ECE/COMPSCI 356 Computer Network Architecture

Lecture 16: DHCP, NAT, and IPv6

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Slides credit: Xiaowei Yang, PD

Overview

- Miscellaneous topics
  - DHCP
  - NAT
  - IPv6

Dynamic Host Configuration Protocol (DHCP)

Host Configurations

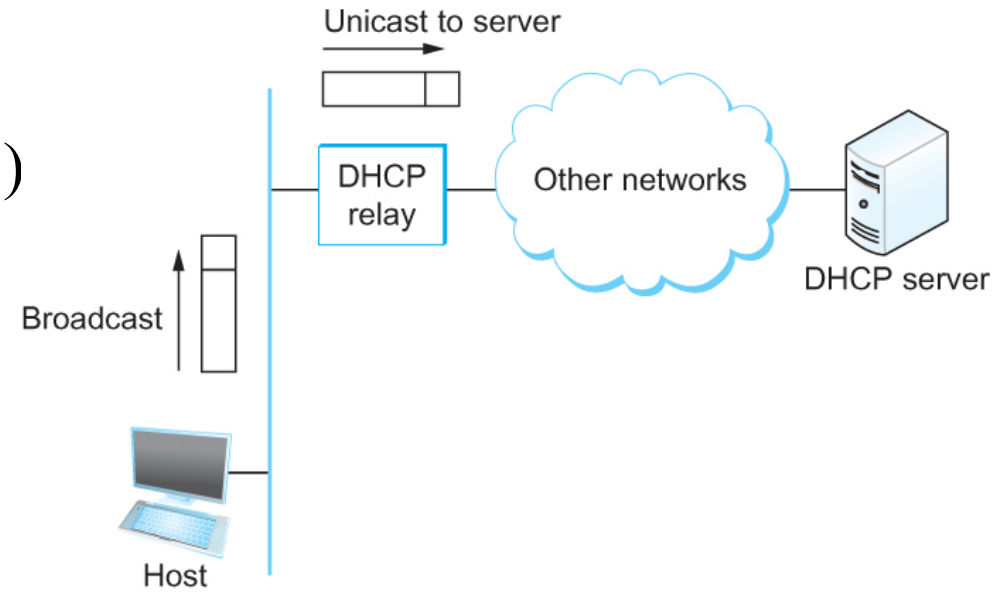
- Ethernet addresses are configured into network by manufacturer and they are unique
- IP addresses must be unique on a given internetwork but also must reflect the structure of the internetwork
- Most host Operating Systems provide a way to manually configure the IP information for the host
- Drawbacks of manual configuration
  - A lot of work to configure all the hosts in a large network
  - Configuration process is error-prune

Dynamic Host Configuration Protocol (DHCP)

- DHCP server is responsible for providing configuration information to hosts
- There is at least one DHCP server for an administrative domain
  - Serve for multiple networks in the administrative domain
  - Each network has a relay agent
- DHCP server maintains a pool of available addresses

DHCP

- Newly booted or attached host sends DHCPDISCOVER message to a special IP address (255.255.255.255)
- DHCP relay agent unicasts the message to DHCP server and waits for the response
- Forward response to host
  - IP address, default router, network mask, DNS resolver

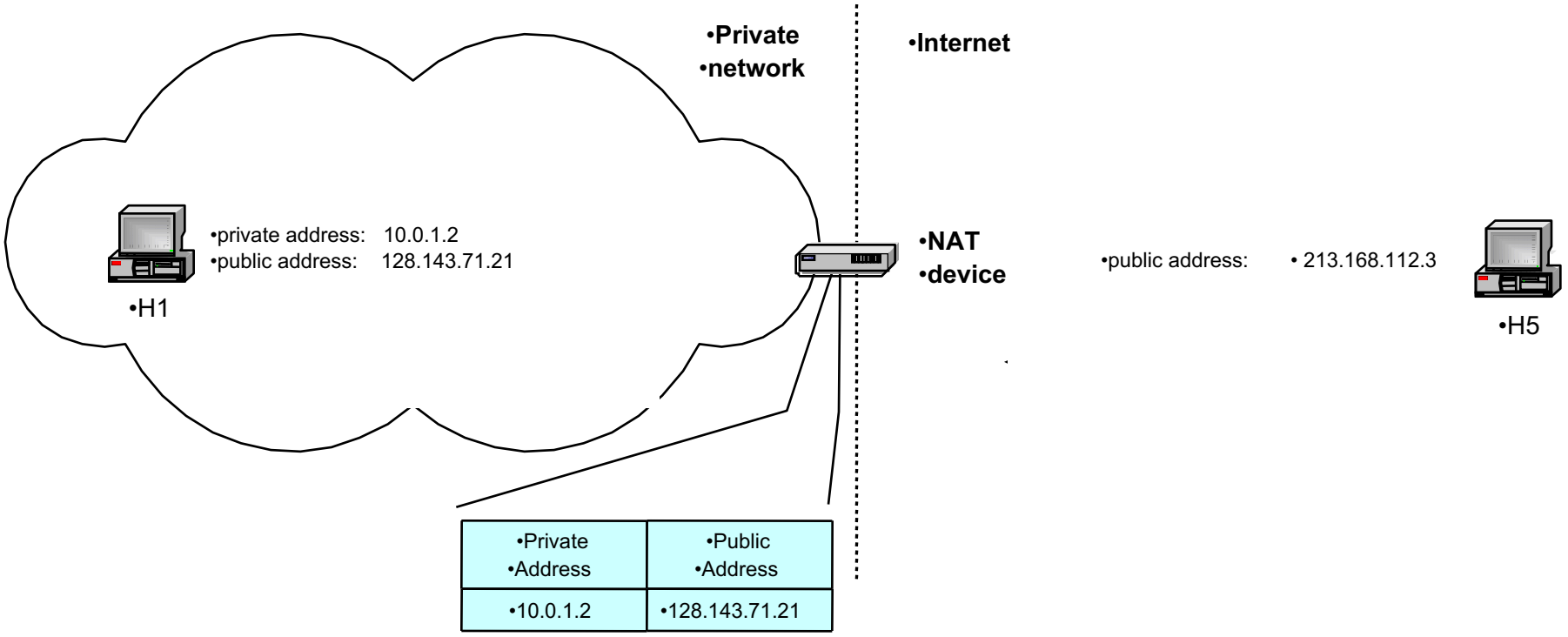


IPv4 address depletion issue

- Not enough IPv4 addresses
- A subnetwork may waste some IP addresses
- Growing needs for more addresses
  - IoT
  - Smart appliance
  - Smart TV
- Solution
  - NAT
  - IPv6

Network Address Translation

Basic operation of NAT



- NAT device has address translation table

Private Network

- *Private IP* network is an IP network that is not directly connected to the Internet

- IP addresses in a private network can be assigned arbitrarily.
  - Not registered and not guaranteed to be globally unique
  - Public IP address are assigned via Internet registries

- Generally, private networks use addresses from the following experimental address ranges (*non-routable addresses*):
  - 10.0.0.0 – 10.255.255.255
  - 172.16.0.0 – 172.31.255.255
  - 192.168.0.0 – 192.168.255.255

Main uses of NAT

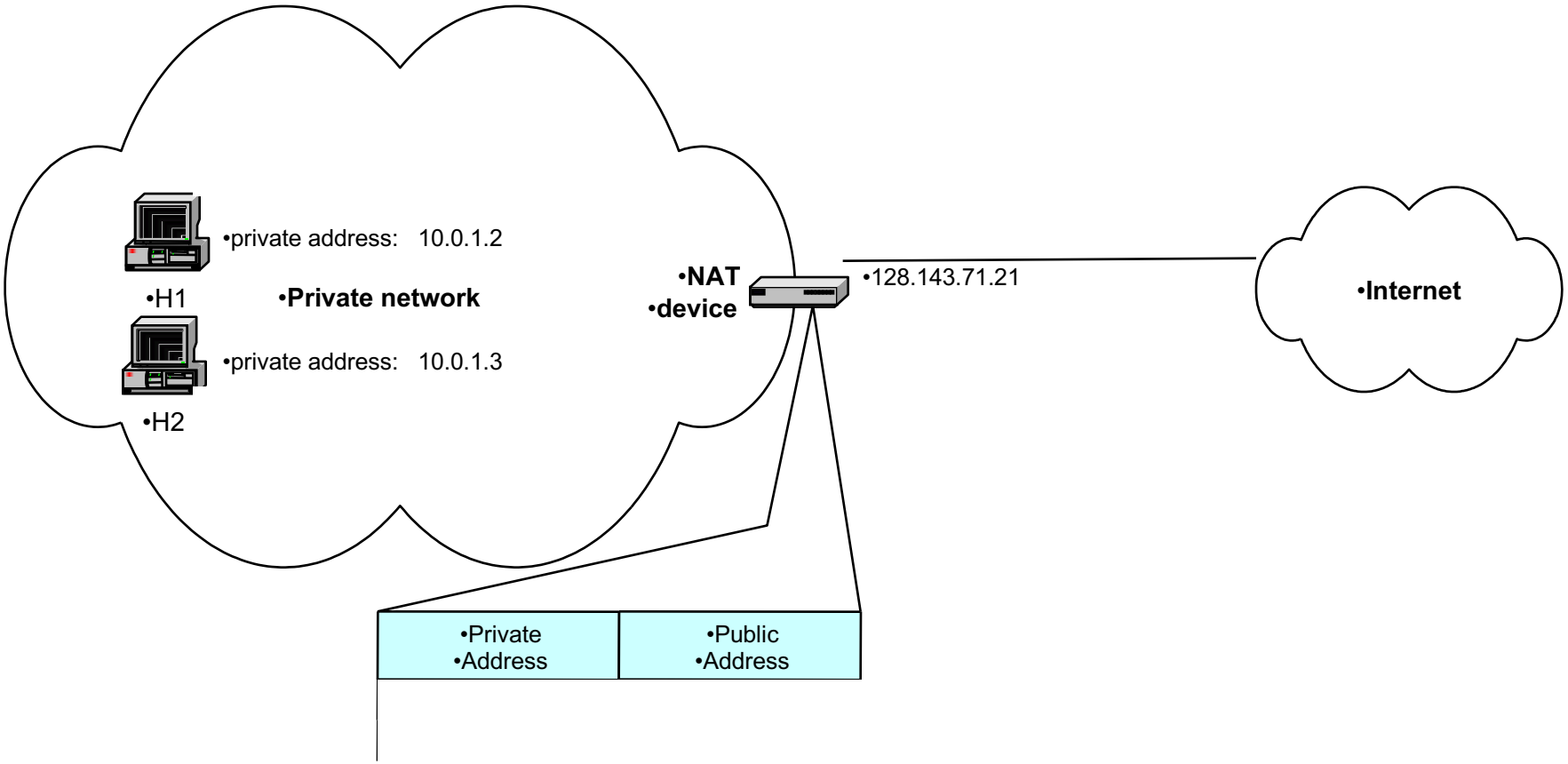
- IP masquerading
- Supporting migration between network service providers
- Load balancing of servers

IP masquerading

- **Scenario:** Corporate network has many hosts but only a small number of public IP addresses

- **NAT solution:**
  - Assign private addresses to the hosts of the corporate network
  - NAT device manages a pool of public IP addresses
  - NAT device modifies the port numbers for outgoing traffic

IP masquerading

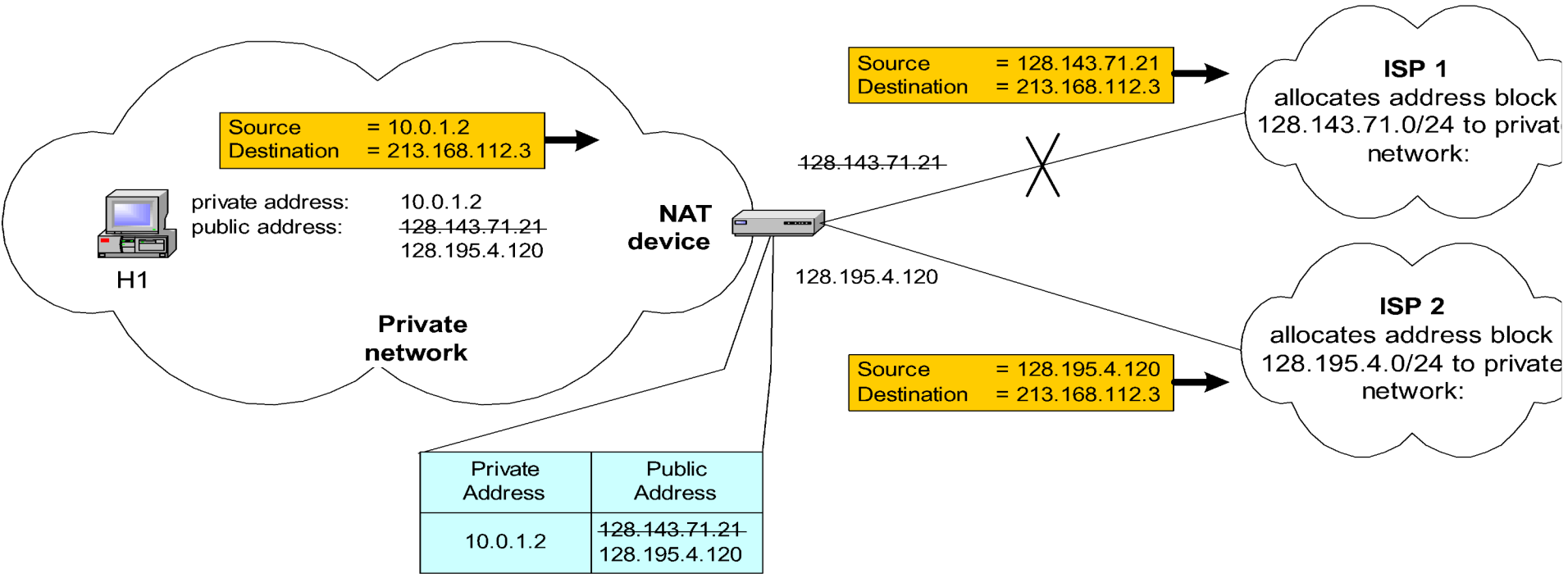


Supporting migration between network service providers

- **Scenario:** a corporate network changes its ISP
  - change all IP addresses in the network?

- **NAT solution:**
  - Assign private addresses to the hosts of the corporate network
  - NAT device has address translation entries which bind the private address of a host to the public address.
  - Migration to a new network service provider merely requires an update of the NAT device. The migration is not noticeable to the hosts on the network.

Supporting migration between network service providers

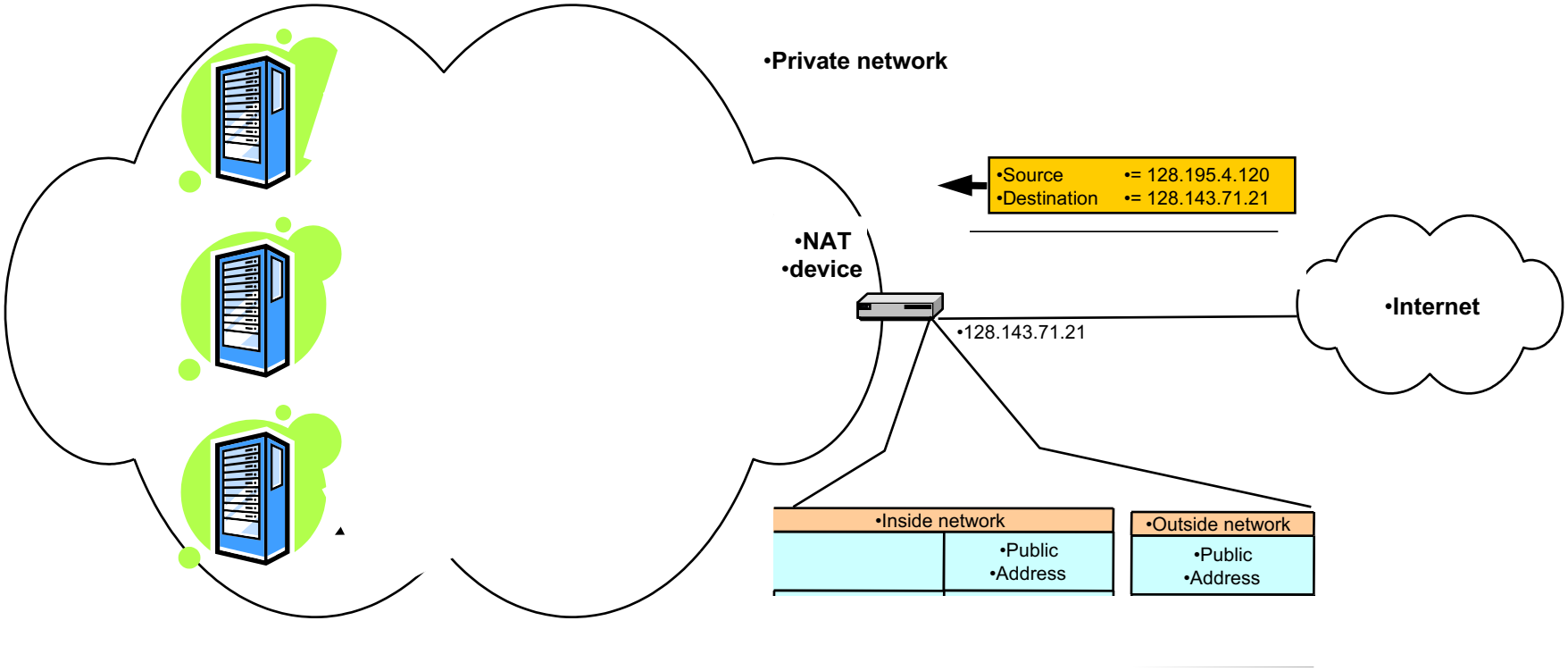


Load balancing of servers

- **Scenario:** Balance the load on a set of identical servers, which are accessible from a single IP address
  - Used by many distributed service providers such as Google

- **NAT solution:**
  - Here, the servers are assigned private addresses
  - NAT device acts as a proxy for requests to the server from the public network
  - The NAT device changes the destination IP address of arriving packets to one of the private addresses for a server
  - A strategy for balancing the load of the servers is to assign the addresses of the servers in a round-robin fashion

Load balancing of servers



Concerns about NAT

- **Performance:**
  - Modifying the IP header by changing the IP address requires that NAT boxes recalculate the IP header checksum
  - Modifying port number requires that NAT boxes recalculate TCP checksum

Concerns about NAT

- **End-to-end connectivity:**
  - NAT destroys universal end-to-end reachability of hosts on the Internet.
  - A host in the public Internet often cannot initiate communication to a host in a private network.

Next Generation IP (IPv6)

IPv6 Addressing

- 128-bit addresses
  - 2^{128}
- "if the earth were made entirely out of 1 cubic millimetre grains of sand, then you could give a unique [IPv6] address to each grain in 300 million planets the size of the earth"
- http://en.wikipedia.org/wiki/IP_address
- Or, using a more earthly analogy:
- The optimistic estimate would allow for 3.9 x 10^18 addresses per square meter of the surface of the planet Earth.

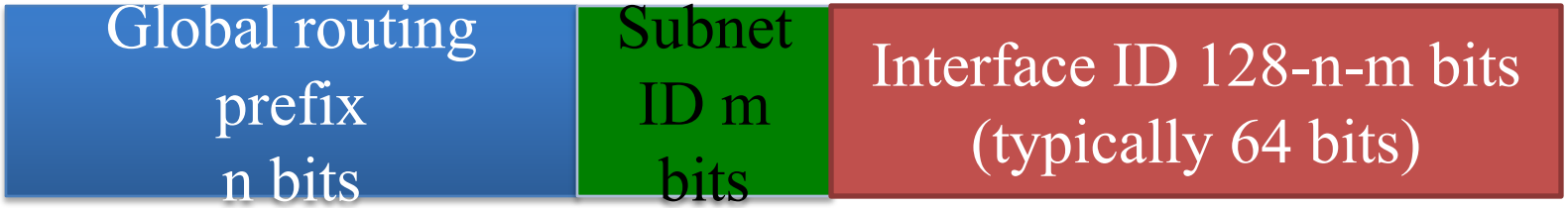
IPv6 Addresses

- Classless addressing/routing (similar to CIDR)
- Notation: x:x:x:x:x:x:x:x (x = 16-bit hex number)
  - contiguous 0s are compressed: 47CD::A456:0124
  - IPv6 compatible IPv4 address:
    ::FFFF:128.42.1.87
- All addresses are assigned to interfaces, not nodes

Types of IPv6 addresses

Address type	Binary prefix	IPv6 notation
Unspecified	00...0 (128 bits)	::/128
Loopback	00...1 (128 bits)	::1/128
Multicast	11111111	FF00::/8
Link-local unicast	1111111010	FE80::/10
Global unicast	Everything else	
Anycast	Allocated from unicast space	

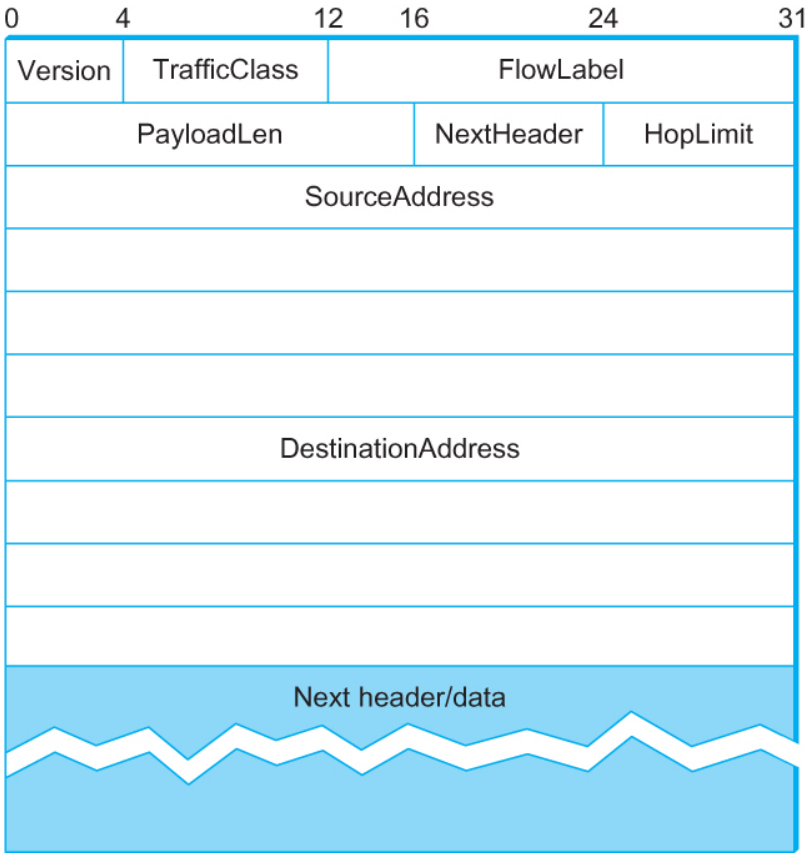
Global Unicast Addresses



- For all unicast addresses, except those that start with the binary value 000, Interface IDs are required to be 64 bits long

IPv6 Header

- At least 40 bytes



IPv6 adoption

- https://www.google.com/intl/en/ipv6/statistics.html#tab=ipv6-adoption