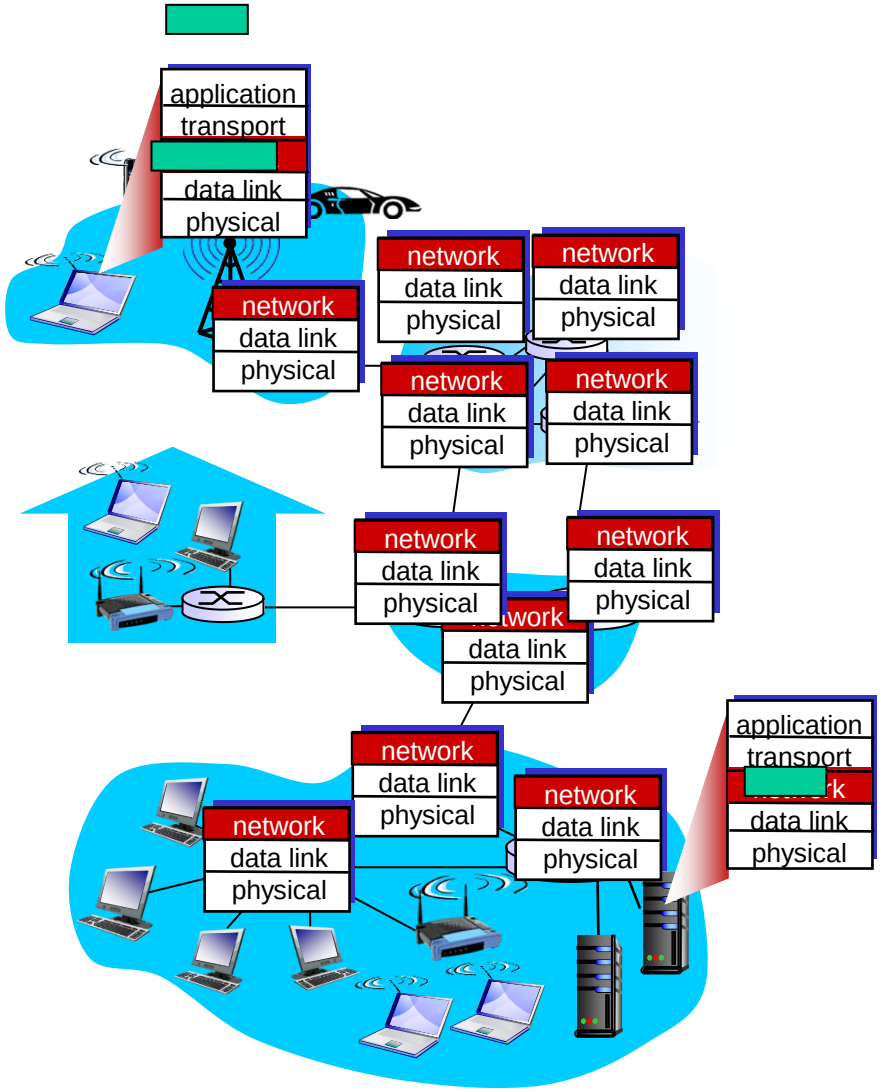
Computer Networks

Unit - 4

Network Layer

Introduction: Network Layer



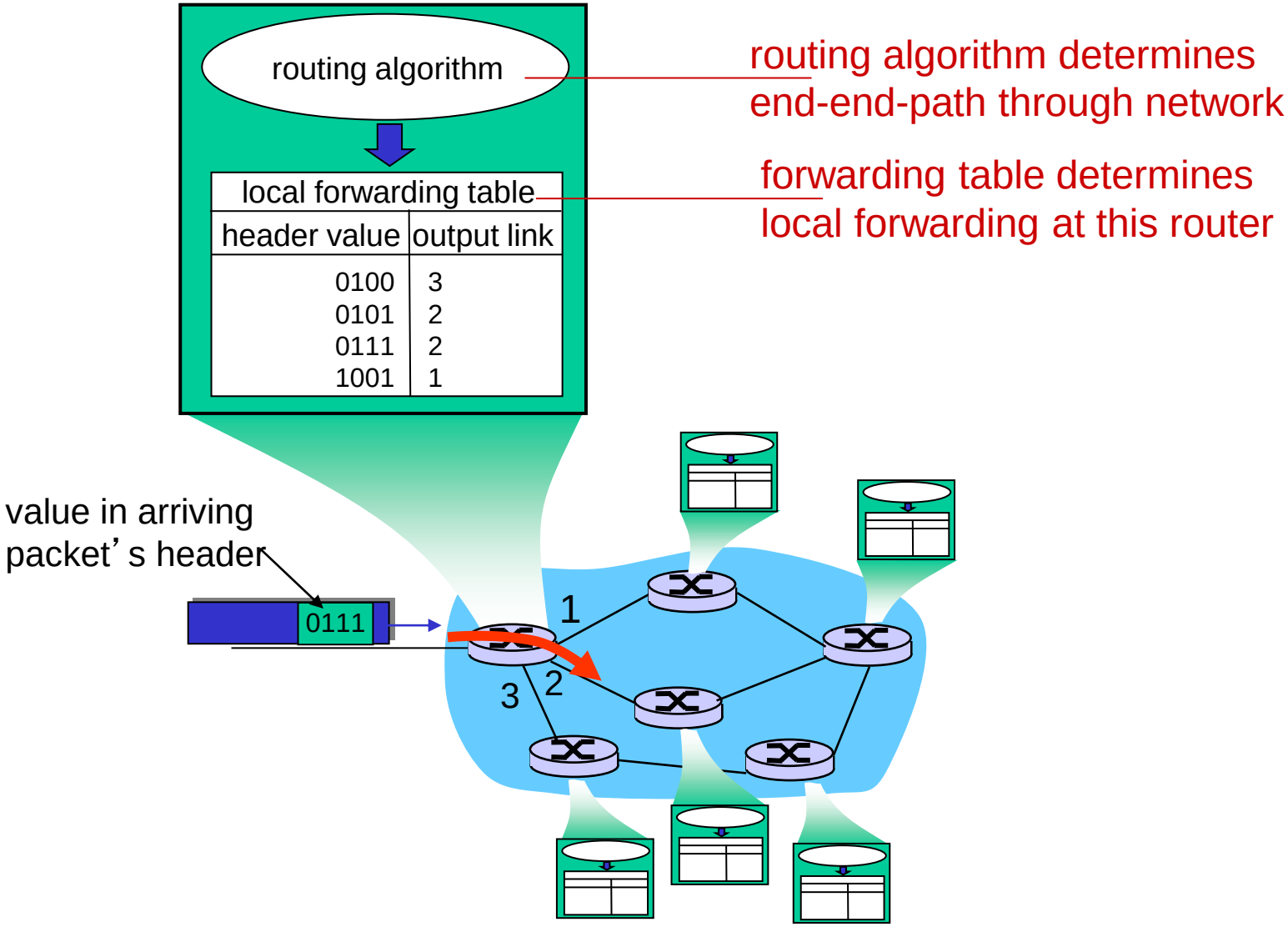
- To deliver segment from sending to receiving host/ router.
- On sending side, it encapsulates segments into datagrams.
- On receiving side, it delivers segments to transport layer.
- Network layer protocols in every host and router.
- Router examines header fields in all IP datagrams passing through it.

Key Function of Network Layer

- Role of the network layer is simple - to move packets from a sending host to a receiving host.
- Two important network layer functions can be identified:

1. **Forwarding**
   - When a packet arrives at a router's input link, the router must move the packet to the appropriate output link.
2. **Routing**
   - It's a process of selecting best paths in a network.
   - The network layer must determine the route or path taken by packets as they flow from a sender to a receiver.
   - The algorithms that calculate these paths are referred to as **routing algorithms.**

Routing and Forwarding



- Services provided by network layer for individual datagrams.
- **Guaranteed delivery**
  - This service guarantees that the packet will eventually arrive at its destination.
- **Guaranteed delivery with bounded delay**
  - This service not only guarantees delivery of the packet, but delivery within a specified host-to-host delay bound.

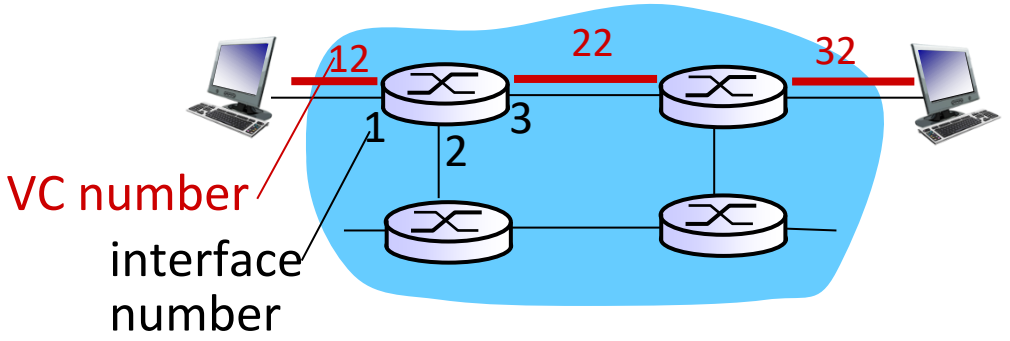
- Services provided by network layer for a flow of datagrams.
- **In-order packet delivery**
  - This service guarantees that packets arrive at the destination in the order that they were sent.
- **Guaranteed minimal bandwidth**
  - This network-layer service emulates the behaviour of a transmission link of a specified bit rate (for example, 1 Mbps) between sending and receiving hosts.
  - As long as the sending host transmits bits at a rate below the specified bit rate, then no packet is lost.

- **Guaranteed maximum jitter**
  - This service guarantees that the amount of time between the transmission of two successive packets at the sender is equal to the amount of time between their receipt at the receiver.
- **Security services**
  - Using a secret session key known only by a source and destination host, the network layer in the source host could encrypt the payloads of all datagrams being sent to the destination host.
  - The network layer in the destination host would then be responsible for decrypting the payloads.

Transport Layer	Network Layer
process to- process services	host-to-host services
UDP, a connectionless service	**connectionless service** at the network layer are called **datagram networks**. does not have any handshaking preliminaries.
TCP, a connection-oriented service.	**connection service** at the network layer are called **virtual-circuit** (**VC**) **networks**; handshaking between the source and destination hosts

- A VC consists of
  1. A path between the source and destination hosts
  2. VC numbers, one number for each link along the path
  3. Entries in the forwarding table in each router along the path
- A packet belonging to a virtual circuit will carry a VC number in its header.
- VC number can be changed on each link
  - New VC number comes from forwarding table

VC Forwarding Table



forwarding table in router:

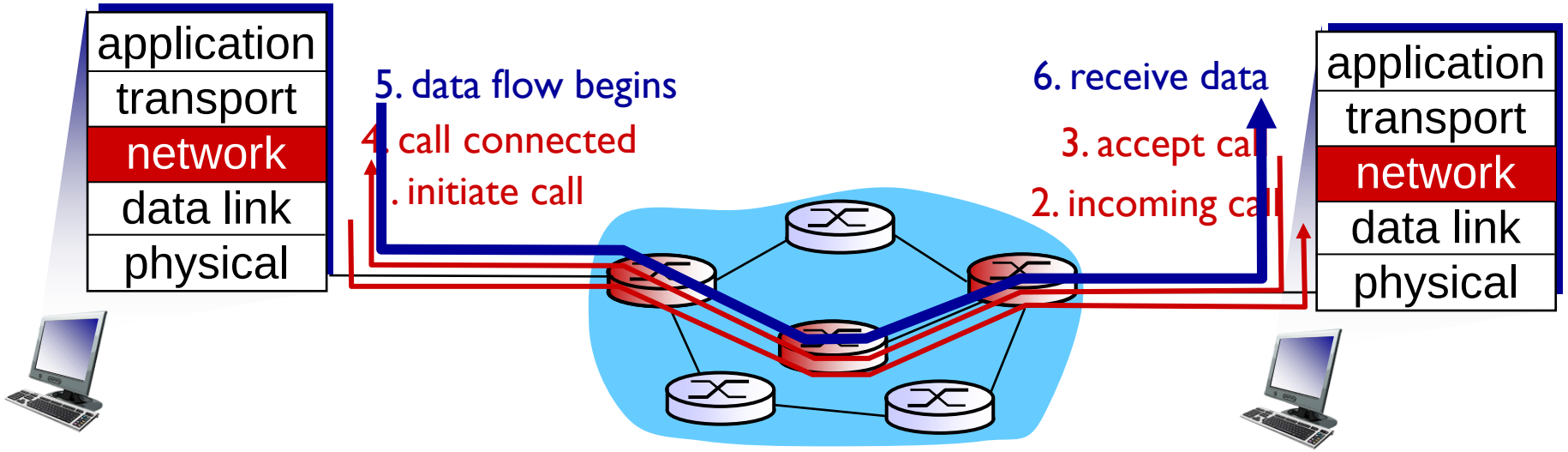
Incoming interface	Incoming VC #	Outgoing interface	Outgoing VC #
1	12	3	22
2	63	1	18
3	7	2	17
1	97	3	87
…	…	…	…

VC routers maintain connection state information

Virtual Circuit Setup

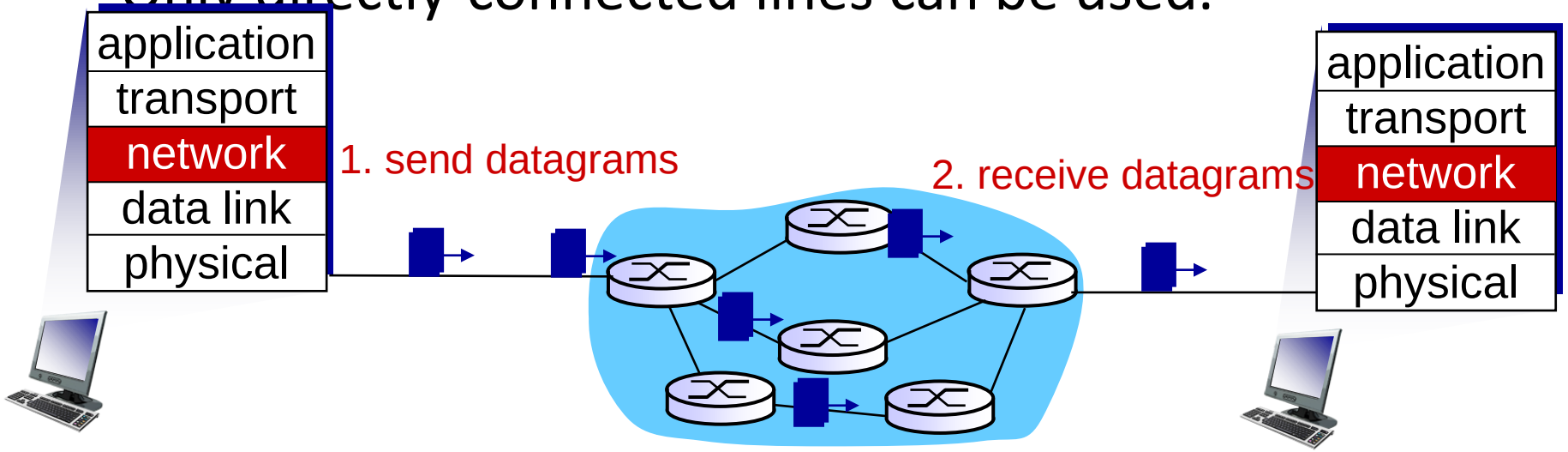
There are three identifiable phases in a virtual circuit:

1. **VC setup**
2. **Data transfer**
3. **VC teardown**



Datagram Network

- In connectionless service, packets are injected into the subnet individually and routed independently of each other.
- No advance setup is needed. The packets are frequently called datagrams and the subnet is called a **datagram subnet**.
- Only directly-connected lines can be used.

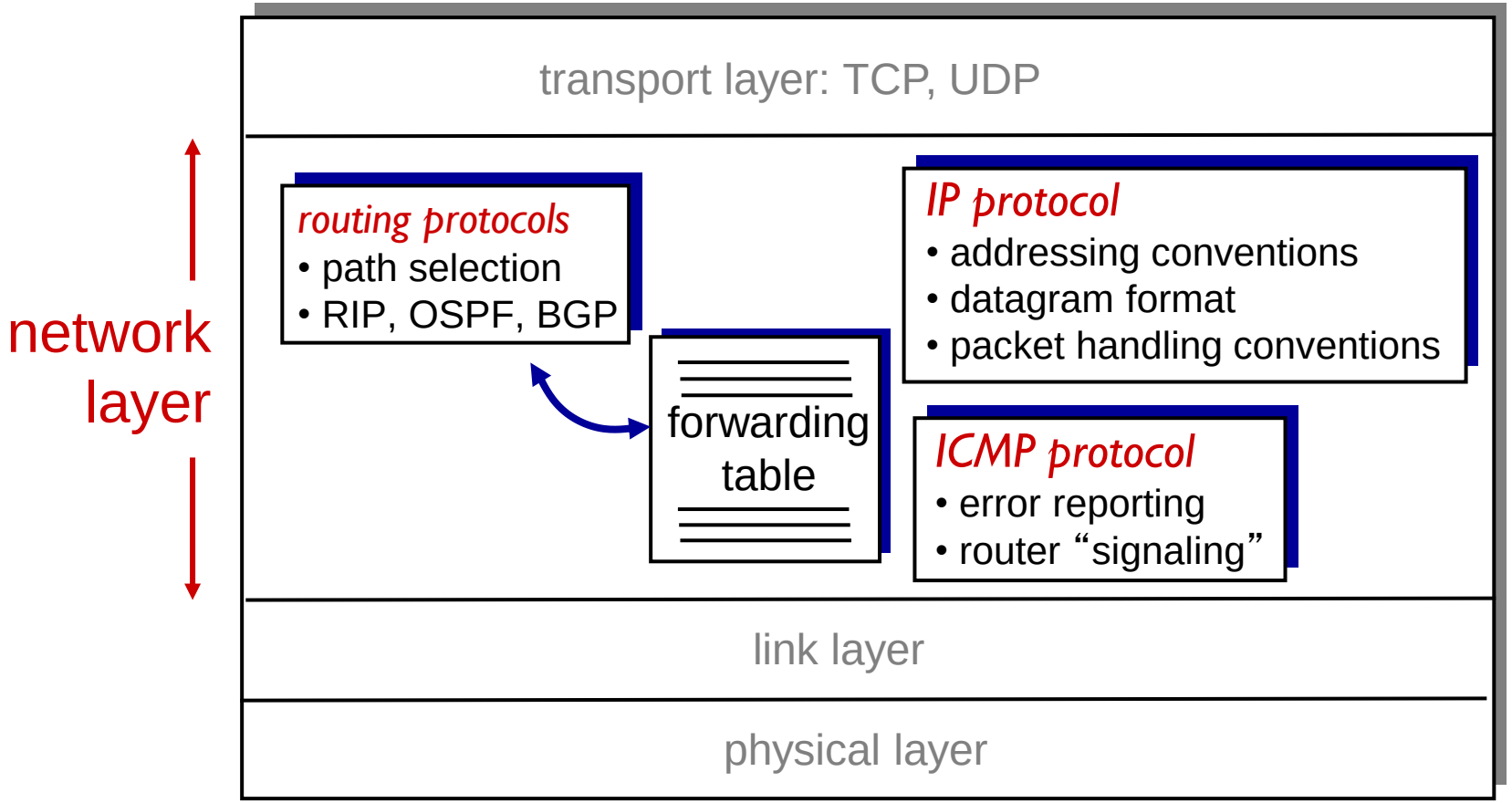


Datagram Network vs. Virtual Circuit Network

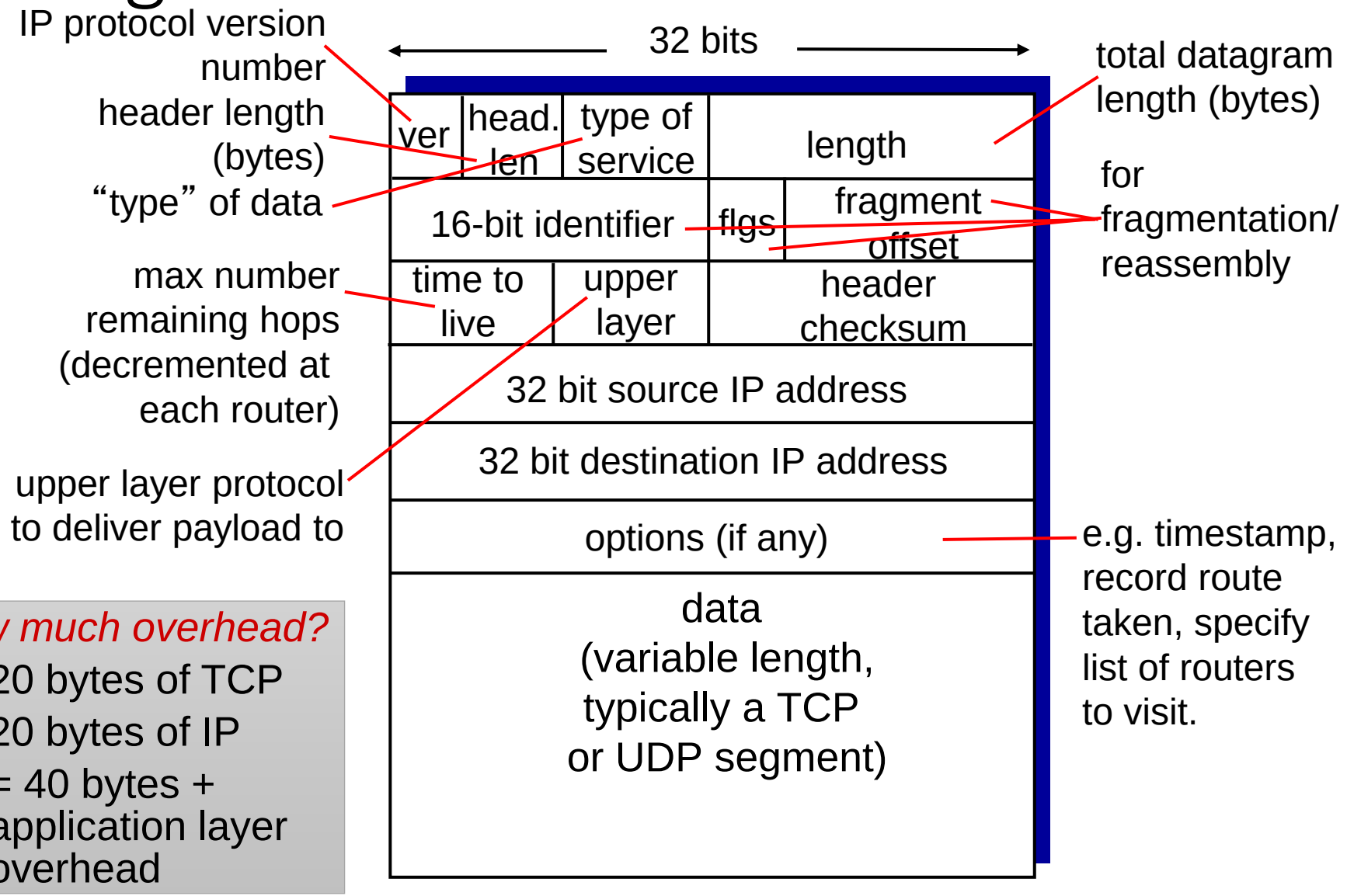
	Datagram	Virtual Circuit
Connection Setup	None	Required
Addressing	Packet contains full source and destination address	Each virtual circuit number entered to table on setup, used for routing.
State Information	None other than router table containing destination network	Route established at setup, all packets follow same route.
Effect of Router Failure	Only on packets lost during crash	All virtual circuits passing through failed router terminated.
Congestion Control	Difficult since all packets routed independently router resource requirements can vary.	Simple by pre-allocating enough buffers to each virtual circuit at setup, since maximum number of circuits fixed.

Datagram Switching	Virtual Circuit
Connectionless	Connection Oriented
No Reservation	Reservation (Bandwidth, CPU Memory, Buffer)
May or May Use different Path	Same Path
Out of Order	Same Order
High Overhead	Less Overhead
Packet Lost High	Packet Lost Less
Used in Internet	Used in X.35, Frame, Relay, ATM
Less Costly	Costly
Not Reliable	Highly Reliable

Internet Network Layer



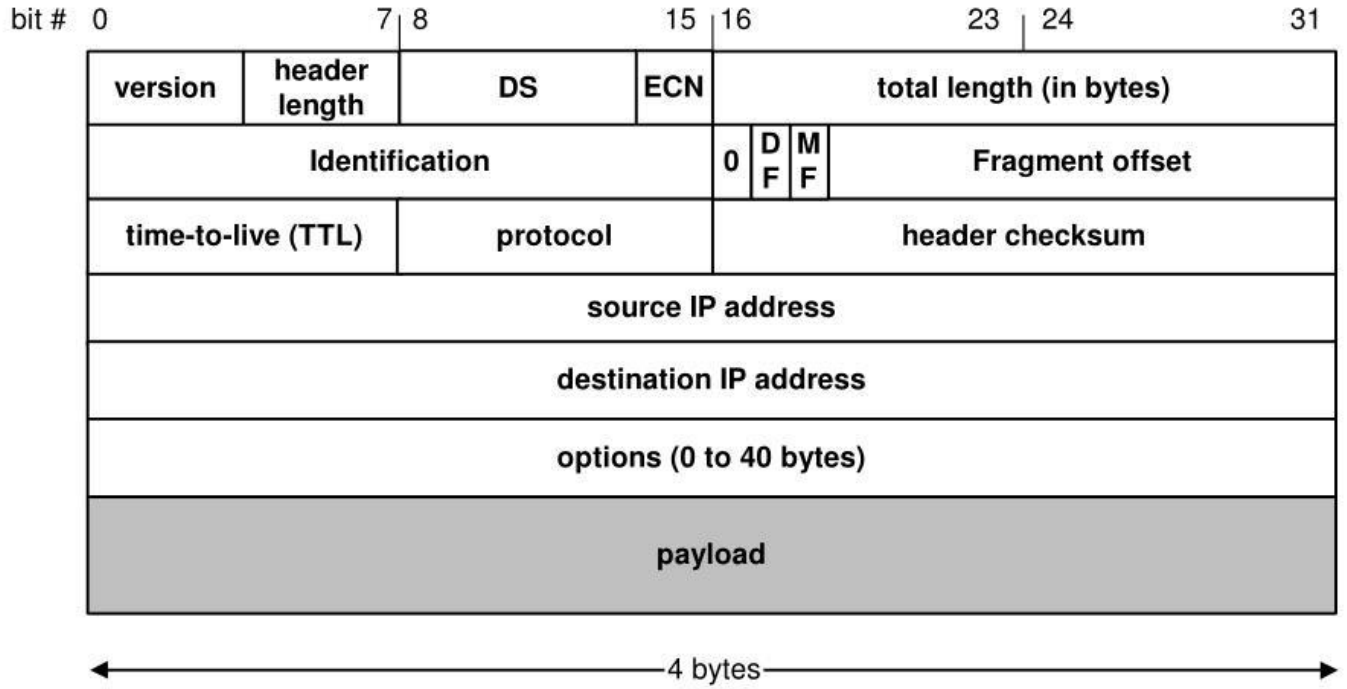
IPv4 Datagram format



how much overhead?

- 20 bytes of TCP
- 20 bytes of IP
- = 40 bytes + application layer overhead

IP Datagram Format



- 20 bytes ≤ Header Size < 2^4 x 4 bytes = 60 bytes
- 20 bytes ≤ Total Length < 2^{16} bytes = 65536 bytes

IP Address

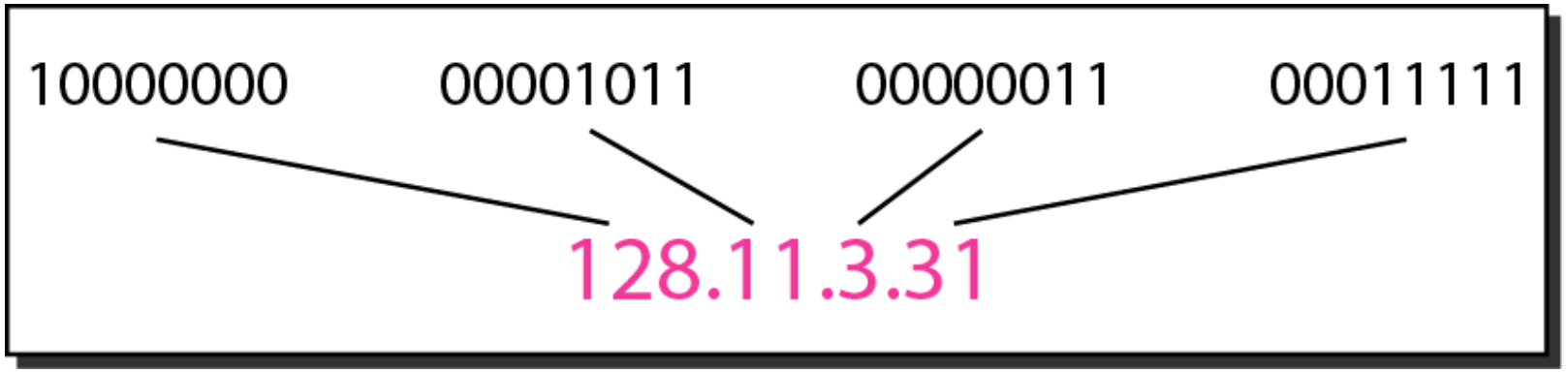
- IP addresses are useful in identifying a specific host in a network.
- IP addresses are 32 bit numbers which are divided into 4 octets. Each octet represents 8 bit binary number.
- Below is an example of an IP address:

10101100	00010000	11111110	00000001
172	**16**	**254**	**1**

IP addresses are divided into 2 parts:
Network ID & Host ID

<NID> <HID> = IP Address

Figure 19.1 *Dotted-decimal notation and binary notation for an IPv4 address*



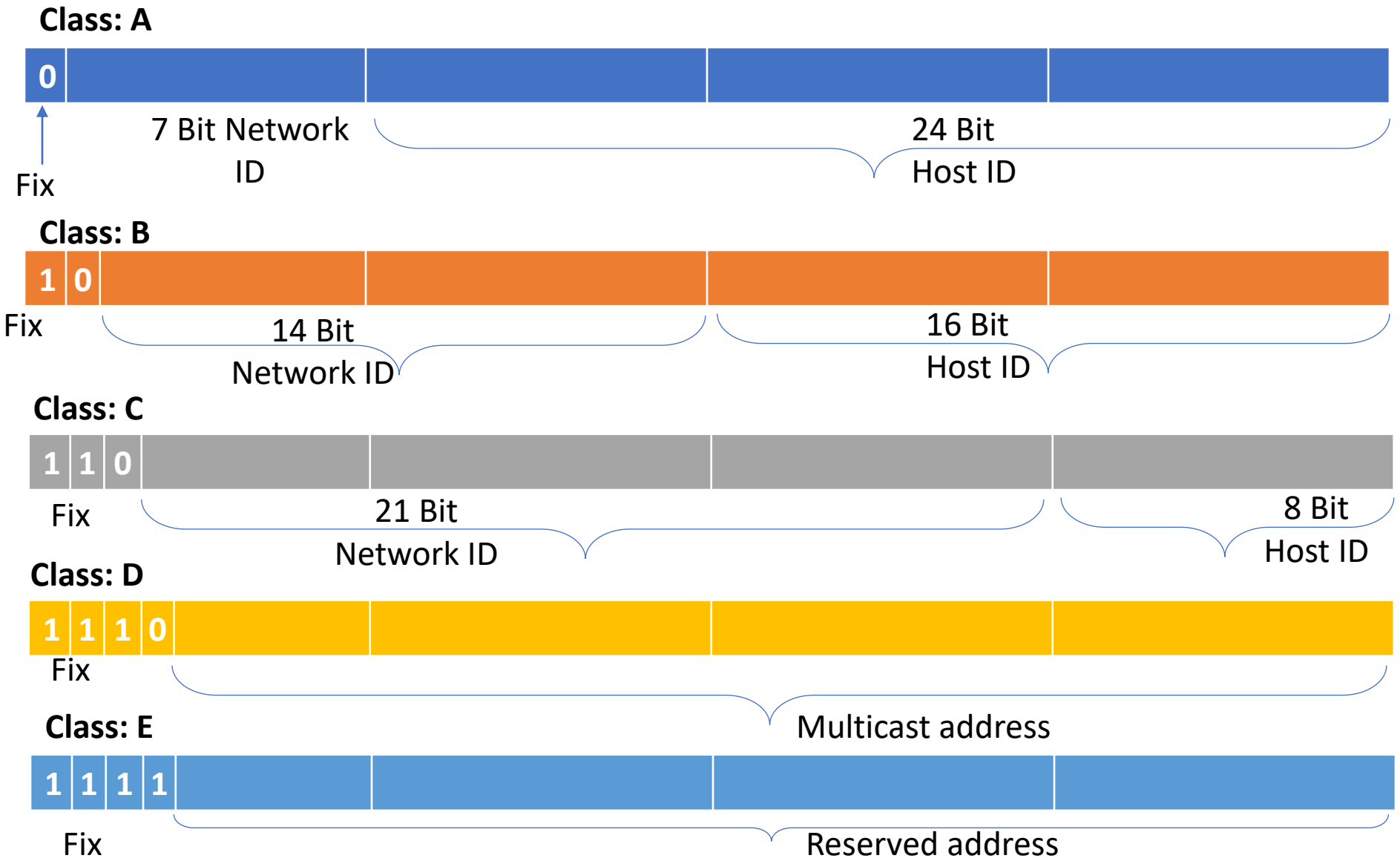
00000001 00001011 00001011 11101111

11000001 10000011 00011011 11111111

14.23.120.8 → Class A

252.5.15.111 →

Classification of IP Addresses (Classful Addressing)



Example

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

Note

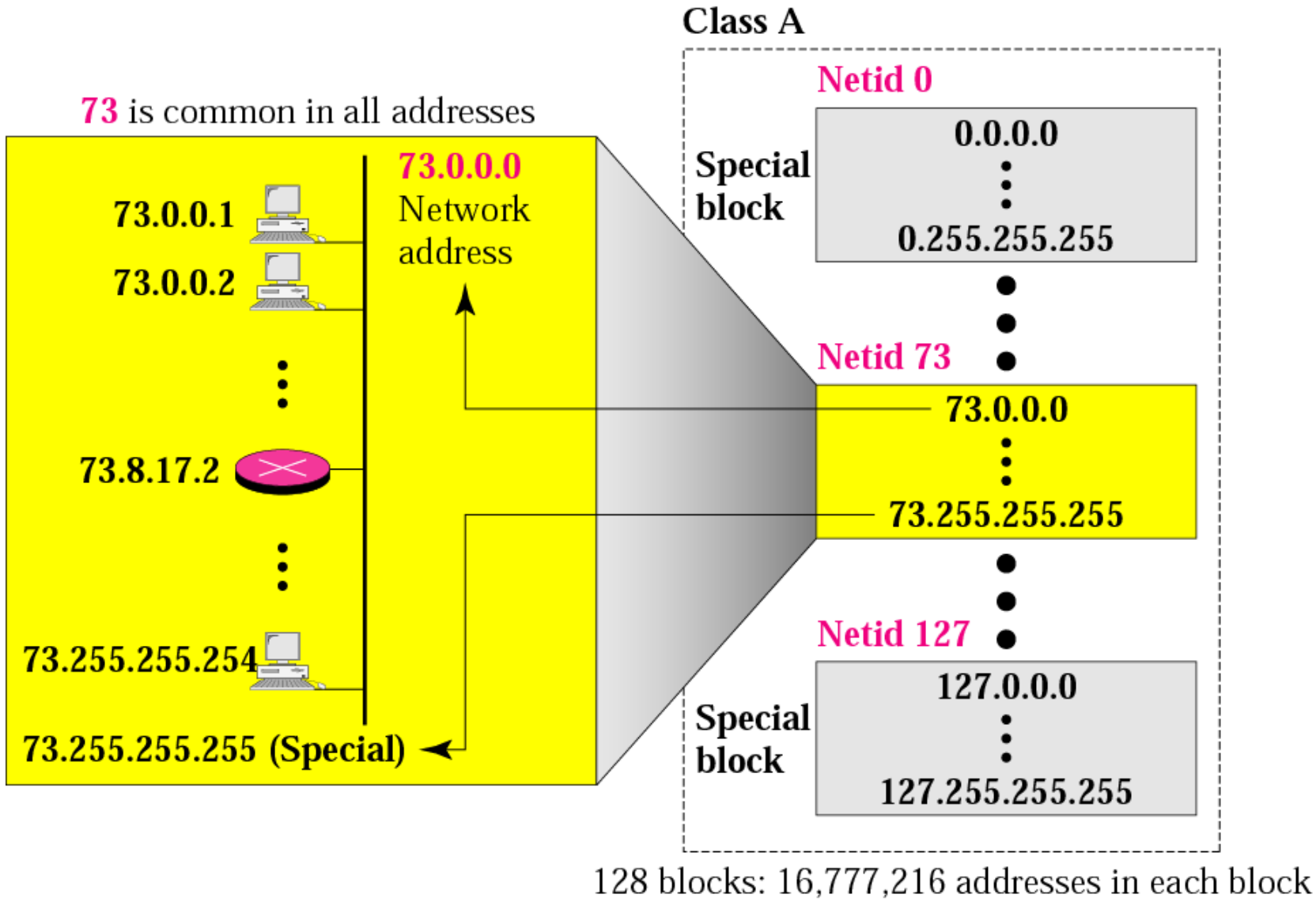
The address space of IPv4 is
2^{32} or 4,294,967,296.

Class A: (0.0.0.0 to 127.255.255.255)

- Only 126 addresses are used for network address.
- All 0's and 1's in Network-ID are dedicated for special IP address. So, total number of IP address in class A can be represented:

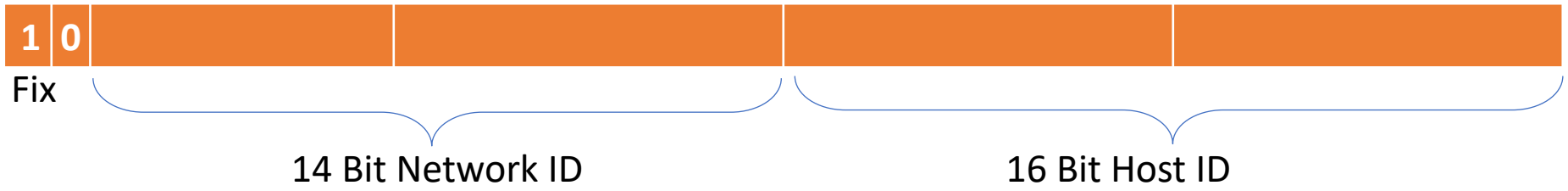
0.0.0.0	**Special IP Address**
00000001.0.0.1 1.0.0.2 1.0.0.3 . . . 126.255.255.254	$2^{24} - 2$ are Host IP
127.255.255.255	Special IP Address – Loopback

Blocks in class A



128 blocks: 16,777,216 addresses in each block

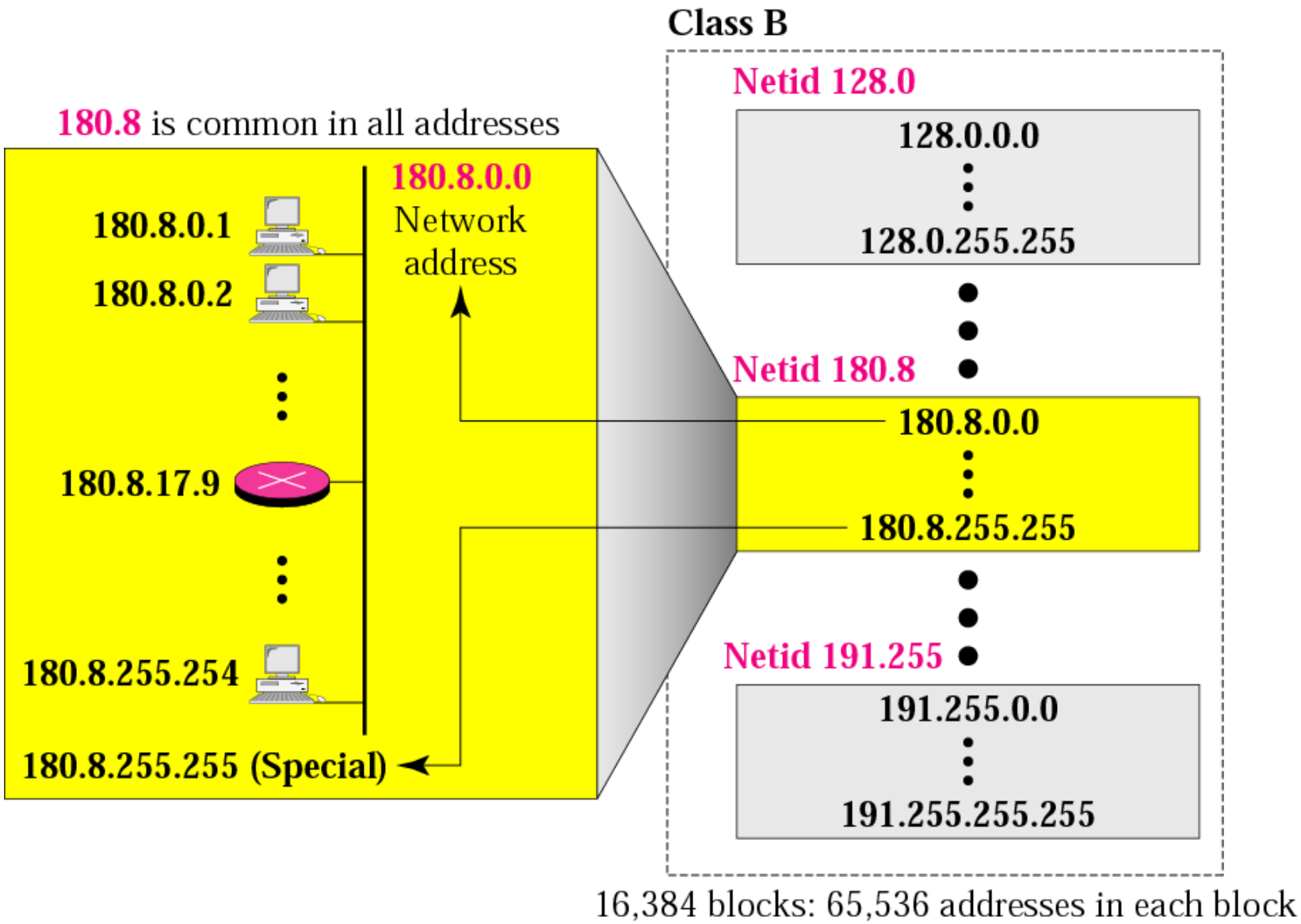
Class B: (128.0.0.0 to 191.255.255.255)



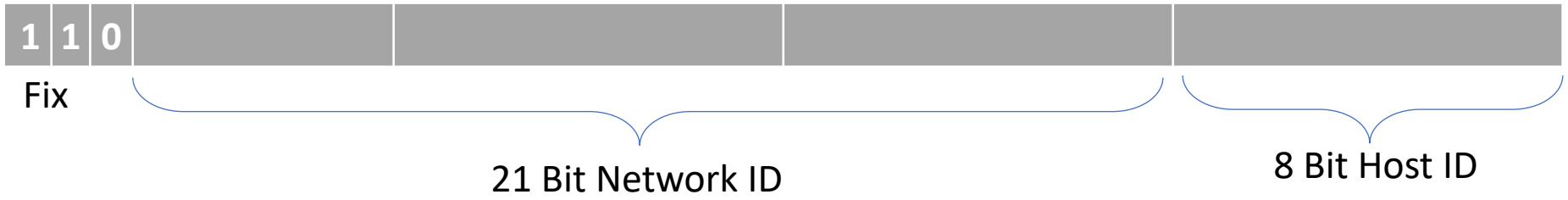
- No special network address here. All are usable.

128.0.0.0	Special IP Address
10000001.0.0.1 130.0.0.2 130.0.0.3 . . . 190.255.255.254	$2^{16} - 2$ are Host IP
10111111.255.255.255	Special IP Address – Loopback

Blocks in class B

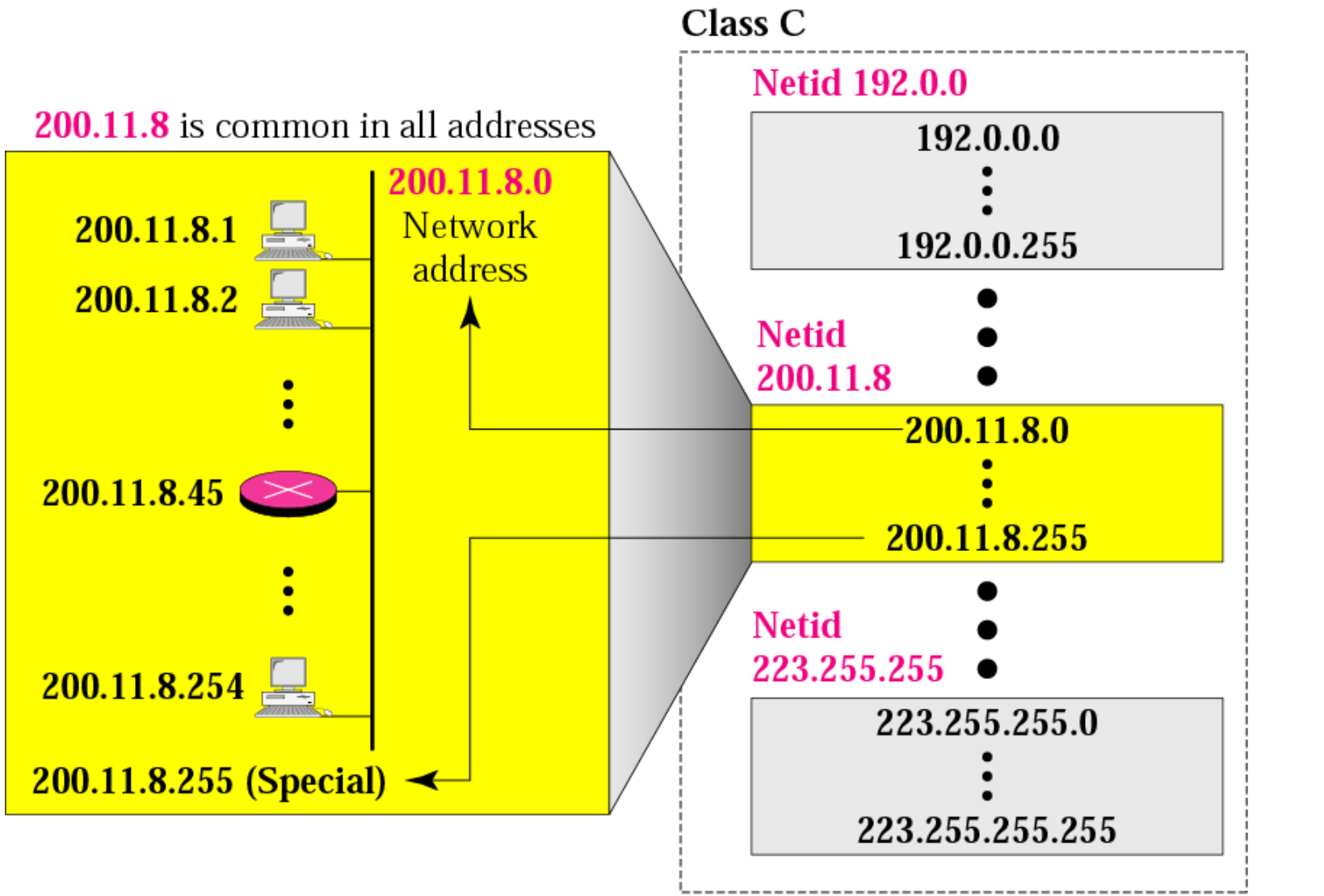


Class C: (192.0.0.0 to 223.255.255.255)



192.0.0.0	**Special IP Address**
11000001.0.0.1 194.0.0.2 194.0.0.3 . . . 222.255.255.254	2^8 – 2 are Host IP
11011111.255.255.255	Special IP Address – Loopback

Blocks in class C



Class D: (224.0.0.0 to 239.255.255.255)

- Very first four bits of the first octet in Class D IP addresses are set to 1110, giving a range of:

11100000 – **1110**1111
224 – 239

- Class D has IP address rage from 224.0.0.0 to 239.255.255.255.
- Class D is reserved for **Multicasting.**
- In multicasting data is not destined for a particular host, that is why there is no need to extract host address from the IP address, and Class D does not have any subnet mask.

Class E: (240.0.0.0 to 255.255.255.255)

- This IP Class is reserved for experimental purposes only for R&D or Study.
- IP addresses in this class ranges from 240.0.0.0 to 255.255.255.254.
- Like Class D, this class too is not equipped with any subnet mask.

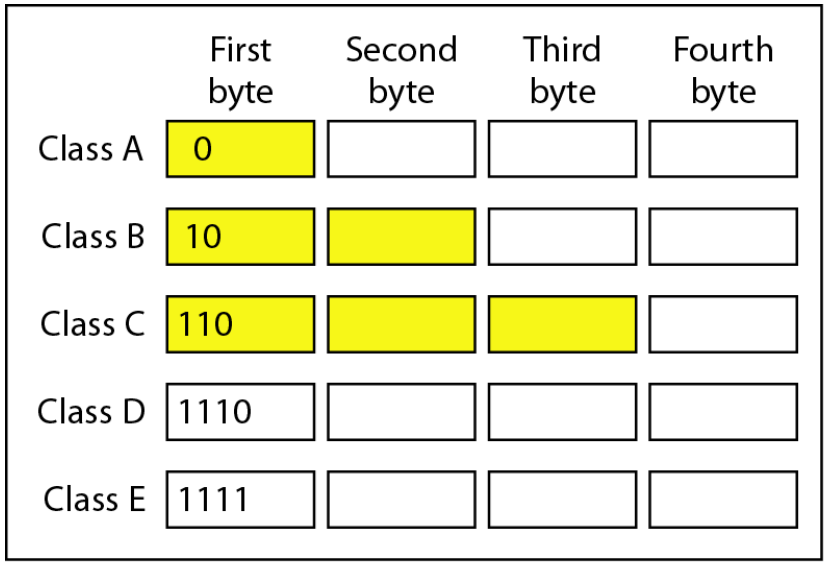
Network Addresses

- The network address is the first address.
- The network address defines the network to the rest of the Internet.
- Given the network address, we can find the class of the address, the block, and the range of the addresses in the block
- The network address is the beginning address of each block.
- It can be found by applying the default mask to any of the addresses in the block(including itself). It retains the netid of the block and sets the hostid to zero.

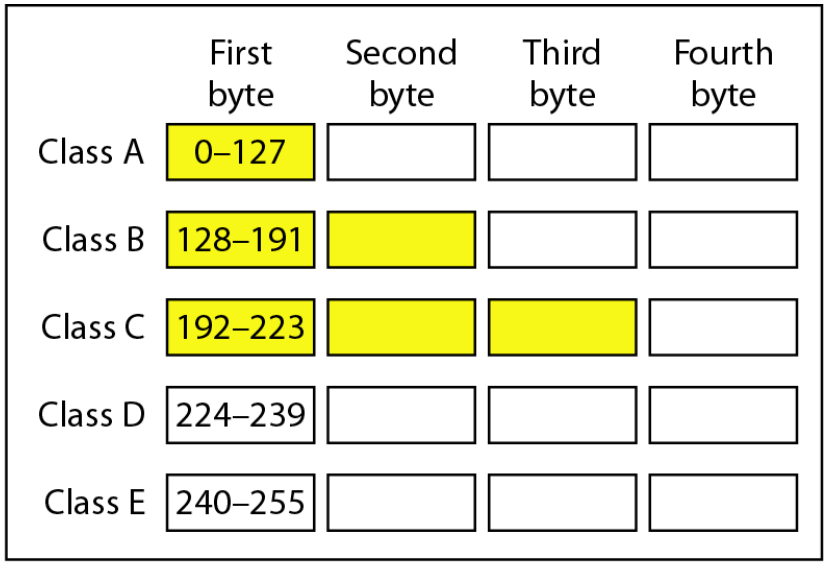
Type of addresses in IPv4 Network

- **Network address** - The address by which we refer to the network.
  - E.g.: 10.0.0.0
- **Broadcast address** - A special address used to send data to all hosts in the network.
  - The broadcast address uses the highest address in the network range.
  - E.g.: 10.0.0.255
- **Host addresses** - The addresses assigned to the end devices in the network.
  - E.g.: 10.0.0.1

Figure 19.2 *Finding the classes in binary and dotted-decimal notation*



a. Binary notation



b. Dotted-decimal notation

IP Addressing Summary

Class	Leading bits	Size of *network number* bit field	Size of *rest* bit field	Number of networks	Addresses per network	Total addresses in class	Start address	End address	Default subnet mask in dot-decimal notation	CIDR notation
Class A	0	8	24	128 (2^7)	16,777,216 (2^{24})	2,147,483,648 (2^{31})	0.0.0.0	127.255.255.255	255.0.0.0	/8
Class B	10	16	16	16,384 (2^{14})	65,536 (2^{16})	1,073,741,824 (2^{30})	128.0.0.0	191.255.255.255	255.255.0.0	/16
Class C	110	24	8	2,097,152 (2^{21})	256 (2^8)	536,870,912 (2^{29})	192.0.0.0	223.255.255.255	255.255.255.0	/24
Class D (multicast)	1110	not defined	not defined	not defined	not defined	268,435,456 (2^{28})	224.0.0.0	239.255.255.255	not defined	not defined
Class E (reserved)	1111	not defined	not defined	not defined	not defined	268,435,456 (2^{28})	240.0.0.0	255.255.255.255	not defined	not defined

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.

Example

- *A block of addresses is granted to a small organization. We know that one of the addresses is 205.16.37.39/28. What is the first address in the block?*

Solution

a. *The first address can be found by ANDing the given addresses with the mask. ANDing here is done bit by bit. The result of ANDing 2 bits is 1 if both bits are 1s; the result is 0 otherwise.*

Address:	11001101	00010000	00100101	00100111
Mask:	**11111111**	**11111111**	**11111111**	**11110000**
First address:	11001101	00010000	00100101	00100000

Example 19.9

b. The last address can be found by ORing the given addresses with the complement of the mask. ORing here is done bit by bit. The result of ORing 2 bits is 0 if both bits are 0s; the result is 1 otherwise. The complement of a number is found by changing each 1 to 0 and each 0 to 1.

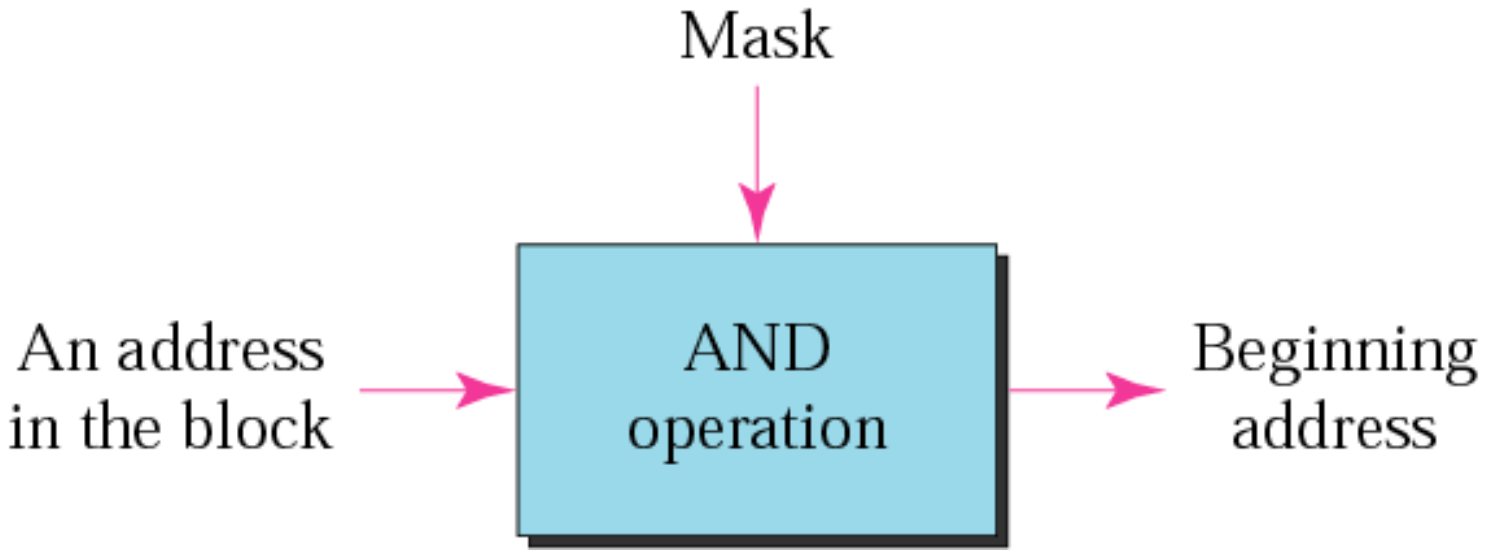
Address:	11001101	00010000	00100101	00100111
Mask complement:	**00000000**	**00000000**	**00000000**	**00001111**
Last address:	11001101	00010000	00100101	00101111

c. *The number of addresses can be found by complementing the mask, interpreting it as a decimal number, and adding 1 to it.*

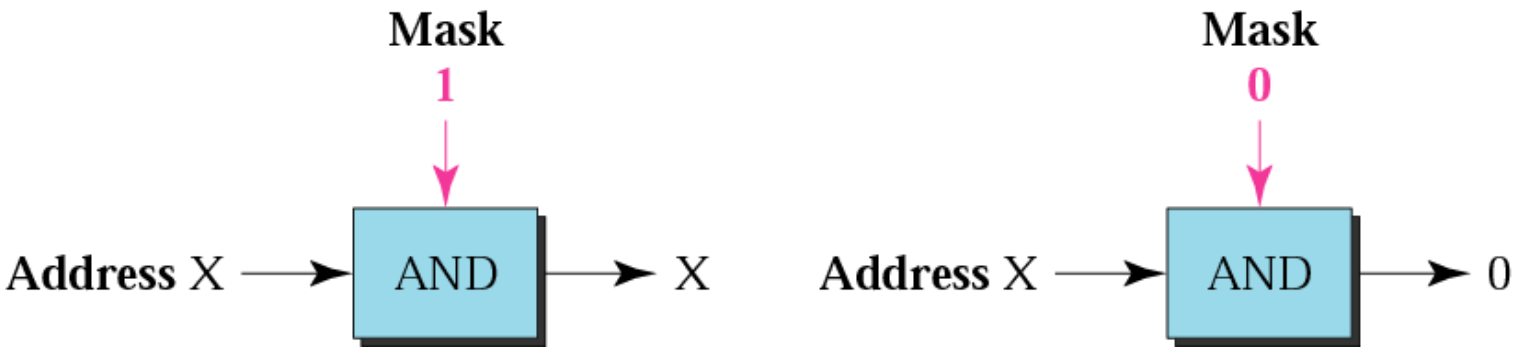
Mask complement:	**00000000 00000000 00000000 00001111**
Number of addresses:	15 + 1 = 16

Mask

- A mask is a 32-bit binary number.
- The mask is ANDeD with IP address to get
  - The block address (Network address)
  - Mask And IP address = Block Address



Default Mask

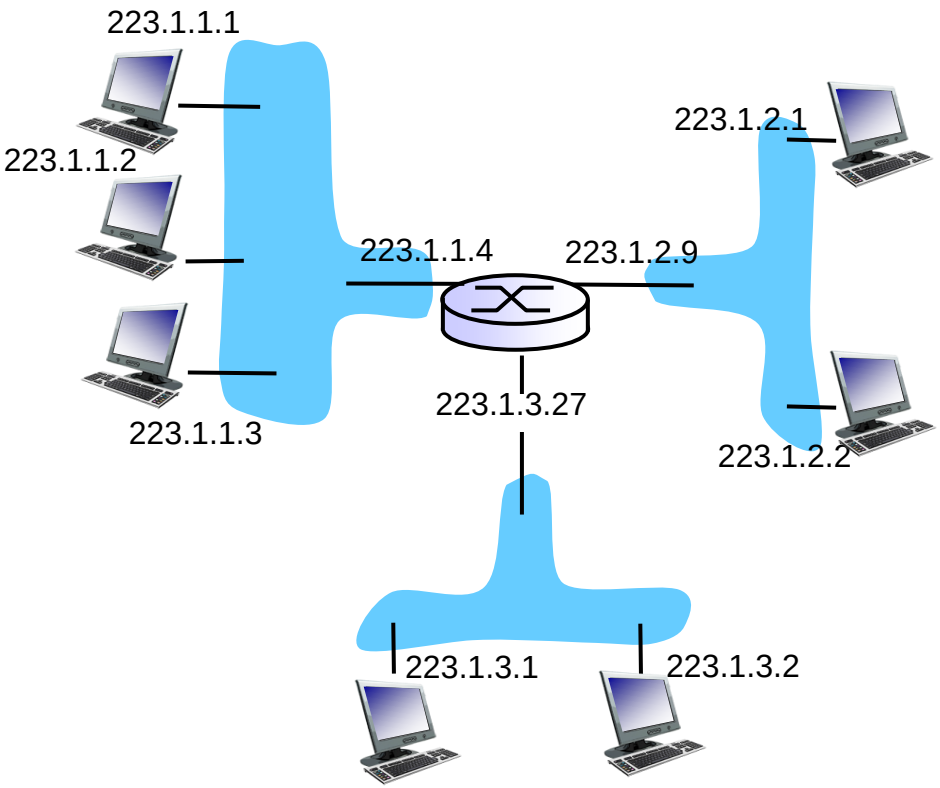


- Class A default mask is 255.0.0.0
- Class B default mask is 255.255.0.0
- Class C Default mask 255.255.255.0

Class	*Binary*	*Dotted-Decimal*	*CIDR*
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

IP Addressing - Example

- **IP address:** It is 32-bit identifier for host, router interface
- **Interface:** It is a connection between host/router and physical link.
  - A router's typically have multiple interfaces
  - A host typically has one or two interfaces
- IP addresses associated with each interface.

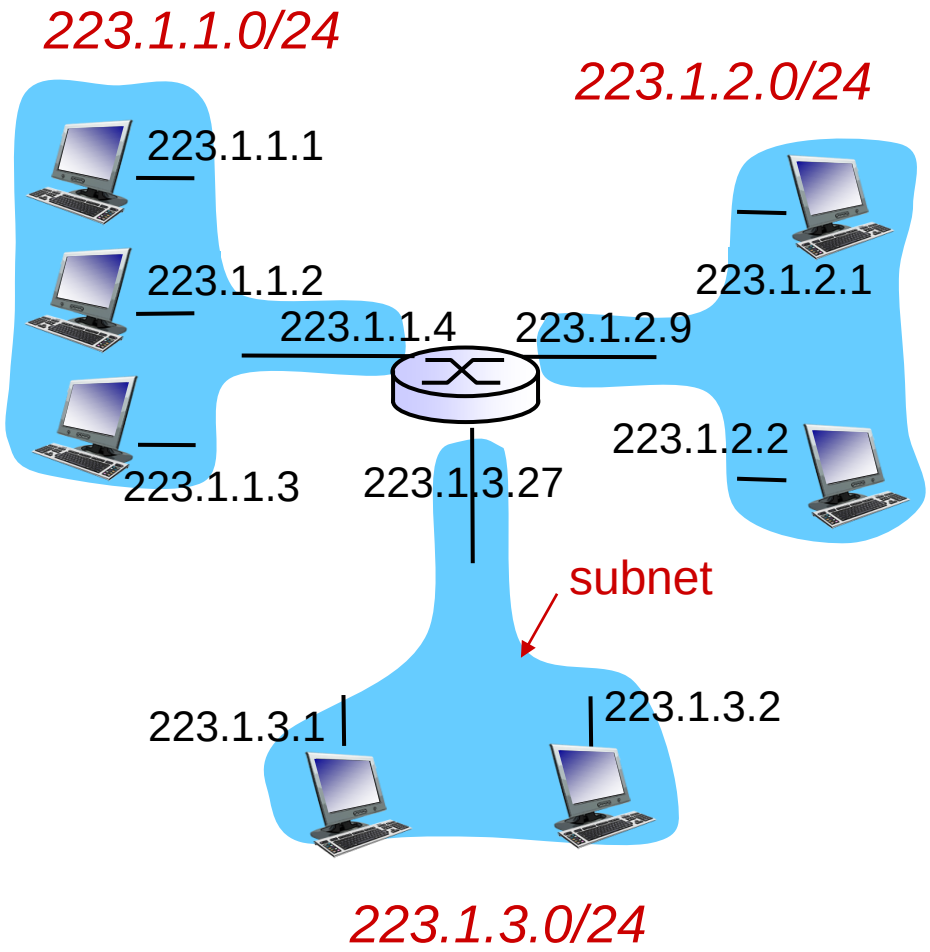


223.1.1.1 = 11011111 00000001 00000001 00000001

223 1 1 1

Subnet

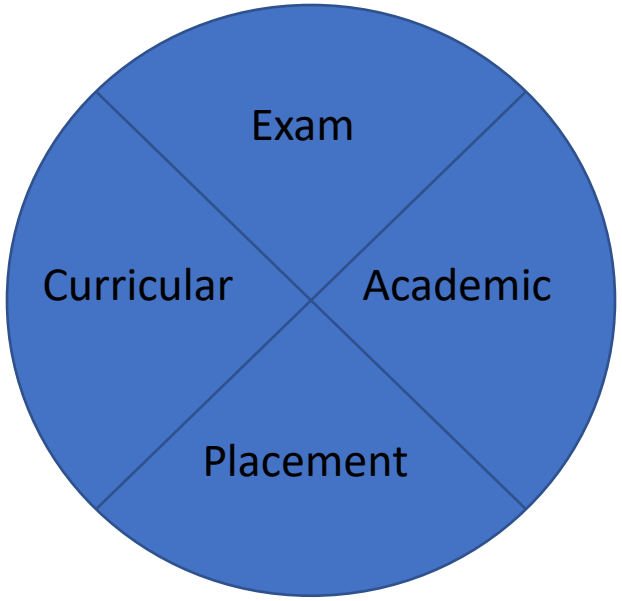
- **Subnet**: high order bits defines subnet
- **Host:** low order bits defines host
- To determine the subnets, detach each interface from its host or router.
- Creating islands of isolated networks, with interfaces terminating the end points of the isolated networks.
- Each of these isolated networks is called a **subnet**.



Network consisting of 3 subnets

Subnetting

- If an organization was granted a large block in class A or b, it could divide the address into several contiguous groups and assign each group to smaller network(called subnets).
- Divide the big network into small networks



Subnetting

2^n=2^2=4
n=2

200.10.20. _ _ _ _ _ _ _ _

200.10.20.**00**

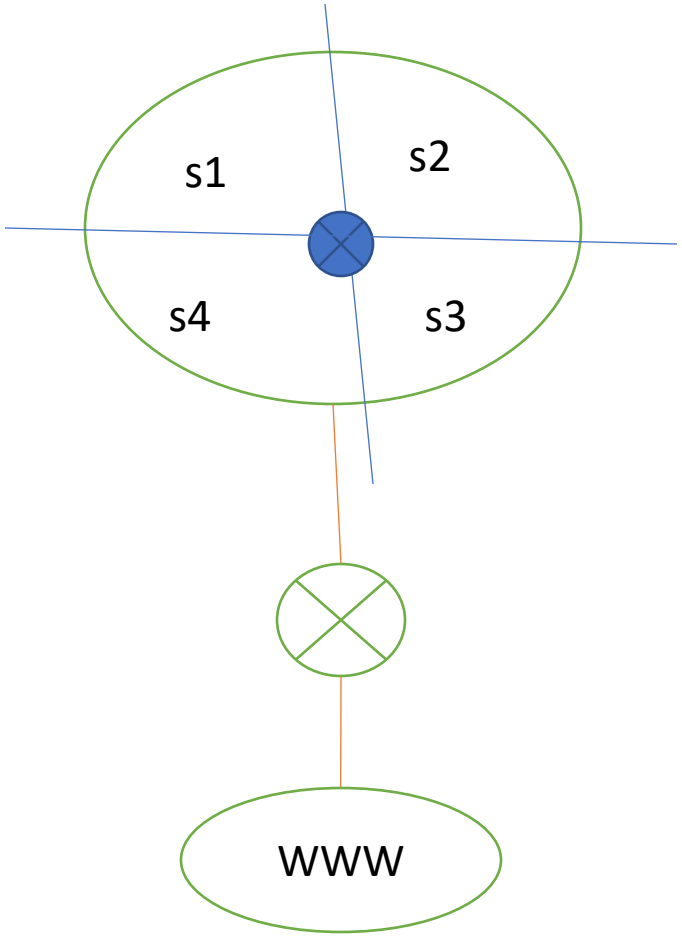
200.10.20.**01000000(64)**

200.10.20.**01111111(127)**

200.10.20.**10**

200.10.20.**11**

255.255.255.11000000(192)

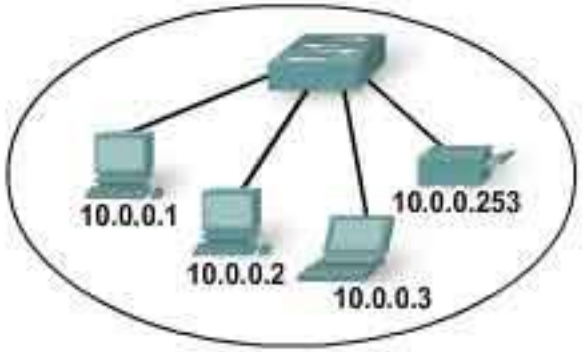


200.10.20.0

Type of addresses – Cont…

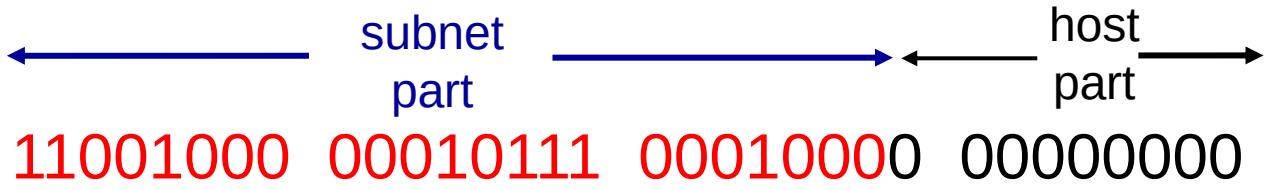
Address Types

	Network			Host
Network Address	10	0	0	0
	00001010	00000000	00000000	00000000
Broadcast Address	10	0	0	255
	00001010	00000000	00000000	11111111
Host Address	10	0	0	1
	00001010	00000000	00000000	00000001



Classless Inter-Domain Routing(CIDR)

- CIDR is a slash notation of subnet mask. CIDR tells us number of on bits in a network address.



- A single IP address can be used to designate many unique IP addresses with CIDR.
- A CIDR IP address looks like a normal IP address except that it ends with a slash followed by a number, called the IP network prefix.
- CIDR addresses reduce the size of routing tables and make more IP addresses available within organizations.

Subnetting

- Subnetting take places when we extend the default subnet mask.
- We cannot perform subnetting with default subnet mask and every classes have default subnet mask.
- Now find the host bits borrowed to create subnets and convert them in decimal.
- For example find the subnet mask of address 188.25.45.48/20 ?
  1. Class B, Default Subnet mask: 255.255.0.0
  2. Borrowed 4 bit from host part so mask is now:

     11111111 11111111 11110000 00000000

     255 255 240 0

How many subnets from given subnet mask?

- To calculate the number of subnets provided by given subnet mask we use 2^N , where N = number of bits borrowed from host bits to create subnets.
- For example in 192.168.1.0/27, N is 3.
- By looking at address we can determined that this address is belong to class C and default subnet mask 255.255.255.0 [/24 in CIDR].
- In given address we borrowed 27 - 24 = 3 host bits to create subnets.
- Now $2^3 = 8$, so our answer is 8.

What are the valid subnets?

- Calculating valid subnet is two steps process.
- First calculate total subnet by using formula 2^N.
- In second step find the block size and count from zero in block until subnet mask value.
- For example calculate the valid subnets for 192.168.1.0/26
  1. Borrowed host bits are 2 [26-24]
  2. Total subnets are $2^2 = 4$
  3. Subnet mask would be 255.255.255.192
  4. Block size would be 256-192 = 64
  5. Start counting from zero at blocks of 64, so our valid subnets would be 0,64,128,192

What are the total hosts?

- Total hosts are the hosts available per subnet
- To calculate total hosts use formula 2^H = Total hosts
- H is the number of host bits
- For example in address 192.168.1.0/26
- We have 32 - 26
    1. [Total bits in IP address - Bits consumed by network address] = 6
    2. Total hosts per subnet would be $2^6 = 64$

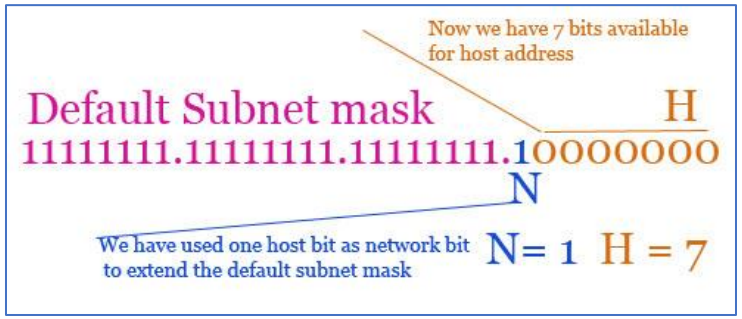
Network Prefixes

- For Class C, Default subnet mask of class C is 255.255.255.0
- CIDR notation of class C is /24, which means 24 bits from IP address are already consumed by network portion.
- We have 8 host bits remain.
- Subnetting moves from left to right. So Class C subnet masks can only be the following:

CIDR	Decimal	Binary
/25	128	10000000
/26	192	11000000
/27	224	11100000
/28	240	11110000
/29	248	11111000
/30	252	11111100

Network Prefixes- Example

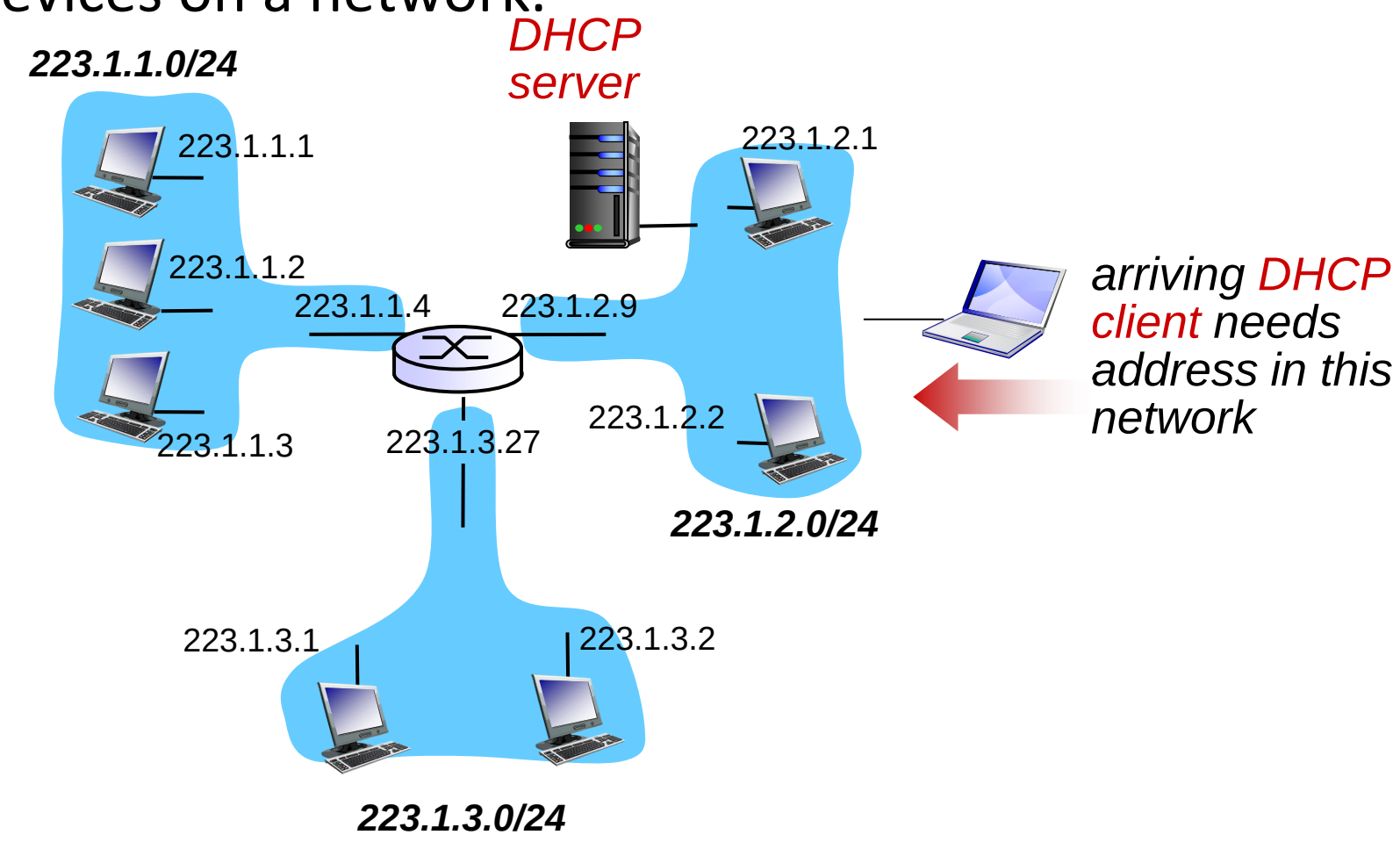
- **/25**
  - CIDR /25 has subnet mask 255.255.255.128 and 128 is 10000000 in binary.
  - We used one host bit in network address.



- N = 1 [Number of host bit]
- H = 7 [Remaining host bits]
- Total subnets (2^N) : $2^1 = 2$
- Block size (256 - subnet mask) :- 256 - 128 = 128
- Valid subnets (Count blocks from 0) :- 0, 128
- Total hosts (2^H) :- $2^7 = 128$
- Valid hosts per subnet (Total host - 2) :- 128 - 2 = 126

Dynamic Host Configuration Protocol - DHCP

- Dynamic Host Configuration Protocol is a protocol for assigning dynamic IP addresses to devices on a network.

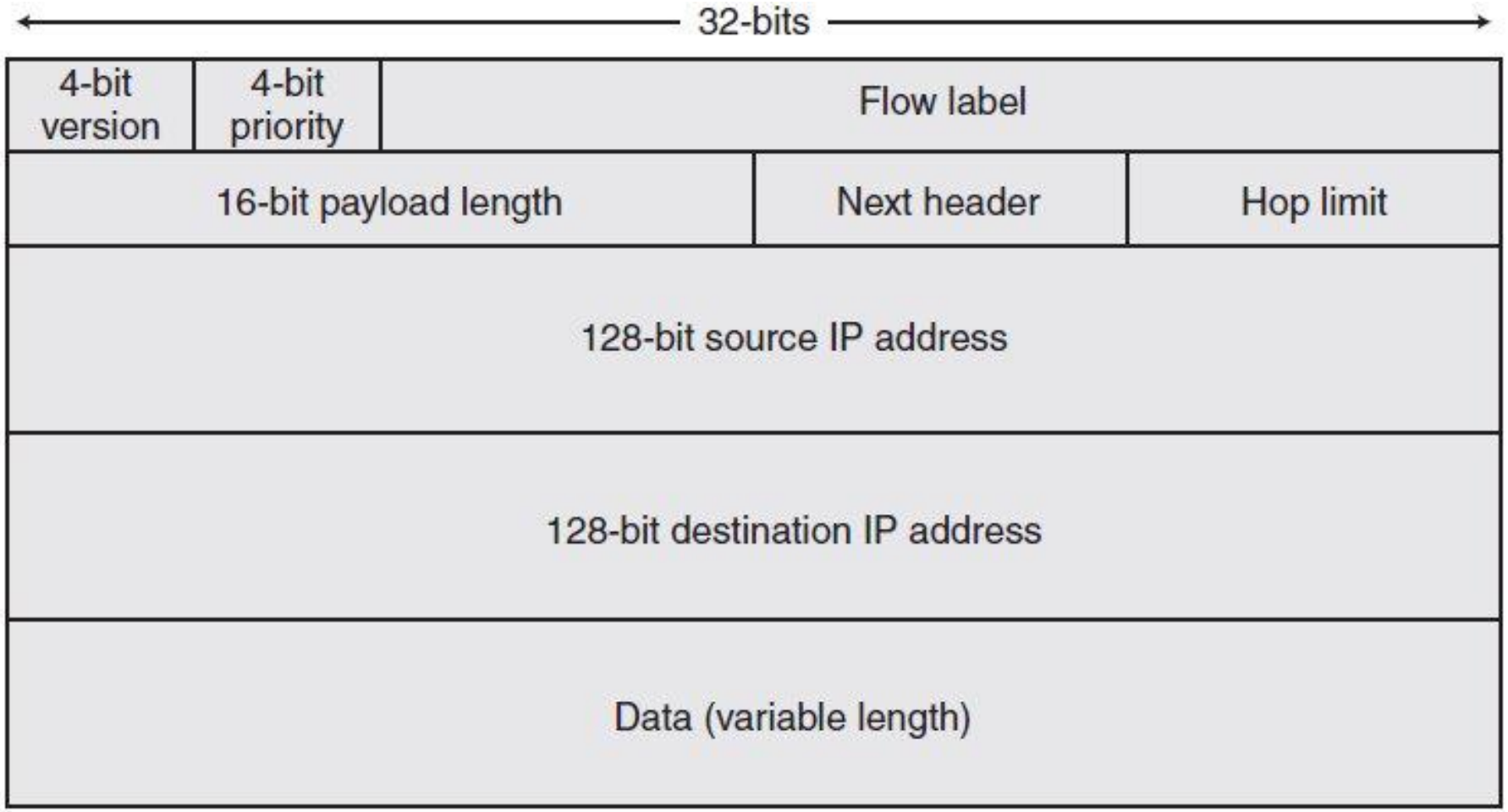


Internet Control Message Protocol - ICMP

- When something unexpected occurs, the event is reported by the ICMP, which is also used to test the Internet.
- About a dozen types of ICMP messages are defined. The most important are listed below. Each ICMP message type is encapsulated in an IP packet.

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	Teach a router about geography
Echo	Ask a machine if it is alive
Echo reply	Yes, I am alive
Timestamp request	Same as Echo request, but with timestamp
Timestamp reply	Same as Echo reply, but with timestamp

IPv6 Datagram Format



Difference between IPv4 & IPv6

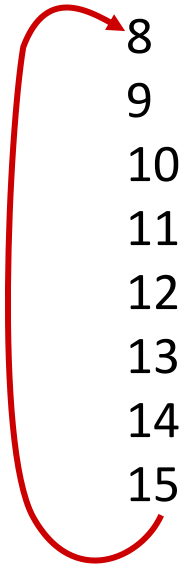
IPv4	IPv6
✓ 32 bit length	✓ 128 bit length
✓ Fragmentation is done by sender and forwarding routers	✓ Fragmentation is done only by sender
✓ No packet flow identification	✓ Packet flow identification is available within the IPv6 header using the Flow Label field
✓ Checksum field in header	✓ No checksum field in header
✓ Options fields are available in header	✓ No option fields, but Extension headers are available
✓ Address Resolution Protocol (ARP)is available to map IPv4 addresses to MAC addresses	✓ Address Resolution Protocol (ARP) is replaced with Neighbor Discovery Protocol
✓ Broadcast messages are available	✓ Broadcast messages are not available
✓ Static IP addresses or DHCP is required to configure IP addresses	✓ Auto-configuration of addresses is available

Link State Routing Algorithm

- Also known as Dijkstra's Algorithm.
- It computes the least-cost path from one node (source node) to all other nodes in the network.
- Its iterative and after the k^{th} least-cost paths are known to k destination nodes.
- **Notation:**
  - **c(x,y):** link cost from node x to y; = ∞ if not direct neighbours
  - **D(v):** current value of cost of path from source to destination v
  - **p(v):** predecessor node along path from source to v
  - **N':** set of nodes whose least cost path definitively known

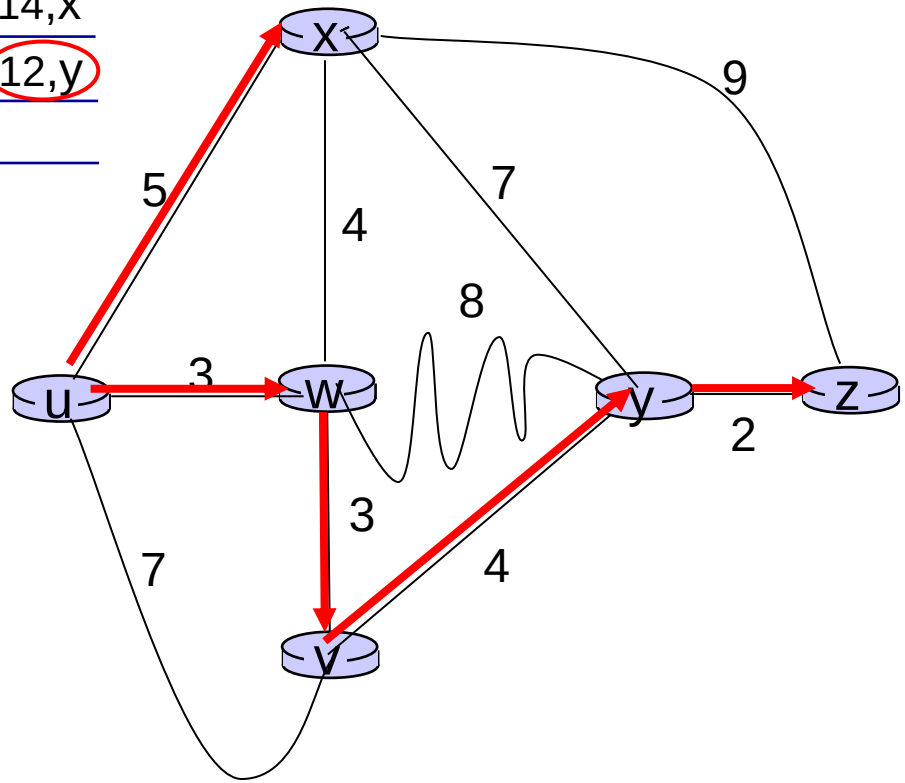
Dijkstra's Algorithm

```
1  Initialization:
2    N' = {u}
3    for all nodes v
4      if v adjacent to u
5          then D(v) = c(u,v)
6      else D(v) = ∞
7
8  Loop
9     find w not in N' such that D(w) is a minimum
10    add w to N'
11    update D(v) for all v adjacent to w and not in N' :
12       D(v) = min( D(v), D(w) + c(w,v) )
13    /* new cost to v is either old cost to v or known
14     shortest path cost to w plus cost from w to v */
15 until all nodes in N'
```



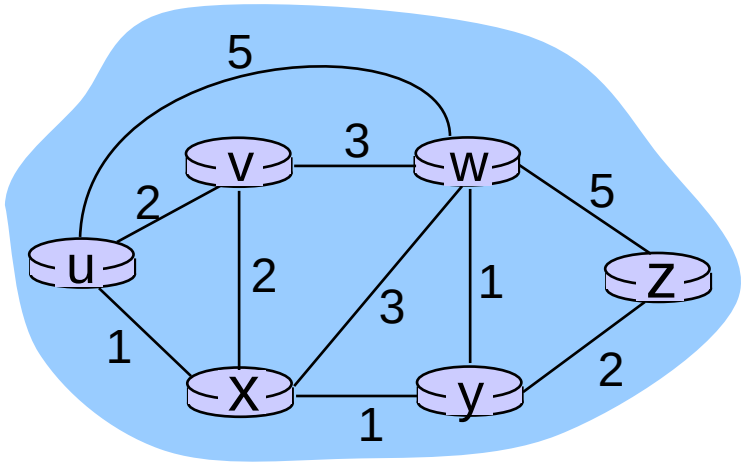
Dijkstra's Algorithm – Example:1

Step	N'	D(v) p(v)	D(w) p(w)	D(x) p(x)	D(y) p(y)	D(z) p(z)
0	u	7,u	3,u	5,u	∞	∞
1	uw	6,w		5,u	11,w	∞
2	uwx	6,w			11,w	14,x
3	uwxv				10,v	14,x
4	uwxvy					12,y
5	uwxvyz					



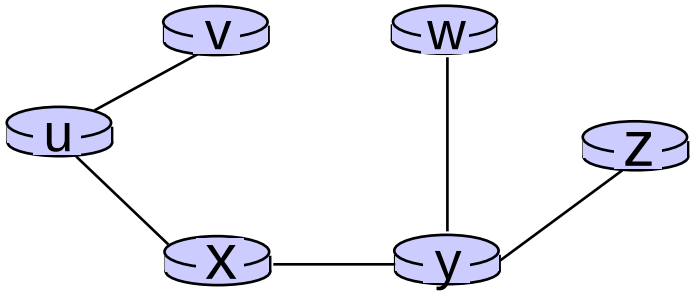
Dijkstra's Algorithm – Example:2

Step	N'	D(v),p(v)	D(w),p(w)	D(x),p(x)	D(y),p(y)	D(z),p(z)
0	u	2,u	5,u	1,u	∞	∞
1	ux	2,u	4,x		2,x	∞
2	uxy	2,u	3,y			4,y
3	uxyv		3,y			4,y
4	uxyvw					4,y
5	uxyvwz					



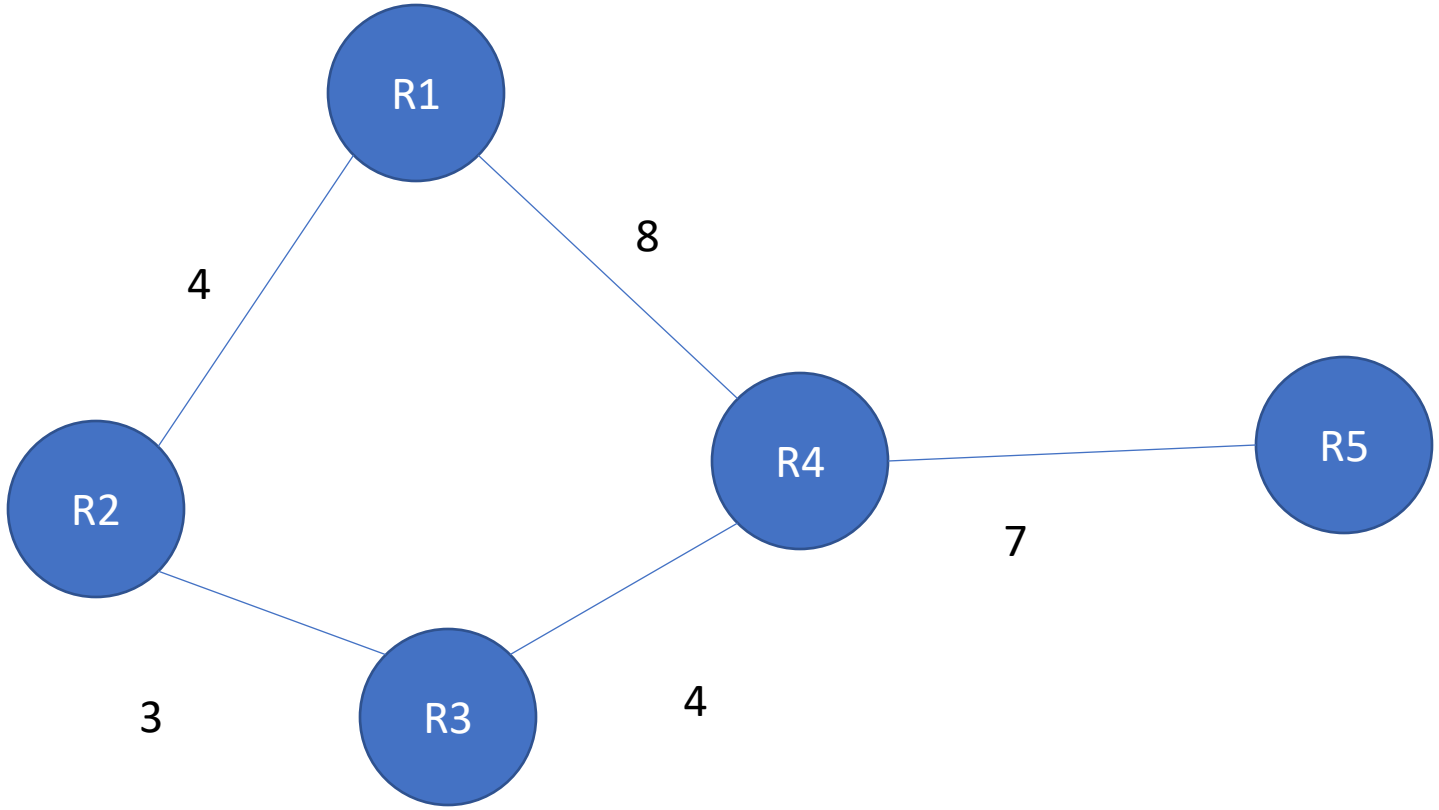
Dijkstra's Algorithm – Example:2

resulting shortest-path tree from u:



resulting forwarding table in u:

destination	link
v	(u,v)
x	(u,x)
y	(u,x)
w	(u,x)
z	(u,x)



Visited	R1	R2	R3	R4	R5
R1	0	4	∞	8	∞
R1,R2			7	8	∞
R1,R2,R3				Min(11,8)=8	∞
R1,R2,R3,R4					Min(18,15)=15

Distance Vector Algorithm

- Distance-vector (DV) algorithm is iterative, asynchronous, and distributed.
- It is distributed in that each node receives some information from one or more of its directly attached neighbours, performs a calculation, and then distributes the results of its calculation back to its neighbours.
- It is iterative. so, process continues on until no more information is exchanged between neighbours.
- The algorithm is asynchronous. It does not require all of the nodes to operate with each other.

Distance Vector Algorithm – Cont…

- Let dx(y) be the cost of the least-cost path from node x to node y.
- Then least costs are related by the celebrated Bellman-Ford equation:

$d_x(y)$ = cost of least-cost path from x to y then

$$d_x(y) = \min_v \{c(x,v) + d_v(y)\}$$

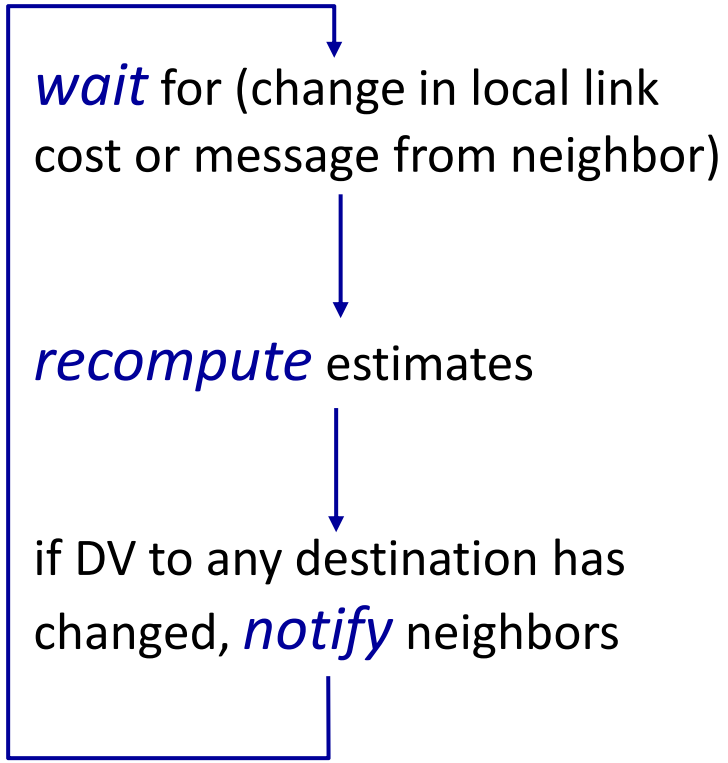
cost from neighbor v to destination y

cost to neighbor v

min taken over all neighbors v of x

Distance Vector Algorithm – Cont…

each node:



Distance Vector Algorithm - Example

node x table

from \ cost to	x	y	z
x	0	2	7
y	∞	∞	∞
z	∞	∞	∞

from \ cost to	x	y	z
x	0	2	3
y	2	0	1
z	7	1	0

$D_x(y) = \min\{c(x,y) + D_y(y), c(x,z) + D_z(y)\}$
$= \min\{2+0 , 7+1\} = 2$

node y table

from \ cost to	x	y	z
x	∞	∞	∞
y	2	0	1
z	∞	∞	∞

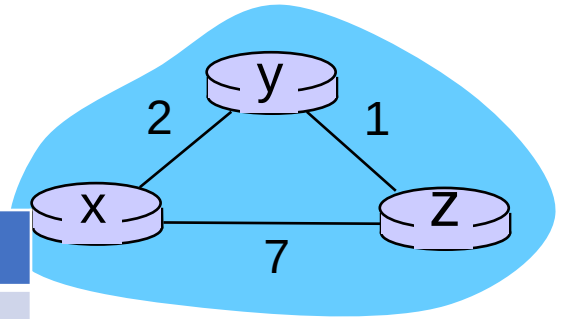
$D_x(z) = \min\{c(x,y) + D_y(z), c(x,z) + D_z(z)\}$
$= \min\{2+1 , 7+0\} = 3$

node z table

from \ cost to	x	y	z
x	∞	∞	∞
y	∞	∞	∞
z	7	1	0

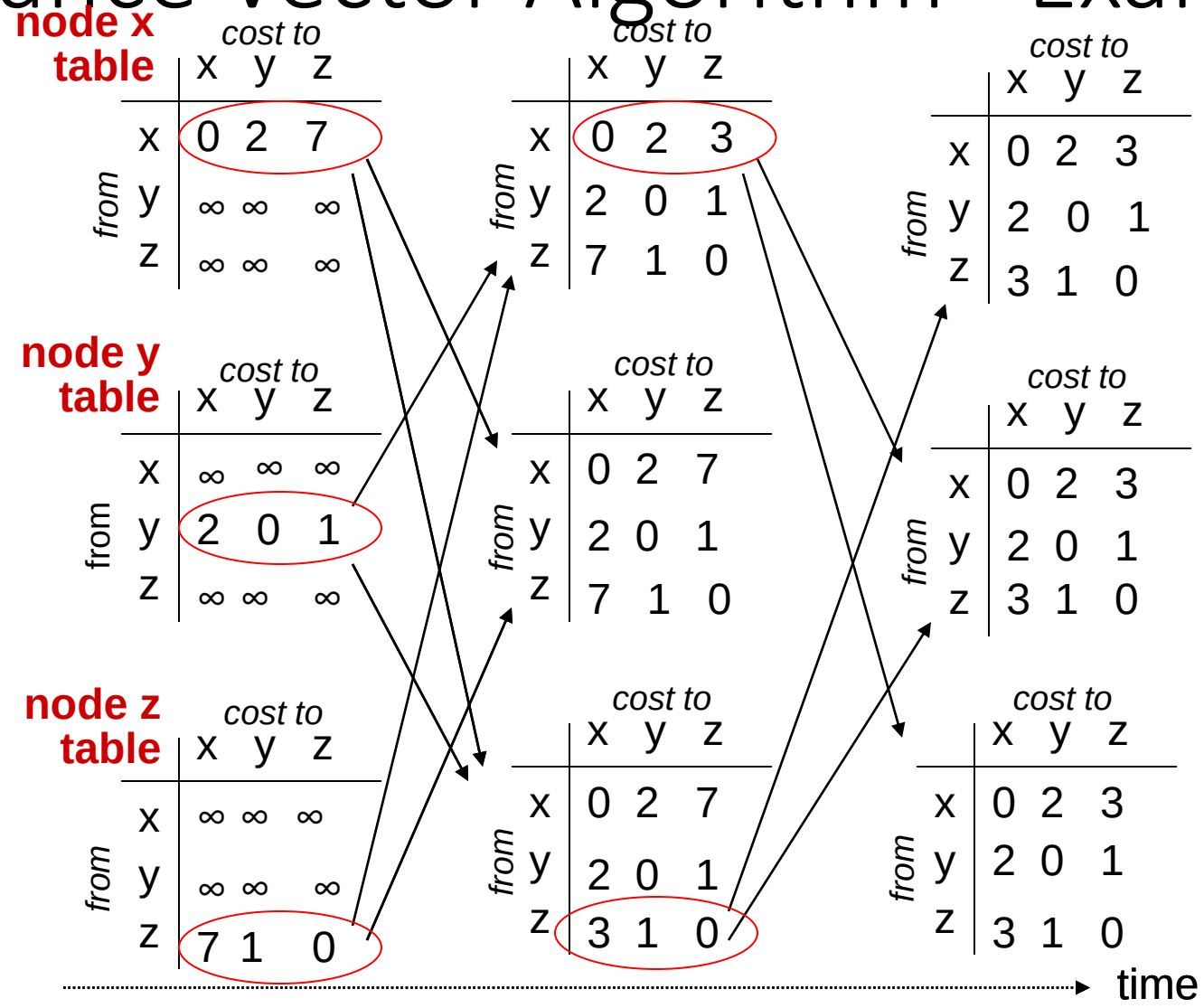
Table for Router X

Dest.	Dist.	Next
X	0	X
Y	2	Y
Z	7	Z



time

Distance Vector Algorithm - Example



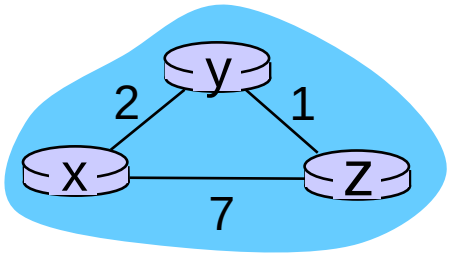
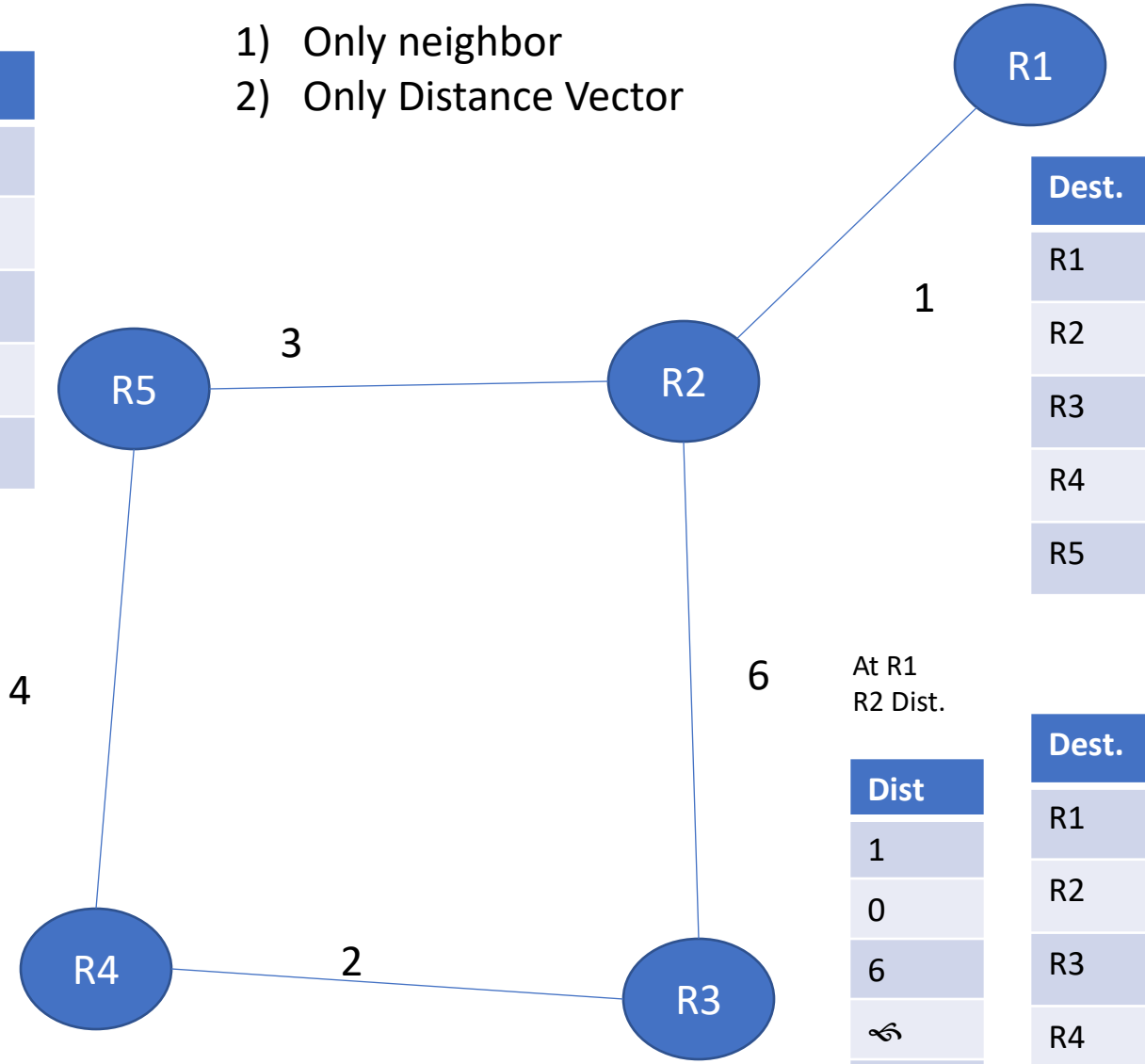


Table for R5

Dest.	Dist.	Next
R1	∞	-
R2	3	R2
R3	∞	-
R4	4	R4
R5	0	R5

1) Only neighbor
2) Only Distance Vector



Dist
1
0
6
∞
3

Dist
1
0
6
∞
3

Table for R1

Dest.	Dist.	Next
R1	0	R1
R2	1	R2
R3	∞	-
R4	∞	-
R5	∞	-

At R1
R2 Dist.

Dist
1
0
6
∞
3

R1 New RT

Dest.	Dist.	Next
R1	0	R1
R2	1	R2
R3	7	R2
R4	∞	-
R5	4	R2

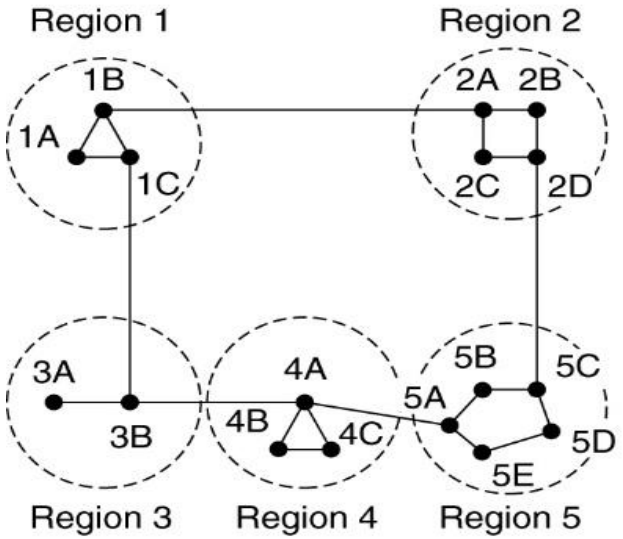
Difference: LS and DV Routing Algorithms

Distance Vector Protocol	Link State Protocol
Entire routing table is sent as an update	Updates are incremental & entire routing table is not sent as update
Distance vector protocol send periodic update at every 30 or 90 second	Updates are triggered not periodic
Update are broadcasted	Updates are multicasted
Updates are sent to directly connected neighbour only	Update are sent to entire network & to just directly connected neighbour
Routers don't have end to end visibility of entire network.	Routers have visibility of entire network of that area only.
It is prone to routing loops	No routing loops

Hierarchical Routing

- As networks grow in size, the router routing tables grow proportionally.
- Router memory, CPU time and more bandwidth consumed to send status reports about them.
- When hierarchical routing is used, the routers are divided into what called **regions**.
- Each router knowing all the details about how to route packets to destinations within its own region.
- But knowing nothing about the internal structure of other regions.

Hierarchical Routing - Example



(a)

Full table for 1A

Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2A	1B	2
2B	1B	3
2C	1B	3
2D	1B	4
3A	1C	3
3B	1C	2
4A	1C	3
4B	1C	4
4C	1C	4
5A	1C	4
5B	1C	5
5C	1B	5
5D	1C	6
5E	1C	5

(b)

Hierarchical table for 1A

Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2	1B	2
3	1C	2
4	1C	3
5	1C	4

(c)

Broadcast Routing

- Host need to send messages to many or all other hosts.
- For example
  - A service distributing weather reports
  - Stock market updates
  - Live radio programs
- In Short, Sending a packet to all destinations simultaneously is called broadcasting.
- First broadcasting method that simply send a distinct packet to each destination.
- So, it waste of bandwidth, but it also requires the source to have a complete list of all destinations.
- In practice this may be the only possibility, but it is the least desirable of the methods.

Broadcast Routing – Cont…

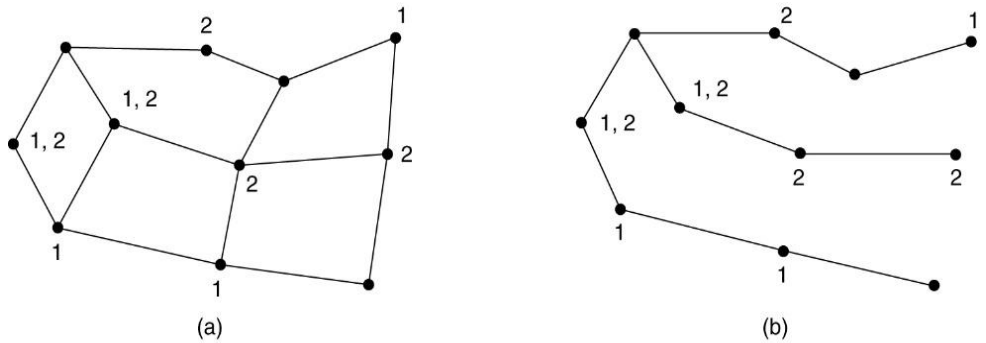
- Flooding is Second method. Although flooding is for ordinary point-to-point communication, for broadcasting it might rate serious consideration, especially if none of the methods are applicable.
- The problem with flooding as a broadcast technique is the same problem it has as a point-to-point routing algorithm.
- It generates too many packets and consumes too much bandwidth.
- A third algorithm is Multi Destination Routing.
- If this method is used, each packet contains either a list of destinations or a bit map indicating the desired destinations.

Broadcast Routing – Cont…

- When a packet arrives at a router, the router checks all the destinations to determine the set of output lines that will be needed.
- The router generates a new copy of the packet for each output line to be used and includes in each packet only those destinations that are to use the line.
- A fourth broadcast algorithm makes explicit use of the sink tree for the router initiating the broadcast-or any other convenient spanning tree for that matter.
- A spanning tree is a subset of the subnet that includes all the routers but contains no loops.
- If each router knows which of its lines belong to the spanning tree, it can copy an incoming broadcast packet onto all the spanning tree lines except the one it arrived on.

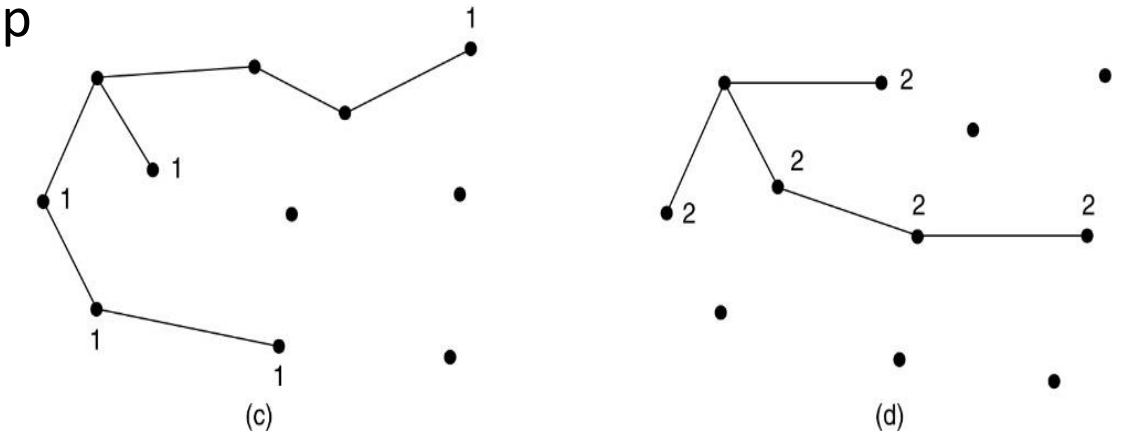
Multicast Routing

- Sending a message to a group is called multicasting, and its routing algorithm is called multicast routing.
- Multicasting requires group management. Need to create and destroy groups, and to allow processes to join and leave groups.
- To do multicast routing, each router computes a spanning tree covering all other routers.
- For example, in Figure (a) we have two groups, 1 and 2.
- Some routers are attached to hosts that belong to one or both of these groups, as indicated in the figure.



Multicast Routing – Cont…

- A spanning tree for the leftmost router is shown in Figure (b).
- When a process sends a multicast packet to a group, the first router examines its spanning tree and prunes it, removing all lines that do not lead to hosts that are members of the group.
- In our example, Figure (c) shows the pruned spanning tree for group 1.
- Figure(d) shows the pruned spanning tree for group 2. Multicast packets are forwarded only along the approp



Comparison between RIP OSPF and BGP

RIP	OSPF	BGP
RIP is intra domain routing protocol used with in the autonomous system	OSPF is also intra domain routing protocol used with in the autonomous system	It is inter domain routing protocol used between the autonomous system
RIP is used for Small networks with maximum number of hops 16	OSPF is used in large autonomous system with no limitation	The BGP protocol is used for very large-scale networks
RIP uses Distance Vector	OSPF uses Link State	BGP uses Path Vector
RIP send entire routing update to all directly connected interface	OSPF send multicast Hello packet to the neighbours, to create session	BGP send Open packet to the neighbours to create session
RIP use Bellman ford Algorithm	OSPF use Dijikstra Algorithm	BGP use Path-Vector Routing

Thank You