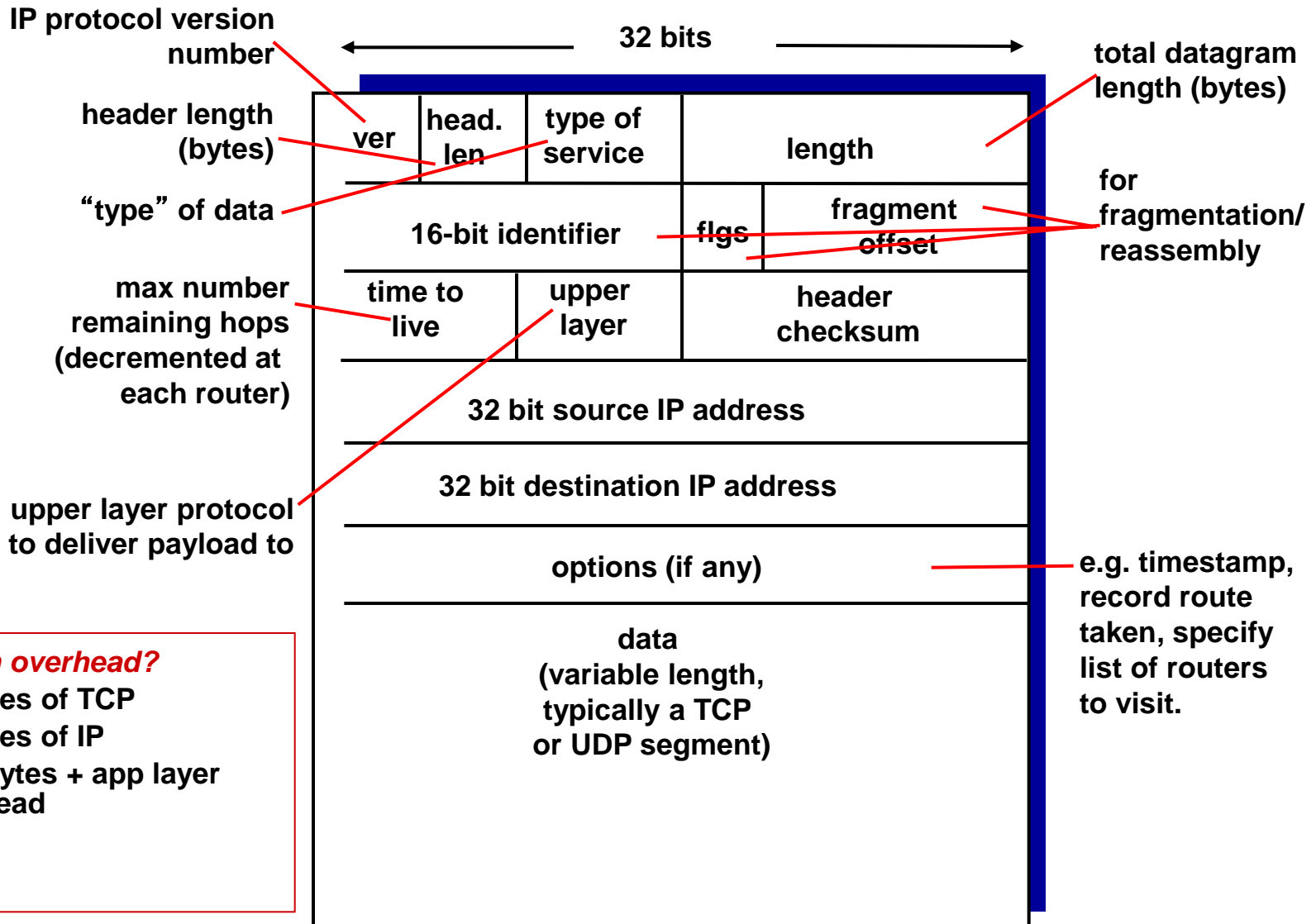


Network Layer: Logical Addressing

IP datagram format



how much overhead?

- ❖ 20 bytes of TCP
- ❖ 20 bytes of IP
- ❖ = 40 bytes + app layer overhead

IPv4 ADDRESSES

*An **IPv4 address** is a **32-bit** address that uniquely and universally defines the connection of a device (for example, a computer or a router) to the Internet.*



An IPv4 address is 32 bits long.

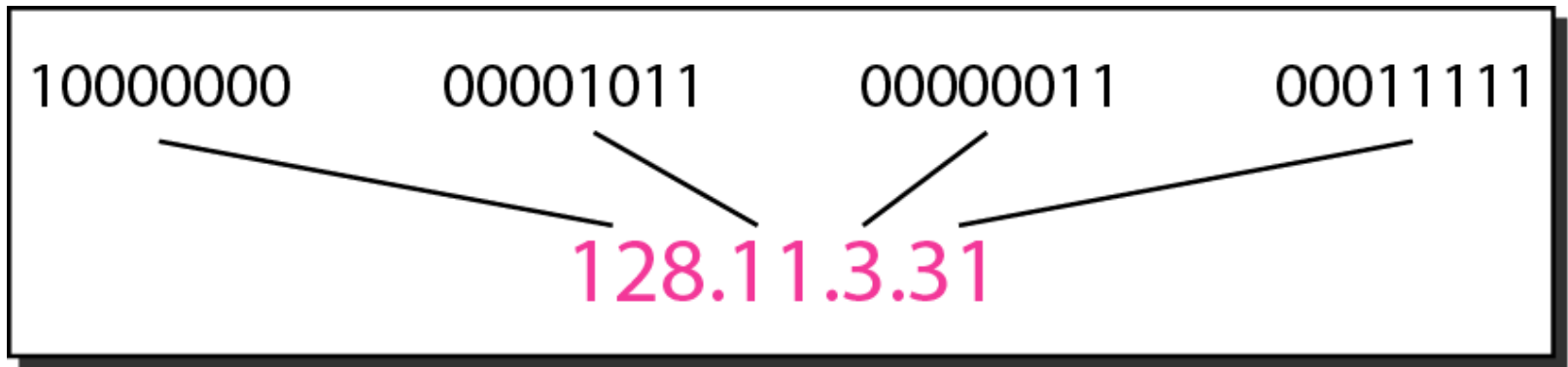


**The IPv4 addresses are unique
and universal.**



**The address space of IPv4 is
 2^{32} or 4,294,967,296.**

Dotted-decimal notation and binary notation for an IPv4 address





Example

Change the following IPv4 addresses from binary notation to dotted-decimal notation.

a. 10000001 00001011 00001011 11101111

b. 11000001 10000011 00011011 11111111

Solution

We replace each group of 8 bits with its equivalent decimal number (see Appendix B) and add dots for separation.

a. 129.11.11.239

b. 193.131.27.255



Example

Change the following IPv4 addresses from dotted-decimal notation to binary notation.

a. 111.56.45.78

b. 221.34.7.82

Solution

We replace each decimal number with its binary equivalent (see Appendix B).

a. 01101111 00111000 00101101 01001110

b. 11011101 00100010 00000111 01010010

19.3

Find the error, if any, in the following IPv4 addresses.

- a. 111.56.045.78
- b. 221.34.7.8.20
- c. 75.45.301.14
- d. 11100010.23.14.67

Solution

- a. There must be no leading zero (045).*
- b. There can be no more than four numbers.*
- c. Each number needs to be less than or equal to 255.*
- d. A mixture of binary notation and dotted-decimal notation is not allowed.*



Classful Addressing

**In classful addressing, the address space is divided into five classes:
A, B, C, D, and E.**

Finding the classes in binary and dotted-decimal notation

	First byte	Second byte	Third byte	Fourth byte
Class A	0			
Class B	10			
Class C	110			
Class D	1110			
Class E	1111			

a. Binary notation

	First byte	Second byte	Third byte	Fourth byte
Class A	0-127			
Class B	128-191			
Class C	192-223			
Class D	224-239			
Class E	240-255			

b. Dotted-decimal notation

Example

Find the class of each address.

a. 00000001 00001011 00001011 11101111

b. 11000001 10000011 00011011 11111111

c. 14.23.120.8

d. 252.5.15.111

Solution

a. *The first bit is 0. This is a class A address.*

b. *The first 2 bits are 1; the third bit is 0. This is a class C address.*

c. *The first byte is 14; the class is A.*

d. *The first byte is 252; the class is E.*

Number of blocks and block size in classful IPv4 addressing

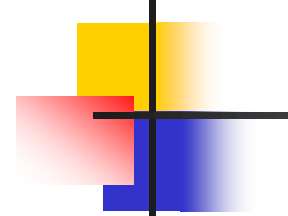
<i>Class</i>	<i>Number of Blocks</i>	<i>Block Size</i>	<i>Application</i>
A	128	16,777,216	Unicast
B	16,384	65,536	Unicast
C	2,097,152	256	Unicast
D	1	268,435,456	Multicast
E	1	268,435,456	Reserved



In classful addressing, a large part of the available addresses were wasted.

Table 19.2 *Default masks for classful addressing*

<i>Class</i>	<i>Binary</i>	<i>Dotted-Decimal</i>	<i>CIDR</i>
A	11111111 00000000 00000000 00000000	255.0.0.0	/8
B	11111111 11111111 00000000 00000000	255.255.0.0	/16
C	11111111 11111111 11111111 00000000	255.255.255.0	/24



Classful addressing, which is almost obsolete, is replaced with classless addressing.

IPv6 ADDRESSES

Despite all short-term solutions, address depletion is still a long-term problem for the Internet. This and other problems in the IP protocol itself have been the motivation for IPv6.

Topics discussed in this section:

Structure

Address Space

IPv6: motivation

- *initial motivation*: 32-bit address space soon to be completely allocated.
- additional motivation:
 - header format helps speed processing/forwarding
 - header changes to facilitate QoS

IPv6 datagram format:

- fixed-length 40 byte header
- no fragmentation allowed

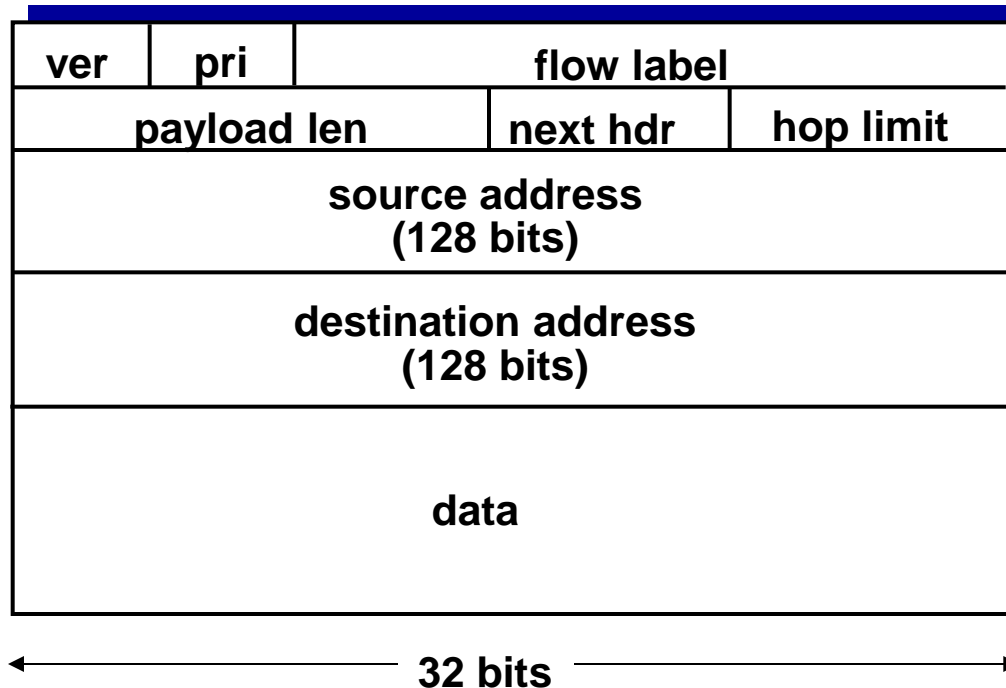
IPv6 datagram format

priority: identify priority among datagrams in flow

flow Label: identify datagrams in same “flow.”

(concept of “flow” not well defined).

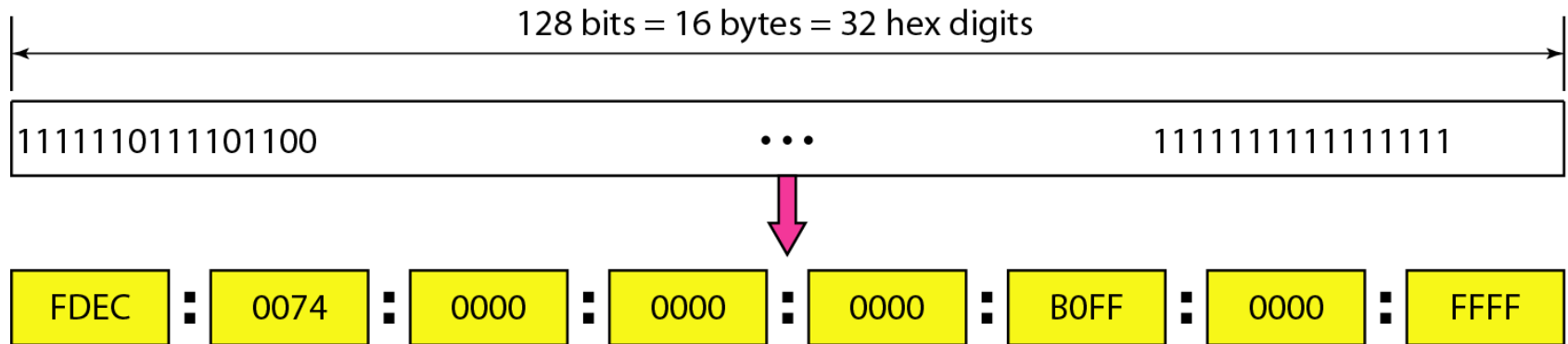
next header: identify upper layer protocol for data





An IPv6 address is 128 bits long.

IPv6 address in binary and hexadecimal colon notation



Original

FDEC ■ 0074 ■ 0000 ■ 0000 ■ 0000 ■ BOFF ■ 0000 ■ FFF0



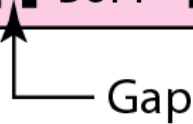
Abbreviated

FDEC ■ 74 ■ 0 ■ 0 ■ 0 ■ BOFF ■ 0 ■ FFF0



More abbreviated

FDEC ■ 74 ■ ■ BOFF ■ 0 ■ FFF0



Example

Expand the address 0:15::1:12:1213 to its original.

Solution

We first need to align the left side of the double colon to the left of the original pattern and the right side of the double colon to the right of the original pattern to find how many 0s we need to replace the double colon.

```
XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX
0: 15:           : 1: 12:1213
```

This means that the original address is.

```
0000:0015:0000:0000:0000:0001:0012:1213
```

Table *Type prefixes for IPv6 addresses*

<i>Type Prefix</i>	<i>Type</i>	<i>Fraction</i>
0000 0000	Reserved	1/256
0000 0001	Unassigned	1/256
0000 001	ISO network addresses	1/128
0000 010	IPX (Novell) network addresses	1/128
0000 011	Unassigned	1/128
0000 1	Unassigned	1/32
0001	Reserved	1/16
001	Reserved	1/8
010	Provider-based unicast addresses	1/8

Table *Type prefixes for IPv6 addresses (continued)*

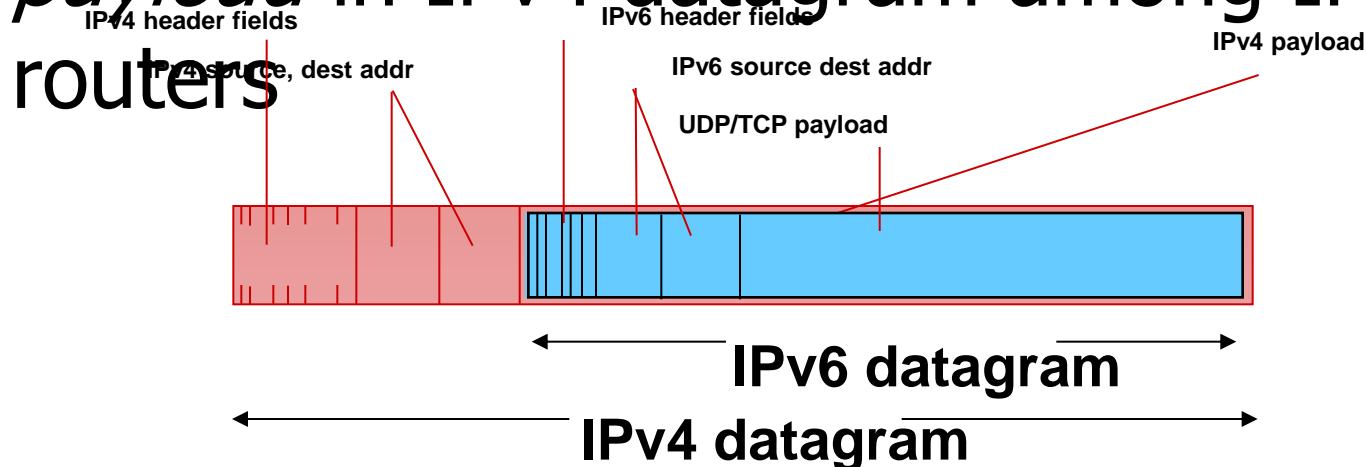
<i>Type Prefix</i>	<i>Type</i>	<i>Fraction</i>
011	Unassigned	1/8
100	Geographic-based unicast addresses	1/8
101	Unassigned	1/8
110	Unassigned	1/8
1110	Unassigned	1/16
1111 0	Unassigned	1/32
1111 10	Unassigned	1/64
1111 110	Unassigned	1/128
1111 1110 0	Unassigned	1/512
1111 1110 10	Link local addresses	1/1024
1111 1110 11	Site local addresses	1/1024
1111 1111	Multicast addresses	1/256

Other changes from IPv4

- *checksum*: removed entirely to reduce processing time at each hop
- *options*: allowed, but outside of header, indicated by “Next Header” field
- *ICMPv6*: new version of ICMP
 - additional message types, e.g. “Packet Too Big”
 - multicast group management functions

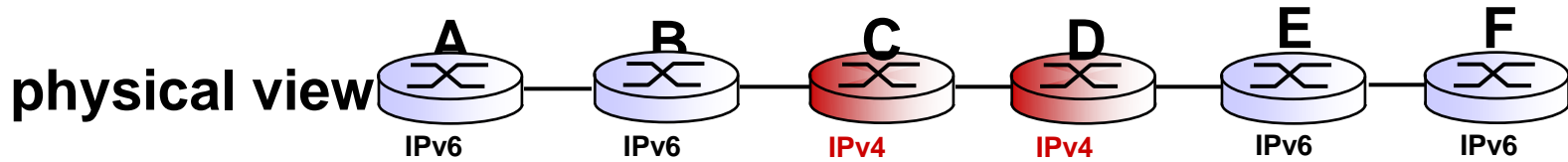
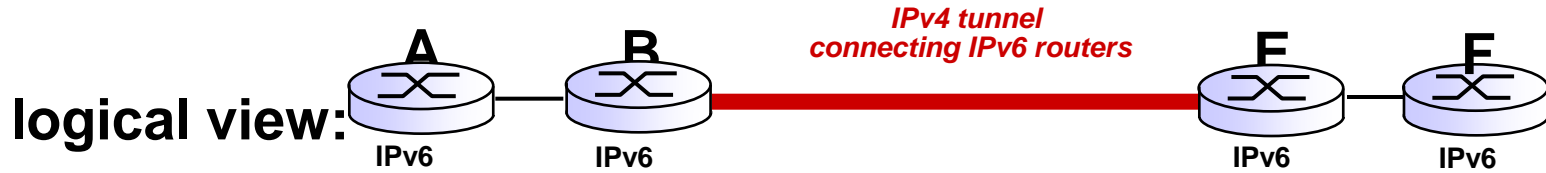
Transition from IPv4 to IPv6

- not all routers can be upgraded simultaneously
 - no “flag days”
 - how will network operate with mixed IPv4 and IPv6 routers?
- *tunneling*: IPv6 datagram carried as *payload* in IPv4 datagram among IPv4 routers

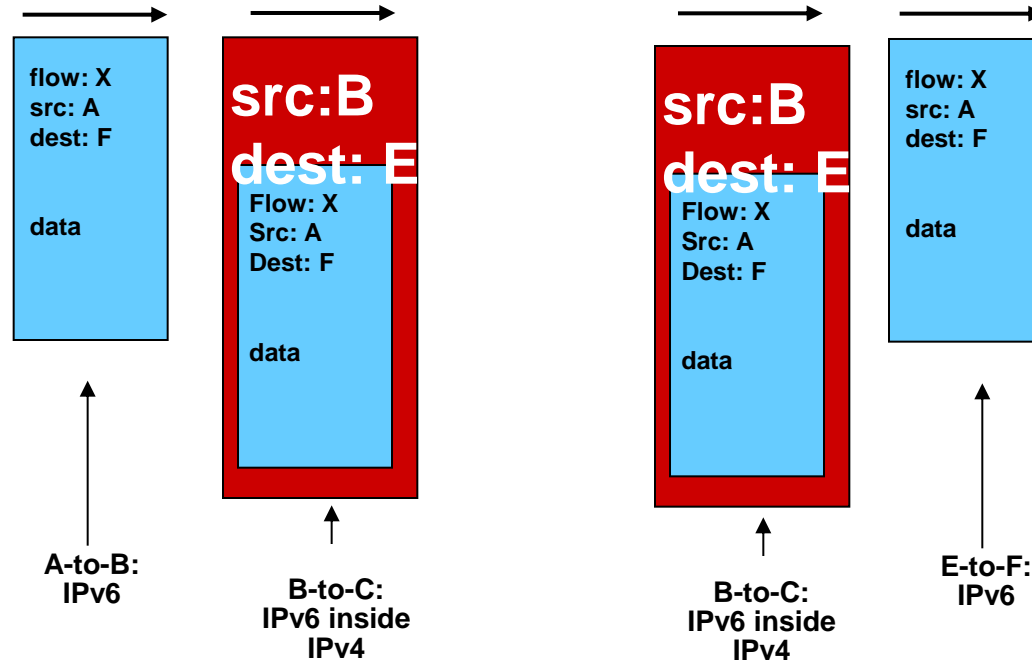
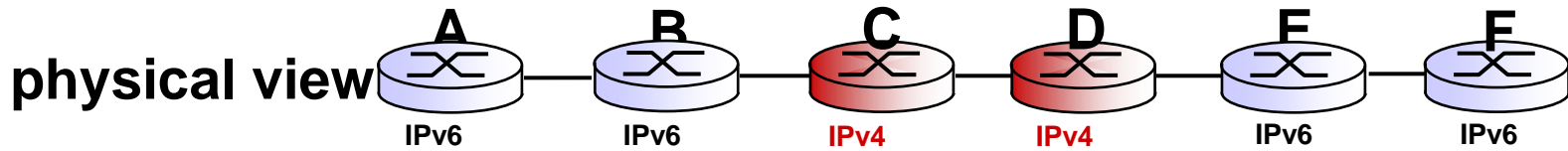
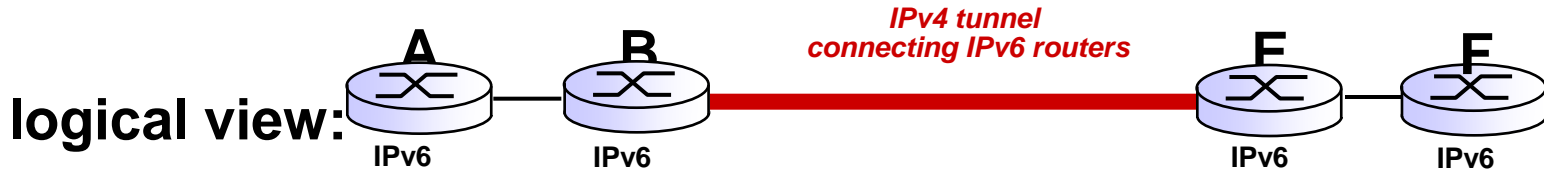


Network Layer

Tunneling



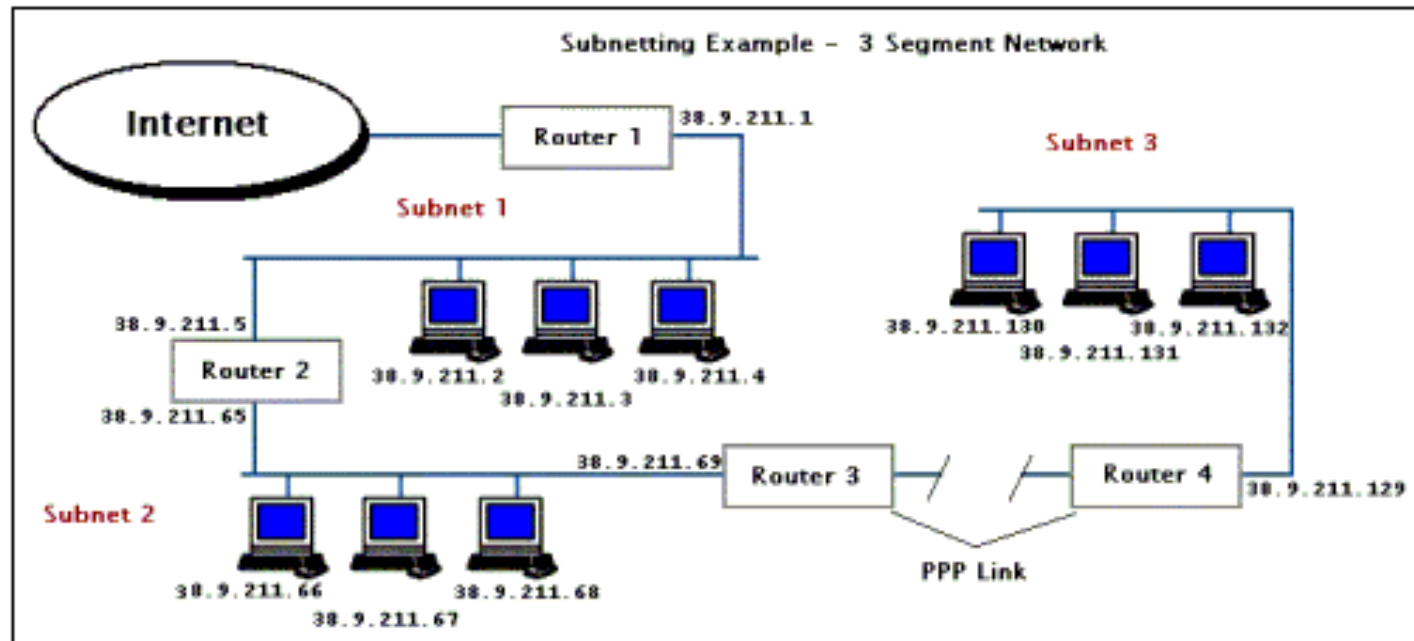
Tunneling



Network Layer

Subnetting

Subnetting is a method for getting the most out of the limited 32-bit IPv4 addressing space and reducing the size of the routing tables in a large internetwork.



Benefits of Subnetting

- Reduced network traffic
- Optimized network performance
- Simplified management
- Facilitated spanning of large geographical distances.

VLSM

Supernetting