Lecture 16: Network Layer – Data Plane III

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Cheol Jeong

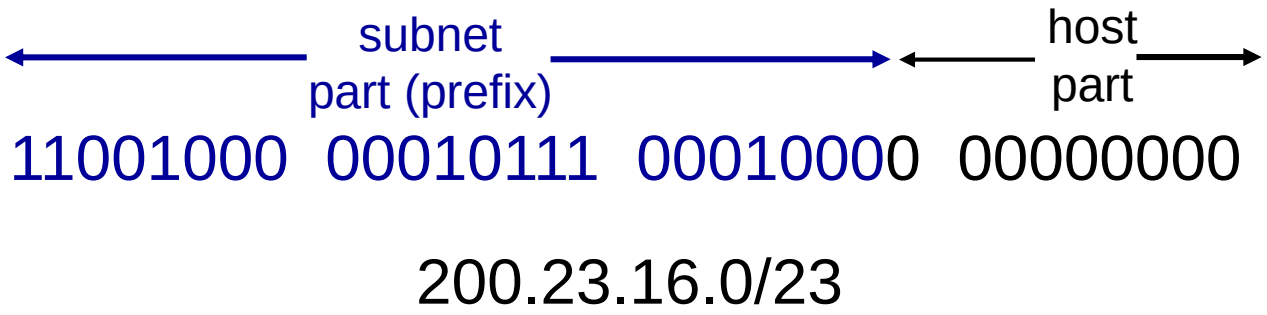
Contents of Chapter 4

- Overview of network layer
- What's inside a router?
- The internet protocol (IP): IPv4, addressing, IPv6, and more
  - IPv4 datagram format
  - IPv4 datagram fragmentation
  - IPv4 Addressing
    - Subnet, CIDR, DHCP
  - Network address translation (NAT) (skipped)
  - IPv6
- Generalized forwarding and SDN **(skipped)**

Classless Interdomain Routing (CIDR)

Address format

- a.b.c.d/x
- x is the number of bits in subnet portion of address



Classfull addressing

- Before CIDR was adopted, the subnet parts were constrained to be 8 (class A), 16 (class B), or 24 (class C) bits in length.

Destination-based Forwarding

forwarding table

Destination Address Range	
11001000 00010111 00010000 00000000 through 11001000 00010111 00010111 11111111	
11001000 00010111 00011000 00000000 through 11001000 00010111 00011000 11111111	
11001000 00010111 00011001 00000000 through 11001000 00010111 00011111 11111111	
otherwise	

Longest Prefix Matching

- **When there are multiple matches,**
  - The router uses the longest prefix matching to determine the link interface to which the packet is forwarded.

Destination Address Range	Link interface
11001000 00010111 00010*** *********	0
11001000 00010111 00011000 *********	1
11001000 00010111 00011*** *********	2
otherwise	3

255.255.255.255

- **IP broadcast address**
  - When a host sends a datagram with destination address 255.255.255.255, the message is delivered to all hosts on the same subnet.
  - Router optionally forward the message into neighboring subnets as well.

Obtaining a Block of Addresses

- **Internet Corporation for Assigned Names and Numbers (ICANN)**
  - http://www.icann.org
  - Allocate IP addresses
  - Manage the DNS root servers
  - Assigning domain names and resolving domain name disputes
- **Address supporting organization of ICANN**
  - Asia-Pacific Network Information (APNIC)
  - American Registry for Internet Numbers (ARIN)
  - African Network Information Center (AFRINIC)
  - …

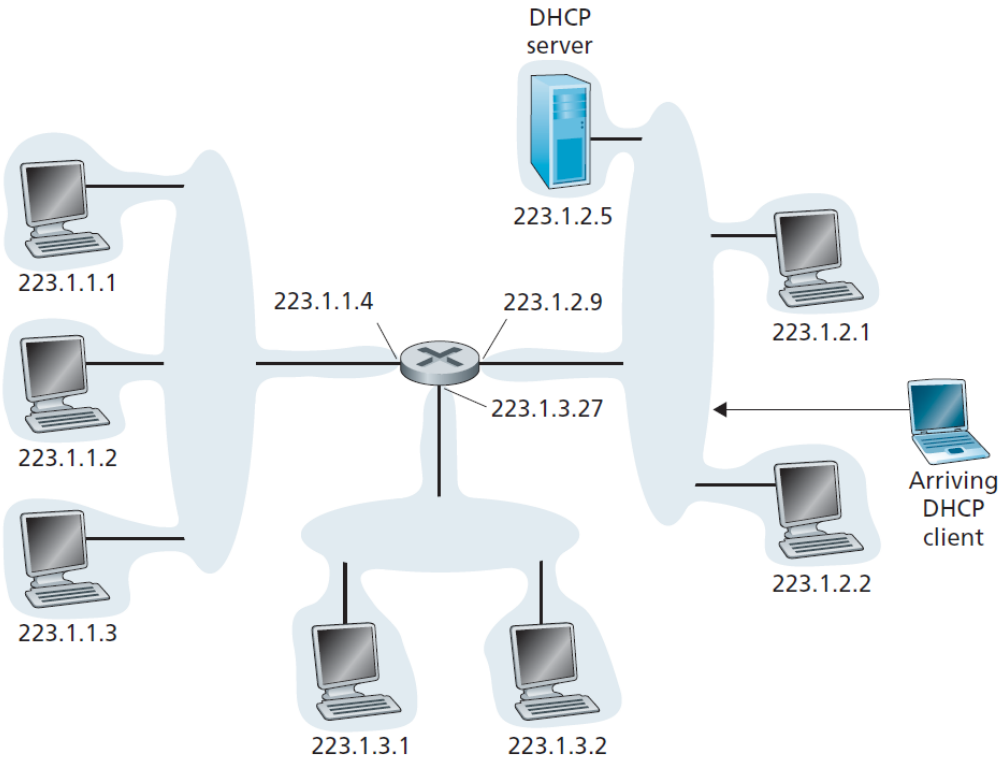
Obtaining a Block of Addresses

- **Example of addresses**

ISP's block	11001000 00010111 00010000	00000000	200.23.16.0/20
Organization 0	11001000 00010111 00010000	00000000	200.23.16.0/23
Organization 1	11001000 00010111 00010010	00000000	200.23.18.0/23
Organization 2	11001000 00010111 00010100	00000000	200.23.20.0/23
...	.....	....	....
Organization 7	11001000 00010111 00011110	00000000	200.23.30.0/23

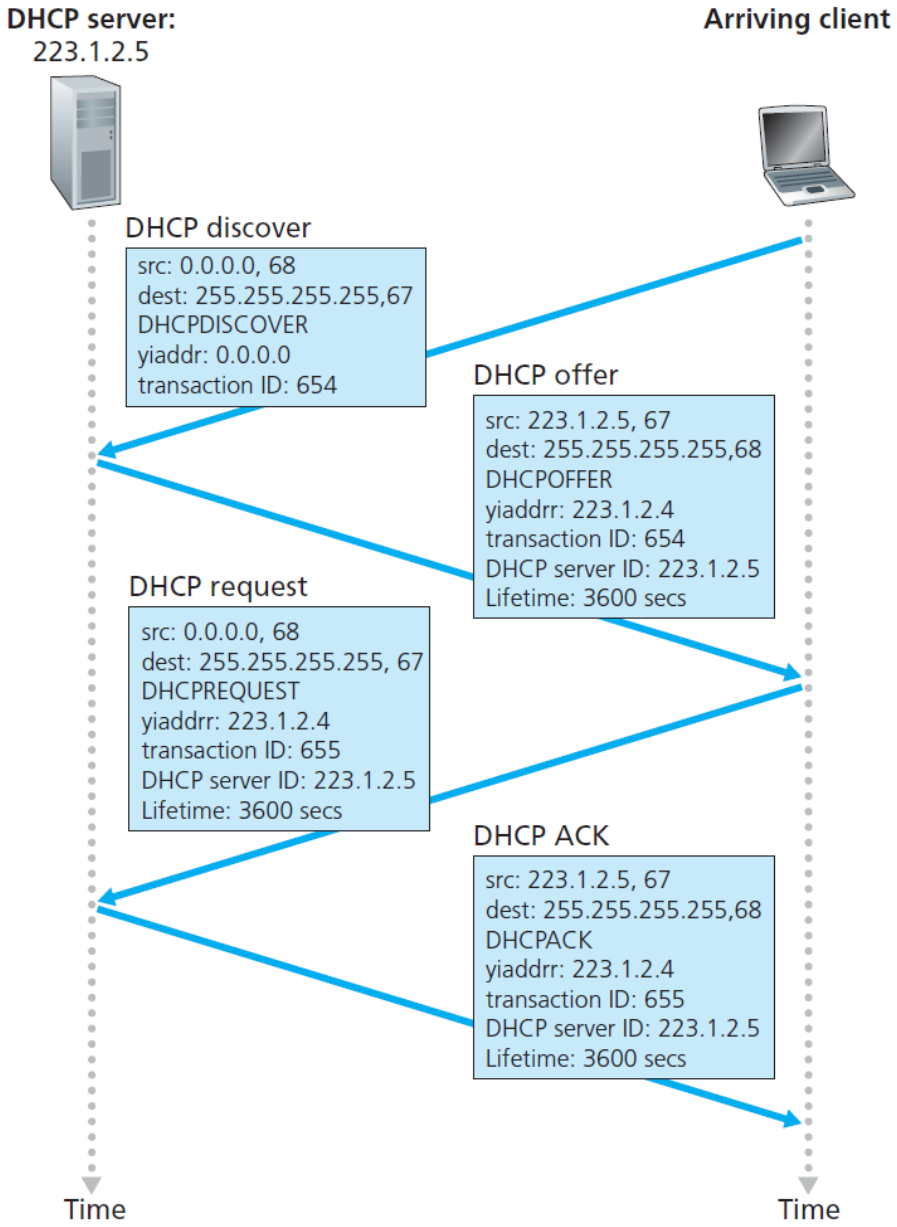
Obtaining a Host Address

- **Dynamic host configuration protocol (DHCP)**
  - Allow a host to obtain an IP address automatically
  - Provide additional information about the subnet mask, the address of its first-hop router (i.e., default gateway), the address of its local DNS server
  - A client-server protocol at an application layer



DHCP Client-Server Interaction

- **DHCP**
  - Use UDP
    - Server port number: 67
    - Client port number: 68
  - Several DHCP servers may respond.



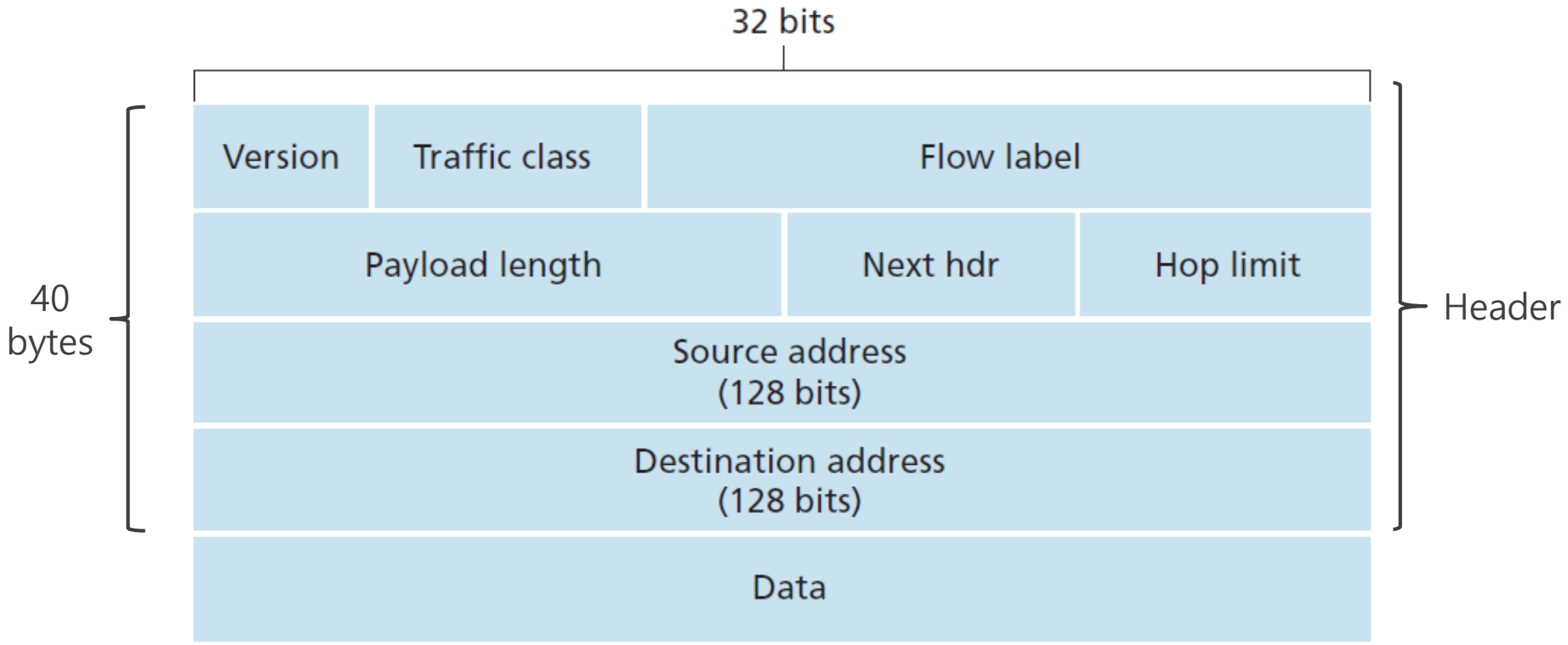
IPv6

- **Initial motivation**
  - 32-bit address space soon to be completely allocated
- **When the IPv6 is designed,**
  - Other aspects such as header format redesing, providing QoS were considered.

Important Changes Introduced in IPv6

- **Expanded addressing capabilities**
  - Increase the size of the IP address from 32 to 128 bits
  - Introduce an anycast address, that allows a datagram to be delivered to any one of a group of hosts
- **A streamlined 40-byte header**
  - Allow faster processing on the IP datagram by a router
- **Flow labeling**
  - Labeling of packets belonging to particular flows for which the sender requests special handling, such as real-time service

IPv6 Datagram Format



Fields in the IPv6 Datagram

- **Version (4 bits)**
  - 4: IP version 4, 6: IP version 6
- **Traffic class (1 byte)**
  - Like TOS in IPv4
  - Can give a priority to certain datagrams
- **Flow label (20 bits)**
  - A unique flow label is used to identify all the datagrams in a particular flow.
  - Can provide additional support for real-time datagram delivery
- **Payload length (2 bytes)**
  - The number of bytes in the data except the 40-byte datagram header

Fields in the IPv6 Datagram

- **Next header (1 byte)**
  - Indicate the specific transport-layer protocol (or an extension header)
  - Like the protocol field in IPv4
- **Hop limit (1 byte)**
  - Specify how long the datagram is allowed to *live* on the network
  - Decremented by one each time the datagram is processed by a router
  - If this field reaches 0, a router must drop that datagram.
  - Like TTL in IPv4
- **Source address (16 bytes)**
- **Destination address (16 bytes)**
- **Data**

IPv4 vs IPv6

- **Fragmentation/reassembly**
  - No fragmentation at routers
  - Fragmentation is performed at the source and the reassembly is performed at the destination.
  - If an datagram is too large, then the router drops the data gram and sends a “Packet Too Big” ICMP error message back to the sender.
- **Header checksum**
  - Removed entirely to reduce processing time at each hop
- **Options**
  - No longer a part of the standard IP header
  - One of the possible next headers pointed to from within the IPv6 header