Computer Networks

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Lect_6

Internet Layer

- This layer defines Logical addressing, routing (forwarding or path selection) and the routing protocols used to learn routes. Hence it can deliver data from end to end

Internet Layer

1. Internet Protocol (IP)
   - The IPv4 was first developed in the 1970s by DARBA (Defense Advanced Research Projects Agency), and the RFC 791 (IPv4) functionality was published in September 1981.
   - A Request for Comments (RFC 791) is a formal document that contains specifications and organizational notes about topics related to the internet and computer networking, such as routing, addressing and transport technologies.
   - RFC 791 is specific for IPv4.
   - Here is link for RFC 791: https://datatracker.ietf.org/doc/html/rfc791

Internet Layer

1. Internet Protocol (IP)
   - IP is responsible for:
     1. Logical addressing.
     2. Encapsulate data from end to end with IP header
   - Logical IP (Internet Protocol) address is an address assigned by software residing (exist) in the router or server, it can change from time to time.
   - Dynamic Host Configuration Protocol (DHCP) is the software used to assign IP address to PCs, servers and routers.
   - Any device that has at least one interface with an IP address can send and receive IP packets and is called an IP host.
   - There are two types of IP: IPv4 and IPv6.
   - We will study in details IPv4.

Internet Layer

- IPv4 consists of two parts:
  1. Network part
  2. Host part
- IPv4 consists of a 32-bit number, hence we have 4,294,967,296 different IPv4 number.
- Usually written in dotted-decimal notation(DDN). The "decimal" part of the term comes from the fact that each byte (8 bits) of the 32-bit IP address is shown as its decimal equivalent.
- For example, 168.1.1.1 is an IP address written in dotted-decimal form; the actual binary version is 10101000 00000001 00000001 00000001.

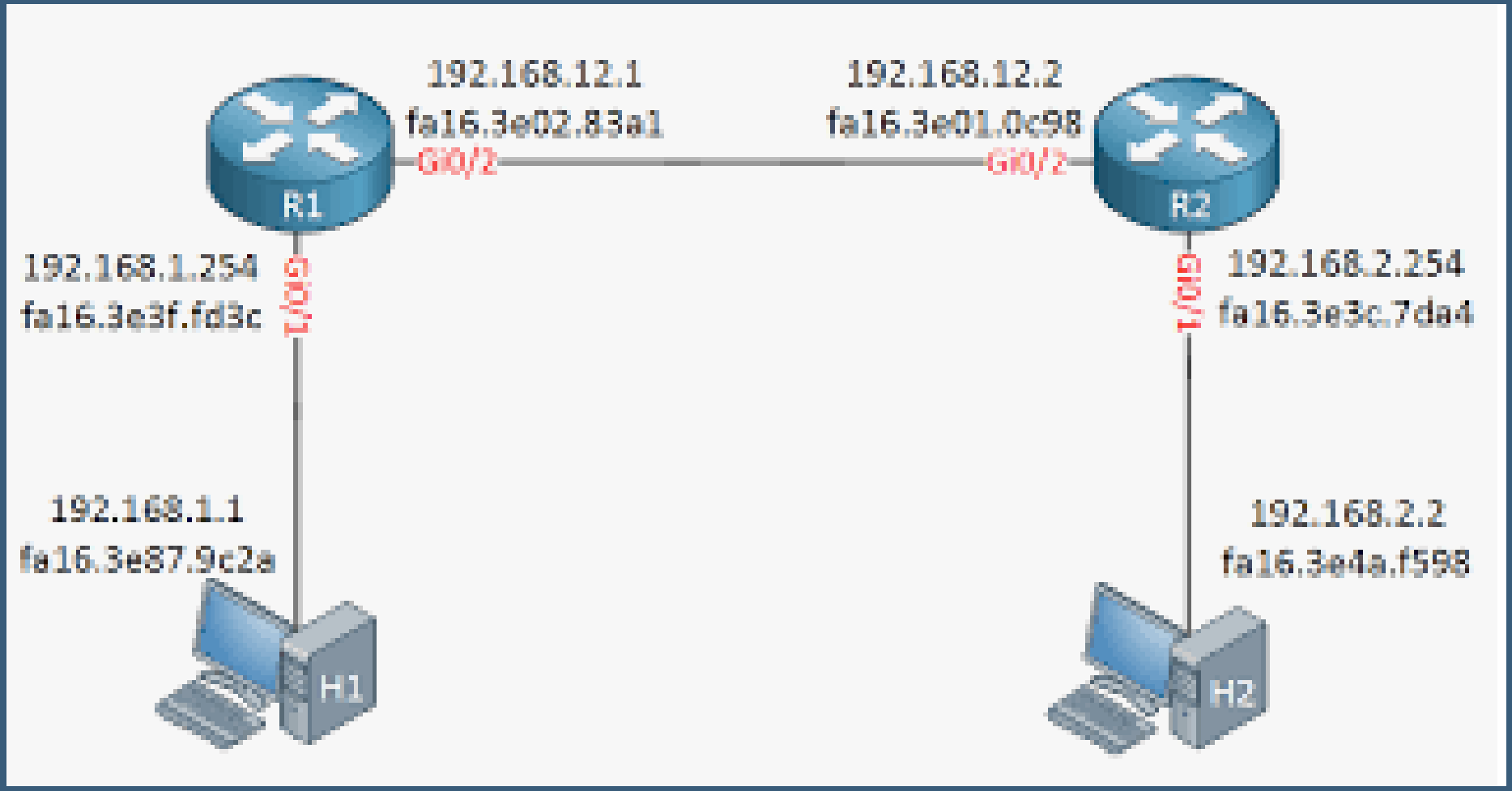
Internet Layer

- Each DDN has four decimal octets, separated by periods.
- A grouping of 8 bits is called octet
- The term octet is just a vendor-neutral term for byte.
- Because each octet represents an 8-bit binary number, the range of decimal numbers in each octet is between 0 and 255, inclusive.
- For example, the IP address of 168.1.1.1 has a first octet of 168, the second octet of 1, and so on.

Internet Layer

- Finally, note that each network interface (NIC) uses a unique IP address.
- Most people tend to think that their computer has an IP address, but actually their computer's network card has an IP address. For example, if your laptop has both an Ethernet network interface card (NIC) and a wireless NIC, with both working at the same time, both will have an IP address.
- Similarly, routers, which typically have many network interfaces that forward IP packets, have an IP address for each interface .

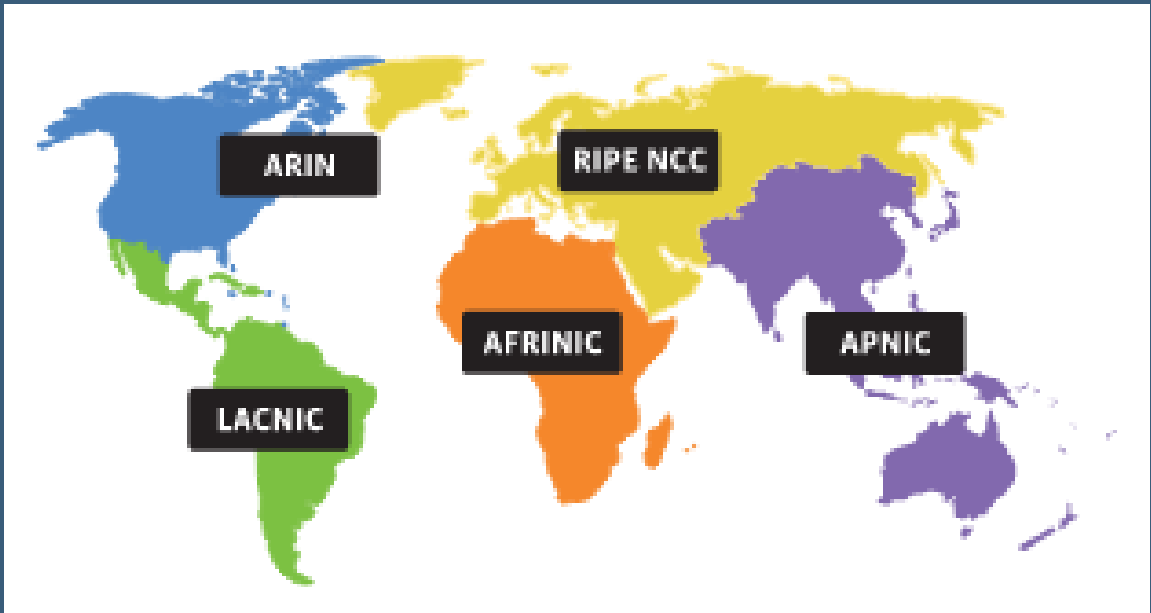
Internet Layer



Internet Layer

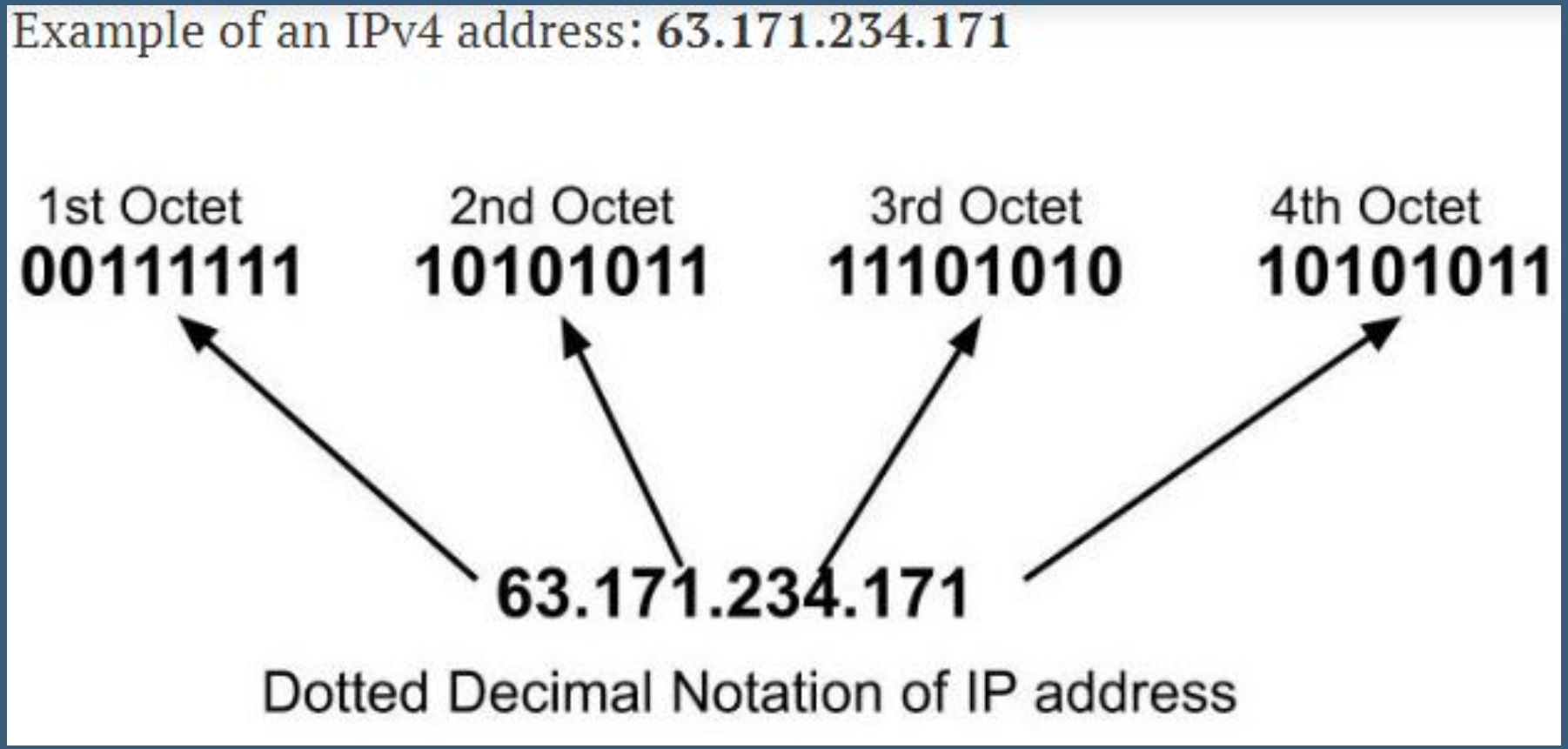
- IPv4 is software address given by an organization called IANA, which stands for Internet Assigned Numbers Authority.
- IANA is a standard organization that oversees (تشرف على) global IP address allocation.
- IANA founded in 1988 by Federal government of the United States.
- IANA assigned IP addressed to an organizations called ISP (Internet Service Provider) such as We, TE-data, Orange, … etc.

Internet Layer

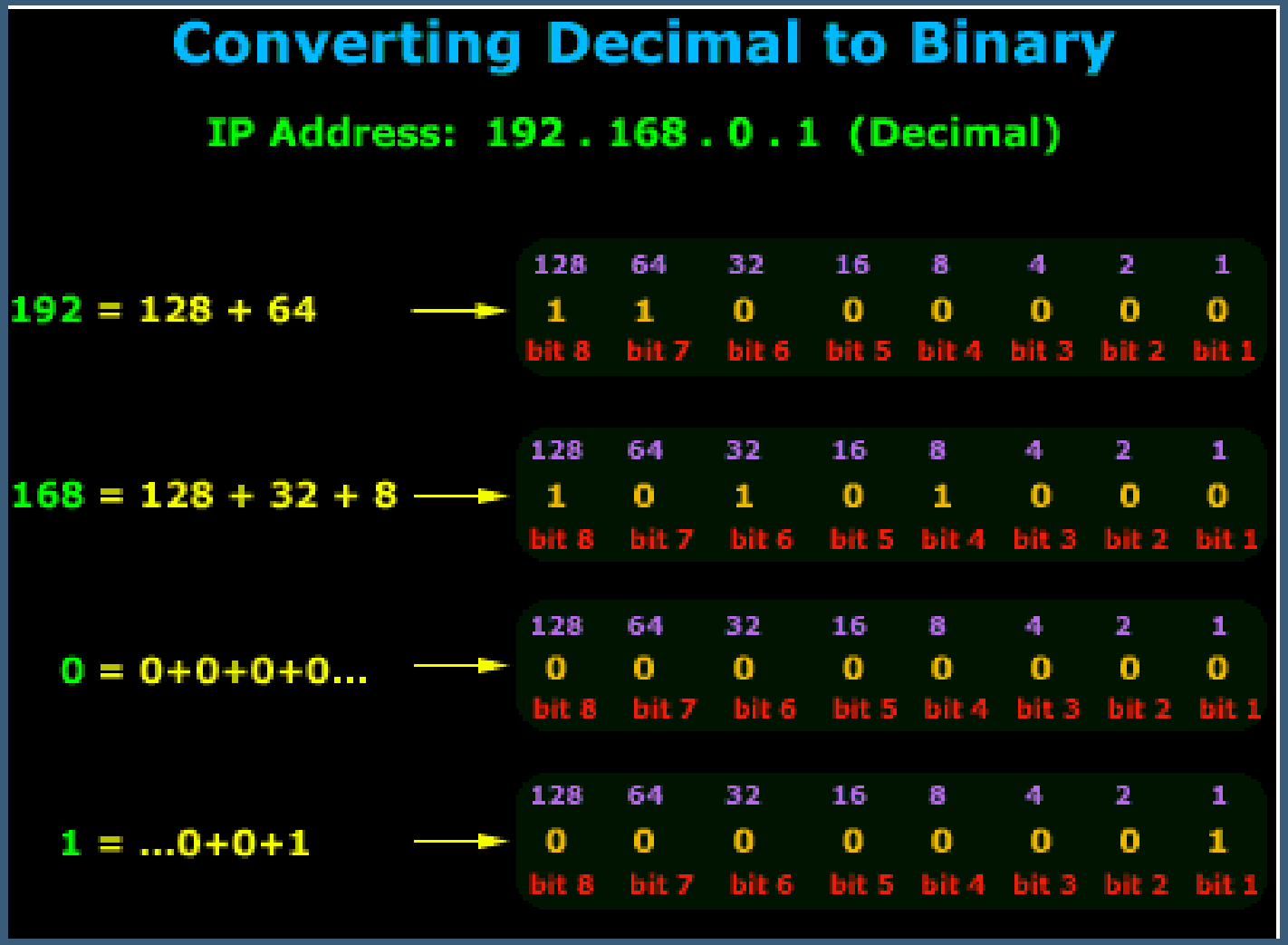


REGISTRY	AREA COVERED
AFRINIC	Africa Region
APNIC	Asia/Pacific Region
ARIN	Canada, USA, and some Caribbean Islands
LACNIC	Latin America and some Caribbean Islands
RIPE NCC	Europe, the Middle East, and Central Asia

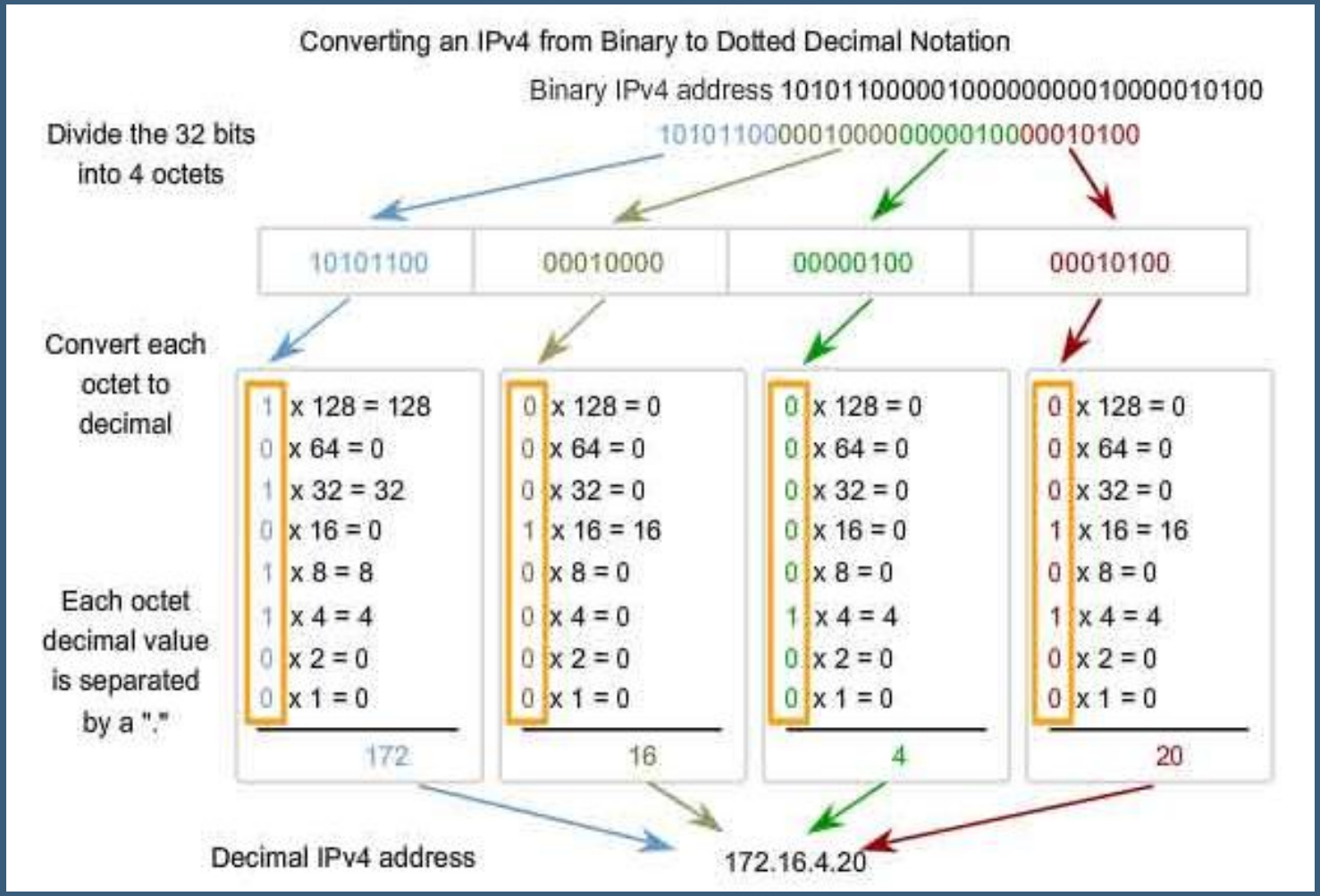
Internet Layer



Internet Layer



Internet Layer



IPv4 classes

- IANA divided the entire IPv4 address into five classes, as identified by the value of the first octet

IP Address Classes

Address Class	1st octet range (decimal)	1st octet bits (green bits do not change)	Network(N) and Host(H) parts of address	Default subnet mask (decimal and binary)	Number of possible networks and hosts per network
A	0-127	00000000-01111111	N.H.H.H	255.0.0.0	128 nets (2^7) 16,777,214 hosts per net (2^24-2)
B	128-191	10000000-10111111	N.N.H.H	255.255.0.0	16,384 nets (2^14) 65,634 hosts per net (2^16-2)
C	192-223	11000000-11011111	N.N.N.H	255.255.255.0	2,097,150 nets (2^21) 254 hosts per net (2^8-2)
D	224-239	11100000-11101111	NA (multicast)		
E	240-255	11110000-11111111	NA (experimental)		

IPv4 classes

- Classes A, B, and C addresses define unicast IP addresses, meaning that the address identifies a single host interface.
- Class D addresses reserved for multicast technologies, it defines multicast addresses, it used to send one packet to multiple hosts.
- Class E addresses reserved for defining experimental (military and scientific) researches. Class E addresses are no longer defined as experimental, and are simply reserved for future use.

IPv4 classes

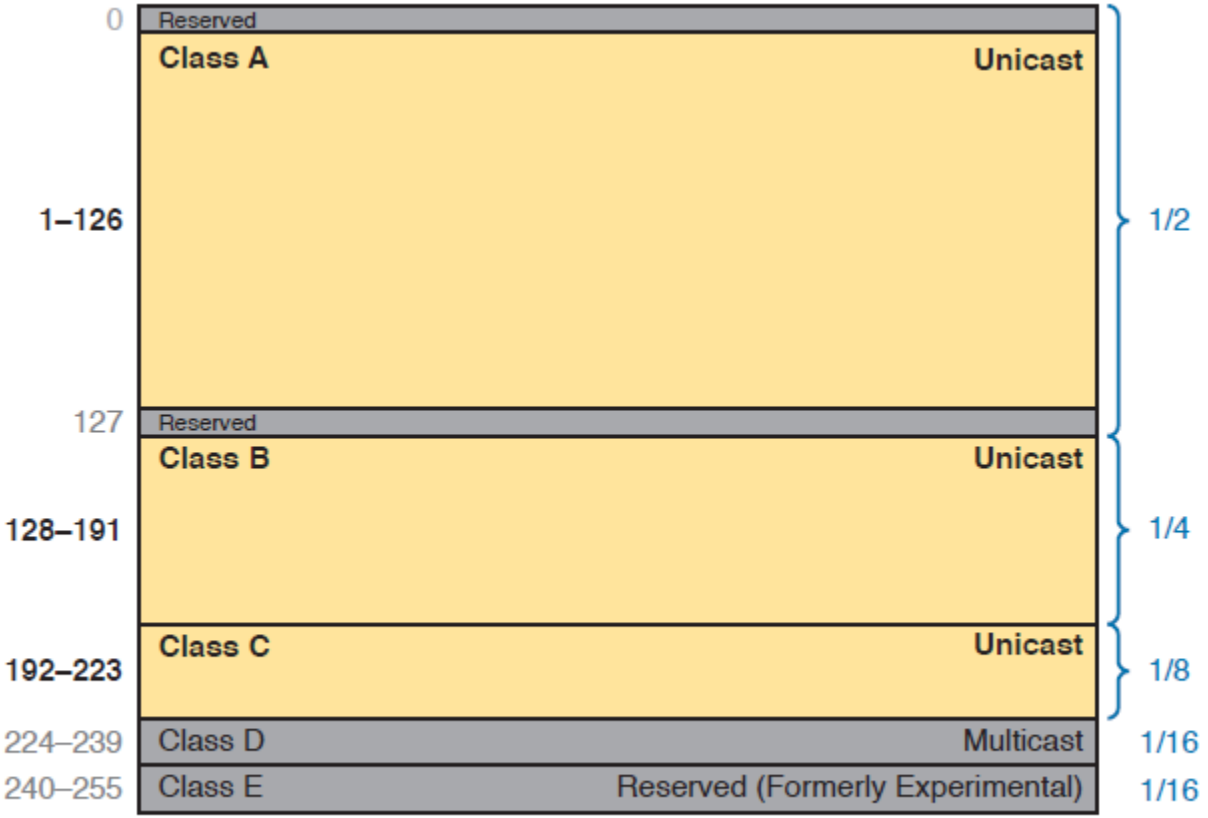


Figure 4-6 *Division of the Entire IPv4 Address Space by Class*

IPv4 classes

Table 4-5 All Possible Valid Network Numbers

Class	First Octet Range	Valid Network Numbers
A	1 to 126	1.0.0.0 to 126.0.0.0
B	128 to 191	128.0.0.0 to 191.255.0.0
C	192 to 223	192.0.0.0 to 223.255.255.0

IPv4 classes

- The first IP and last IP in any network unused:-
  1. The first IP is called network ID (NID), network IP (NIP), network number, or network address.
  2. The last IP is called Broadcast IP (BIP), Direct broadcast, or network broadcast address.

Table 4-2 Sampling of IPv4 Class A Networks

Concept	Class	Network ID	Broadcast IP
All addresses that begin with 8	A	8.0.0.0	8.255.255.255
All addresses that begin with 13	A	13.0.0.0	13.255.255.255
All addresses that begin with 24	A	24.0.0.0	24.255.255.255
All addresses that begin with 125	A	125.0.0.0	125.255.255.255
All addresses that begin with 126	A	126.0.0.0	126.255.255.255

IPv4 classes

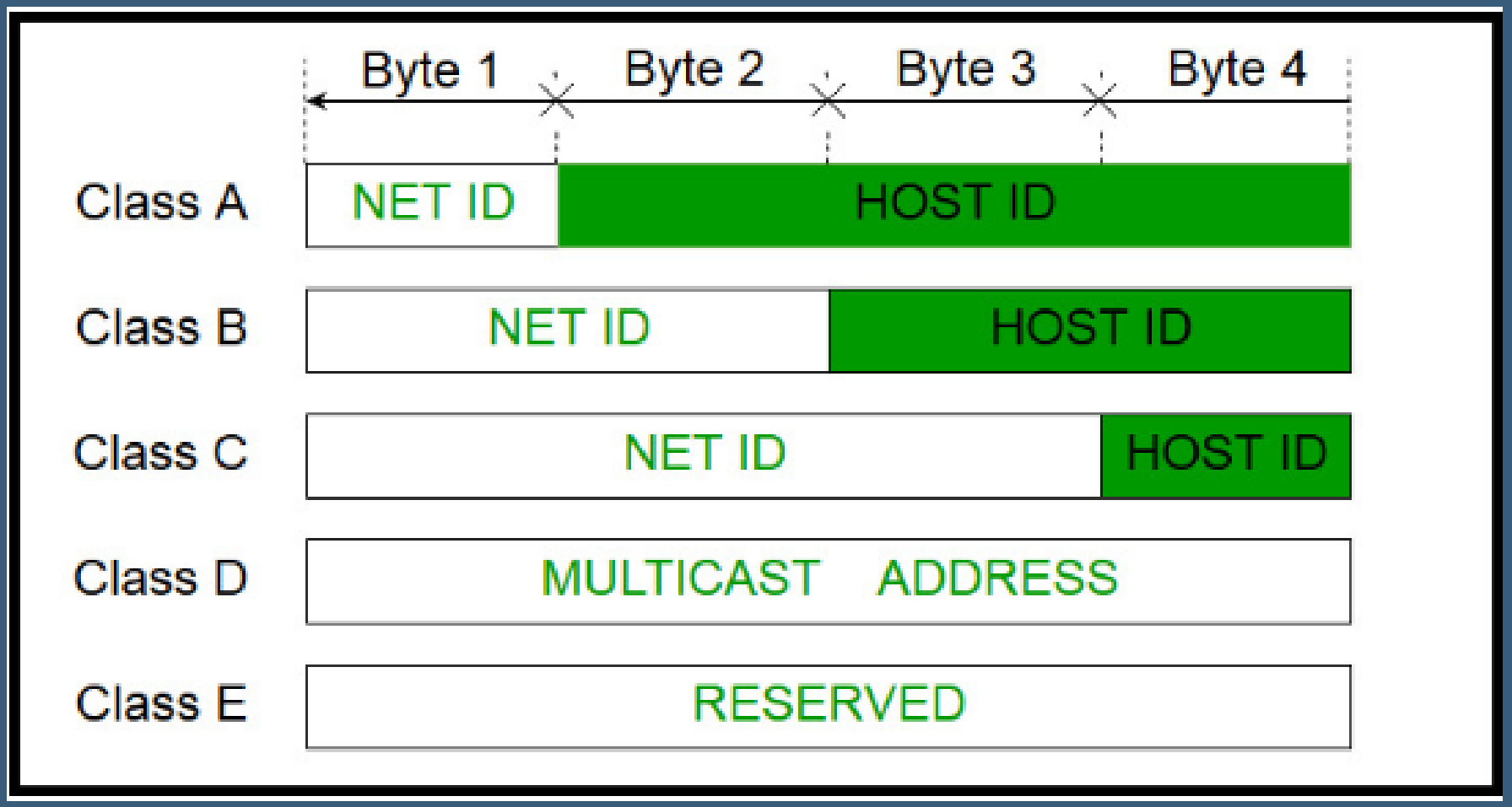
Table 4-3 Sampling of IPv4 Class B Networks

Concept	Class	Network ID	Broadcast IP
All addresses that begin with 128.1	B	128.1.0.0	128.1.255.255
All addresses that begin with 172.20	B	172.20.0.0	172.20.255.255
All addresses that begin with 191.191	B	191.191.0.0	191.191.255.255
All addresses that begin with 150.1	B	150.1.0.0	150.1.255.255

Table 4-4 Sampling of IPv4 Class C Networks

Concept	Class	Network ID	Broadcast IP
All addresses that begin with 199.1.1	C	199.1.1.0	199.1.1.255
All addresses that begin with 200.1.200	C	200.1.200.0	200.1.200.255
All addresses that begin with 223.1.10	C	223.1.10.0	223.1.1.255
All addresses that begin with 209.209.1	C	209.209.1.0	209.209.1.255

IPv4 classes



IPv4 classes

Rule	*Minimums and maximums*	*Decimal range*
Class A: First bit is always 0.	**0**0000000 = 0 **0**1111111 = 127	1 - 126* * 0 and 127 are reserved.
Class B: First two bits are always 10.	**10**000000 = 128 **10**111111 = 191	128 - 191
Class C: First three bits are always 110.	**110**00000 = 192 **110**11111 = 223	192 - 223
Class D: First four bits are always 1110.	**1110**0000 = 224 **1110**1111 = 239	224 - 239

IPv4 classes

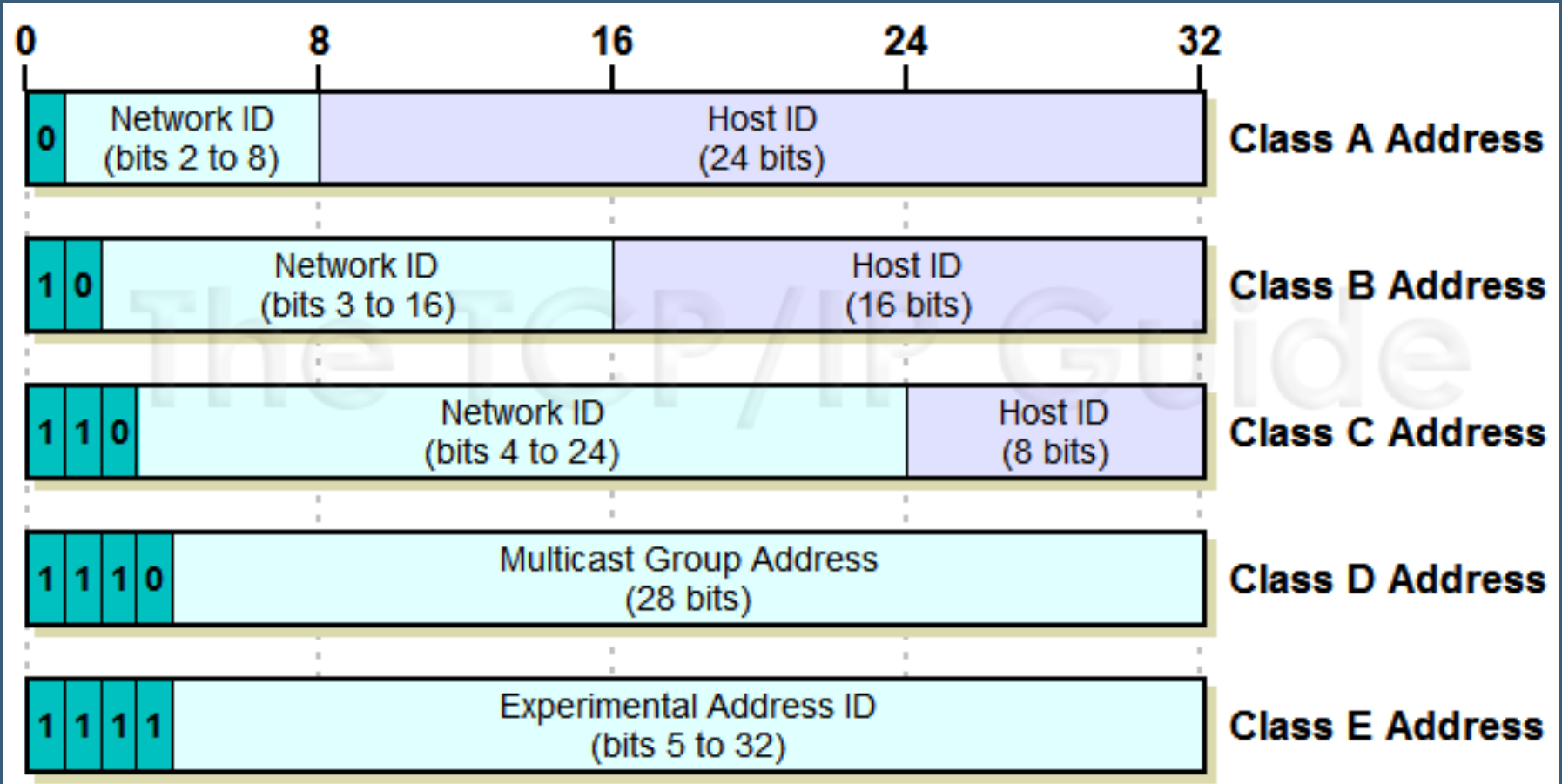


Figure 62: IP Address Class Bit Assignments and Network/Host ID Sizes

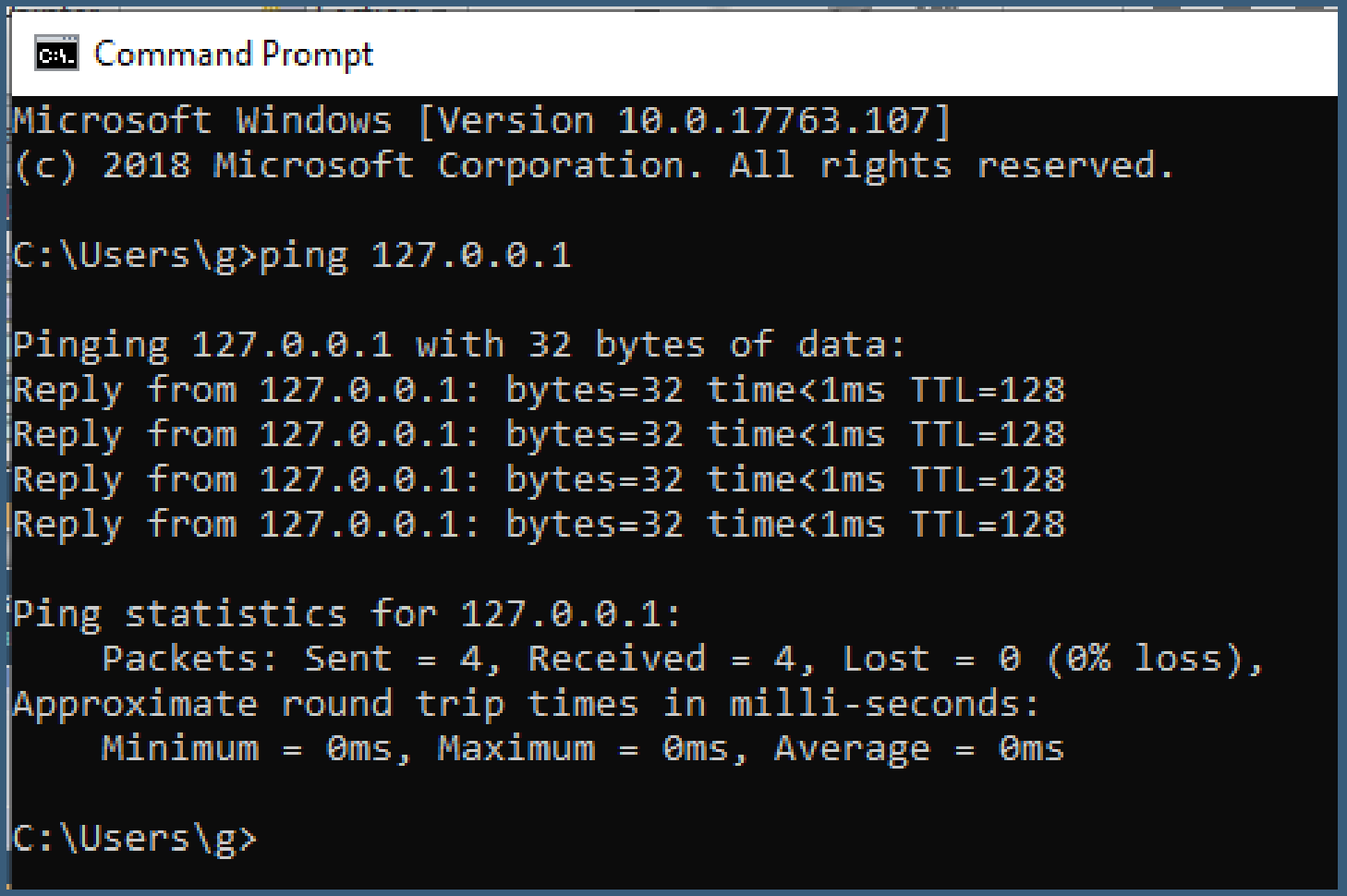
IPv4 classes

- Classless IPv4 (Reserved IPv4)

Classless IP	Used IP	Used for
0.X.X.X	0.0.0.0.	All IPv4 networks address
127.X.X.X	127.0.0.1	Used for software (i.e., TCP/IP model) testing, called the loopback test. 127.0.0.1 called loopback address
255.X.X.X	255.255.255.255	All hosts broadcast address (general broadcast)

IPv4 classes

- Classless IPv4 (Reserved IPv4)



IPv4 classes

- IP address could be one of three categories:-
  1. Network address (Network number or Network ID).
  2. Host address
  3. Broadcast address (Broadcast IP)

- Network address :
The first IP address in it which all host part bits = 0

- Broadcast address:
The last IP address in the network which all host part bits = 1

- other addresses are host addresses = $2^{\text{no. of host bits}} - 2$
- Here are some examples:

Class	Network Address	Broadcast Address
A	12.0.0.0	12.255.255.255
B	172.16.0.0	172.16.255.255
C	192.168.1.0	192.168.1.255

IPv4 classes

- Exercise:- Complete the missing cells through the following table

Table 14-4 Practice Problems: Find the Network ID and Network Broadcast

	IP Address	Class	1, 2, or 3 Network Octets?	1, 2, or 3 Host Octets?	Network ID	Network Broadcast Address
1	1.1.1.1					
2	128.1.6.5					
3	200.1.2.3					
4	192.192.1.1					
5	126.5.4.3					
6	200.1.9.8					
7	192.0.0.1					
8	191.255.1.47					
9	223.223.0.1					

IPv4 limitations

- IPv4, 32 bits allows for 4,294,967,296 addresses. (approximately 4.3 billion).
- Such a number of addresses has become insufficient for the current number of worldwide devices connected to the Internet.
- The population of Earth in 1990 was about 5.3 billion. In 2022 this number exceeds 8 billion.
- Also more and more devices (mobiles, labtops, etc…) will consume IP address.
- IPv4 address space has been getting consumed over the years after 1990's.

IPv4 limitations

- IANA solutions for IPv4 limitations:-
  1. Anew version of IP called IPv6 was published in December 1996.
     - It designed by IETF (Internet Engineering Task Force)
     - RFC 1883 is the name of the documentation that contain the specification of IPv6.
     - Here is the link for RFC 1883: https://datatracker.ietf.org/doc/html/rfc1883
     - IPv6 consist of 128 bit or 16 byte.
     - $2^{128} = 3.5 * 10^{38}$ IPv6.
     - If the previous number is divided over the population of earth in 2024 we will obtain the number $4.2 * 10^{28}$ IPv6.

IPv4 limitations

2. In 1990s, IANA assigned a subset of public IPv4 networks called Private IP addresses.
   - Private IPv4 addresses are commonly used for home, office, and enterprise local area networks (LANs), when globally routable addresses are not mandatory, or are not available for the internet network applications.
   - The private IPv4 spaces were originally defined in an effort to delay IPv4 address exhaustion, but they are also a feature of IPv6, the next generation internet protocol.

IPv4 limitations

- Within the IPv4 address range there are Public and Private IP addresses – defined by IANA.
- Public IPv4 addresses are used by devices that communicate directly on the internet and MUST be unique.
- Private IPv4 addresses are free to be used inside any LAN but Cannot be used to access the internet.
- Private IP address can not travel over public infrastructure.
- Router can replace the private IPv4 with the public IPv4 by using NAT (Network Address Translation) protocol.
- To obtain your public IP visit the site https://www.whatismyip.com/

IPv4 limitations

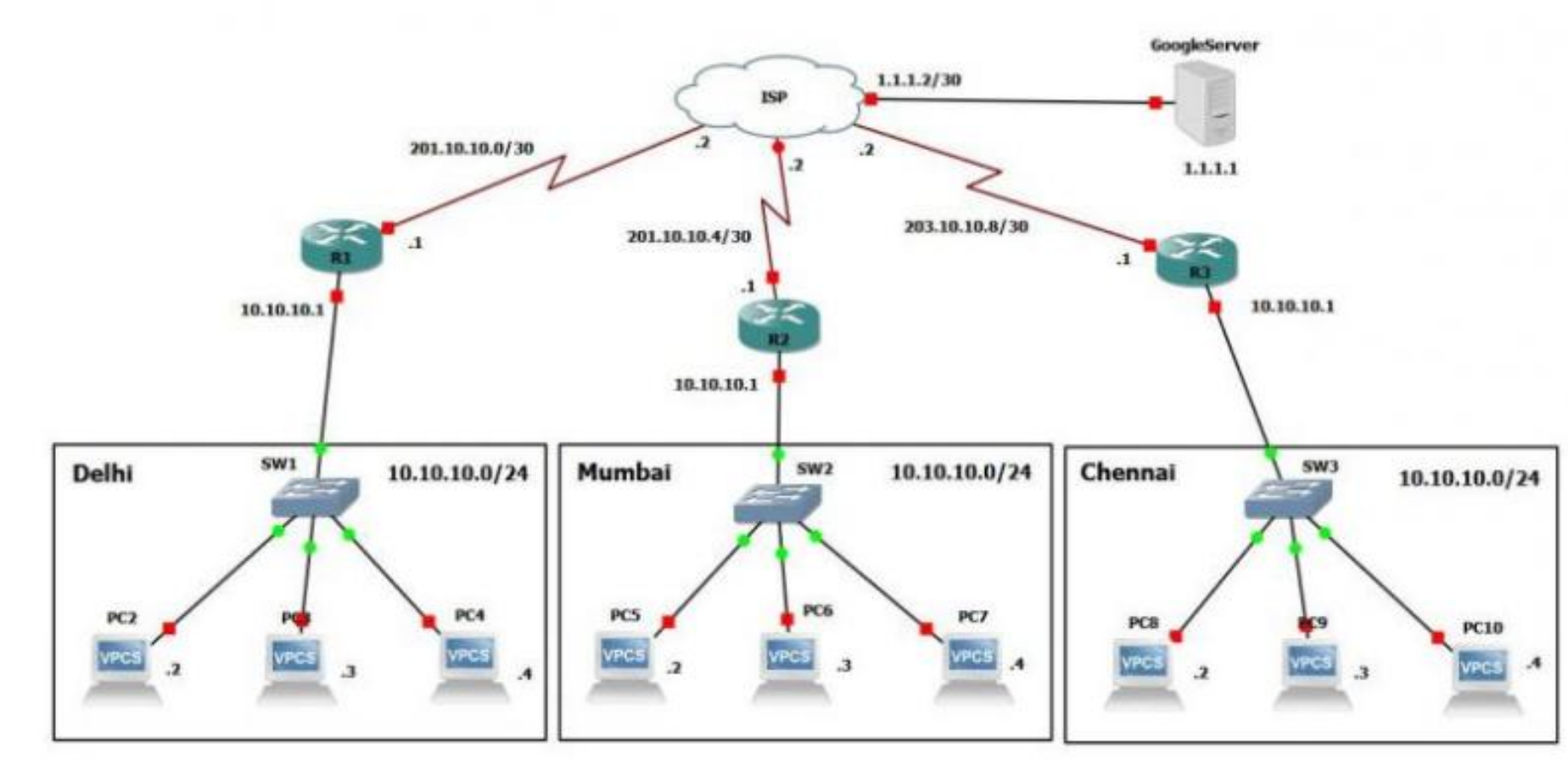
Private IP	Public IP
Used with LAN or Network	Used on Public Network
Not recognized over Internet	Recognized over Internet
Assigned by LAN administrator	Assigned by Service provider / IANA
Unique only in LAN	Unique Globally
Free of charge	Cost associated with using Public IP
Range – Class A -10.0.0.0 to 10.255.255.255 Class B – 172.16.0.0 to 172.31.255.255 Class C – 192.168.0.0 – 192.168.255.255	Range – Class A -1.0.0.0 to 9.255.255.255 11.0.0.0 – 126.255.255.255 Class B -128.0.0.0 to 172.15.255.255 172.32.0.0 to 191.255.255.255 Class C -192.0.0.0 – 192.167.255.255 192.169.0.0 to 223.255.255.255

Private IP address space	
From	**To**
10.0.0.0	10.255.255.255
172.16.0.0	172.31.255.255
192.168.0.0	192.168.255.255

IPv4 limitations

- From Class A we have only one net; all IPv4 of the network 10.0.0.0
- From class B we have 16 nets:
  127.16.0.0, 172.17.0.0, 172.18.0.0, …, 172.31.0.0
- From class C we have 256 nets:
  192.168.0.0, 192.168.1.0, 192.168.2.0, 192.168.3.0 , 192.168.4.0, …, 192.168.255.0

IPv4 limitations



Question

Assume that source S and destination D are connected through two intermediate routers labeled R. Determine how many times each packet has to visit the network layer and the data link layer during a transmission from S to D.

1. Network layer – 4 times and Data link layer – 4 times
2. Network layer – 4 times and Data link layer – 3 times
3. Network layer – 4 times and Data link layer – 6 times
4. Network layer – 2 times and Data link layer – 6 times

Question

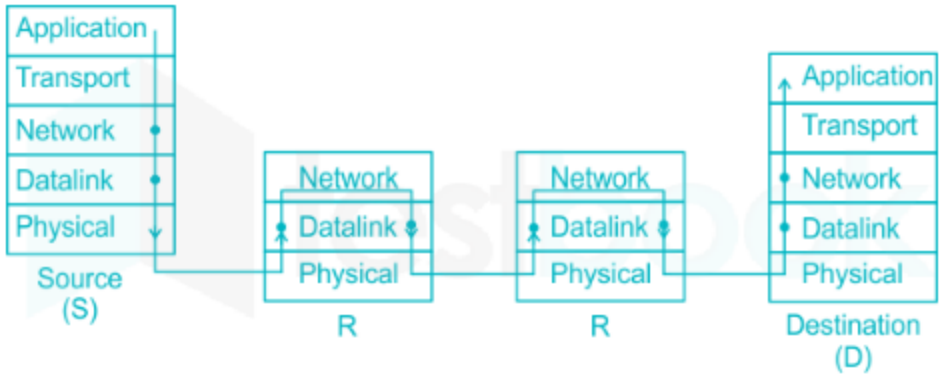
Answer: Option 3

Concept:

The Routers only contains 3 layer that's the reason sometimes they also called as 3-layer switch.

The Router is a physical or virtual internetworking device that is designed to receive, analyze, and forward data packets between computer networks. A router examines a destination IP address of a given data packet, and it uses the headers and forwarding tables to decide the best way to transfer the packets.

Explanation:



At Intermediate Router R the packet will not go beyond the network layer. Hence Network layer will only be visited once at both the routers.

But the Data link layer will be visited twice.

Hence Network layer will be visited 4 times and the Data link layer will be visited 6 times (1 + 2 (at R) + 2 (at R) + 1 = 6)

THANK YOU

For any questions feel free
to contact me by mail

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