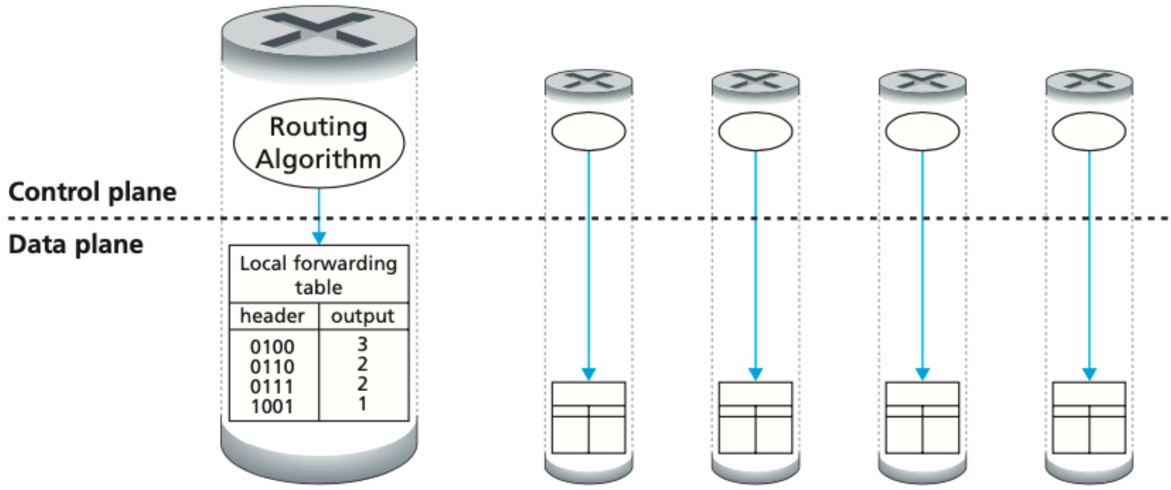
Chap 4: Network Layer

Forwarding and Routing: The Data and Control Planes

forwarding: move packets from router's input to appropriate router output

routing: determine route taken by packets from source to dest.



Network Service Model

Guaranteed delivery. This service guarantees that a packet sent by a source host will eventually arrive at the destination host.

Guaranteed delivery with bounded delay. This service not only guarantees delivery of the packet, but delivery within a specified host-to-host delay bound (for example, within 100 msec).

In-order packet delivery. This service guarantees that packets arrive at the destination in the order that they were sent.

Guaranteed minimal bandwidth. This network-layer service emulates the behavior of a transmission link of a specified bit rate (for example, 1 Mbps) between sending and receiving hosts. As long as the sending host transmits bits (as part of packets) at a rate below the specified bit rate, then all packets are eventually delivered to the destination host.

Security. The network layer could encrypt all datagrams at the source and decrypt them at the destination, thereby providing confidentiality to all transport-layer segments.

individual datagrams: **guaranteed delivery** chắc chắn tới cung cấp dịch vụ theo từng gói datagram, **guaranteed delivery with less than 40 msec delay**

flow of datagrams: dich vu cho ca flow **in-order datagram delivery, guaranteed minimum bandwidt**h to flow and **restrictions on changes in inter-packet spacing** giua 2 packets gửi không quá ms trong cung 1 flow .

Connection, connection-less service

datagram network provides network-layer **connectionless service**

virtual-circuit network provides network-layer **connection service**

analogous to TCP/UDP connecton-oriented / connectionless transport-layer services, but: service**: host-to-host, no choice:** network provides one or the other**, implementation:** in network core

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Virtual circuits

call setup: tìm đường đi từ src đến dest, tất cả packet chỉ đi con đường đó, đến từng router đưa bản chỉ đường, khi kết thúc nhớ tháo bản chỉ đường => **maintain states for each passing connection**, link, router resouces(bandwidth, buffers) allocated for VC, không có địa chỉ người nhận.
a vc consist of" path, vcnumbers đến router đổi vc numbers, entries in forwading tables: bản chỉ đường ở mỗi router

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Datagram networks(IP): routing and forwarding

Longest prefix matching: when looking for forwarding table entry for given destination address, **use longest address prefix that matches destination address.**

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

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IP fragmentation in IPV4

Internet datagram: simple inside network "smart" end systems , complex at edge vs ATM(VC) complex inside network. "dumb" end systems

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What's Inside a Router?

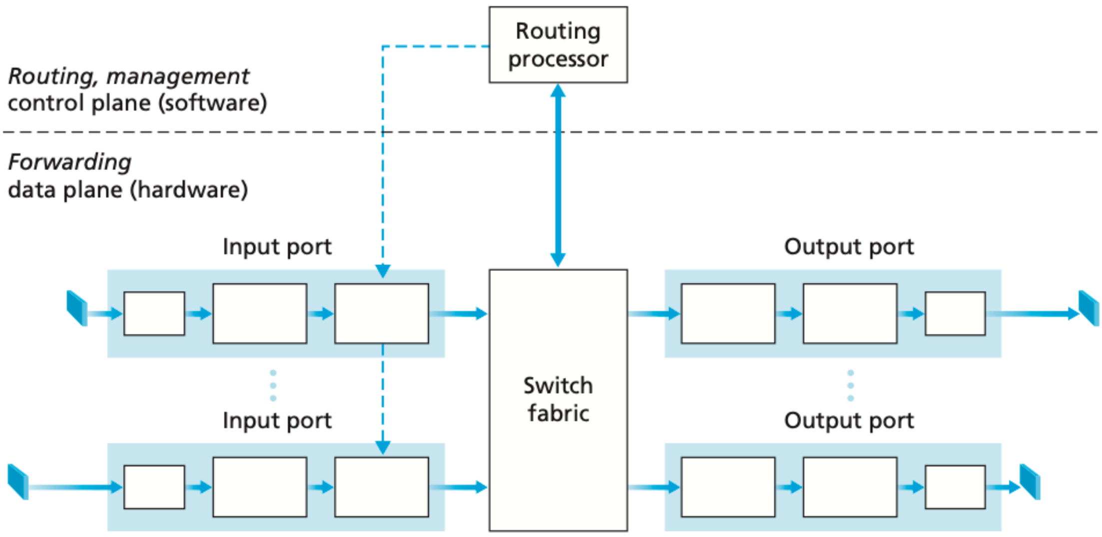

Figure 4.4 ♦ Router architecture

Four components: input port, switch fabric, routing processor, output port

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Input Queueing

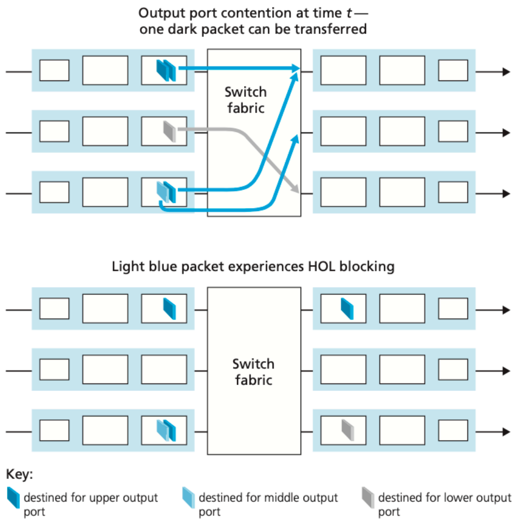


Figure 4.8 ♦ HOL blocking at and input-queued switch

Head Of Line Blocking

Cái xanh đậm phía trái dưới cùng phải chờ vì tới chung port nhưng cái xanh nhạt phải chờ vì HOL blocking.

Output Queueing

packet scheduling: buffer size = an average round-trip time (*RTT*, say 250 msec) times the link capacity *(C) why?*

Packet Scheduling

First-in-First-Out (FIFO)

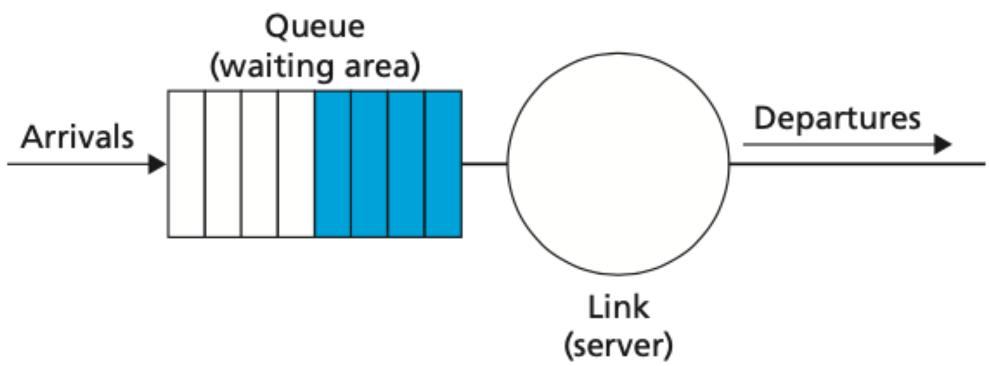
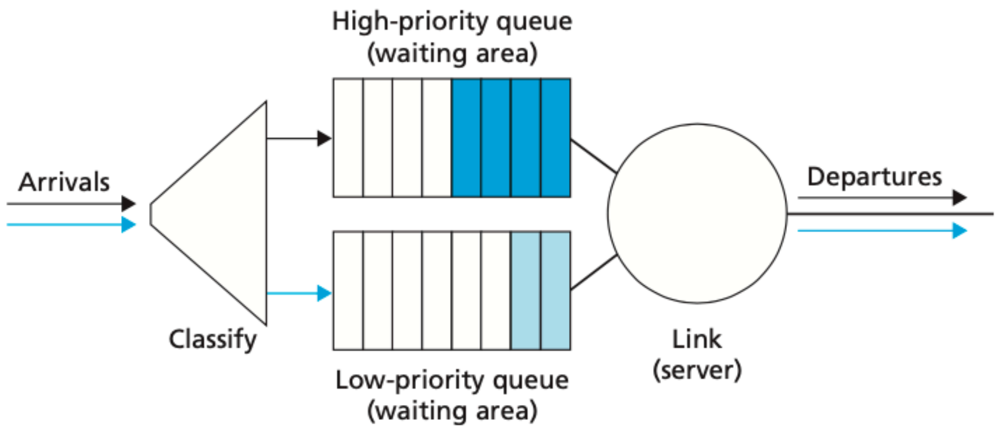


Figure 4.10 ♦ FIFO queueing abstraction

Priority Queuing

Non-preemptive and preemptive



jure 4.12 ♦ The priority queueing model

Round Robin and Weighted Fair Queuing (WFQ)

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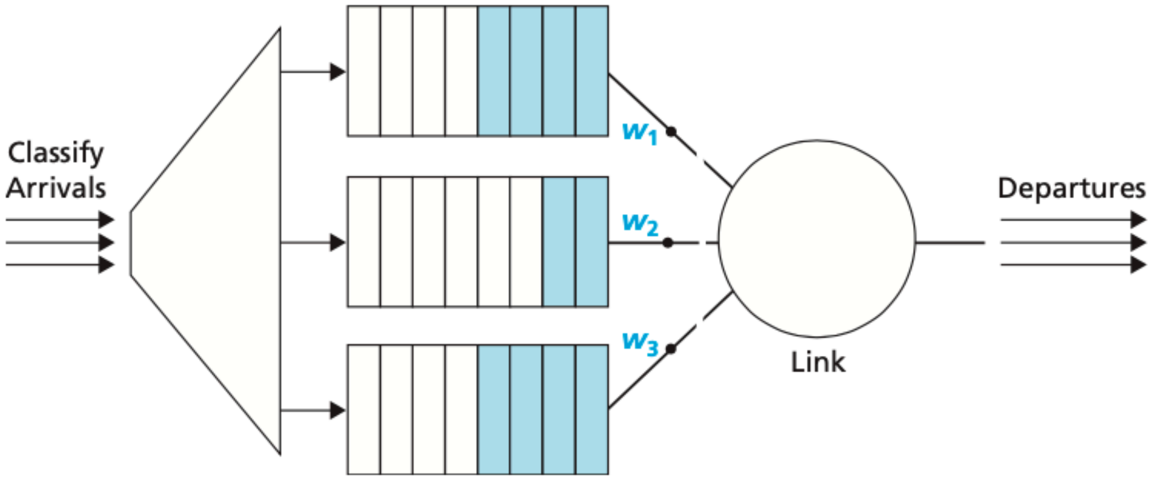

Figure 4.15 ♦ Weighted fair queueing

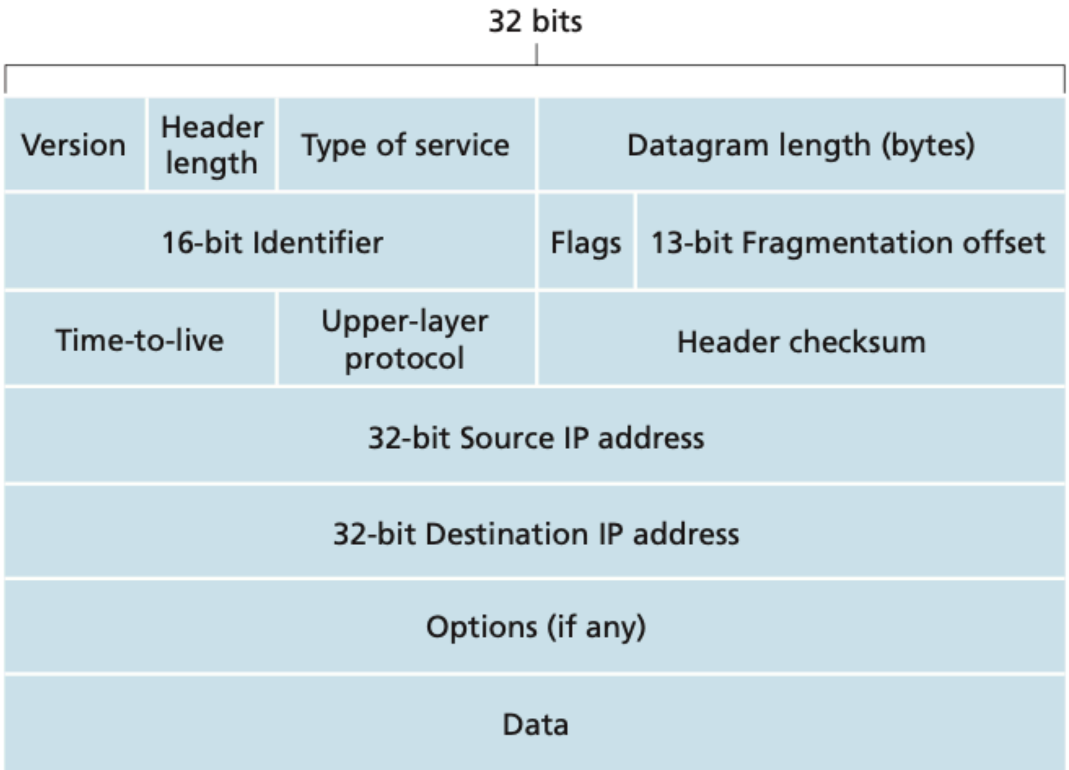

Figure 4.16 ♦ IPv4 datagram format

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The Internet Protocol (IP): IPv4, Addressing, IPv6, and More

IPv4 Datagram Format

Version number. These 4 bits specify the IP protocol version of the datagram. Different versions of IP use different datagram formats.

Header length can contain a variable number of options => determine where in the IP datagram the payload actually begins.
Type of service. different types of IP datagrams to be distinguished from each other
Datagram length. This is the total length of the IP datagram (header plus data),
Identifier, flags, fragmentation offset. These three fields have to do with so-called IP fragmentation, a topic we will consider shortly.

Time-to-live This field is decremented by one each time the datagram is processed by a router. If the TTL field reaches 0, a router must drop that datagram.
Protocol. This field is typically used only when an IP datagram reaches its final destination

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IPv4 Datagram Fragmentation

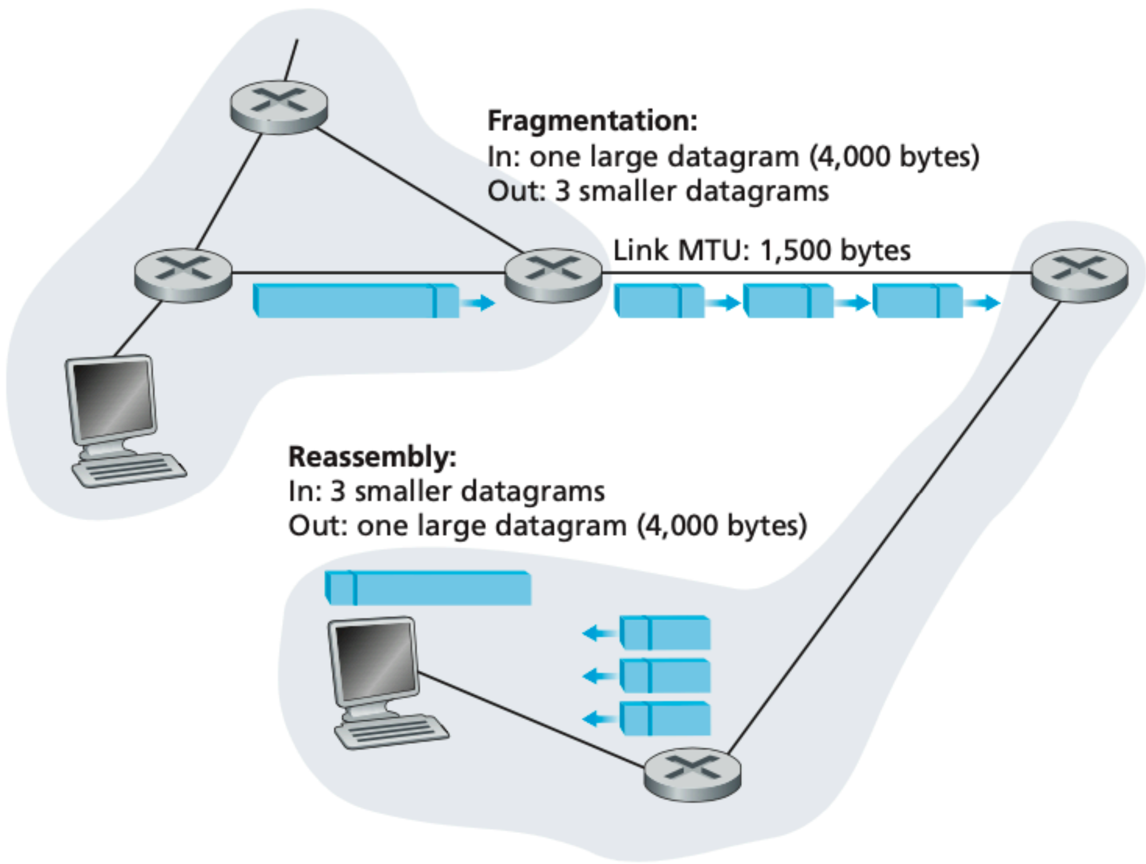


Figure 4.17 ♦ IP fragmentation and reassembly

IPv4 Addressing

Obtaining a Block of Addresses: Classless InterDomain Routing

Obtaining a Host Address: The Dynamic Host Configuration Protocol DHCP

DHCP: server client model,

4 steps:

DHCP discover:

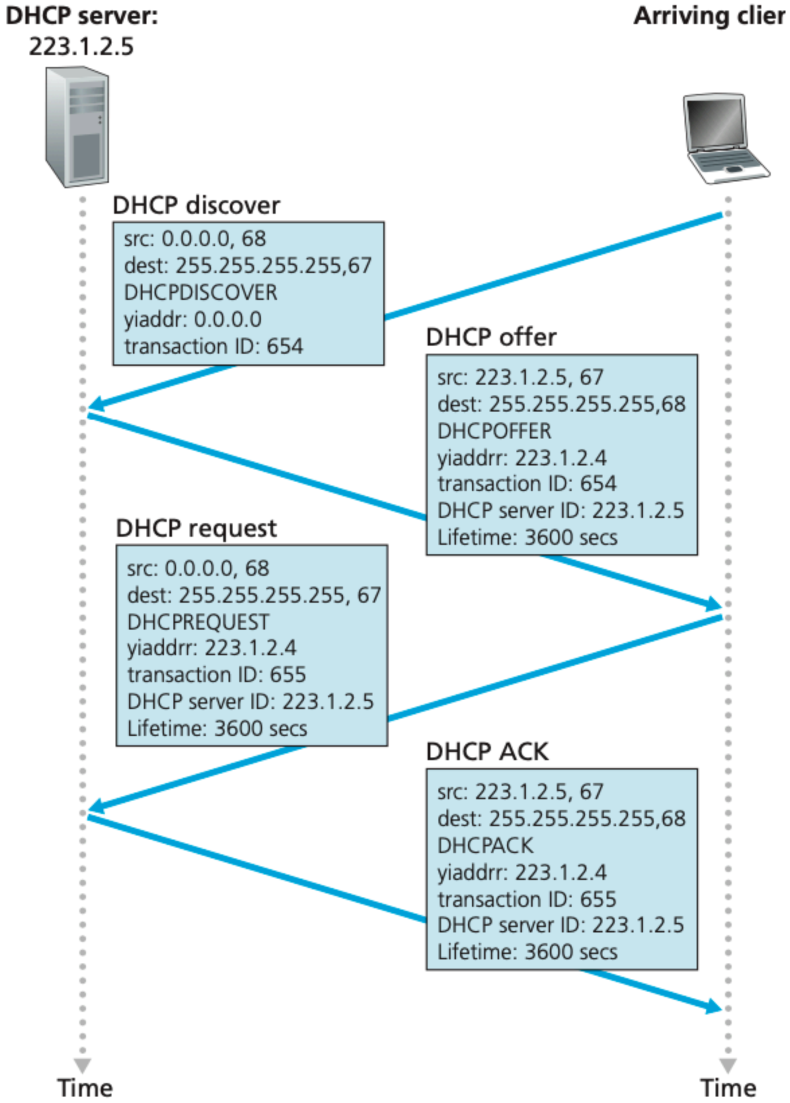


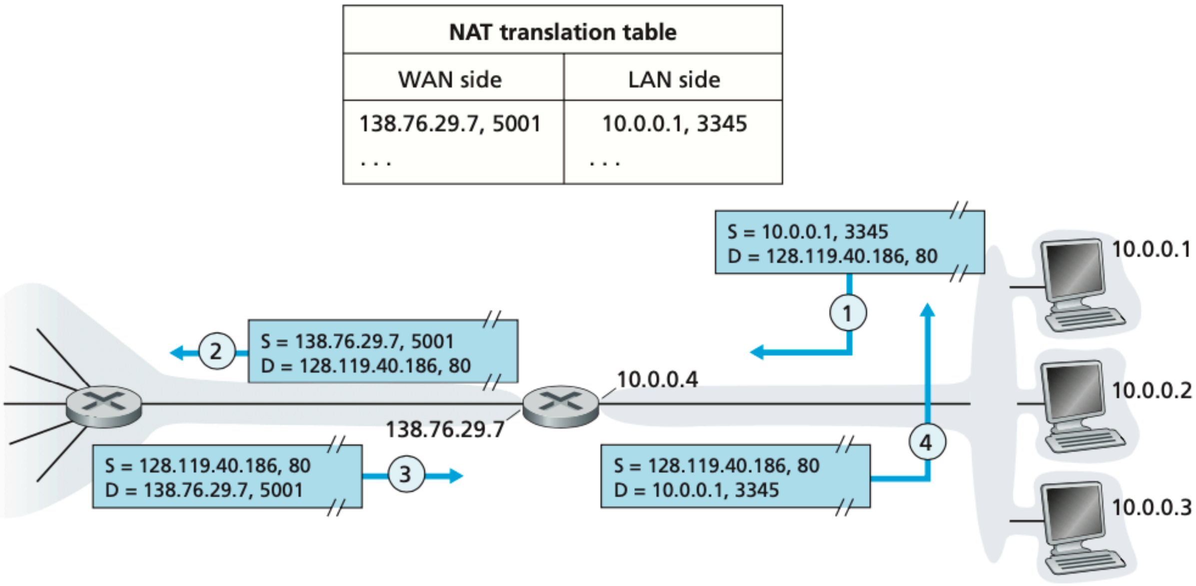
Figure 4.24 ♦ DHCP client-server interaction

Network Address Translation (NAT)

10.0.0.0/8 and 192.168.x.x is one of three portions of the IP address space that is reserved in [RFC 1918] for a **private network** or a **realm with private addresses**,

NAT router behaves to the outside world as a *single* device with a *single* IP address.

The trick is to use a **NAT translation table** at the NAT router, and to **include port numbers** as well as IP addresses in the table entries.



gure 4.25 ♦ Network address translation

IPv6

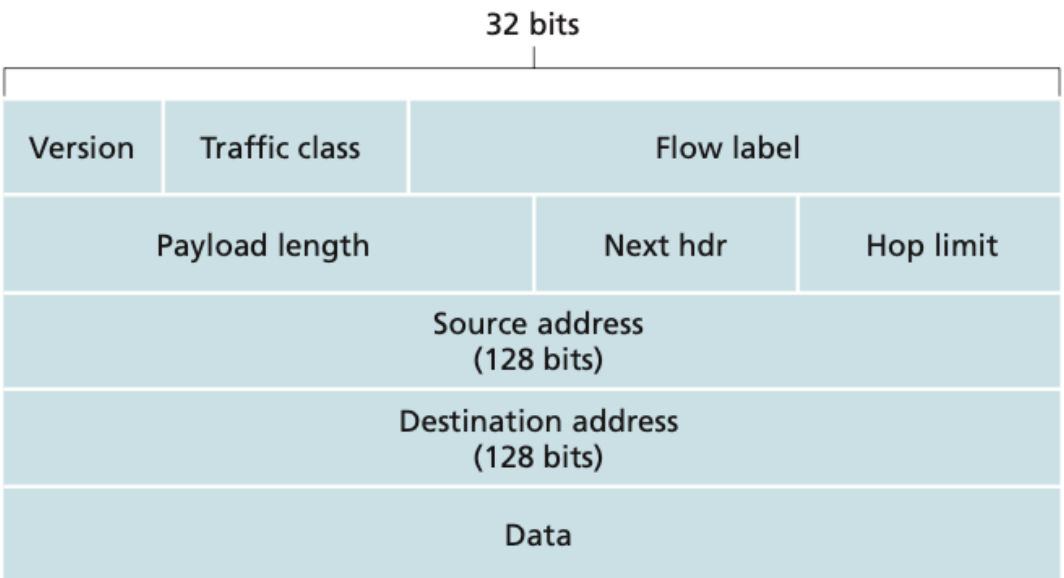


Figure 4.26 ♦ IPv6 datagram format

Expanded addressing capabilities. IPv6 increases the size of the IP address from 32 to 128 bits.

A streamlined 40-byte header.: fixed header length easy for processing

Version. This 4-bit field identifies the IP version number. Not surprisingly, IPv6 carries a value of 6 in this field

Traffic class. The 8-bit traffic class field, like the TOS field in IPv4, can be used to give priority to certain datagrams within a flow

Next header. This field identifies the protocol to which the contents (data field) of this datagram will be delivered (for example, to TCP or UDP).

Hop limit. The contents of this field are decremented by one by each router that forwards the datagram. If the hop limit count reaches zero, the datagram is discarded

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Transitioning from IPv4 to IPv6: tunneling

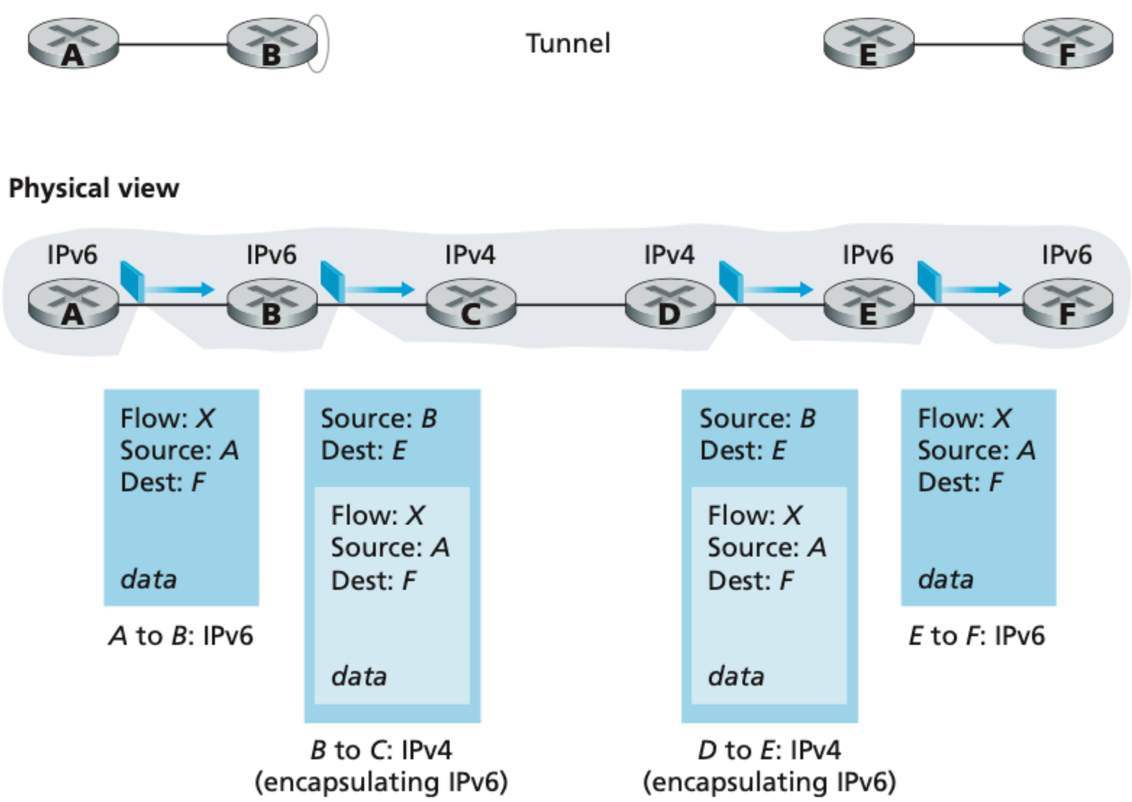

Figure 4.27 ♦ Tunneling

Section 4.4: Để đọc sau Generalized Forwarding and SDN