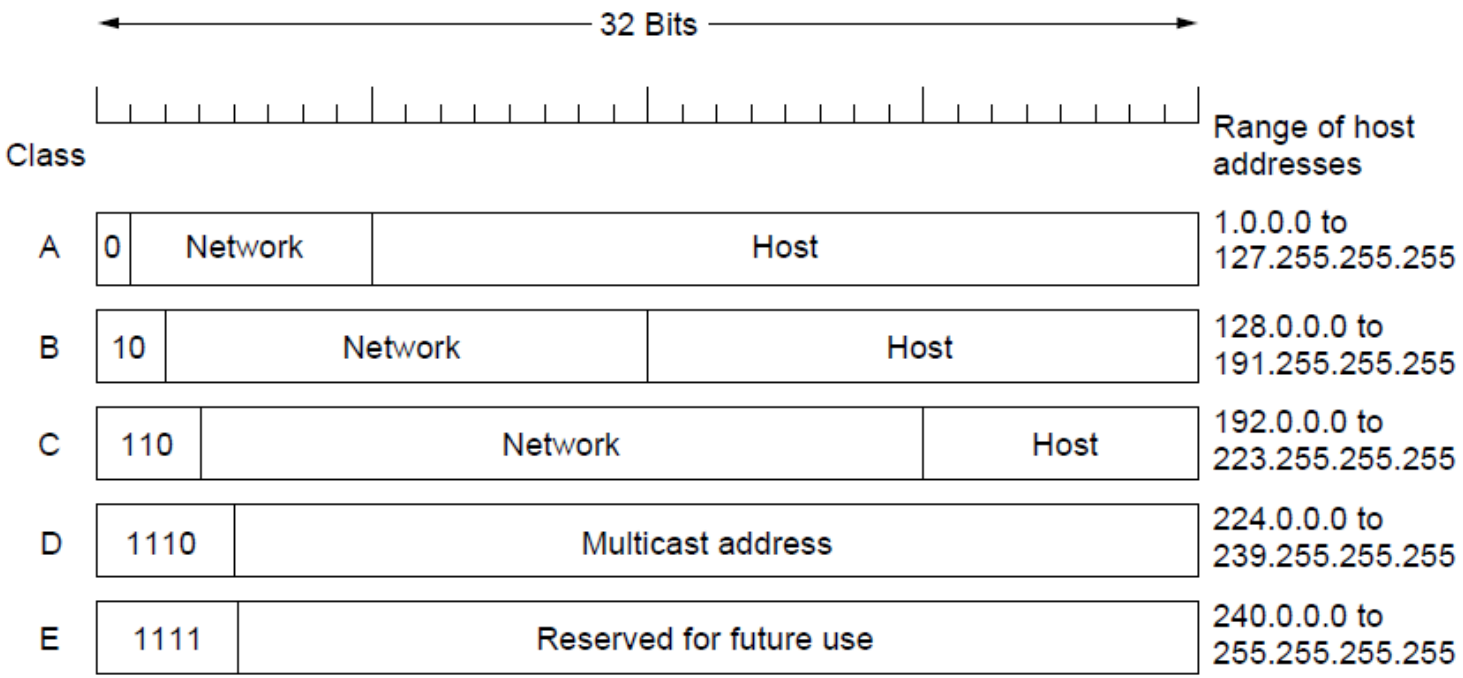
  2) If not, then see if it matches /19



Prefix Address	Subnet Mask	Interface
192.24.12.0	255.255.252.0	Eth 0
192.24.0.0	255.255.224.0	Eth 1

Classful Addressing

- Old design: addresses came in blocks of fixed size (A, B, C, D, E)
  - Carries size as part of address, but lacks flexibility

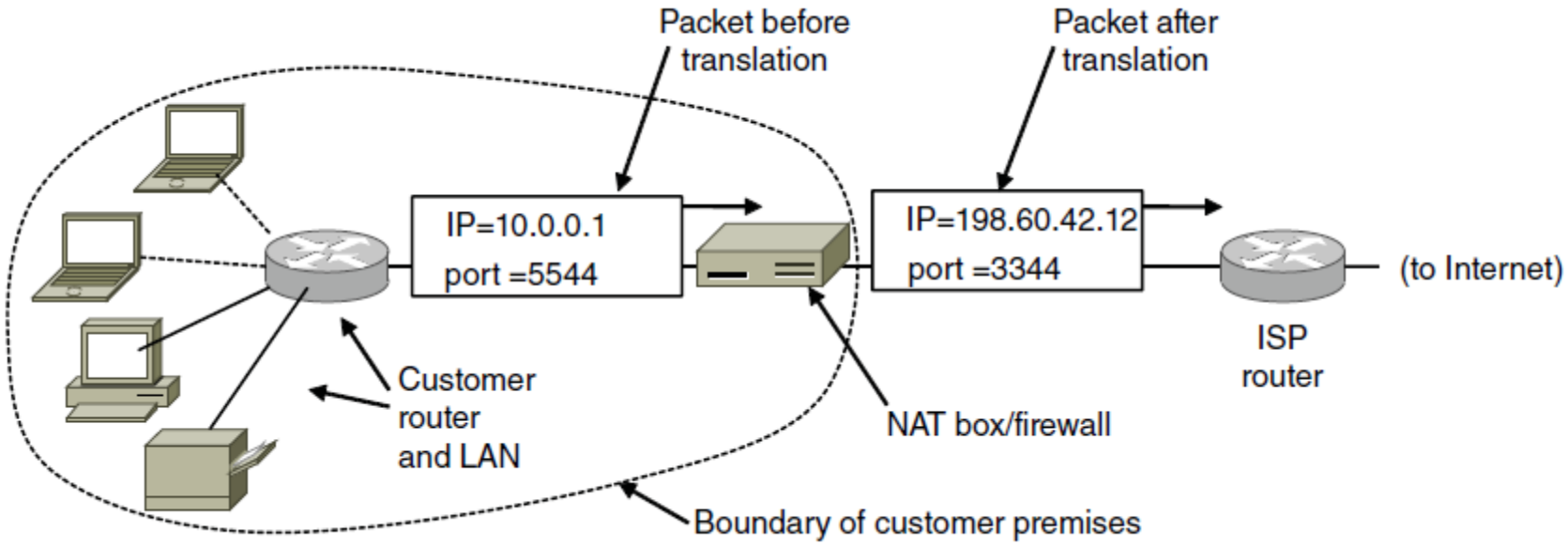


Private IP Ranges

- Range of IP addresses that CANNOT appear in the Internet
- Only for private networks
  - 10.0.0.0/8 (16,777,216 hosts)
  - 172.16.0.0/12 (1,048,576 hosts)
  - 192.168.0.0 /16 (65,536 hosts)

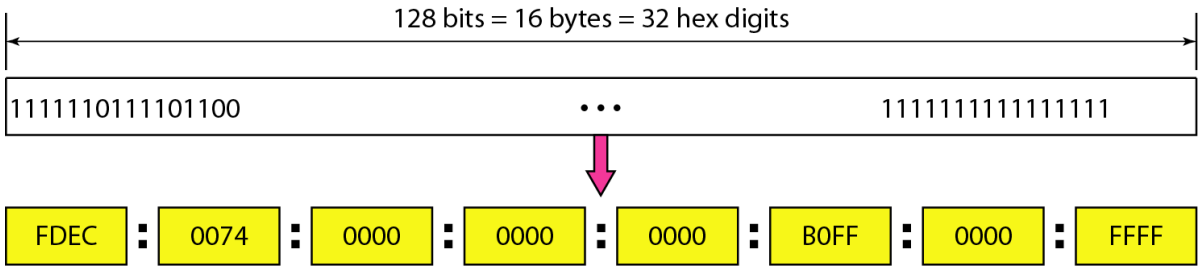
Network Address Translation (NAT)

- NAT box maps one external IP address to many internal IP addresses
  - Uses TCP/UDP port to tell connections apart
  - Violates layering; very common in homes, etc.



IPv6 (1)

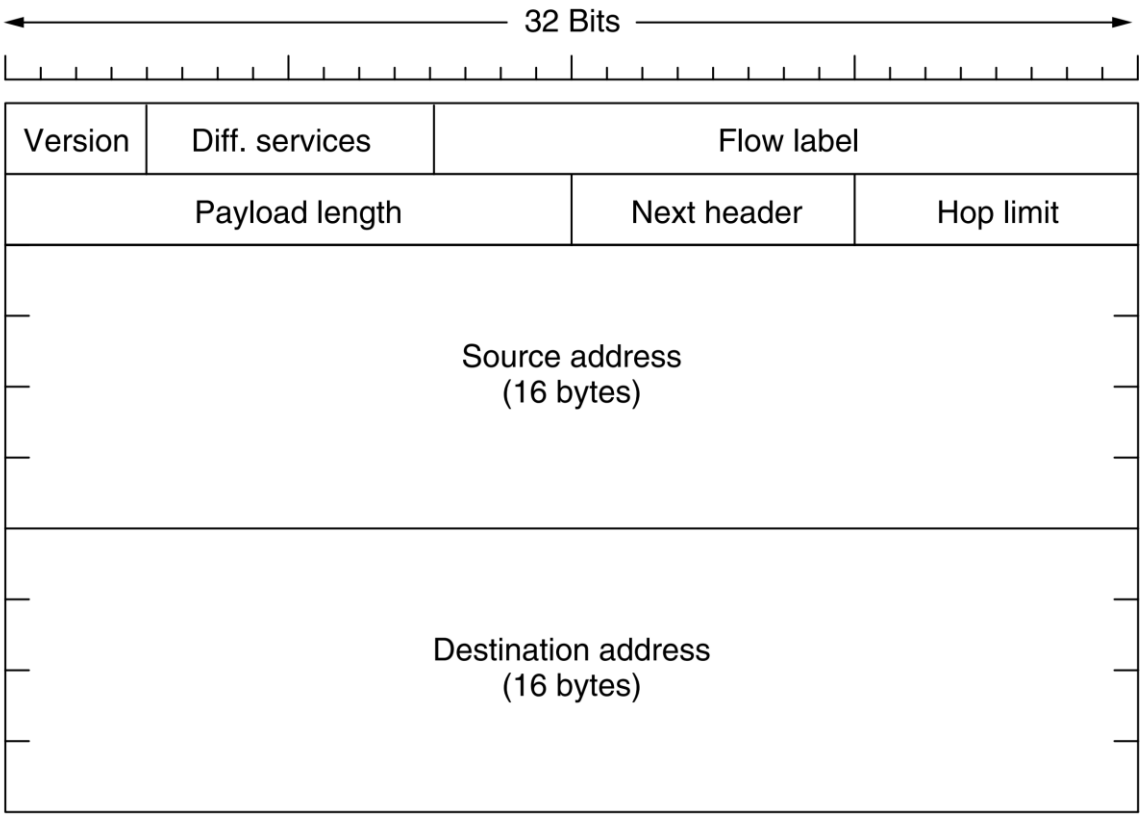
- Larger address space: 128-bit address
  use hexadecimal colon notation



- The format of header is simplified: required fields + options
- Support for more security: encryption and authentication
- Transition: dual stack, tunneling

IPv6 (2)

- Required fields in IPv6 header



Internet Control Protocols

- IP works with the help of several control protocols:
  - ICMP is a companion to IP that returns error info
    - Required, and used in many ways, e.g., for traceroute
  - ARP finds MAC address of a local IP address
    - Glue that is needed to send any IP packets
    - Host queries an address and the owner replies
  - DHCP assigns a local IP address to a host
    - Gets host started by automatically configuring it
    - Host sends request to server, which grants a lease

ICMP

- Internet Control Message Protocol
- Used for testing and monitoring ambient conditions between hosts and routers

Message type	Description
Destination unreachable	Packet could not be delivered
Time exceeded	Time to live field hit 0
Parameter problem	Invalid header field
Source quench	Choke packet
Redirect	Teach a router about geography
Echo and Echo reply	Check if a machine is alive
Timestamp request/reply	Same as Echo, but with timestamp
Router advertisement/solicitation	Find a nearby router