

# Network Layer

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COMP90007 Internet Technologies  
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# IP Addresses (1)

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

128.18.3.11

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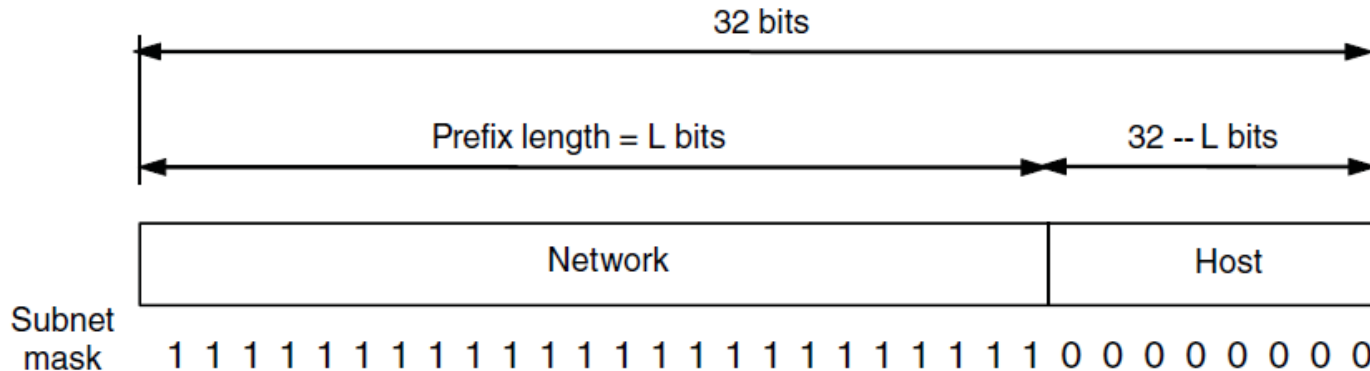
range: 0-255

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- 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)

# 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  
128.18.3.0/24 18.2.0.0/16
- **Subnet mask:** all 1s in the network portion
- **Extract prefix:** ANDed the IP address with the subnet mask



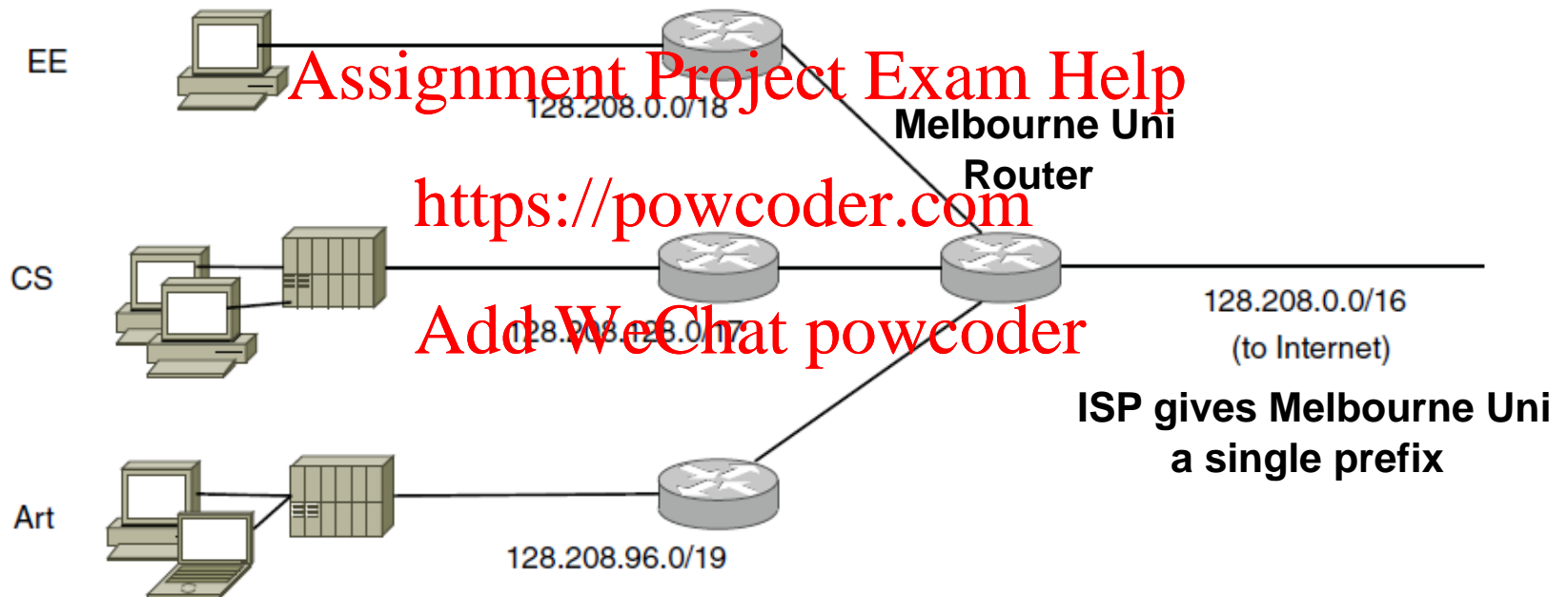
# IP Addressing and Routing Tables

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

Prefix	Subnet Mask	Interface
128.18.3.0/24	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



**Network is divided into subnets internally, but looks like a single prefix outside the network**

# Subnets (2)

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

<b>block</b>	128.208.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	$2^{16}$
		1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	$2^{15}$
<b>CS</b>	128.208.	0	0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	$2^{14}$
		0	1	1	x	x	x	x	x	x	x	x	x	x	x	x	x	$2^{13}$
<b>EE</b>	128.208.	0	1	0	x	x	x	x	x	x	x	x	x	x	x	x	x	$2^{13}$
<b>Art</b>	128.208.	0	1	0	x	x	x	x	x	x	x	x	x	x	x	x	x	$2^{13}$
<b>Left</b>	128.208.	0	1	0	x	x	x	x	x	x	x	x	x	x	x	x	x	$2^{13}$

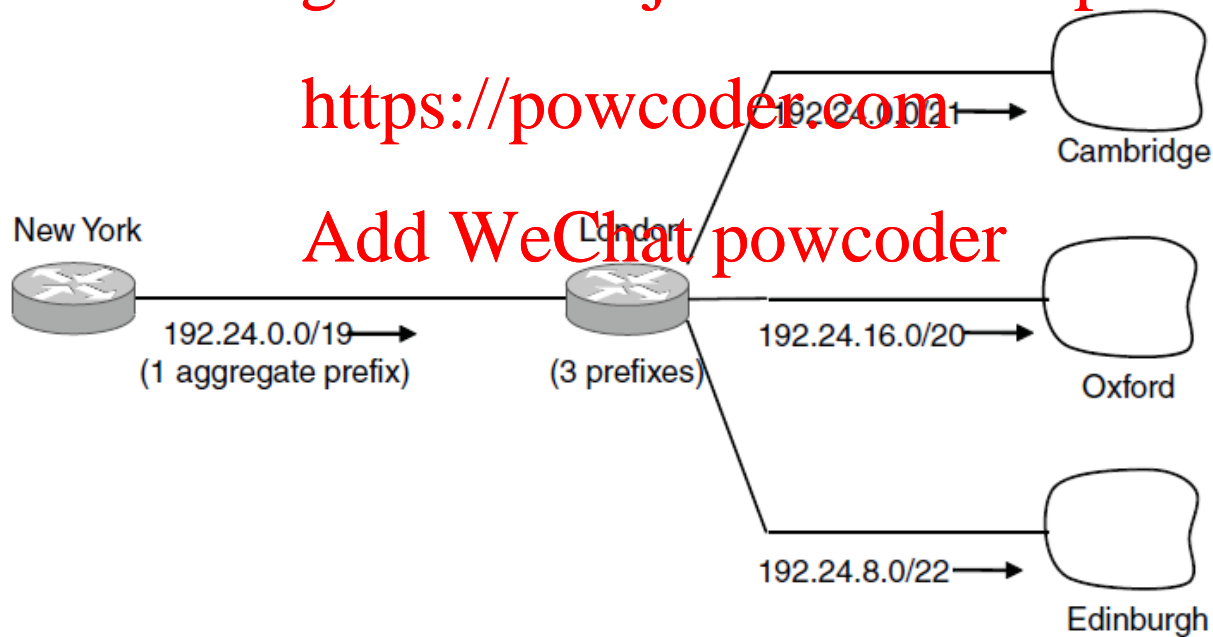
# Classless Inter-Domain Routing (1)

- Routing table explosion? Backbone router connecting networks around the world → 300k networks
- Aggregation: process of joining multiple IP prefixes into a single larger prefix to reduce size of routing table

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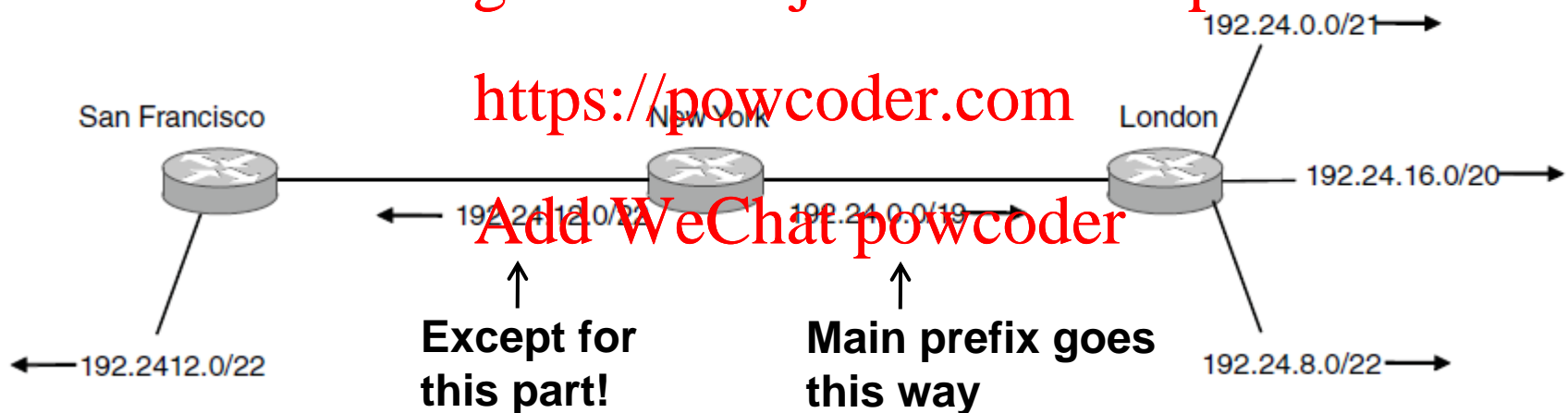
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# Classless Inter-Domain Routing (2)

- Packets are forwarded to the entry with the **longest matching prefix** (i.e. smallest address block)
- Complicates forwarding process 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
192.24.12.0/22	255.255.252.0	Eth 0 (to SF)
192.24.0.0/19	255.255.224.0	Eth 1 (to London)



# Classless Inter-Domain Routing (3)

192.24.0.0/19 → number of addresses  $2^{13}$  (8192)

London

192.24.

0

0

0

x

x

x

x

x

x

x

x

x

x

x

x

x

x

2<sup>13</sup>

London  
Cambridge

192.24.

0

0

0

0

0

x

x

x

x

x

x

x

x

x

x

x

x

2<sup>11</sup>

London  
Edinburgh

192.24.

0

0

0

0

1

0

x

x

x

x

x

x

x

x

x

x

x

2<sup>10</sup>

San  
Francisco

192.24.

0

0

0

0

1

1

x

x

x

x

x

x

x

x

x

x

x

2<sup>10</sup>

London  
Oxford

192.24.

0

0

0

1

x

x

x

x

x

x

x

x

x

x

x

x

x

2<sup>12</sup>

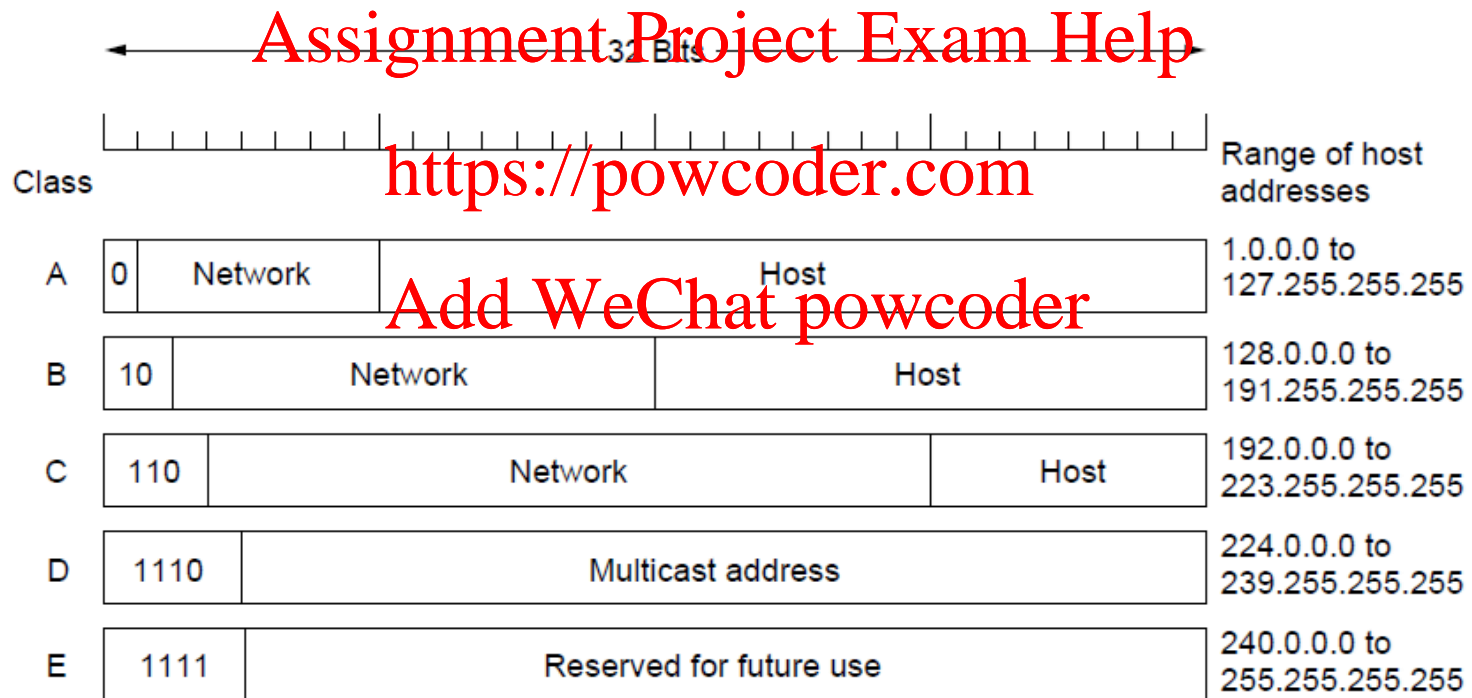
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# Classful Addressing

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



# Private IP Ranges

- Range of IP addresses that CANNOT appear on the Internet
- Reserved only for private networks
  - ❑ 10.0.0.0/8 ( $2^{24} = 16,777,216$  hosts)
  - ❑ 172.16.0.0/12 ( $2^{20} = 1,048,576$  hosts)
  - ❑ 192.168.0.0/16 ( $2^{16} = 65,536$  hosts)

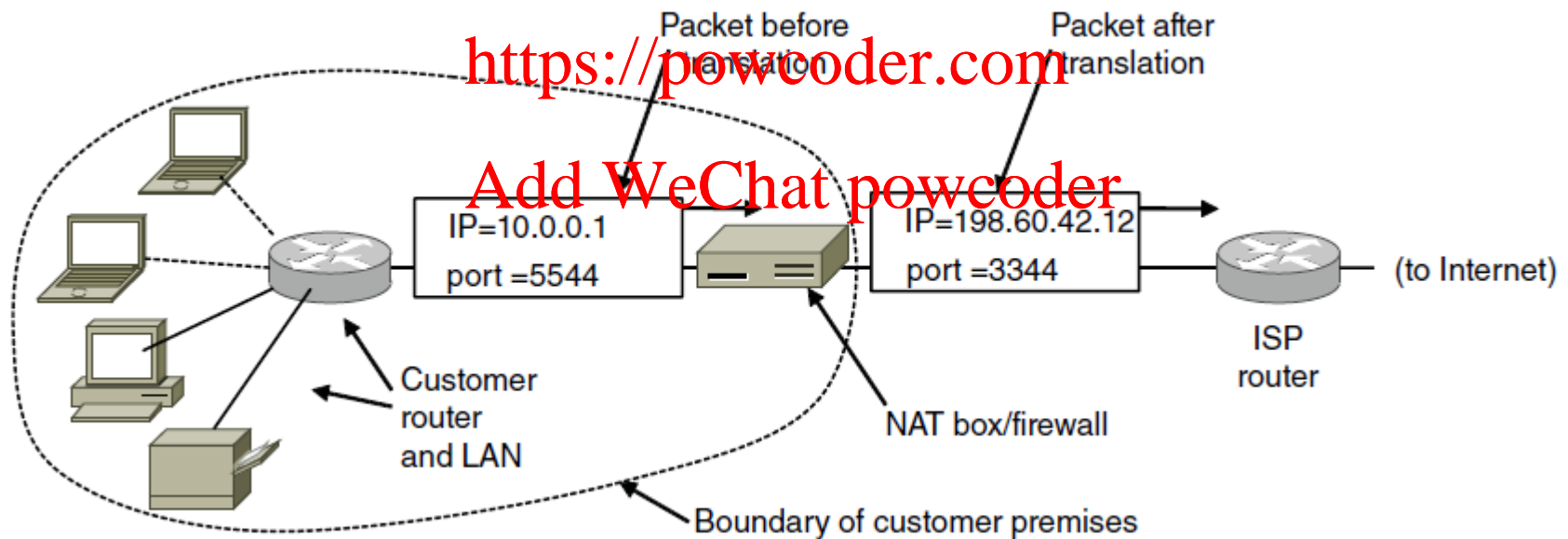
# Network Address Translation (NAT)

- NAT box maps one external IP address to many internal IP addresses
  - Uses TCP/UDP port to distinguish connections
  - Violates layering; popular tool in conserving global address space

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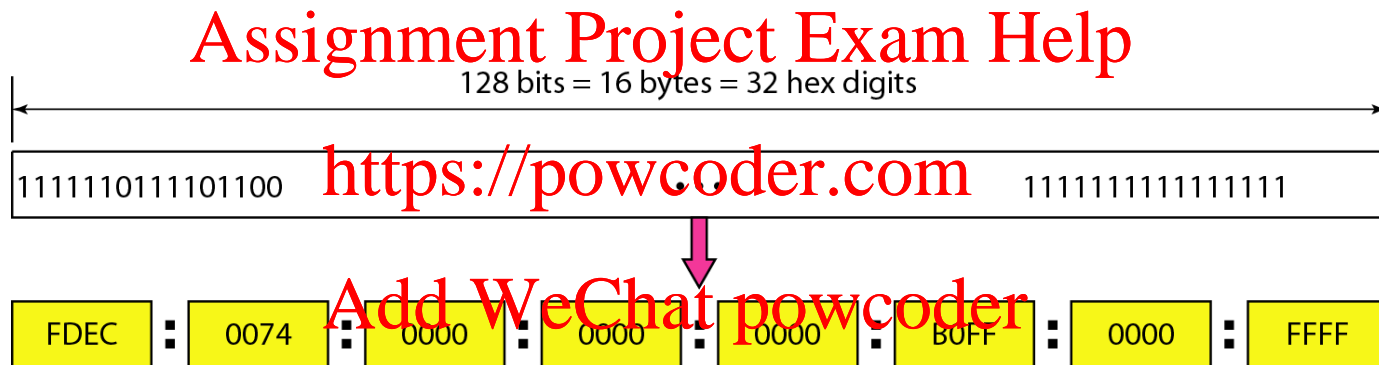
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# IPv6 (1)

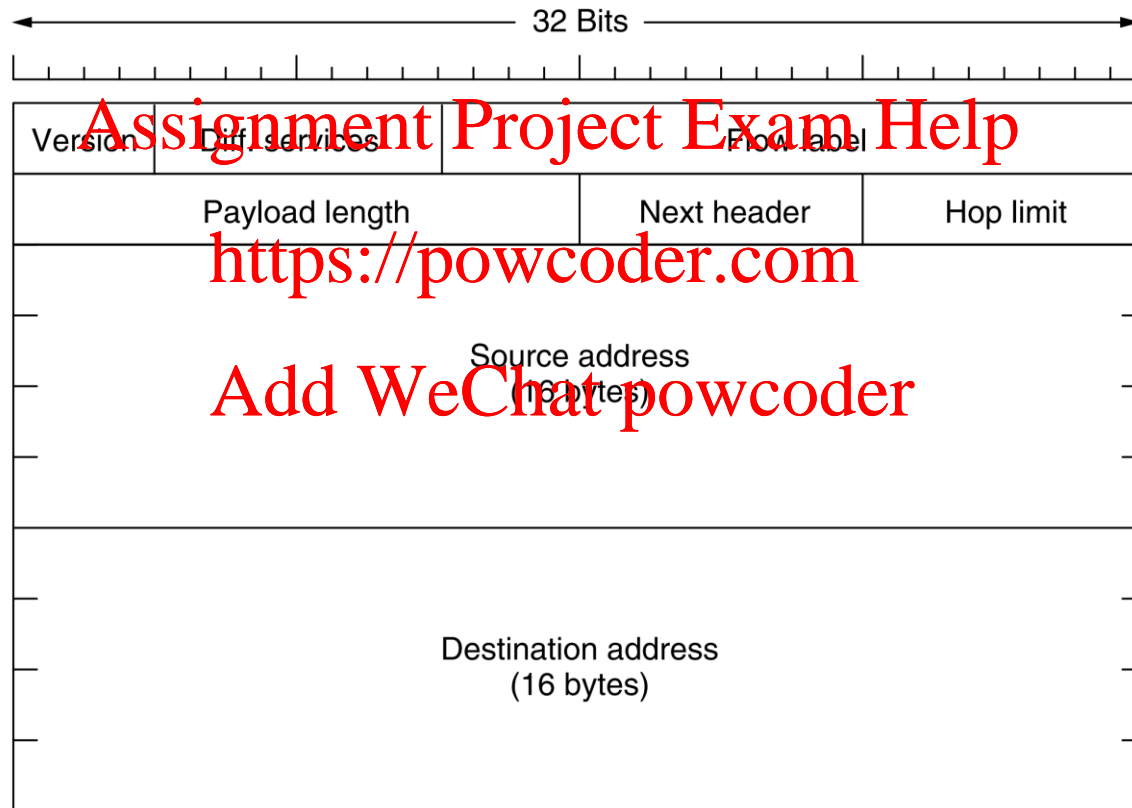
- Larger address space: 128-bit address using hexadecimal colon notation



- Support for more security: encryption and authentication
- Transition: dual stack, tunneling, header translation

# IPv6 (2)

- Required fields in IPv6 header (40 bytes)



# Internet Control Protocols

- IP works with the help of several control protocols:
  - **ICMP** (Internet Control Message Protocol) is a companion to IP that returns error info
    - Required, and used in many ways, e.g., traceroute, ping
  - **ARP** (Address Resolution Protocol) finds MAC address of a local IP address
    - Host queries an address and the owner replies
  - **DHCP** (Dynamic Host Control Protocol) 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

- 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	Tell 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