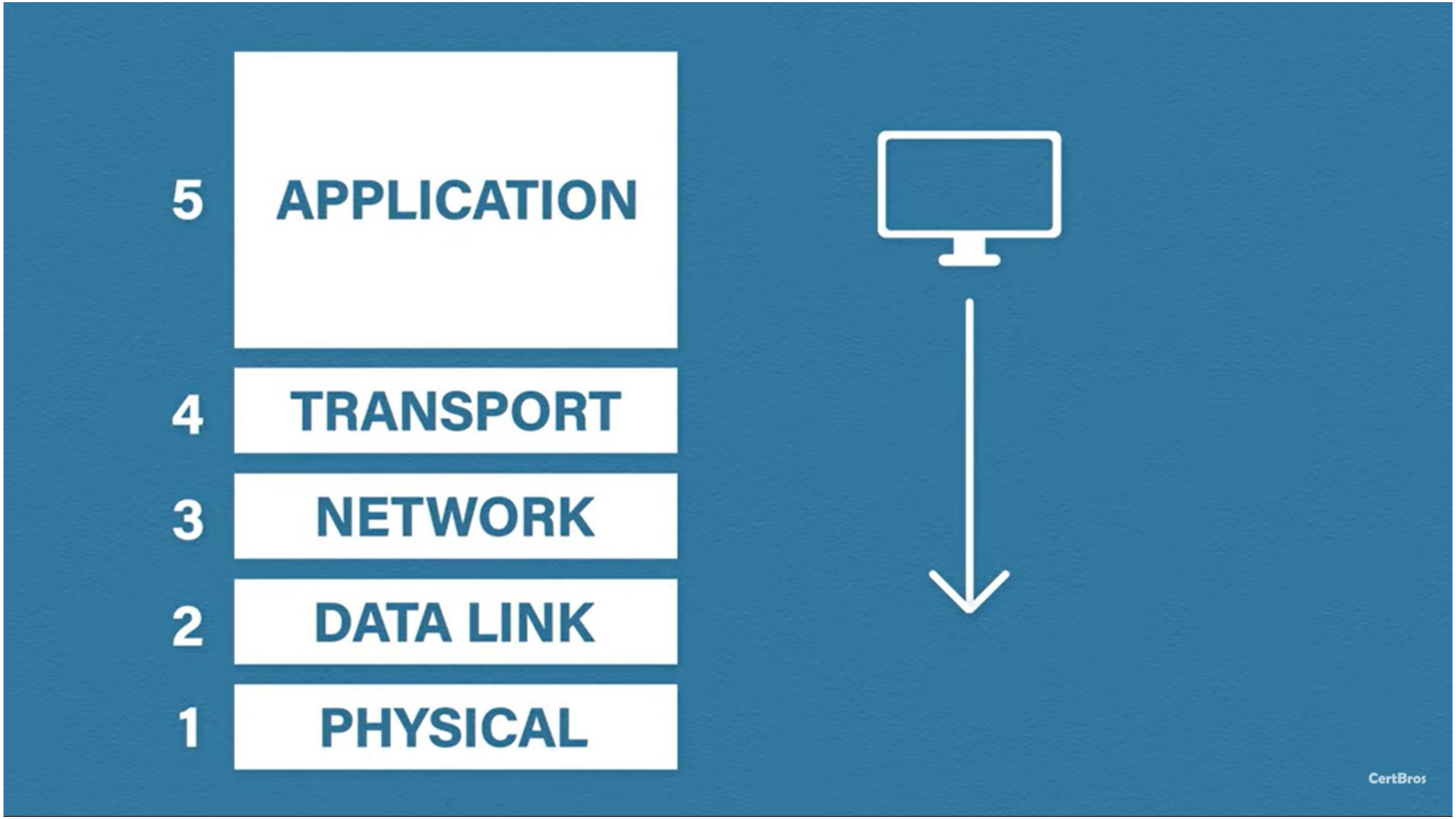
IP Addressing & Subnetting


5 APPLICATION
4 TRANSPORT
3 NETWORK
2 DATA LINK
1 PHYSICAL
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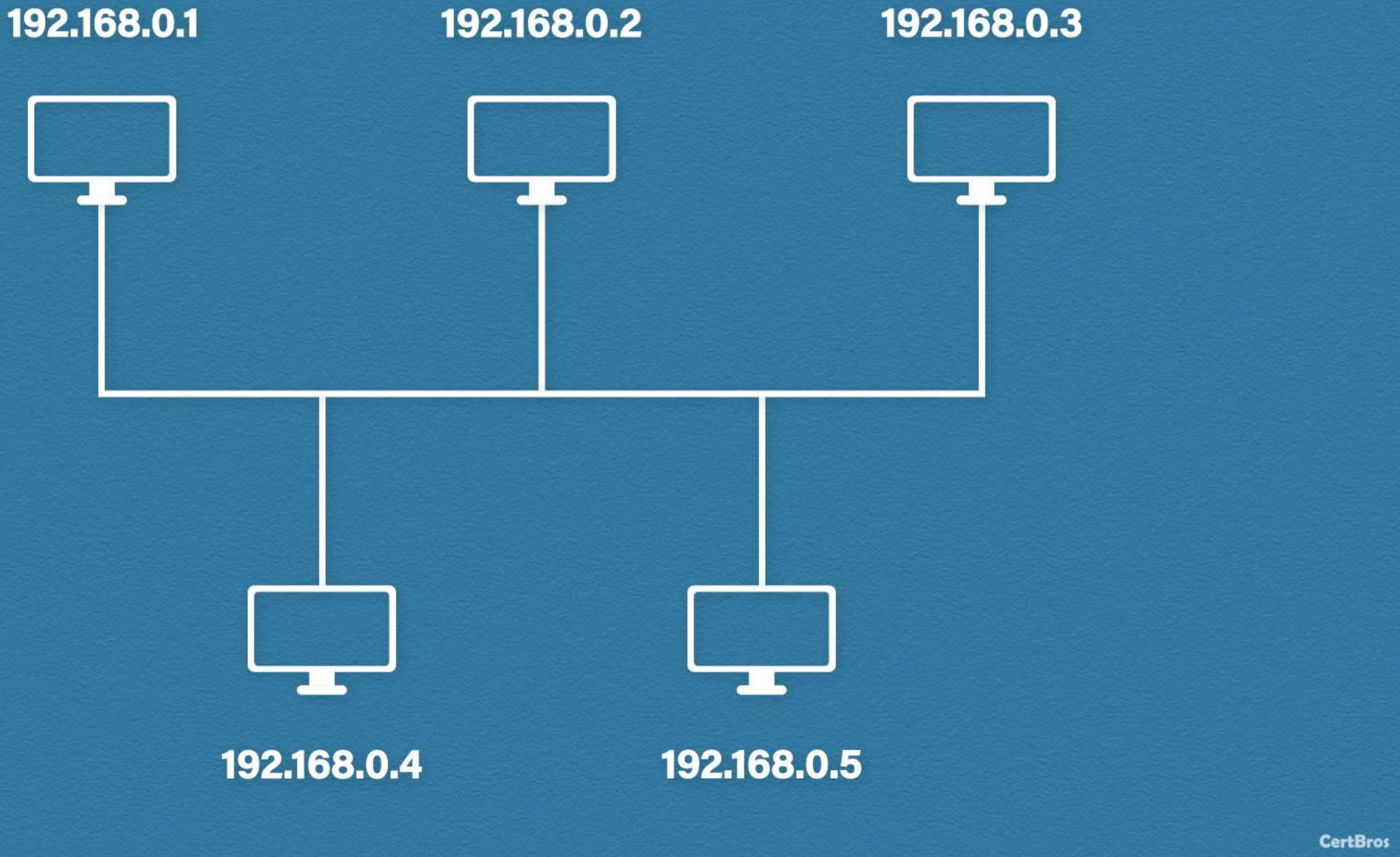
IP Addresses

An IP address is a number that uniquely identifies every host on an IP network. IP addresses operate at the Network layer of the TCP/IP protocol stack, so they are independent of lower-level Data Link layer MAC addresses, such as Ethernet MAC addresses.

IP addresses are 32-bit binary numbers, which means that theoretically, a maximum of something in the neighborhood of 4 billion unique host addresses can exist throughout the Internet.

You'd think that would be enough, but TCP/IP places certain restrictions on how IP addresses are allocated. These restrictions severely limit the total number of usable IP addresses, and today, about half of the total available IP addresses have already been assigned.

However, new techniques for working with IP addresses have helped to alleviate this problem, and a new standard for 128-bit IP addresses known as IPv6 is used.


192.168.0.1
192.168.0.2
192.168.0.3
192.168.0.4
192.168.0.5
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What is a byte?

A byte is a group of 8 bits. A bit is the most basic unit and can be either 1 or 0. A byte is not just 8 values between 0 and 1, but 256 (28) different combinations (rather permutations) ranging from 00000000 via e.g. 01010101 to 11111111. Thus, one byte can represent a decimal number between 0(00) and 255.

Puzzled? Remember that 3 decimal numbers also don’t just stand for 3 values between 0 and 9, but 1000 (103 permutations) from 0(00) to 999.

Table 2-1 Powers of Two

Power	*Bytes*	*Kilobytes*	*Power*	*Bytes*	*K, MB, or GB*
2^{1}	2		2^{17}	131,072	128K
2^{2}	4		2^{18}	262,144	256K
2^{3}	8		2^{19}	524,288	512K
2^{4}	16		2^{20}	1,048,576	1MB
2^{5}	32		2^{21}	2,097,152	2MB
2^{6}	64		2^{22}	4,194,304	4MB
2^{7}	128		2^{23}	8,388,608	8MB
2^{8}	256		2^{24}	16,777,216	16MB
2^{9}	512		2^{25}	33,554,432	32MB
2^{10}	1,024	1K	2^{26}	67,108,864	64MB
2^{11}	2,048	2K	2^{27}	134,217,728	128MB
2^{12}	4,096	4K	2^{28}	268,435,456	256MB
2^{13}	8,192	8K	2^{29}	536,870,912	512MB
2^{14}	16,384	16K	2^{30}	1,073,741,824	1GB
2^{15}	32,768	32K	2^{31}	2,147,483,648	2GB
2^{16}	65,536	64K	2^{32}	4,294,967,296	4GB

The dotted-decimal dance

IP addresses are usually represented in a format known as dotted-decimal notation. In dotted-decimal notation, each group of eight bits, known as an octet, is represented by its decimal equivalent.

For example, consider the following binary IP address:

11000000101010001000100000011100

To convert this value to dotted-decimal notation, first divide it into four octets, as follows:

11000000 10101000 10001000 00011100

Then, convert each of the octets to its decimal equivalent:

11000000 10101000 10001000 00011100

192 168 136 28

0 - 255

OCTET		OCTET		OCTET		OCTET
192	.	168	.	32	.	152

What about IPv6?

IPv6 offers several advantages over IPv4, but the most important is that it uses 128 (2,128 combinations) bits for Internet addresses rather than 32 bits (232 combinations).The number of host addresses possible with 128 bits is a number so large that it would make Carl Sagan proud. It doesn’t just double or triple the number of available addresses.

Just for the fun of it, here is the number of unique Internet addresses provided by IPv6:

340,282,366,920,938,463,463,374,607,431,768,211,456

2001:0db8:0000:0000:0000:8a2e:0370:7334

This number is so large it defies understanding. If the IANA were around at the creation of the universe and started handing out IPv6 addresses at a rate of one per millisecond, they would now, 15 billion years later, have not yet allocated even 1 percent of the available addresses. Unfortunately, the transition from IPv4 to IPv6 has been a slow one. IPv6 is available on all new computers and has been supported on Windows XP since Service Pack 1 was released in 2002. However, most Internet service providers still base their service on IPv4. Thus, the Internet will continue to be driven by IPv4 for at least a few more years.

Networks and hosts

As a result, a 32-bit IP address actually consists of two parts:

✦ The network ID (or network address): Identifies the network on which a host computer can be found.

✦ The host ID (or host address): Identifies a specific device on the network indicated by the network ID.

Most of the complexity of working with IP addresses has to do with figuring out which part of the complete 32-bit IP address is the network ID and which part is the host ID. The original IP specification uses a system called address classes to determine which part of the IP address is the network ID and which part is the host ID. A newer system, known as classless IP addresses are used extensively.

NETWORK HOST

192 . 168 . 32 . 152

255 . 255 . 255 . 0


PARK AVENUE
1
2
3
HIGH STREET
1
2
3


NETWORK: 192.168.5.0
.1
.2
.3
NETWORK: 192.168.10.0
.1
.2
.3

Classifying IP Addresses

- When the original designers of the IP protocol created the IP addressing scheme, they could have assigned an arbitrary number of IP address bits for the network ID. The remaining bits would then be used for the host ID.
- For example, suppose that the designers decided that half of the address (16 bits) would be used for the network, and the remaining 16 bits would be used for the host ID. The result of that scheme would be that the Internet could have a total of 65,536 networks, and each of those networks could have 65,536 hosts.
- In the early days of the Internet, this scheme probably seemed like several orders of magnitude more than would ever be needed. However, the IP designers realized from the start that few networks would actually have tens of thousands of hosts.
- Suppose that a network of 1,000 computers joins the Internet and is assigned one of these hypothetical network IDs. Because that network will use only 1,000 of its 65,536 host addresses, more than 64,000 IP addresses would be wasted.

Classifying IP Addresses

The IP protocol defines five different address classes: A, B, C, D, and E. The first three classes, A through C, each use a different size for the network ID and host ID portion of the address. Class D is for a special type of address called a multicast address. Class E is an experimental address class that isn't used.

The first four bits of the IP address are used to determine into which class a particular address fits, as follows:

- ✦ If the first bit is a zero, the address is a Class A address.
- ✦ If the first bit is one and if the second bit is zero, the address is a Class B address.
- ✦ If the first two bits are both one and if the third bit is zero, the address is a Class C address.
- ✦ If the first three bits are all one and if the fourth bit is zero, the address is a Class D address.
- ✦ If the first four bits are all one, the address is a Class E address.

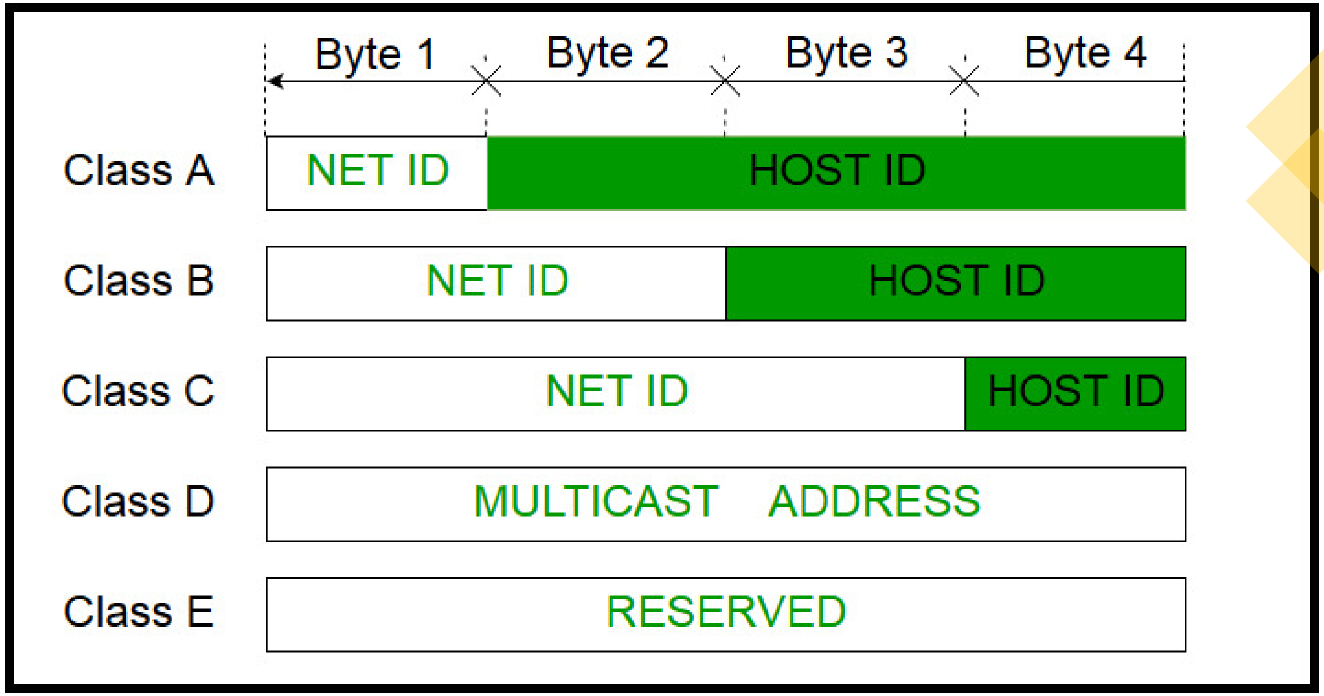
IPv4 address is divided into two parts:

Network ID: identify the network that the address is a part of

Host ID: used to specify a specific host within that network

The class of IP address is used to determine the bits used for network ID and host ID and the number of total networks and hosts possible in that particular class. Each ISP or network administrator assigns IP address to each device that is connected to its network.

Most of the complexity of working with IP addresses has to do with figuring out which part of the complete 32-bit IP address is the network ID and which part is the host ID.



Note: IP addresses are globally managed by Internet Assigned Numbers Authority(IANA) and regional Internet registries(RIR).

Note: While finding the total number of host IP addresses, 2 IP addresses are not counted and are therefore, decreased from the total count because the first IP address of any network is the network number and whereas the last IP address is reserved for broadcast IP.

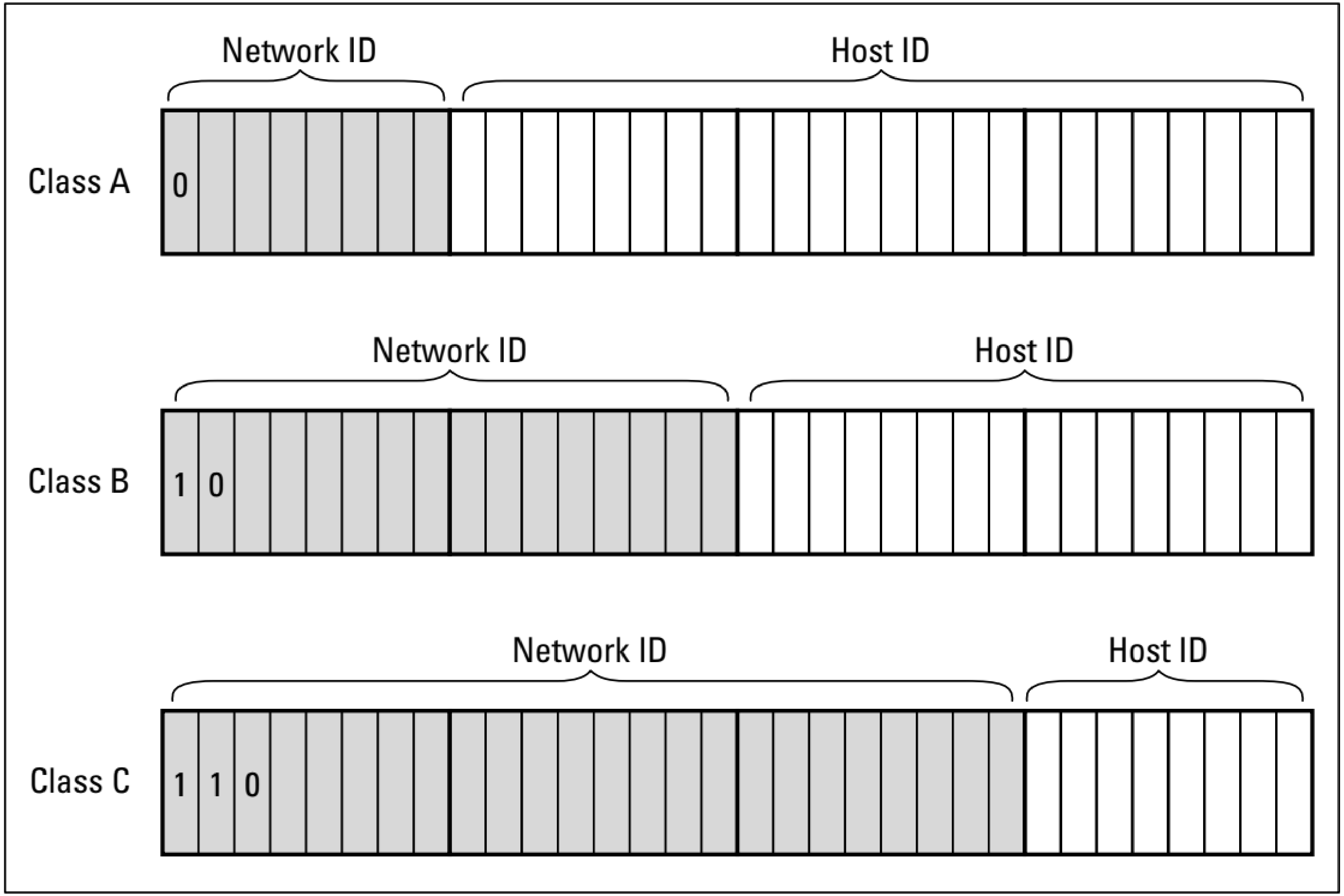
Class	Address Number Range	Starting Bits	Length of Network ID	Number of Networks	Hosts
A	1–126.x.y.z	0	8	126	16,777,214
B	128–191.x.y.z	10	16	16,384	65,534
C	192–223.x.y.z	110	24	2,097,152	254

A 1.0.0.0 - 126.255.255.255
SUBNET: 255.0.0.0

B 128.0.0.0 - 191.255.255.255
SUBNET: 255.255.0.0

C 192.0.0.0 - 223.255.255.255
SUBNET: 255.255.255.0

- If you're trying to determine the class of an IP address, you need to look at the first number.
- If the first number is 1 through 126, it'll be a class A address. If the first number is 128 through 191, it's a class B address.
- Finally, if it's 192 through 223, it's a class C address. Each of these classes has a valid range of IP addresses. Classes D and E are reserved for multicast and experimental purposes respectively.


Network ID
Host ID
Class A
0
Network ID
Host ID
Class B
1 0
Network ID
Host ID
Class C
1 1 0

	Public IP Range	Subnet Mask	# of Networks	# of Hosts per Network
Class A	1.0.0.0 to 126.0.0.0	255.0.0.0	126	16,777,214
Class B	128.0.0.0 to 191.255.0.0	255.255.0.0	16,382	65,534
Class C	192.0.0.0 to 223.255.255.0	255.255.255.0	2,097,150	254

- Because Class A addresses can accommodate such a large number of hosts, they are generally reserved for use by organizations with a very large number of devices or users.

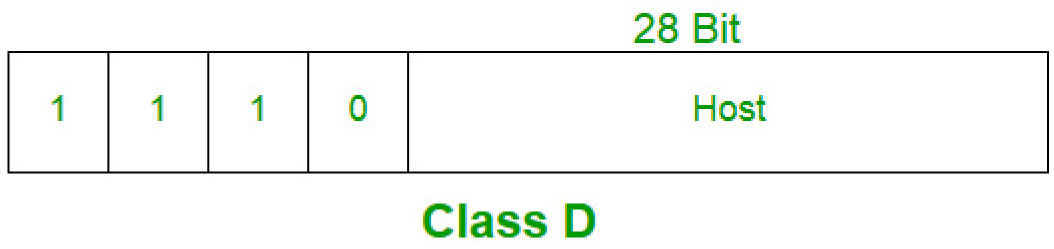
- For example, the United States government uses several Class A addresses, including 10.x.x.x for private networks and 192.x.x.x for public networks.

- Other examples of organizations that use Class A IP addresses include IBM (9.x.x.x), Apple (17.x.x.x), and Xerox (13.x.x.x).

- However, with the depletion of IPv4 addresses, Class A addresses are becoming increasingly scarce and are now mainly used by internet service providers and backbone networks. Most organizations now use Class B or Class C addresses, which are more suited to smaller networks.

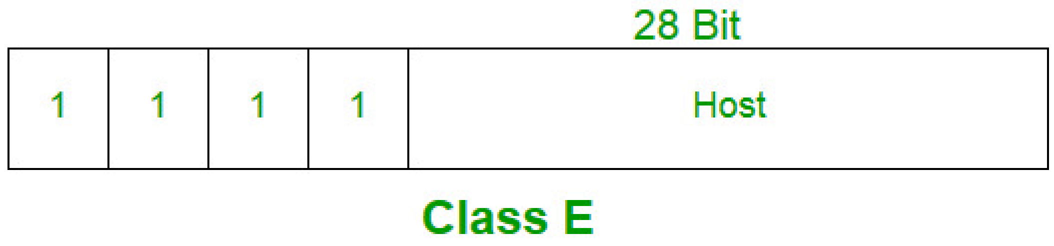
Class D

- IP address belonging to class D is reserved for multi-casting. The higher-order bits of the first octet of IP addresses belonging to class D is always set to 1110. The remaining bits are for the address that interested hosts recognize.
- Class D does not possess any subnet mask. IP addresses belonging to class D range from 224.0.0.0 – 239.255.255.255.

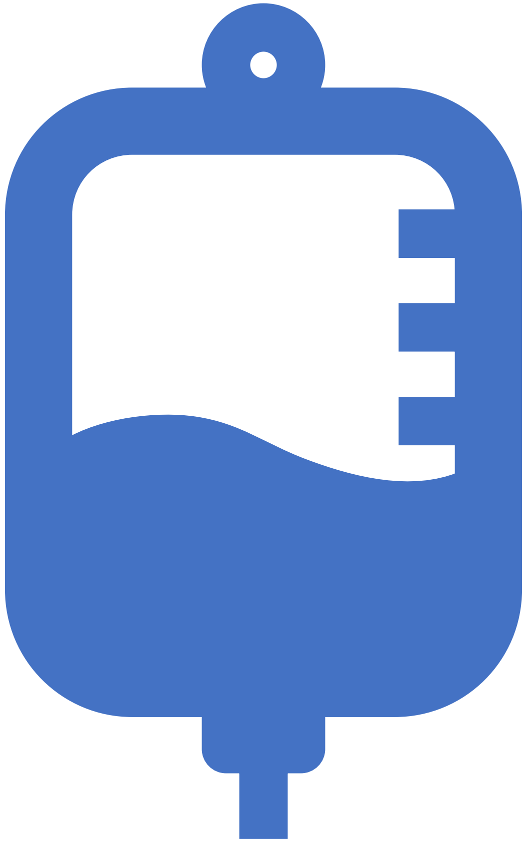


Class E

IP addresses belonging to class E are reserved for experimental and research purposes. IP addresses of class E range from 240.0.0.0 – 255.255.255.255. This class doesn't have any subnet mask. The higher-order bits of the first octet of class E are always set to 1111.



Prolonging the life of IPv4



TWO TYPES OF IP ADDRESSES

PUBLIC IP ADDRESSES

PRIVATE IP ADDRESSES

IPv4 Private Address

- According to standards set forth in Internet Engineering Task Force (IETF) document RFC-1918 , the following IPv4 address ranges are reserved by the IANA for private internets, and are *not* publicly routable on the global internet:

PRIVATE IP ADDRESSES CANNOT GO ON THE INTERNET … They can only travel in the local network

	PUBLIC	PRIVATE
A	1.0.0.0 - 126.255.255.255 SUBNET: 255.0.0.0	10.0.0.0 - 10.255.255.255
B	128.0.0.0 - 191.255.255.255 SUBNET: 255.255.0.0	172.16.0.0 - 172.31.255.255
C	192.0.0.0 - 223.255.255.255 SUBNET: 255.255.255.0	192.168.0.0 - 192.168.255.255

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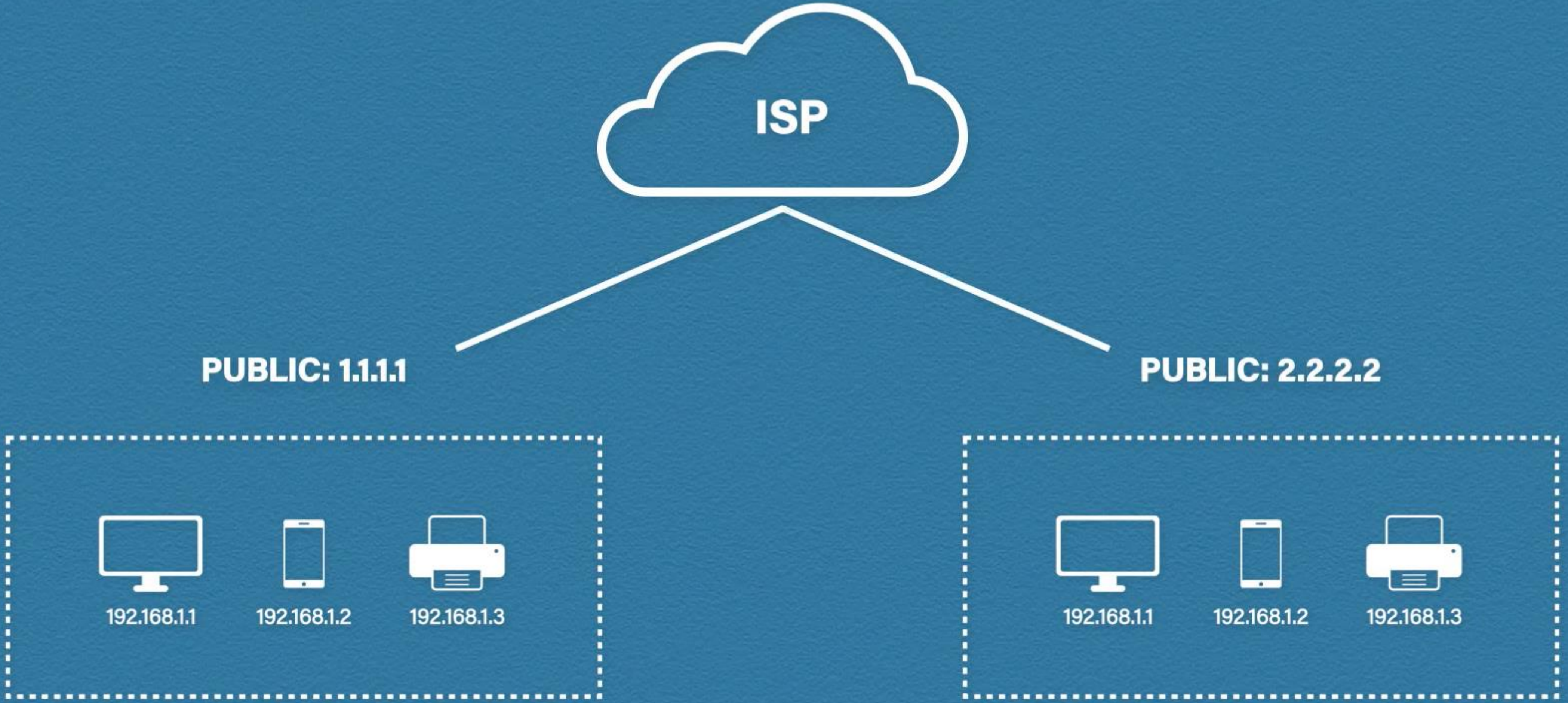
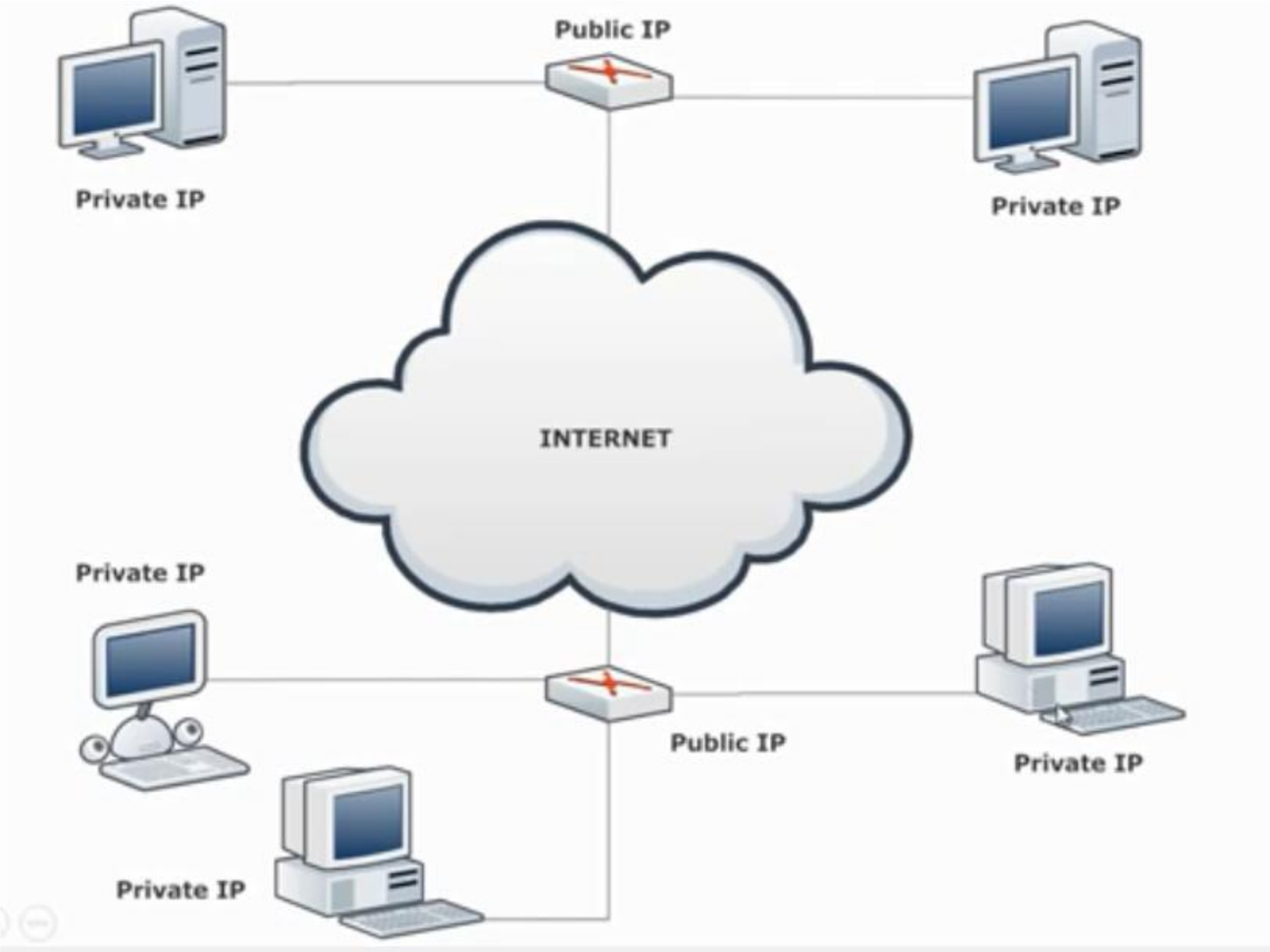
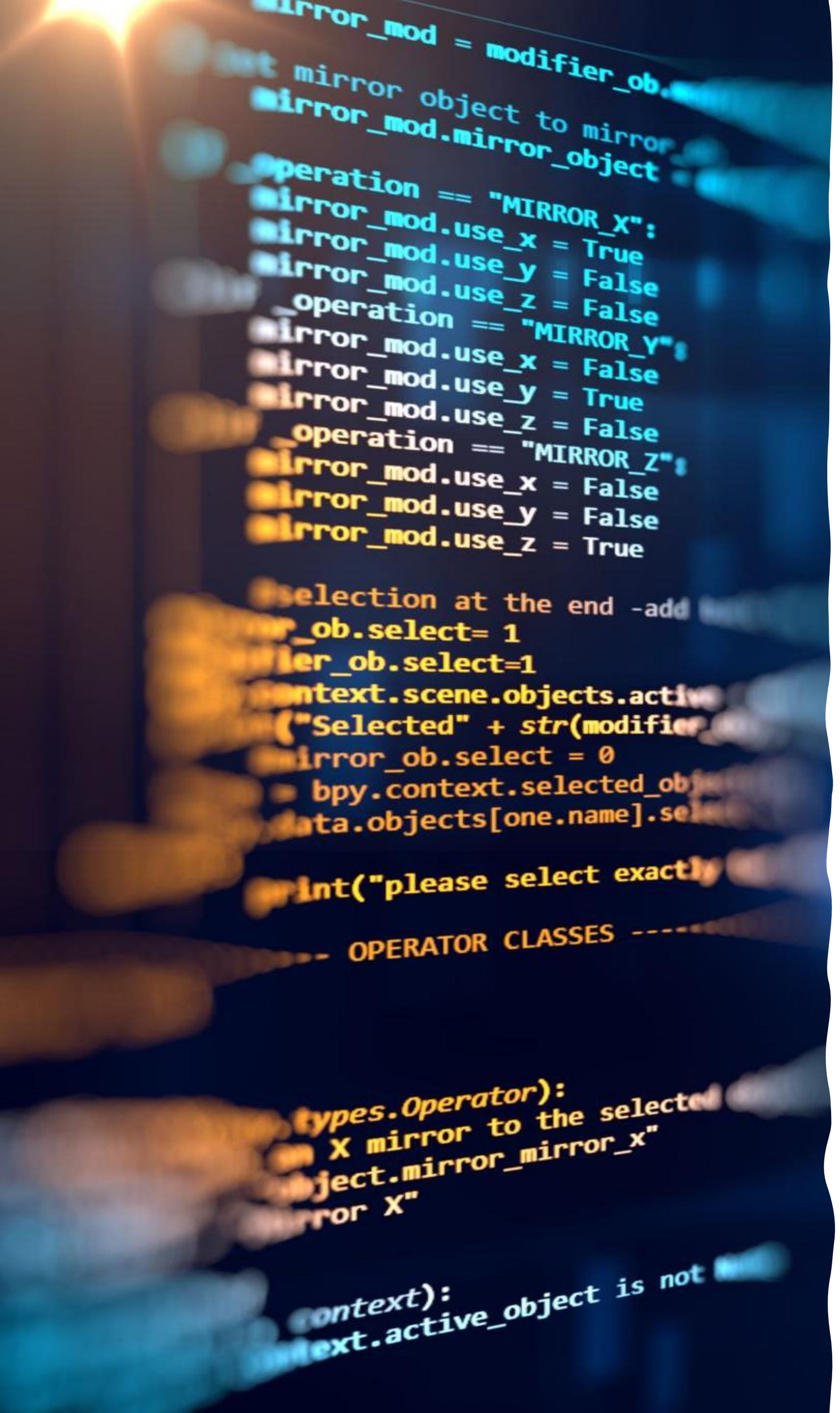

ISP
PUBLIC: 1.1.1.1
PUBLIC: 2.2.2.2
192.168.1.1
192.168.1.2
192.168.1.3
192.168.1.1
192.168.1.2
192.168.1.3
CertBros

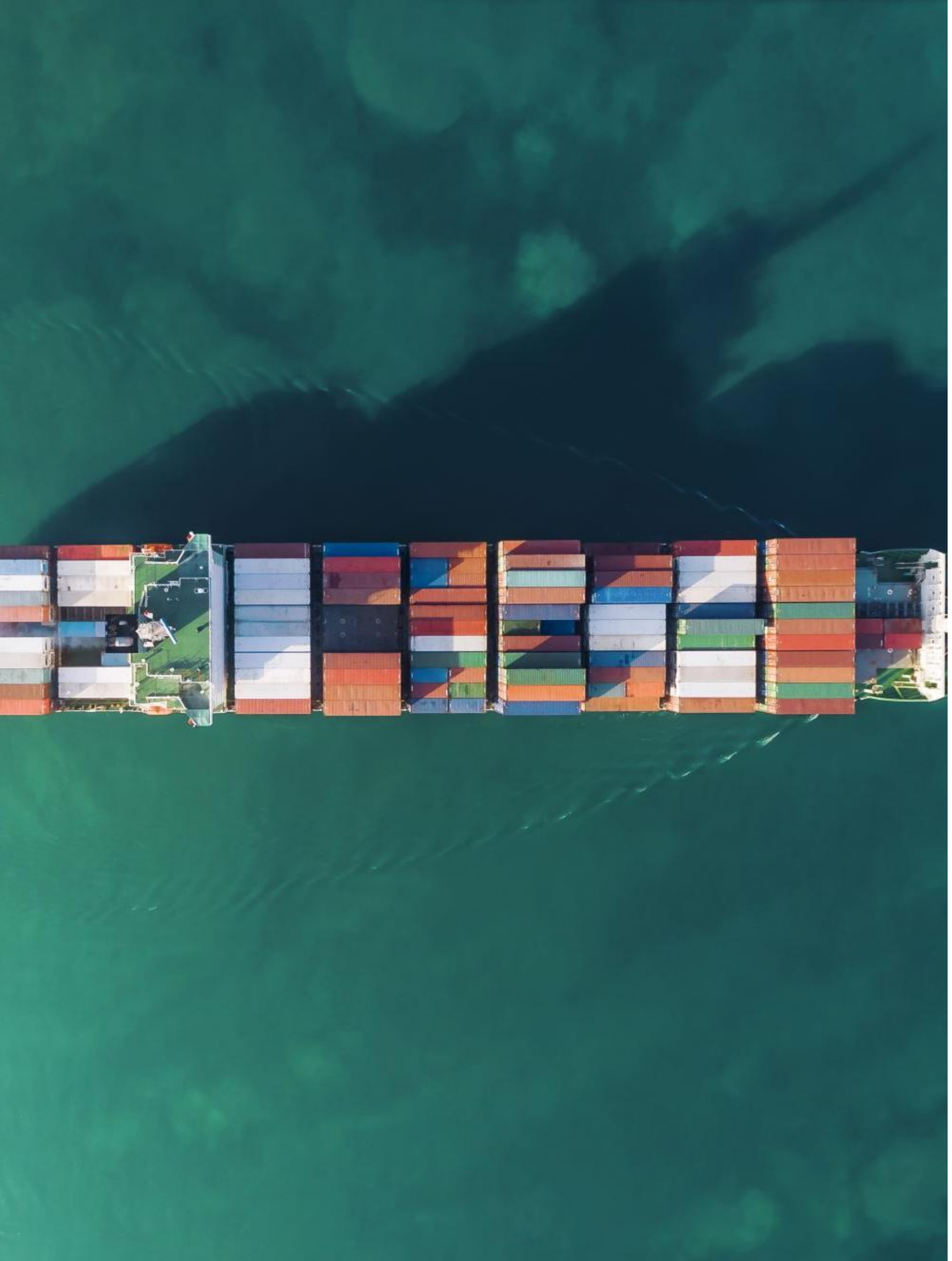

Public IP
Private IP
Private IP
INTERNET
Private IP
Public IP
Private IP
Private IP

Network Address Translation (NAT)



Network Address Translation (NAT)

- Network Address Translation (NAT) is a process in which one or more local IP address is translated into one or more Global IP address and vice versa in order to provide Internet access to the local hosts.
- Also, it does the translation of port numbers i.e. masks the port number of the host with another port number, in the packet that will be routed to the destination.
- It then makes the corresponding entries of IP address and port number in the NAT table. NAT generally operates on a router or firewall.



Types of NAT

There are three types of NAT, some more common than others but it’s a good idea to know exactly how each one works and how they can be used.

PAT (Overload): Port Address Transaction (PAT) or Overload as it is often called is the most popular version used today. The way PAT works is it converts the private address + port number to the public address + port number.

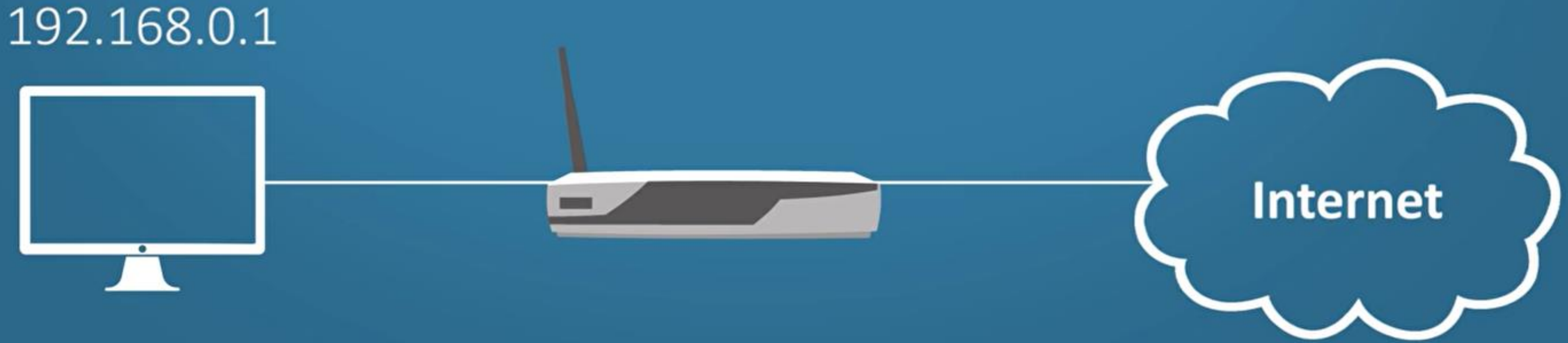
Dynamic: The way Dynamic NAT works is by assigning each private IP to a public IP from a manually created pool of available public addresses. You can use this to merge two networks with the same subnet together. You would configure the connecting routers to make the subnets appear to be different to what they actually are.

S**tatic**: Static NAT is when you manually assign each private IP address + port number a public IP address + port number. This could be used when running web server or mail serve.

Overload (PAT)

Inside	Outside

Source 192.168.0.1:8897 **Destination** 55.66.77.88:80

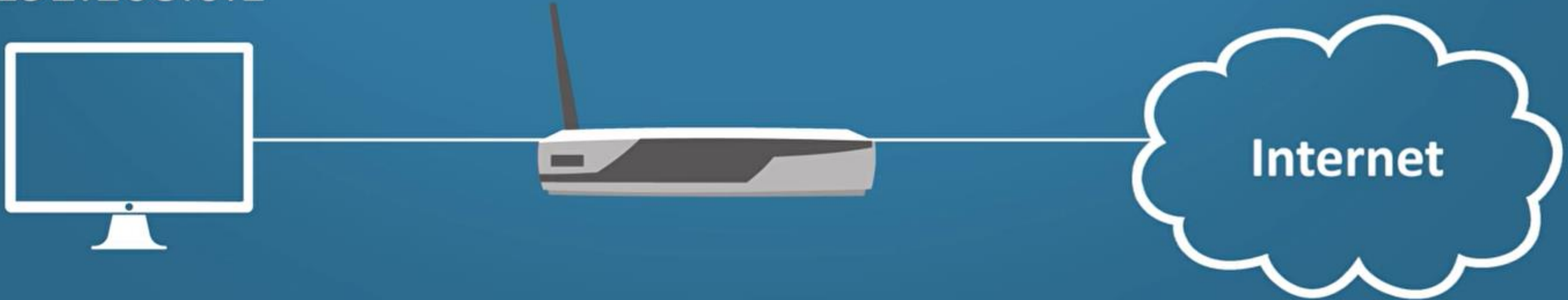


Overload (PAT)

Inside	Outside
192.168.0.1:8897	11.22.33.44:8897

Source 11.22.33.44:8879 **Destination** 55.66.77.88:80

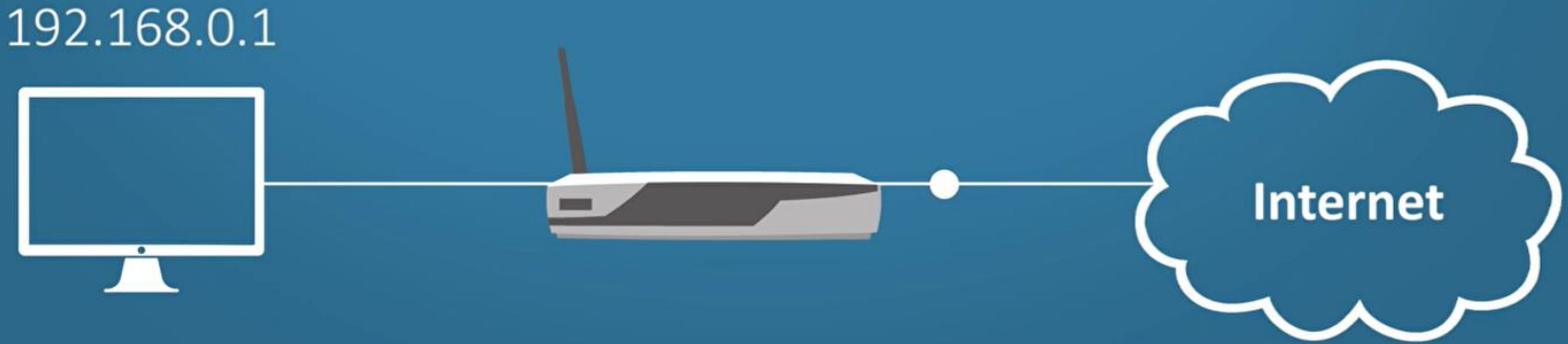
192.168.0.1



Overload (PAT)

Inside	Outside
192.168.0.1:8897	11.22.33.44:8897

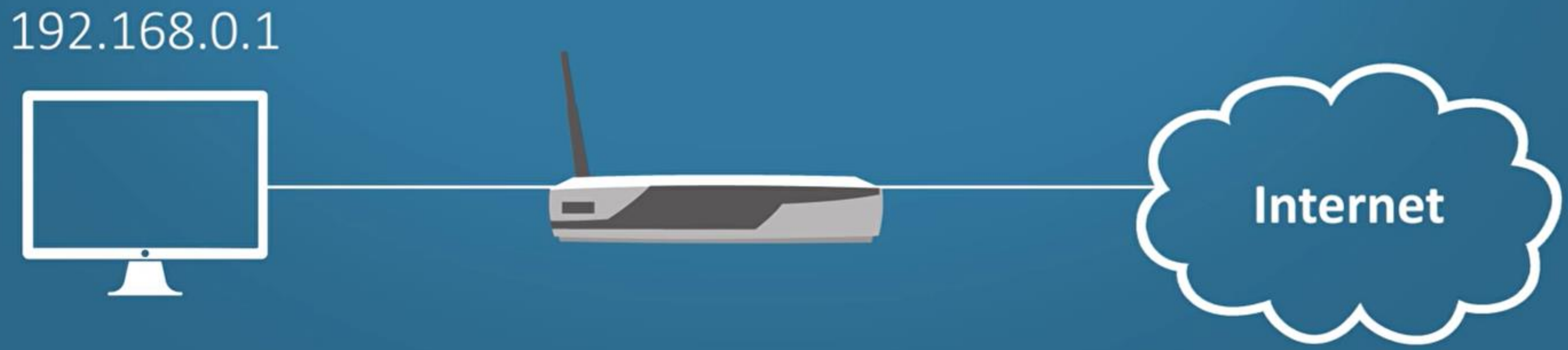
Source 55.66.77.88:80 **Destination** 11.22.33.44:8897



Overload (PAT)

Inside	Outside
192.168.0.1:8897	11.22.33.44:8897

Source 55.66.77.88:80 **Destination** 192.168.0.1:8897

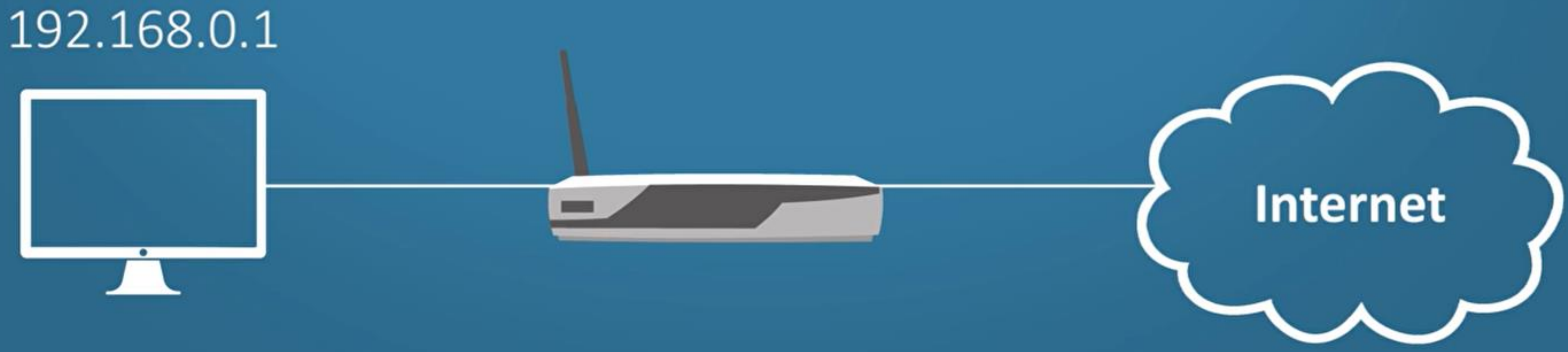



Dynamic
11.22.33.44
-
11.22.33.99
Source 192.168.0.1:8897 Destination 55.66.77.88:80
192.168.0.1
Internet

Dynamic

Inside	Outside
192.168.0.1	11.22.33.52

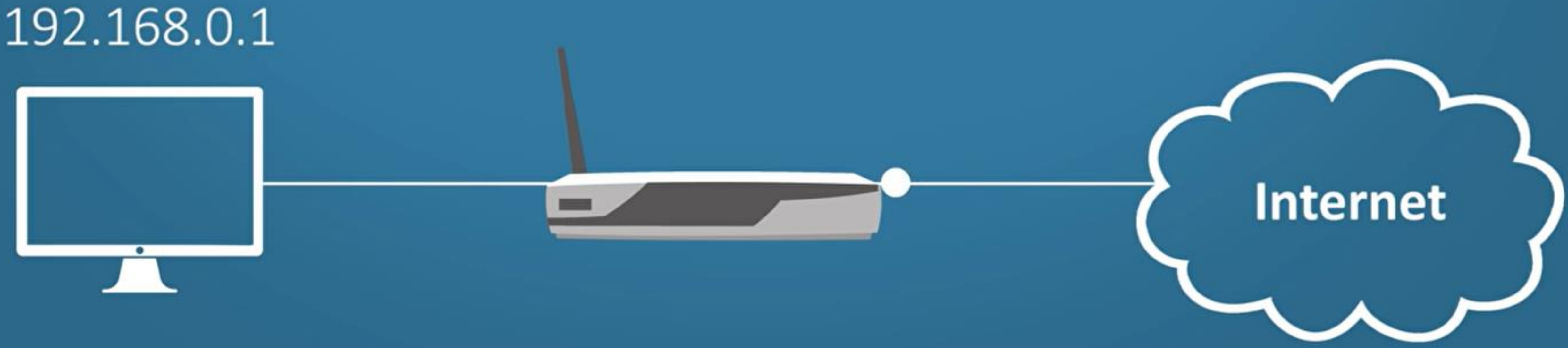
Source 11.22.33.52:8897 **Destination** 55.66.77.88:80



Dynamic

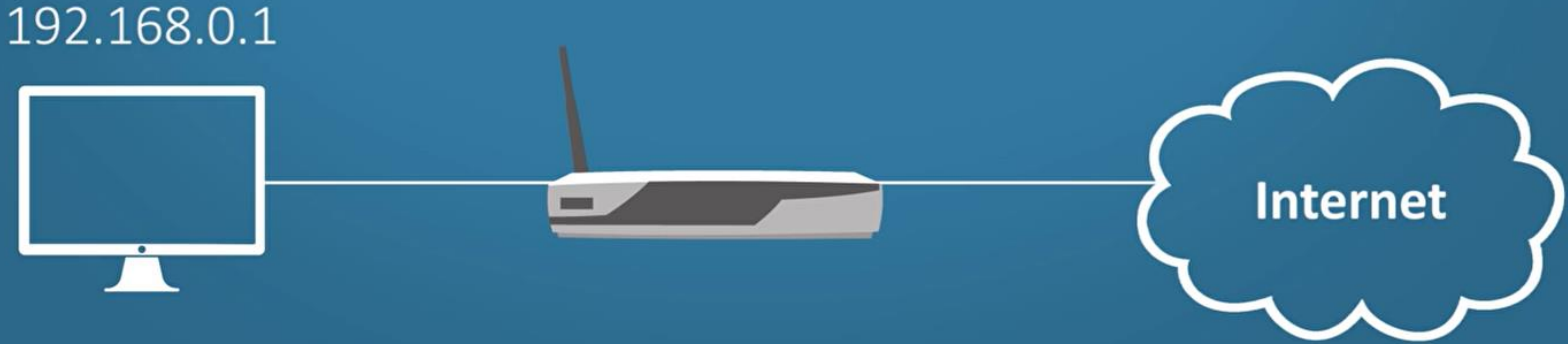
Inside	Outside
192.168.0.1	11.22.33.52

Source 55.66.77.88:80 **Destination** 11.22.33.52:8897



Static

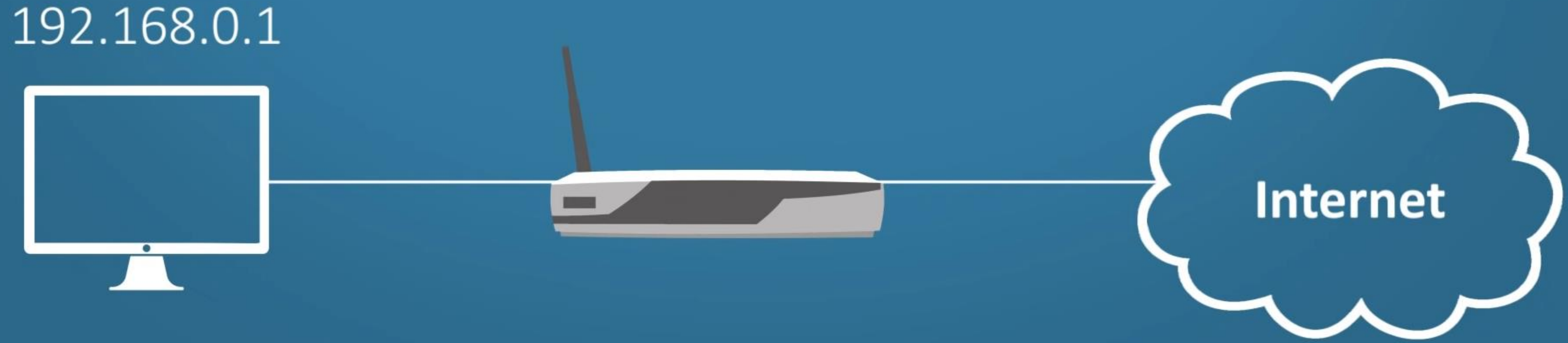
Inside	Outside
192.168.0.1:8897	11.22.33.44:1111



Static

Inside	Outside
192.168.0.1:8897	11.22.33.44:1111

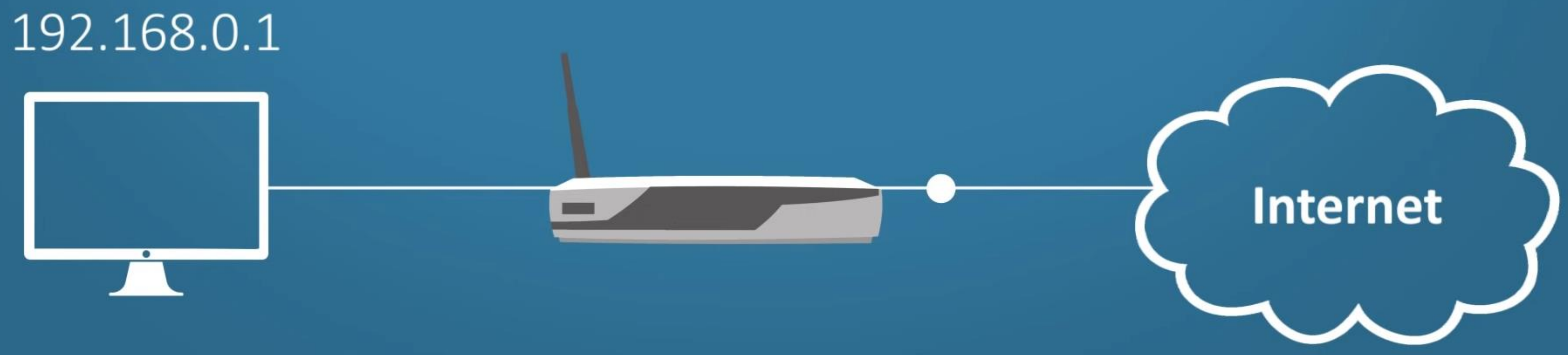
Source 192.168.0.1:8897 **Destination** 55.66.77.88:80



Static

Inside	Outside
192.168.0.1:8897	11.22.33.44:1111

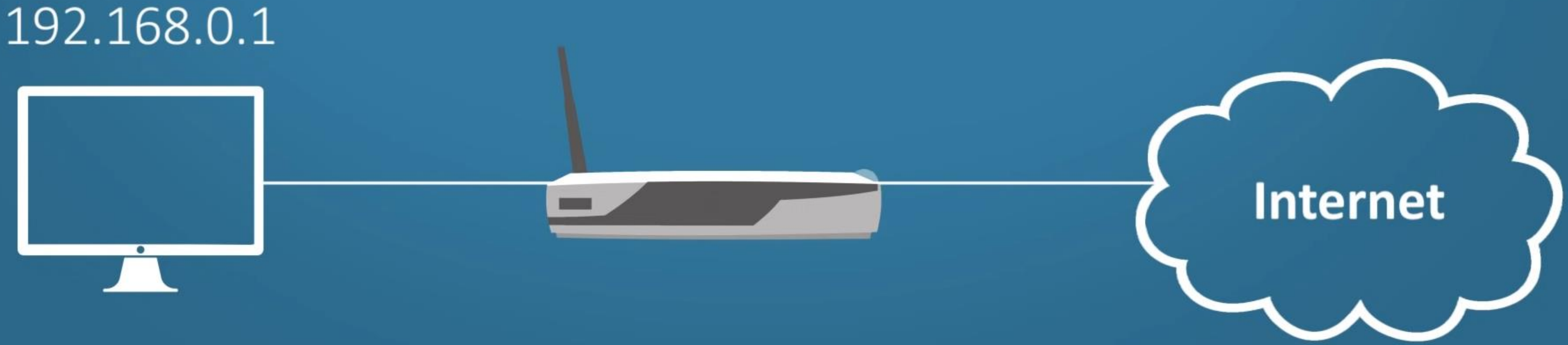
Source 11.22.33.44:1111 **Destination** 55.66.77.88:80



Static

Inside	Outside
192.168.0.1:8897	11.22.33.44:1111

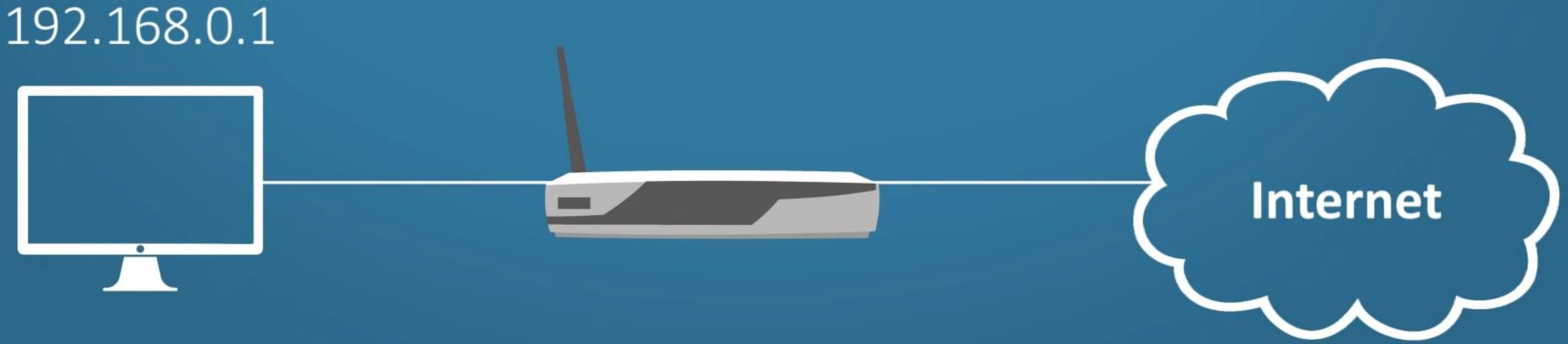
Source 55.66.77.88:80 **Destination** 11.22.33.44:1111



Static

Inside	Outside
192.168.0.1:8897	11.22.33.44:1111

Source 55.66.77.88:80 **Destination** 192.168.0.1:8897



Class A addresses

- Class A addresses are designed for very large networks. In a Class A address, the first octet of the address is the network ID, and the remaining three octets are the host ID. Because only eight bits are allocated to the network ID and the first of these bits is used to indicate that the address is a Class A address, only 126 Class A networks can exist in the entire Internet.
- **0—** : If the first bit of an IPv4 address is “0”, this means that the address is part of class A. This means that any address from **0.0.0.0 to 126.255.255.255** is in class A.
- However, each Class A network can accommodate more than 16 million hosts. Only about 40 Class A addresses are actually assigned to companies or organizations. The rest are either reserved for use by the IANA (Internet Assigned Numbers Authority) or are assigned to organizations that manage IP assignments for geographic regions such as Europe, Asia, and Latin America.

Table 2-4	Some Well-Known Class A Networks		
Net	*Description*	*Net*	*Description*
3	General Electric Company	32	Norsk Informasjonsteknology
4	Bolt Beranek and Newman Inc.	33	DLA Systems Automation Center
6	Army Information Systems Center	35	MERIT Computer Network
8	Bolt Beranek and Newman Inc.	38	Performance Systems International
9	IBM	40	Eli Lilly and Company
11	DoD Intel Information Systems	43	Japan Inet
12	AT&T Bell Laboratories	44	Amateur Radio Digital Communications
13	Xerox Corporation	45	Interop Show Network
15	Hewlett-Packard Company	46	Bolt Beranek and Newman Inc.
16	Digital Equipment Corporation	47	Bell-Northern Research
17	Apple Computer Inc.	48	Prudential Securities Inc.
18	MIT	51	Department of Social Security of UK
19	Ford Motor Company	52	E.I. duPont de Nemours and Co., Inc.
20	Computer Sciences Corporation	53	Cap Debis CCS (Germany)
22	Defense Information Systems Agency	54	Merck and Co., Inc.
25	Royal Signals and Radar Establishment	55	Boeing Computer Services
26	Defense Information Systems Agency	56	U.S. Postal Service
28	Decision Sciences Institute (North)	57	SITA
29–30	Defense Information Systems Agency		

Class B addresses

- In a Class B address, the first two octets of the IP address are used as the network ID, and the second two octets are used as the host ID. Thus, a Class B address comes close to my hypothetical scheme of splitting the address down the middle, using half for the network ID and half for the host ID. It isn’t identical to this scheme, however, because the first two bits of the first octet are required to be 10, in order to indicate that the address is a Class B address.
- As a result, a total of 16,384 Class B networks can exist. All Class B addresses fall within the range 128.x.y.z to 191.x.y.z. Each Class B address can accommodate more than 65,000 hosts. The problem with Class B networks is that even though they are much smaller than Class A networks, they still allocate far too many host IDs. Very few networks have tens of thousands of hosts. Thus, careless assignment of Class B addresses can lead to a large percentage of the available host addresses being wasted on organizations that don’t need them.
- **10–** : Class B includes any address from **128.0.0.0 to 191.255.255.255**. This represents the addresses that have a “1” for their first bit, but don’t have a “1” for their second bit.

Class C addresses

- In a Class C address, the first three octets are used for the network ID, and the fourth octet is used for the host ID. With only eight bits for the host ID, each Class C network can accommodate only 254 hosts. However, with 24 network ID bits, Class C addresses allow for more than 2 million networks. T
- he problem with Class C networks is that they're too small. Although few organizations need the tens of thousands of host addresses provided by a Class B address, many organizations need more than a few hundred. The large discrepancy between Class B networks and Class C networks is what led to the development of subnetting.
- **110-** : Class C is defined as the addresses ranging from **192.0.0.0 to 223.255.255.255**. This represents all of the addresses with a "1" for their first two bits, but without a "1" for their third bit.

Class D and E

- **Class D and E** addresses are least used. Class D is reserved for a not widely used, and reserved for special cases largely for services and applications to stream audio and video to many subscribers at once. Class E addresses are reserved for research purposes by those responsible for Internet networking and IP address research, management, and development.

Who gives IP addresses to the Internet Service Provier(ISP)?

- IANA (Internet Assigned Numbers Authority), a department of ICANN (Internet Corporation for Assigned Names and Numbers), is responsible for allocation of the IP Addresses.
- IANA delegates Public IP addresses to the RIRs (Regional Internet Registries) who, in turn, delegate them to Internet Service Providers (ISPs) and end-user organizations and charge a fee for the same.

Currently, there are five RIRs in the world.

- AFRINIC for Africa Region
- APNIC for Asia Pacific Region
- ARIN for Canada, USA and some Caribbean Islands
- LACNIC for Latin America and some Caribbean Islands
- RIPE NCC for Europe, Middle East and Central Asia

The Internet Service Providers (ISPs) allocate the IP Addresses to their customers.

All the above classes are termed as **Classful IP Addressing**

RECAP

A

1.0.0.0 - 126.255.255.255

SUBNET: 255.0.0.0

HOSTS: 16,777,214

B

128.0.0.0 - 191.255.255.255

SUBNET: 255.255.0.0

HOSTS: 65,534

C

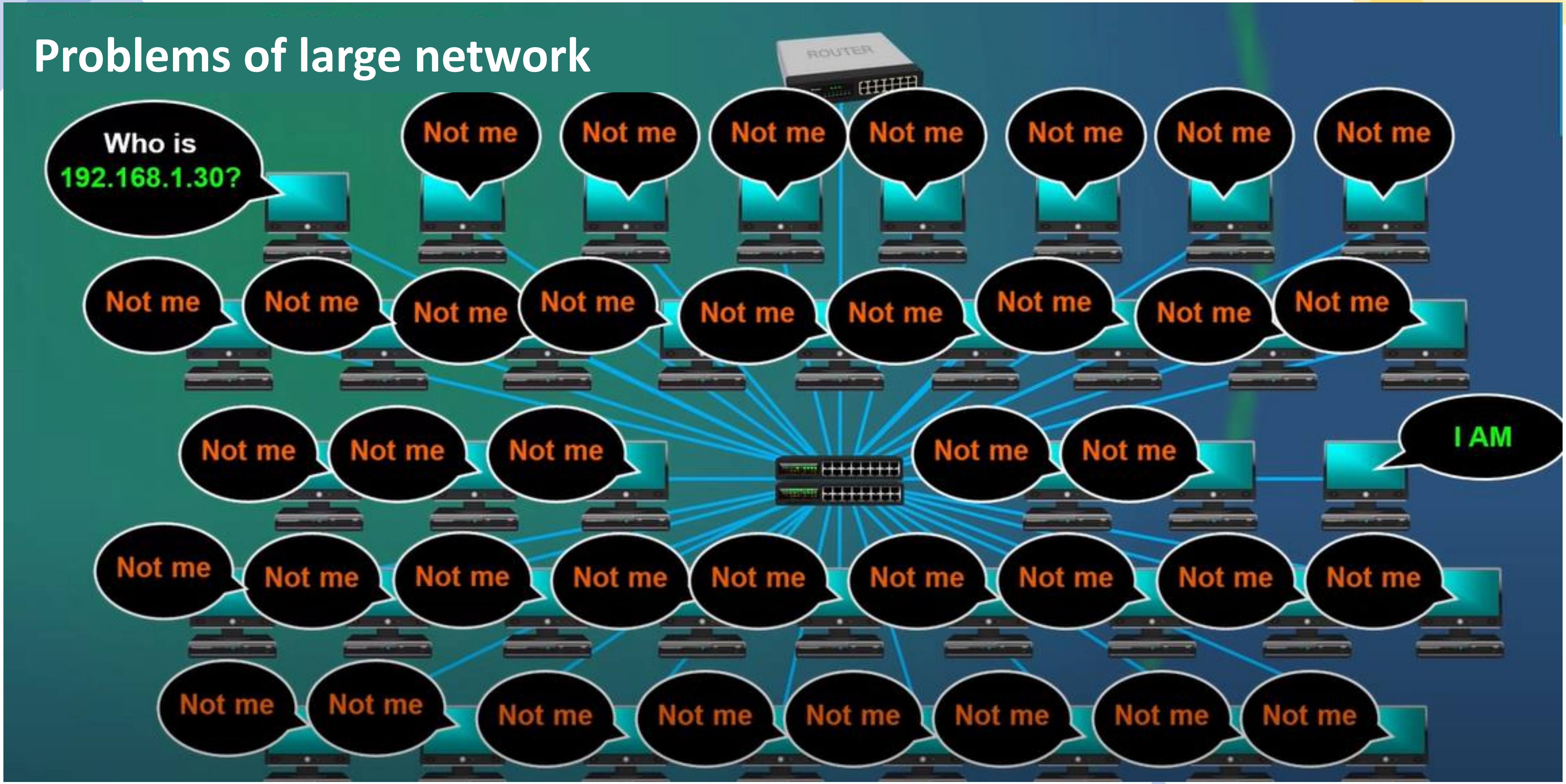
192.0.0.0 - 223.255.255.255

SUBNET: 255.255.255.0

HOSTS: 254

Subnetting

Problems of large network



IP Address	192	168	100	225
Subnet Mask	255	255	255	0
Gateway	192	168	100	1

4 Octet

5 Classes

0 - 255

32 bits

Host/Net

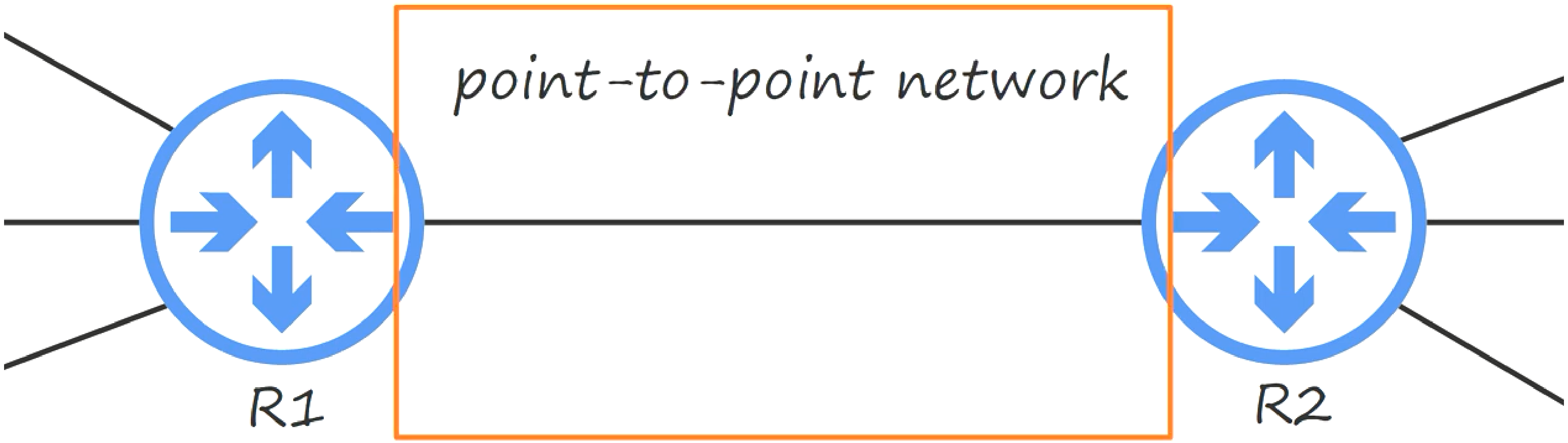
Default subnets

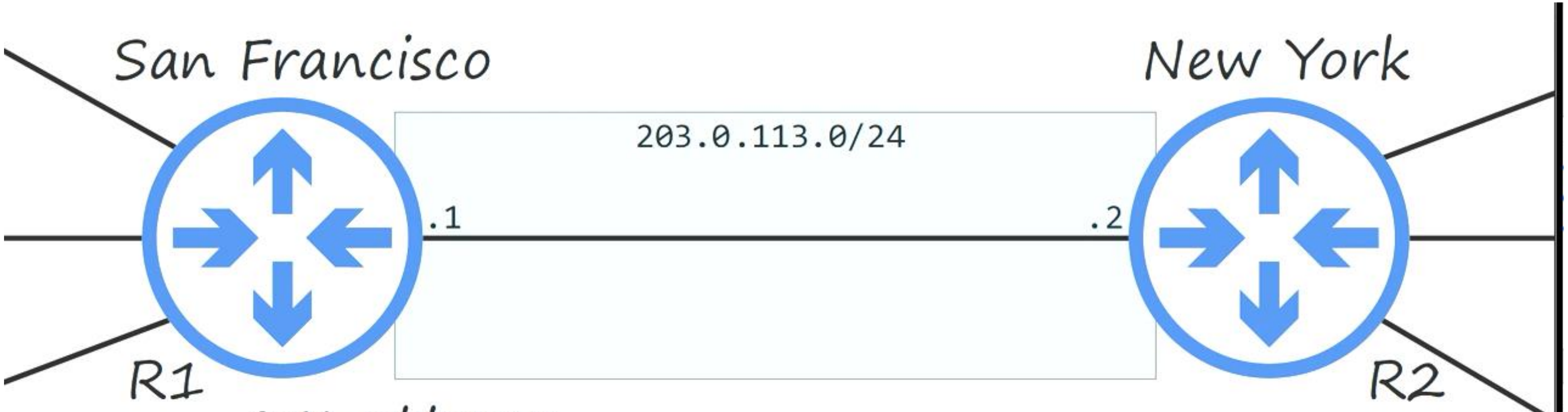
The *default subnet masks* are three subnet masks that correspond to the standard Class A, B, and C address assignments.

Table 2-5 The Default Subnet Masks

Class	*Binary*	*Dotted-Decimal*	*Network Prefix*
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

Keep in mind that a subnet mask is not actually required in order to use one of these defaults. That's because the IP address class can be determined by examining the first three bits of the IP address. If the first bit is 0, the address is Class A, and the subnet mask 255.0.0.0 is applied. If the first two bits are 10, the address is Class B, and 255.255.0.0 is used. If the first three bits are 110, the Class C default mask 255.255.255.0 is used.


point-to-point network
R1
R2



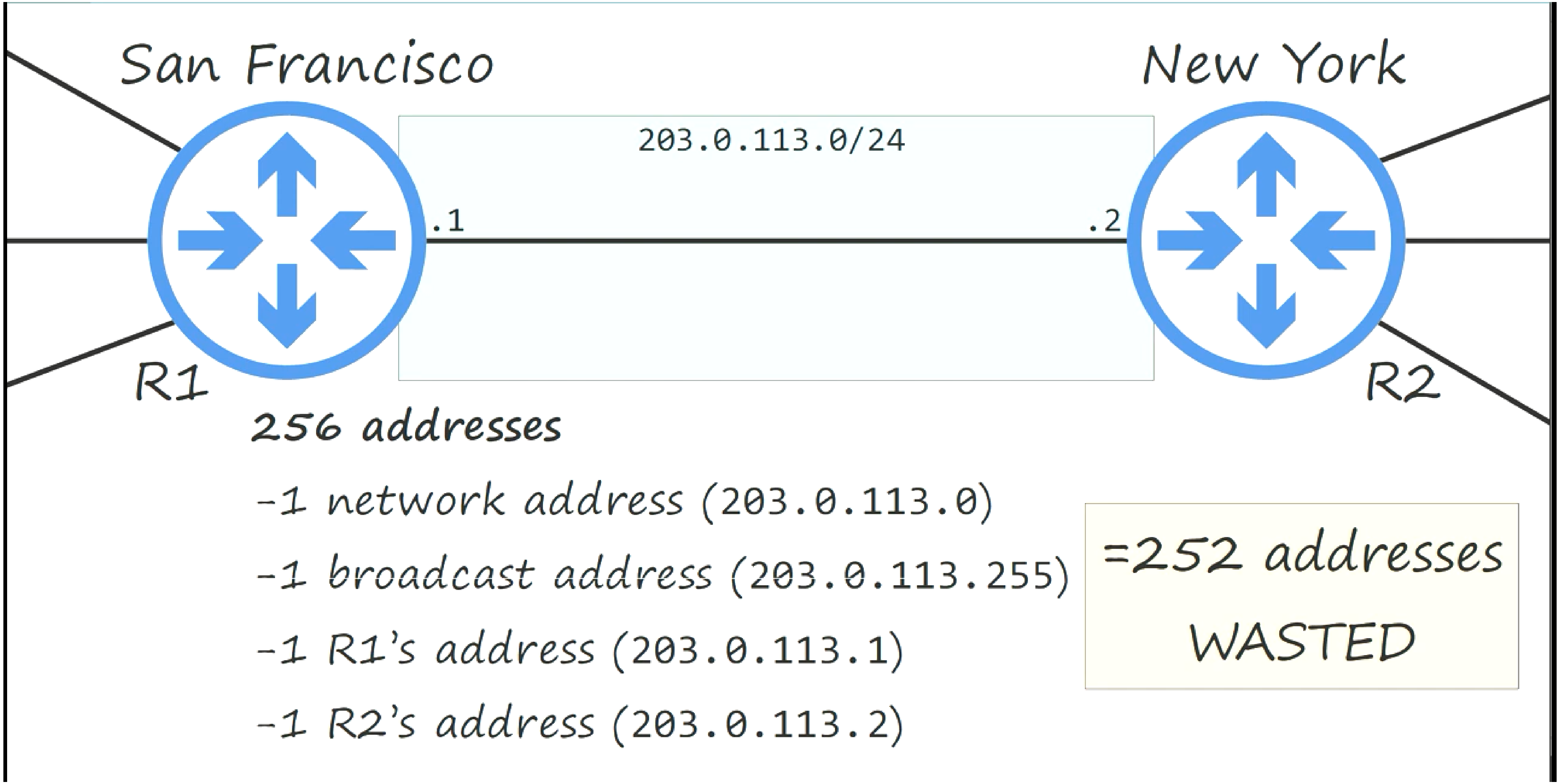
256 addresses

-1 network address (203.0.113.0)

-1 broadcast address (203.0.113.255)

-1 R1's address (203.0.113.1)

-1 R2's address (203.0.113.2)


San Francisco
New York
203.0.113.0/24
.1
.2
R1
R2
256 addresses
-1 network address (203.0.113.0)
-1 broadcast address (203.0.113.255)
-1 R1's address (203.0.113.1)
-1 R2's address (203.0.113.2)
=252 addresses
WASTED

Subnetting

- Subnetting is a technique that lets network administrators use the 32 bits available in an IP address more efficiently by creating networks that aren’t limited to the scales provided by Class A, B, and C IP addresses. With subnetting, you can create networks with more realistic host limits.

- Subnetting provides a more flexible way to designate which portion of an IP address represents the network ID and which portion represents the host ID. With standard IP address classes, only three possible network ID sizes exist: 8 bits for Class A, 16 bits for Class B, and 24 bits for Class C. Subnetting lets you select an arbitrary number of bits to use for the network ID.

Two reasons compel people to use subnetting.

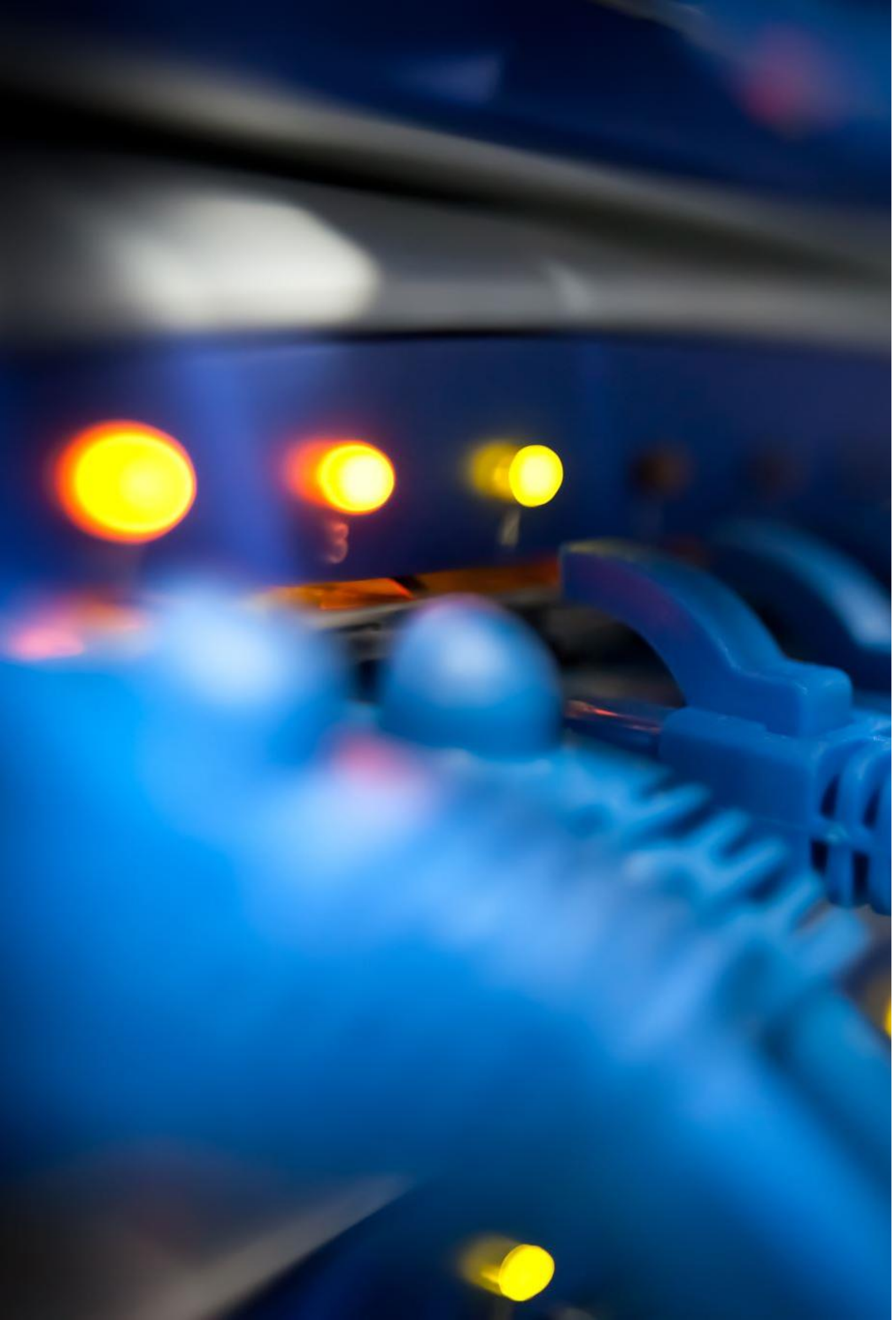
- The first is to allocate the limited IP address space more efficiently. If the Internet was limited to Class A, B, or C addresses, every network would be allocated 254, 65 thousand, or 16 million IP addresses for host devices. Although many networks with more than 254 devices exist, few (if any) exist with 65 thousand, let alone 16 million. Unfortunately, any network with more than 254 devices would need a Class B allocation and probably waste tens of thousands of IP addresses.
- The second reason for subnetting is that even if a single organization has thousands of network devices, operating all those devices with the same network ID would slow the network down to a crawl. The way TCP/IP works dictates that all the computers with the same network ID must be on the same physical network. The physical network comprises a single broadcast domain, which means that a single network medium must carry all the traffic for the network. For performance reasons, networks are usually segmented into broadcast domains that are smaller than even Class C addresses provide.

Subnetting

- Creates multiple logical networks that exist within a single Class A, B, or C network.
- If you do not subnet, you will only be able to use one network from your Class A, B, or C network, which is unrealistic
- Each data link on a network must have a unique network ID, with every node on that link being a member of the same network

Benefits of Subnetting

1) Reduced network traffic
2) Optimized network performance
3) Simplified management
4) Facilitated spanning of large geographical distances



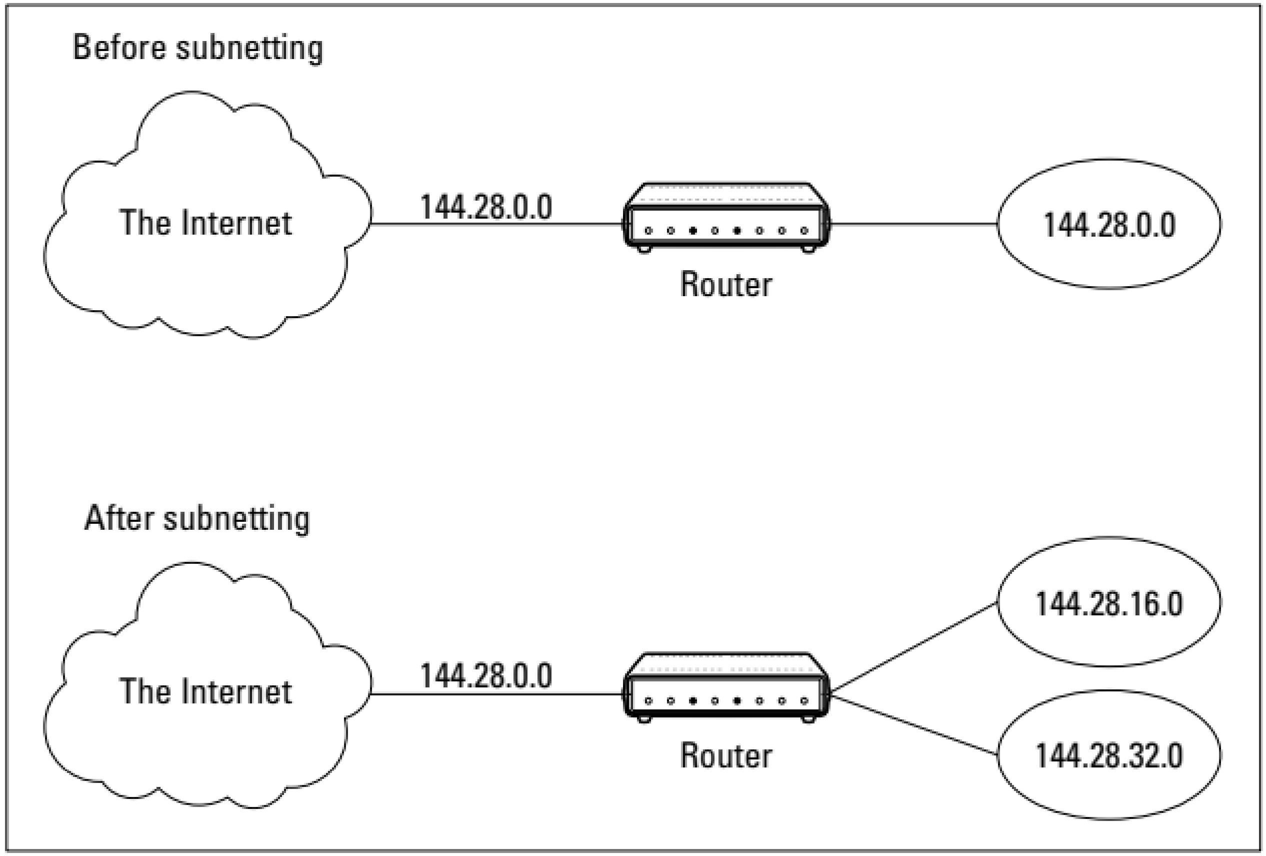
Why is subnetting necessary?

- The way IP addresses are constructed makes it relatively simple for Internet routers to find the right network to route data into. However, in a Class A network (for instance), there could be millions of connected devices, and it could take some time for the data to find the right device. This is why subnetting comes in handy: subnetting narrows down the IP address to usage within a range of devices.
- Because an IP address is limited to indicating the network and the device address, IP addresses cannot be used to indicate which subnet an IP packet should go to. Routers within a network use something called a subnet mask to sort data into subnetworks.

Subnets

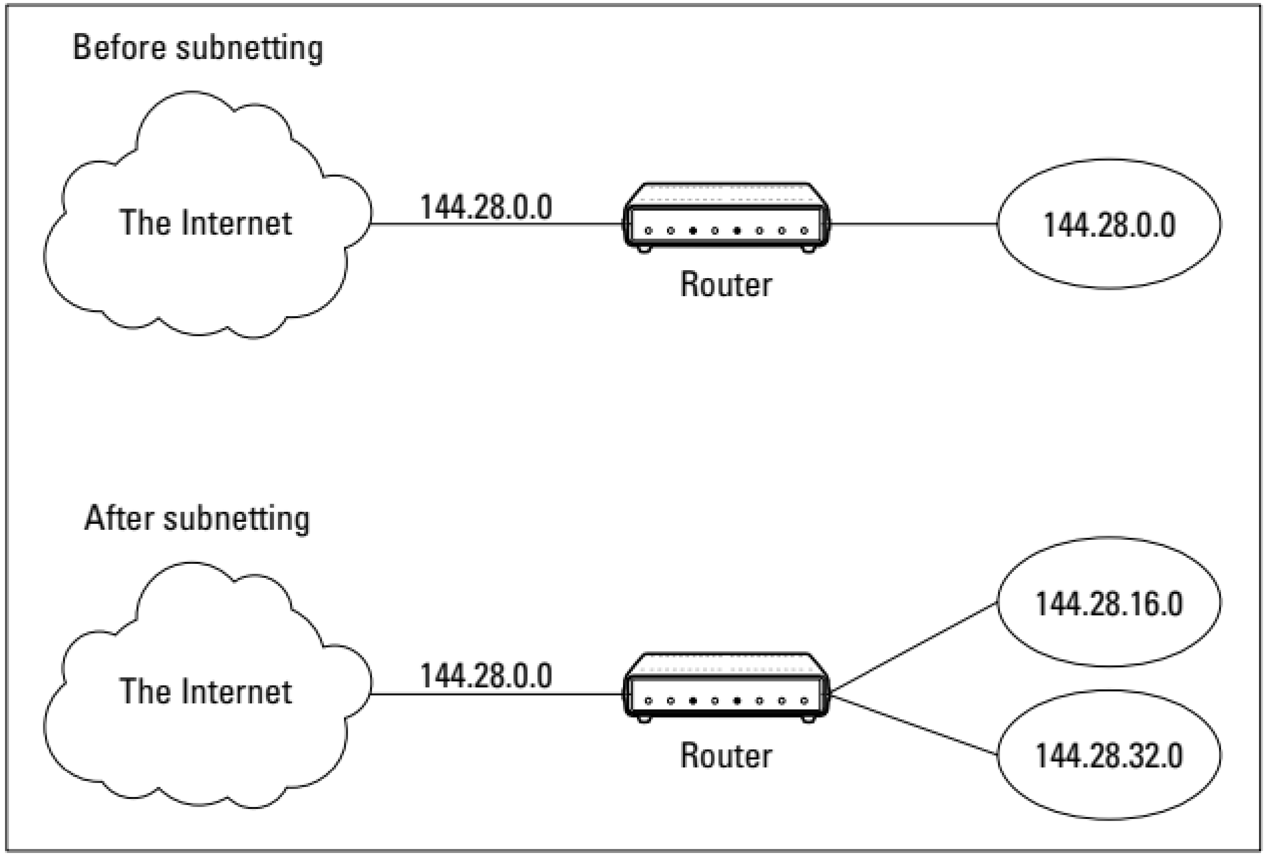
A subnet is a network that falls within a Class A, B, or C network. Subnets are created by using one or more of the Class A, B, or C host bits to extend the network ID. Thus, instead of the standard 8-, 16-, or 24-bit network ID, subnets can have network IDs of any length.

Figure shows an example of a network before and after subnetting has been applied. In the unsubnetted network, the network has been assigned the Class B address 144.28.0.0. All the devices on this network must share the same broadcast domain.



In the second network, the first four bits of the host ID are used to divide the network into two small networks, identified as subnets 16 and 32. To the outside world (that is, on the other side of the router), these two networks still appear to be a single network identified as 144.28.0.0.

For example, the outside world considers the device at 144.28.16.22 to belong to the 144.28.0.0 network. As a result, a packet sent to this device will be delivered to the router at 144.28.0.0. The router then considers the subnet portion of the host ID to decide whether to route the packet to subnet 16 or subnet 32.

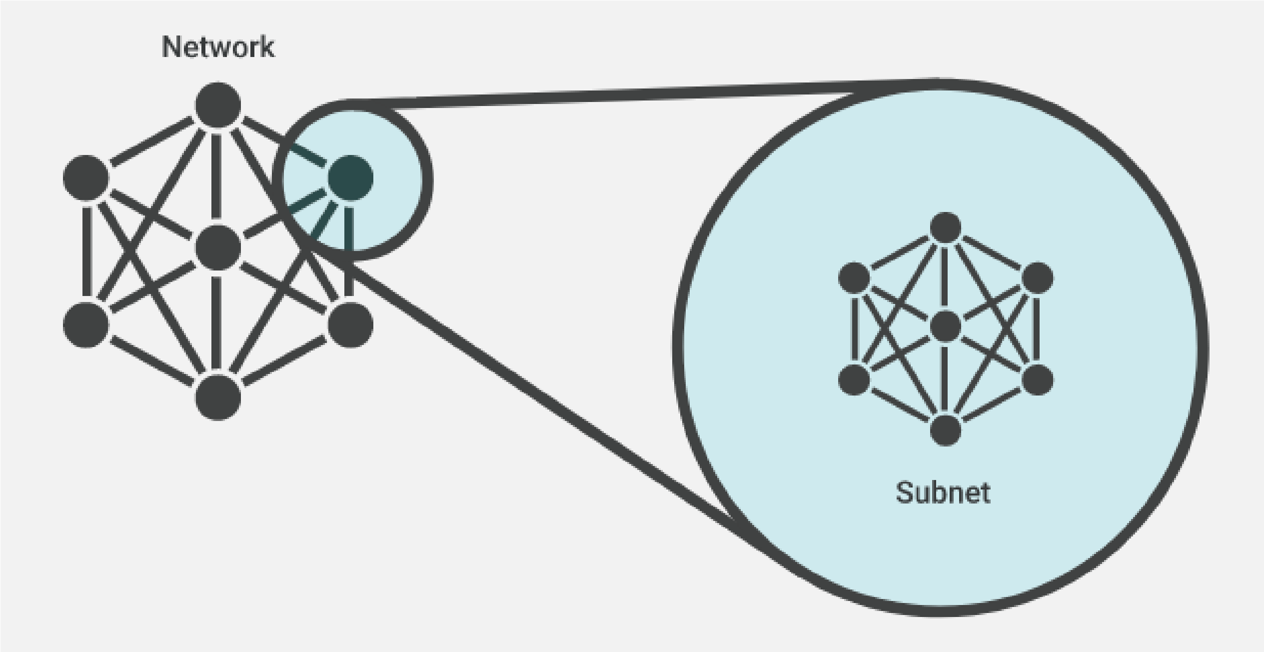


How subnetting works

A subnet, or subnetwork, is a network inside a network. Subnets make networks more efficient. Through subnetting, network traffic can travel a shorter distance without passing through unnecessary routers to reach its destination.

Imagine Alice puts a letter in the mail that is addressed to Bob, who lives in the town right next to hers. For the letter to reach Bob as quickly as possible, it should be delivered right from Alice's post office to the post office in Bob's town, and then to Bob. If the letter is first sent to a post office hundreds of miles away, Alice's letter could take a lot longer to reach Bob.

Like the postal service, networks are more efficient when messages travel as directly as possible. When a network receives data packets from another network, it will sort and route those packets by subnet so that the packets do not take an inefficient route to their destination.



What is a subnet mask?

A subnet mask is like an IP address, but for only internal usage within a network. Routers use subnet masks to route data packets to the right place. Subnet masks are not indicated within data packets traversing the Internet — those packets only indicate the destination IP address, which a router will match with a subnet.

Suppose Bob answers Alice's letter, but he sends his reply to Alice's place of employment rather than her home. Alice's office is quite large with many different departments. To ensure employees receive their correspondence quickly, the administrative team at Alice's workplace sorts mail by department rather than by individual employee. After receiving Bob's letter, they look up Alice's department and see she works in Customer Support. They send the letter to the Customer Support department instead of to Alice, and the customer support department gives it to Alice.

- In this analogy, "Alice" is like an IP address and "Customer Support" is like a subnet mask. By matching Alice to her department, Bob's letter was quickly sorted into the right group of potential recipients. Without this step, office administrators would have to spend time laboriously looking for the exact location of Alice's desk, which could be anywhere in the building.
- For a real-world example, suppose an IP packet is addressed to the IP address 192.0.2.15. This IP address is a Class C network, so the network is identified by "192.0.2" (or to be technically precise, 192.0.2.0/24). Network routers forward the packet to a host on the network indicated by "192.0.2."
- Once the packet arrives at that network, a router within the network consults its routing table. It does some binary mathematics using its subnet mask of 255.255.255.0, sees the device address "15" (the rest of the IP address indicates the network), and calculates which subnet the packet should go to. It forwards the packet to the router or switch responsible for delivering packets within that subnet, and the packet arrives at IP address 192.0.2.15 (learn more about routers and switches).

IP Address:	192	.	0	.	2	.	15
	11000000		00000000		00000010		00001111
Subnet Mask:	11111111	.	11111111	.	11111111	.	00000000
Network ID:	192	.	0	.	2	.	0
Device ID:	15						

Class C

Class	Range
Class A	1 – 126
Class B	128 – 191
Class C	192 - 223

IP Address	192 . 168 . 100 . 225
Subnet Mask	255 . 255 . 255 . 0
Gateway	192 . 168 . 100 . 1

254 Rooms/Hosts
(2^8 – 2)

Class C

Class	Range
Class A	1 – 126
Class B	128 – 191
Class C	192 - 223

IP Address 192 . 168 . 100 . 225

Subnet Mask 255 . 255 . 255 . 0

Gateway 192 . 168 . 100 . 1

Network Id (First): 192.168.100.0

Valid IP Address Start: 192.168.100.1

Valid IP Address End: 192.168.100.254

Broadcast Id (Last):192.168.100.255

254 Rooms/Hosts

(2^8 – 2)

Class C

Class	Range
Class A	1 – 126
Class B	128 – 191
Class C	192 - 223

IP Address	192 . 168 . 100 . 225	/24
Subnet Mask	255 . 255 . 255 . 0	
Gateway	192 . 168 . 100 . 1	

Network Id (First): 192.168.100.0
Valid IP Address Start: 192.168.100.1
Valid IP Address End: 192.168.100.254
Broadcast Id (Last):192.168.100.255

254 Rooms/Hosts
(2^8 – 2)

Class C

Class	Range
Class A	1 – 126
Class B	128 – 191
Class C	192 - 223

IP Address	192 . 168 . 100 . 225	/24
Subnet Mask	11111111 . 11111111 . 11111111 . 00000000	
Gateway	192 . 168 . 100 . 1	

Network Id (First): 192.168.100.0
Valid IP Address Start: 192.168.100.1
Valid IP Address End: 192.168.100.254
Broadcast Id (Last):192.168.100.255

254 Rooms/Hosts
(2^8 – 2)

Class B

Class	Range
Class A	1 – 126
Class B	128 – 191
Class C	192 - 223

IP Address	172 . 123 . 100 . 225
Subnet Mask	255 . 255 . 0 . 0
Gateway	172 . 123 . 1 . 225

65,534
Rooms/Hosts
(2^16 – 2)

Class B

Class	Range
Class A	1 – 126
Class B	128 – 191
Class C	192 - 223

IP Address	172	. 123	. 100	. 225
Subnet Mask	255	. 255	. 0	. 0
Gateway	172	. 123	. 1	. 225

Network Id (First): 172.123.0.0

Valid IP Address Start: 172.123.0.1

Valid IP Address End: 172.123.255.254

Broadcast Id (Last):172.123.255.255

65,534

Rooms/Hosts

(2^16 – 2)

Class B

Class	Range
Class A	1 – 126
Class B	128 – 191
Class C	192 - 223

IP Address	172 .	123 .	100 .	225	/16
Subnet Mask	255 .	255 .	0 .	0	
Gateway	172 .	123 .	1 .	225	

Network Id (First): 172.123.0.0
Valid IP Address Start: 172.123.0.1
Valid IP Address End: 172.123.255.254
Broadcast Id (Last):172.123.255.255

65,534
Rooms/Hosts
(2^16 – 2)

Class A

Class	Range
Class A	1 – 126
Class B	128 – 191
Class C	192 - 223

IP Address	100	. 228	. 111	. 225
Subnet Mask	255	. 0	. 0	. 0
Gateway	100	. 101	. 123	. 1

11111111 . 00000000 . 00000000. 00000000

2,097,150
Rooms/Hosts
(2^24 – 2)

Class A

Class	Range
Class A	1 – 126
Class B	128 – 191
Class C	192 - 223

IP Address 100 . 228 . 111 . 225

Subnet Mask 255 . 0 . 0 . 0

Gateway 100 . 101 . 123 . 1

11111111 . 00000000 . 00000000. 00000000

2,097,150
Rooms/Hosts
(2^24 – 2)

Network Id (First): 100.0.0.0
Valid IP Address Start: 100.0.0.1
Valid IP Address End: 100.255.255.254
Broadcast Id (Last):100.255.255.255

Class A

Class	Range
Class A	1 – 126
Class B	128 – 191
Class C	192 - 223

IP Address	100 .	228 .	111 .	225	/8
Subnet Mask	255 .	0 .	0 .	0	
Gateway	100 .	101 .	123 .	1	

11111111 . 00000000 . 00000000. 00000000

2,097,150
Rooms/Hosts
($2^{24} - 2$)

Network Id (First): 100.0.0.0
Valid IP Address Start: 100.0.0.1
Valid IP Address End: 100.255.255.254
Broadcast Id (Last):100.255.255.255

Class A

Class	Range
Class A	1 – 126
Class B	128 – 191
Class C	192 - 223

IP Address 100 . 228 . 111 . 225 /8

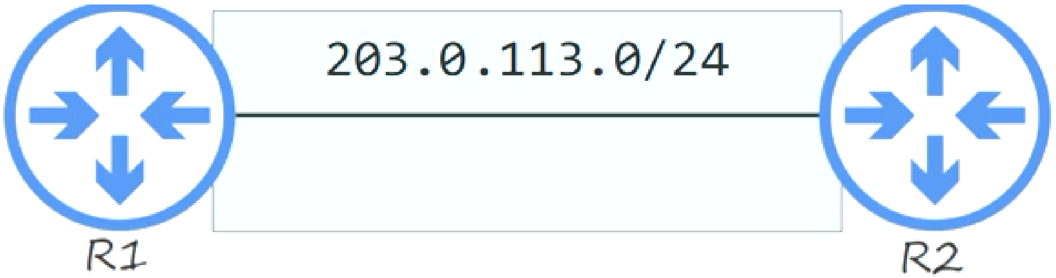
Subnet Mask 11111111 . 00000000 . 00000000. 00000000

Gateway 100 . 101 . 123 . 1

11111111 . 00000000 . 00000000. 00000000

2,097,150
Rooms/Hosts
(2^24 – 2)

Network Id (First): 100.0.0.0
Valid IP Address Start: 100.0.0.1
Valid IP Address End: 100.255.255.254
Broadcast Id (Last):100.255.255.255



1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 0

203 . 0 . 113 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0

255 . 255 . 255 . 0

network address, broadcast address

$2^{8} - 2 = 254$ usable addresses.

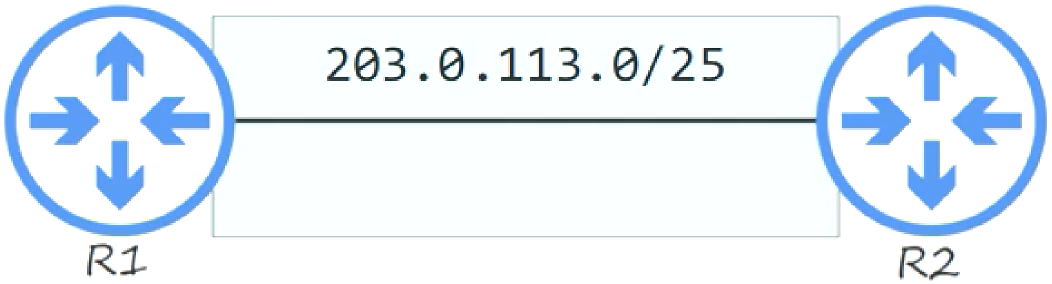
number of host bits

How many usable addresses are there in each network?

- 203.0.113.0/25
- 203.0.113.0/26
- 203.0.113.0/27
- 203.0.113.0/28
- 203.0.113.0/29
- 203.0.113.0/30
- 203.0.113.0/31
- 203.0.113.0/32

$2^n - 2$ = usable addresses

n = number of host bits



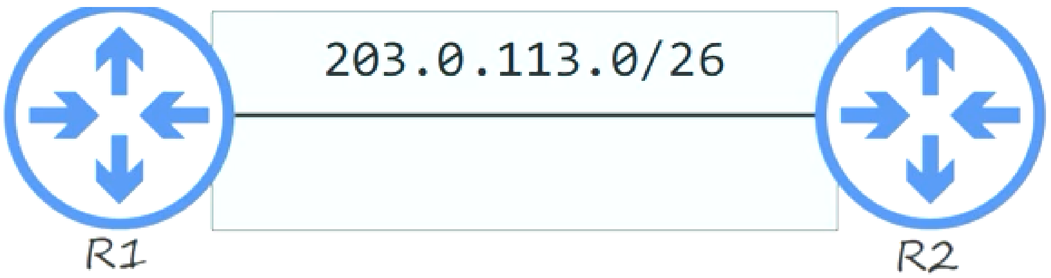
1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 0

203 . 0 . 113 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 0 0 0 0 0 0 0

255 . 255 . 255 . $\boxed{128}$

$2^7 - 2 = 126$ usable addresses.



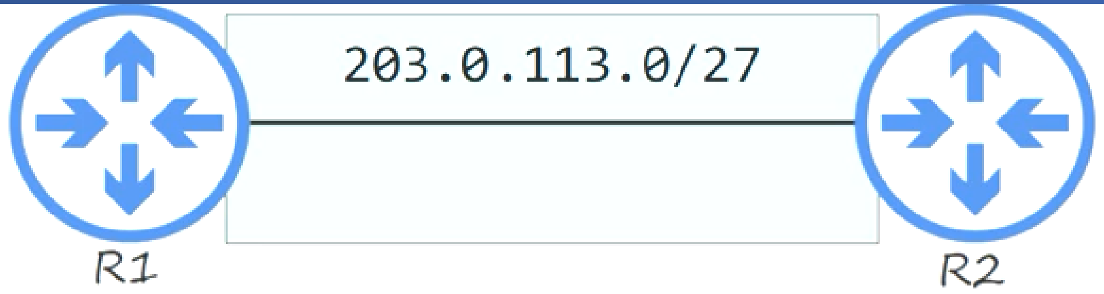
1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 0

203 . 0 . 113 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 0 0 0 0 0 0

255 . 255 . 255 . $\boxed{192}$

$2^6 - 2 = 62$ usable addresses.



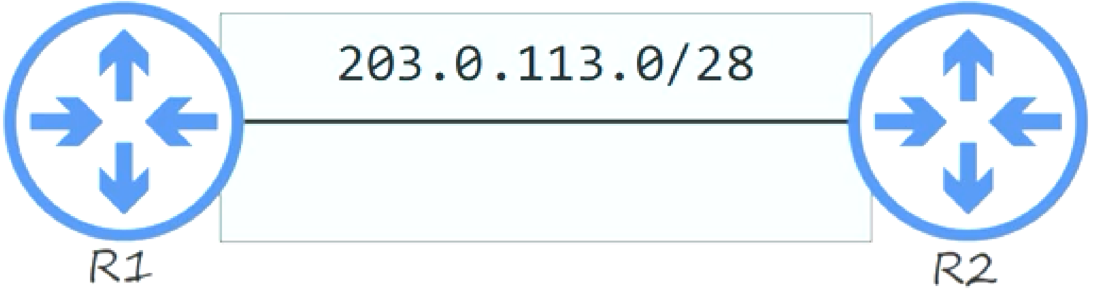
1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 0

203 . 0 . 113 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 0 0 0 0 0

255 . 255 . 255 . $\boxed{224}$

$2^5 - 2 = 30$ usable addresses.



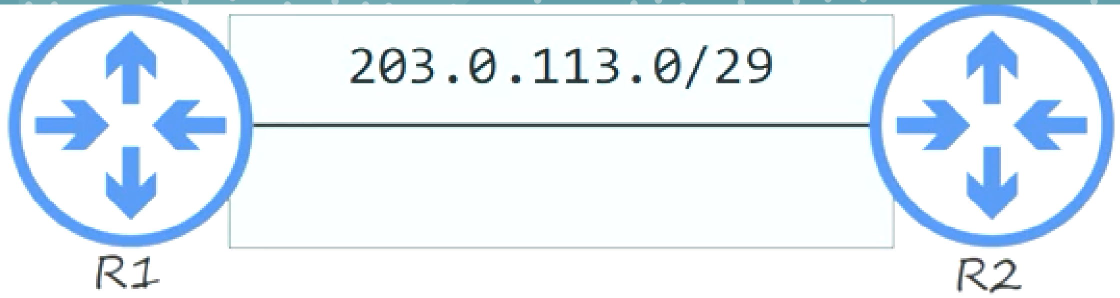
1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0

203 . 0 . 113 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 0 0 0

255 . 255 . 255 . $\boxed{240}$

$2^4 - 2 = 14$ usable addresses.



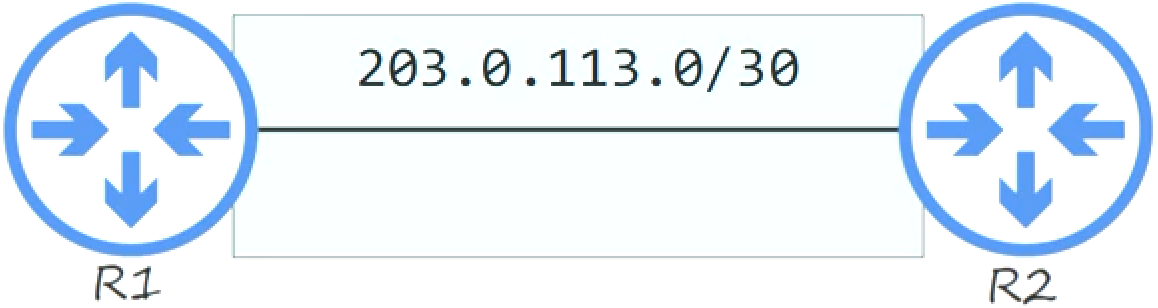
1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0

203 . 0 . 113 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 0

255 . 255 . 255 . $\boxed{248}$

$2^3 - 2 = 6$ usable addresses.



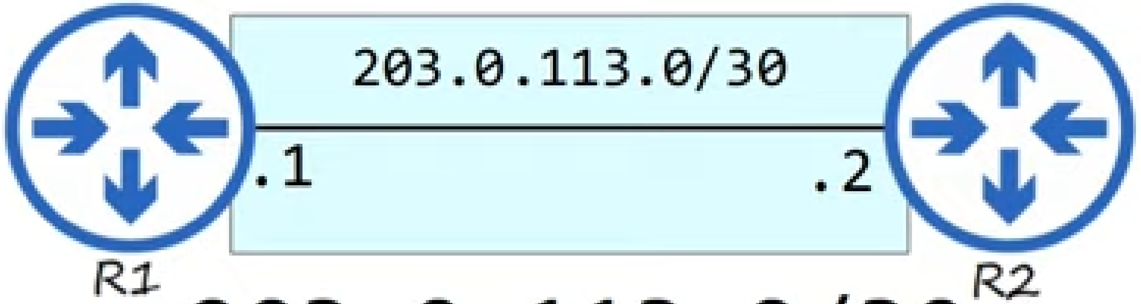
1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 0

203 . 0 . 113 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 0 0

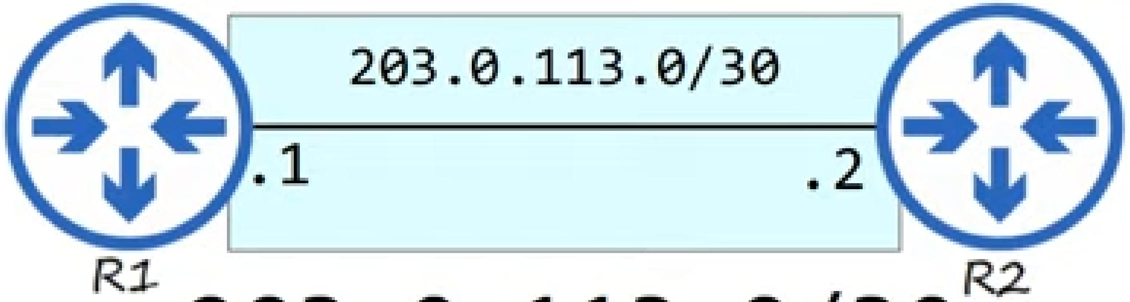
255 . 255 . 255 . $\boxed{252}$

$2^2 - 2 = 2$ usable addresses.



203.0.113.0/30

= 203.0.113.0 – 203.0.113.3



$$203.0.113.0/30$$
$$= 203.0.113.0 - 203.0.113.3$$

11001011 . 00000000 . 01110001 . 00000000

11001011 . 00000000 . 01110001 . 00000001

11001011 . 00000000 . 01110001 . 00000010

11001011 . 00000000 . 01110001 . 00000011

203.0.113.0/30

= 203.0.113.0 - 203.0.113.3

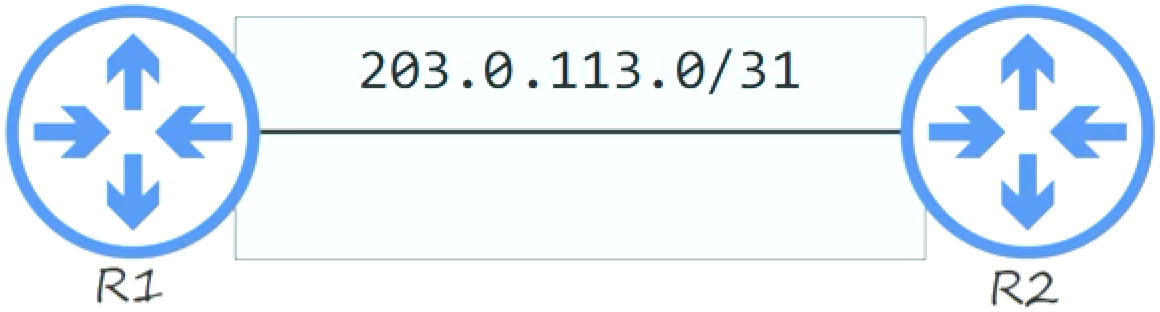
1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 0

1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 1

1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 1 0

1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 1 1

The remaining addresses in the 203.0.113.0/24 address block (203.0.113.4 - 203.0.113.255) are now available to be used in other subnets!



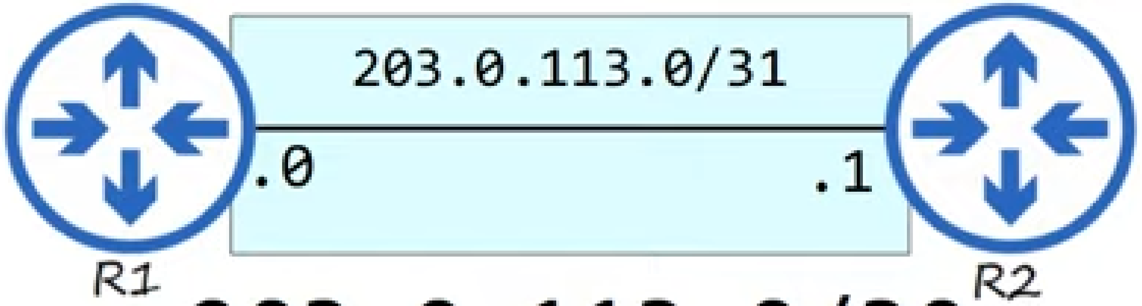
1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 0

203 . 0 . 113 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 0

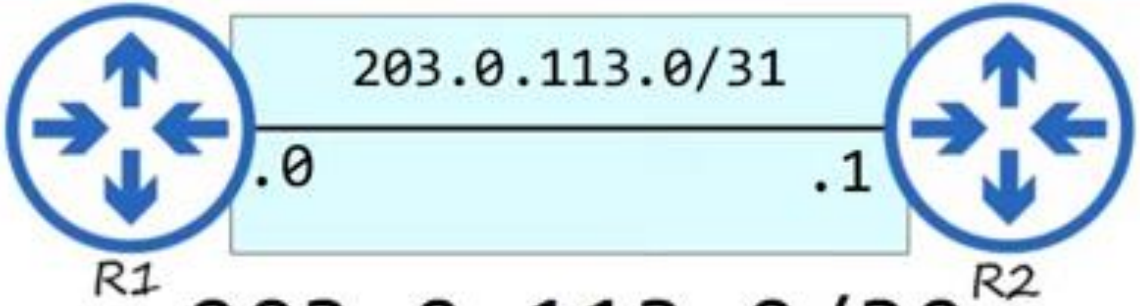
255 . 255 . 255 . $\boxed{254}$

$2^1 - 2 = 0$ usable addresses.



203.0.113.0/30

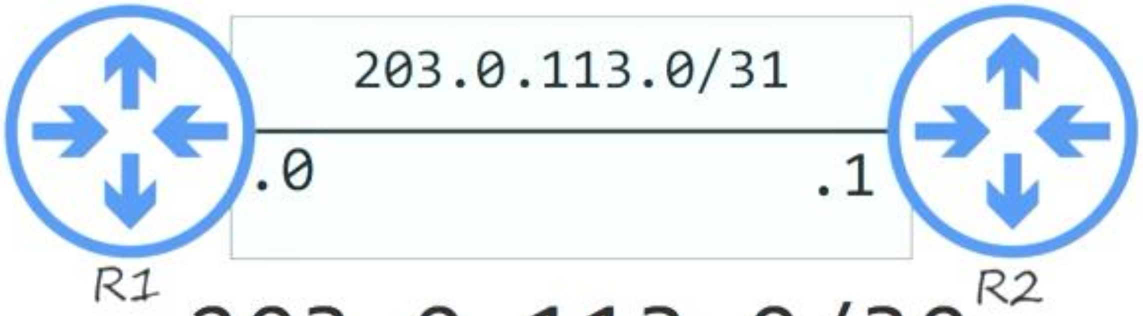
= 203.0.113.0 – 203.0.113.1



203.0.113.0/30

= 203.0.113.0 – 203.0.113.1

1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 0
1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 1

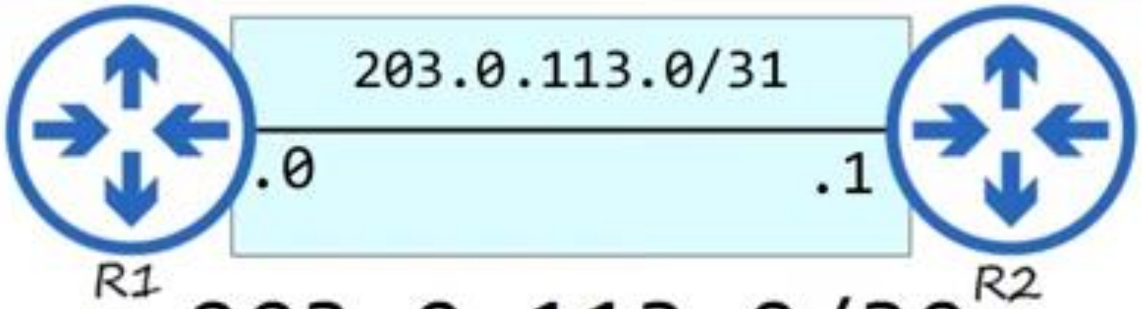


203.0.113.0/30

= 203.0.113.0 – 203.0.113.1

1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 0
1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 1

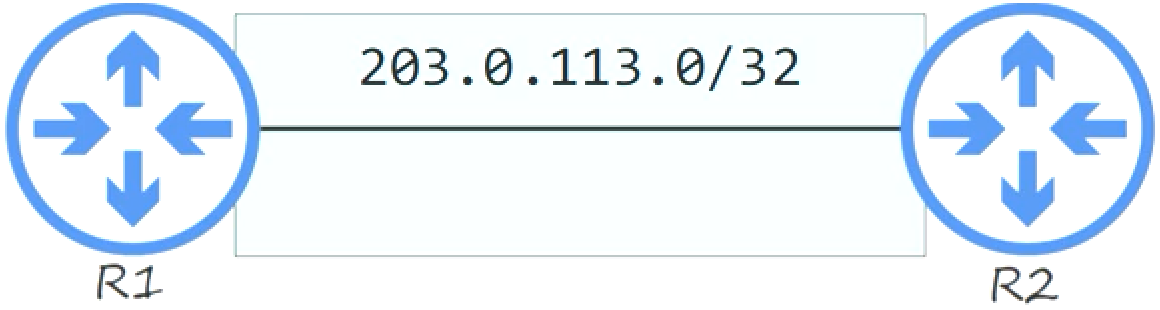
```
Router(config-if)#ip address 203.0.113.0 255.255.255.254
% Warning: use /31 mask on non point-to-point interface cautiously
Router(config-if)#
```



203.0.113.0/30
= 203.0.113.0 – 203.0.113.1

1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 0
1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 1

The remaining addresses in the 203.0.113.0/24 address block (203.0.113.2 – 203.0.113.255) are now available to be used in other networks!



1 1 0 0 1 0 1 1 . 0 0 0 0 0 0 0 0 . 0 1 1 1 0 0 0 1 . 0 0 0 0 0 0 0 0

203 . 0 . 113 . 0

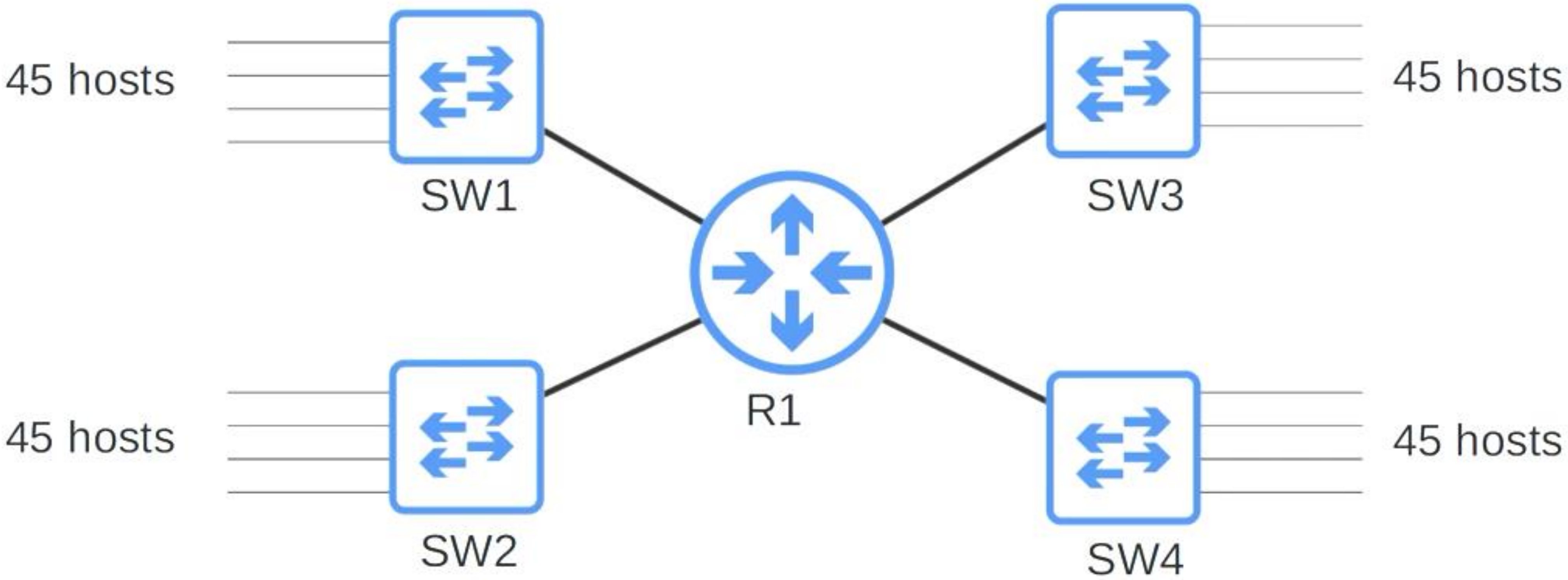
1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1

255 . 255 . 255 . $\boxed{255}$

$2^{0} - 2 = -1$ usable addresses?

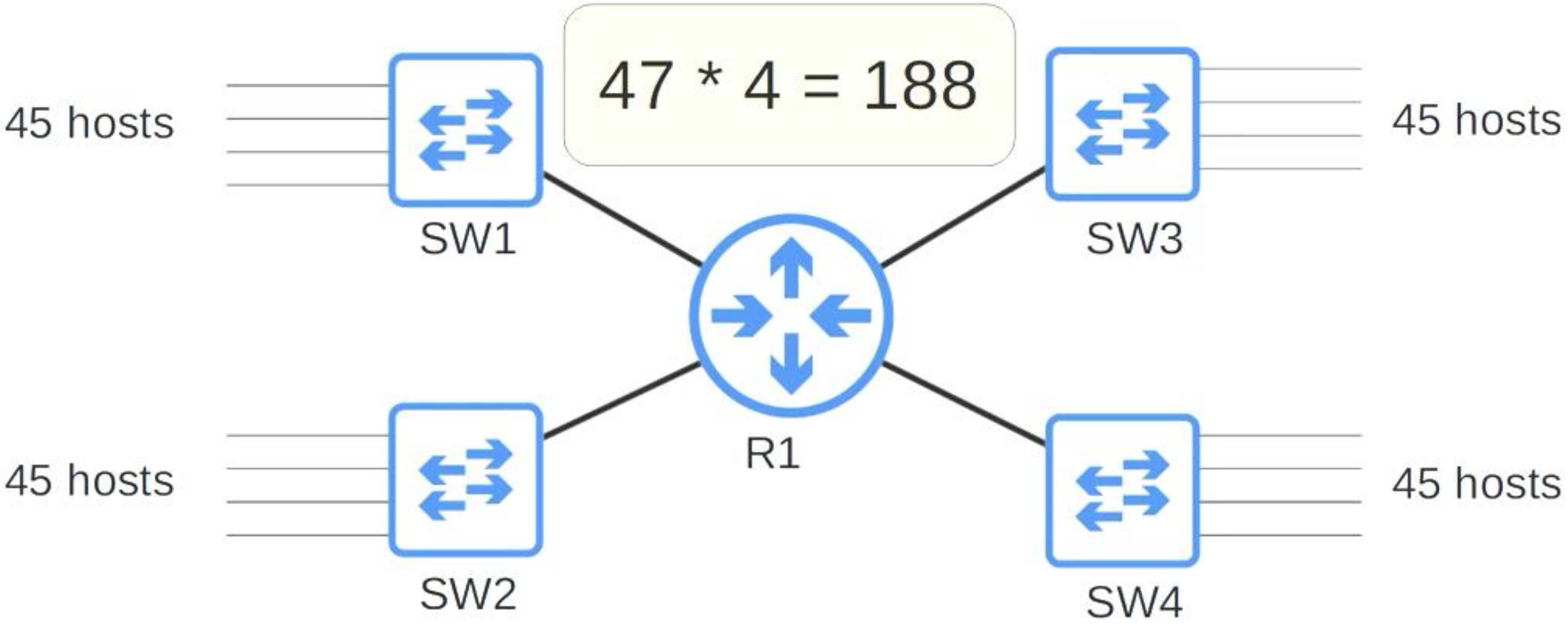
Dotted Decimal	CIDR Notation
255.255.255.128	/25
255.255.255.192	/26
255.255.255.224	/27
255.255.255.240	/28
255.255.255.248	/29
255.255.255.252	/30
255.255.255.254	/31
255.255.255.255	/32

Borrowed Bits	1	2	3	4	5	6
Mask Value	128	192	224	240	248	252
Subnets	2	4	8	16	32	64
Hosts	126	62	30	14	6	2
CIDR	/25	/26	/27	/28	/29	/30
Block Size	128	64	32	16	8	4



192.168.1.0/24

Divide the **192.168.1.0/24** *network into four subnets that can accommodate the number of hosts required.*



192.168.1.0/24

Divide the **192.168.1.0/24** *network into four subnets that can accommodate the number of hosts required.*

/30

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 0 0 1 . 0 0 0 0 0 0 0 0

192 . 168 . 1 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 0 0

255 . 255 . 255 . 252

$2^2 - 2 = 2$ usable addresses

$\downarrow$

$\boxed{2 * 2 = 4}$

/29

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 0 0 1 . 0 0 0 0 0 0 0 0

192 . 168 . 1 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 0 0 0

255 . 255 . 255 . 248

$2^3 - 2 = 6$ usable addresses

$2 * 2 * 2 = 8$

/28

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 0 0 1 . 0 0 0 0 0 0 0 0

192 . 168 . 1 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 0 0 0 0

255 . 255 . 255 . 240

$2^4 - 2 = 14$ usable addresses

$2 * 2 * 2 * 2 = 16$

/27

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 0 0 1 . 0 0 0 0 0 0 0 0

192 . 168 . 1 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 0 0 0 0 0

255 . 255 . 255 . 224

$$2^5 - 2 =$$

$$2 * 2 * 2 * 2 * 2 = 32$$

/26

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 0 0 1 . 0 0 0 0 0 0 0 0

192 . 168 . 1 . 0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 0 0 0 0 0 0

255 . 255 . 255 . 192

$$2^6 - 2 = \boxed{\text{62 usable addresses}}$$

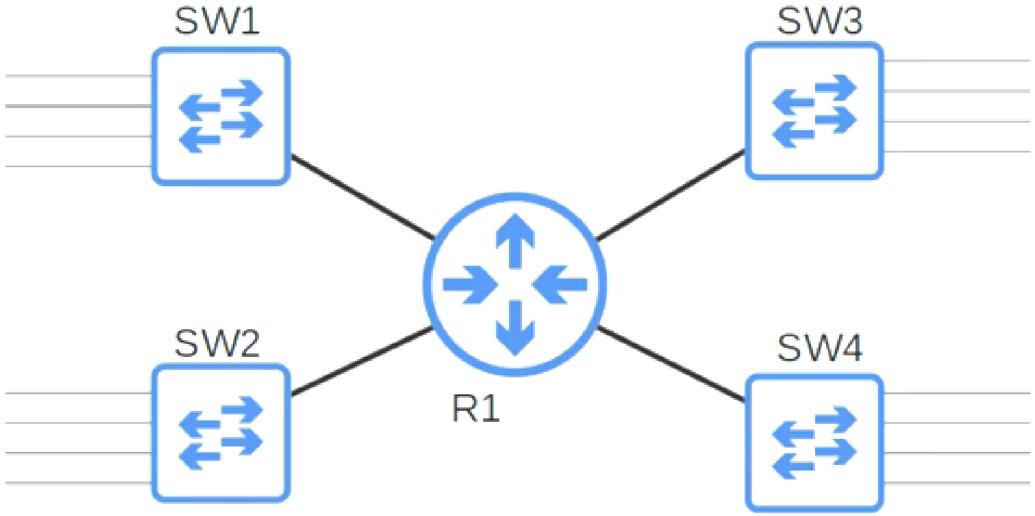
$$2 * 2 * 2 * 2 * 2 * 2 = 64$$

The first subnet (Subnet 1) is 192.168.1.0/26. What are the remaining subnets?

HINT: Find the broadcast address of Subnet 1. The next address is the network address of Subnet 2. Repeat the process for Subnets 3 and 4.

Subnet 1:
192.168.1.0/26

Subnet 2:
(   )/26



Subnet 3:
(   )/26

Subnet 4:
(   )/26

192.168.1.0/24

Subnet 1: 192.168.1.0/26

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 0 0 1 . 0 0 0 0 0 0 0 0

192 . 168 . 1 . 0

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 0 0 1 . 0 0 1 1 1 1 1 1

192 . 168 . 1 . 63

192.168.1.0 – 192.168.1.63

Subnet 2: 192.168.1.64/26

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 0 0 1 . 0 1 0 0 0 0 0 0

192 . 168 . 1 . 64

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 0 0 1 . 0 1 1 1 1 1 1 1

192 . 168 . 1 . 127

192.168.1.63 – 192.168.1.127

Subnet 3: 192.168.1.128/26

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 0 0 1 . 1 0 0 0 0 0 0 0

192 . 168 . 1 . 128

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 0 0 1 . 1 0 1 1 1 1 1 1

192 . 168 . 1 . 191

192.168.1.128 – 192.168.1.191

Subnet 4: 192.168.1.192/26

1 1 0 0 0.0.0.0	.	1 0 1 0 1 0 0 0	.	0 0 0 0 0 0 0 1	.	1 1 0 0 0 0 0 0
192	.	168	.	1	.	192
1 1 0 0 0.0.0.0	.	1 0 1 0 1 0 0 0	.	0 0 0 0 0 0 0 1	.	1 1 1 1 1 1 1 1
192	.	168	.	1	.	255

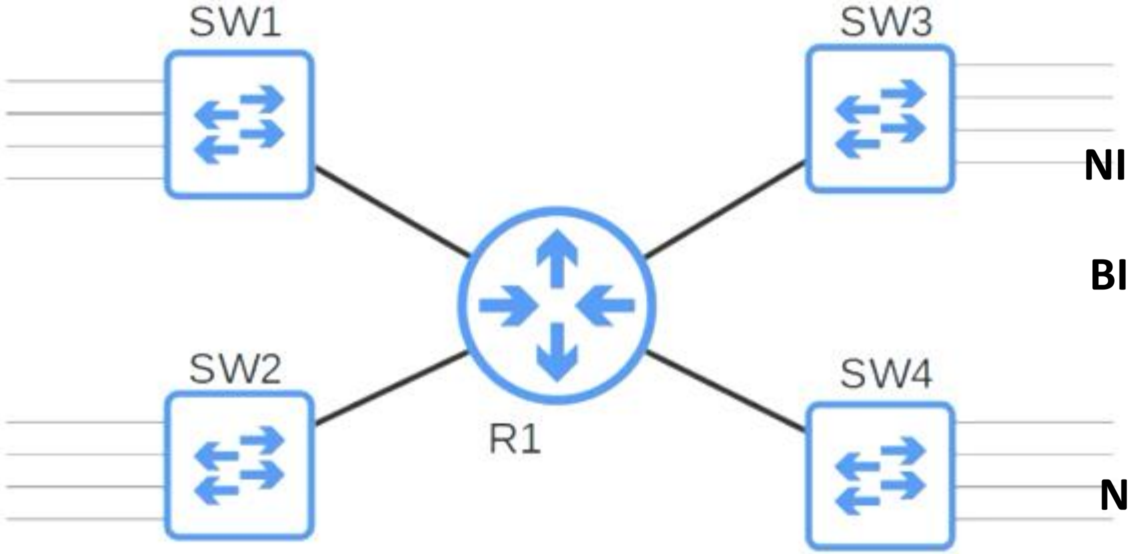
192.168.1.192 – 192.168.1.255

The first subnet (Subnet 1) is 192.168.1.0/26. What are the remaining subnets?

HINT: Find the broadcast address of Subnet 1. The next address is the network address of Subnet 2. Repeat the process for Subnets 3 and 4.

Subnet 1:
NI 192.168.1.0/26
BI 192.168.1.63/26

Subnet 2:
NI 192.168.1.64/26
BI 192.168.1.127/26



Subnet 3:
NI 192.168.1.128/26
BI 192.168.1.191/26

Subnet 4:
NI 192.168.1.192/26
BI 192.168.1.255/26

192.168.1.0/24

192.168.1.0/26

NETWORK PORTION | HOST PORTION

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 0 0 1 . 0 0 | 0 0 0 0 0 0

192 . 168 . 1 . 0

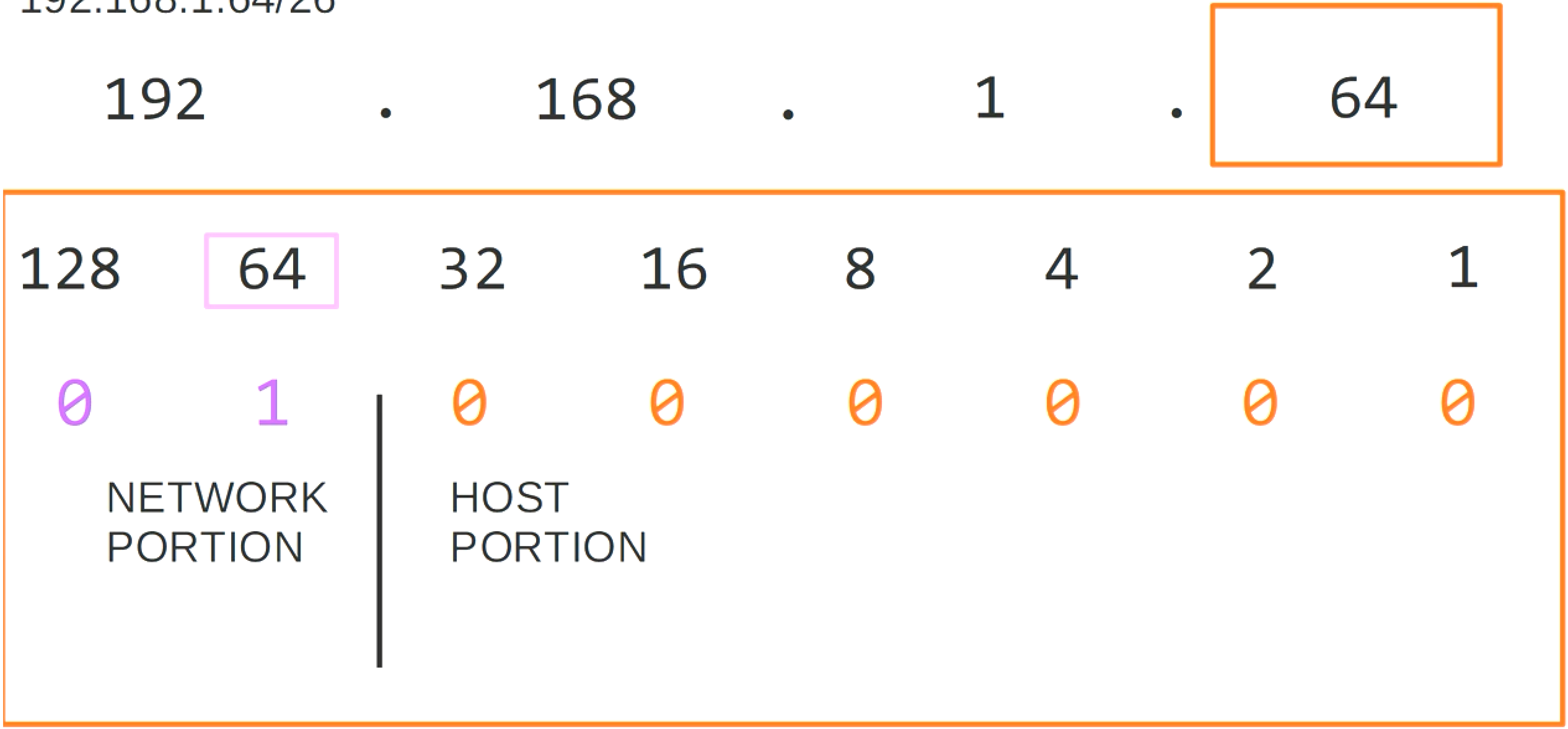
192.168.1.0/26

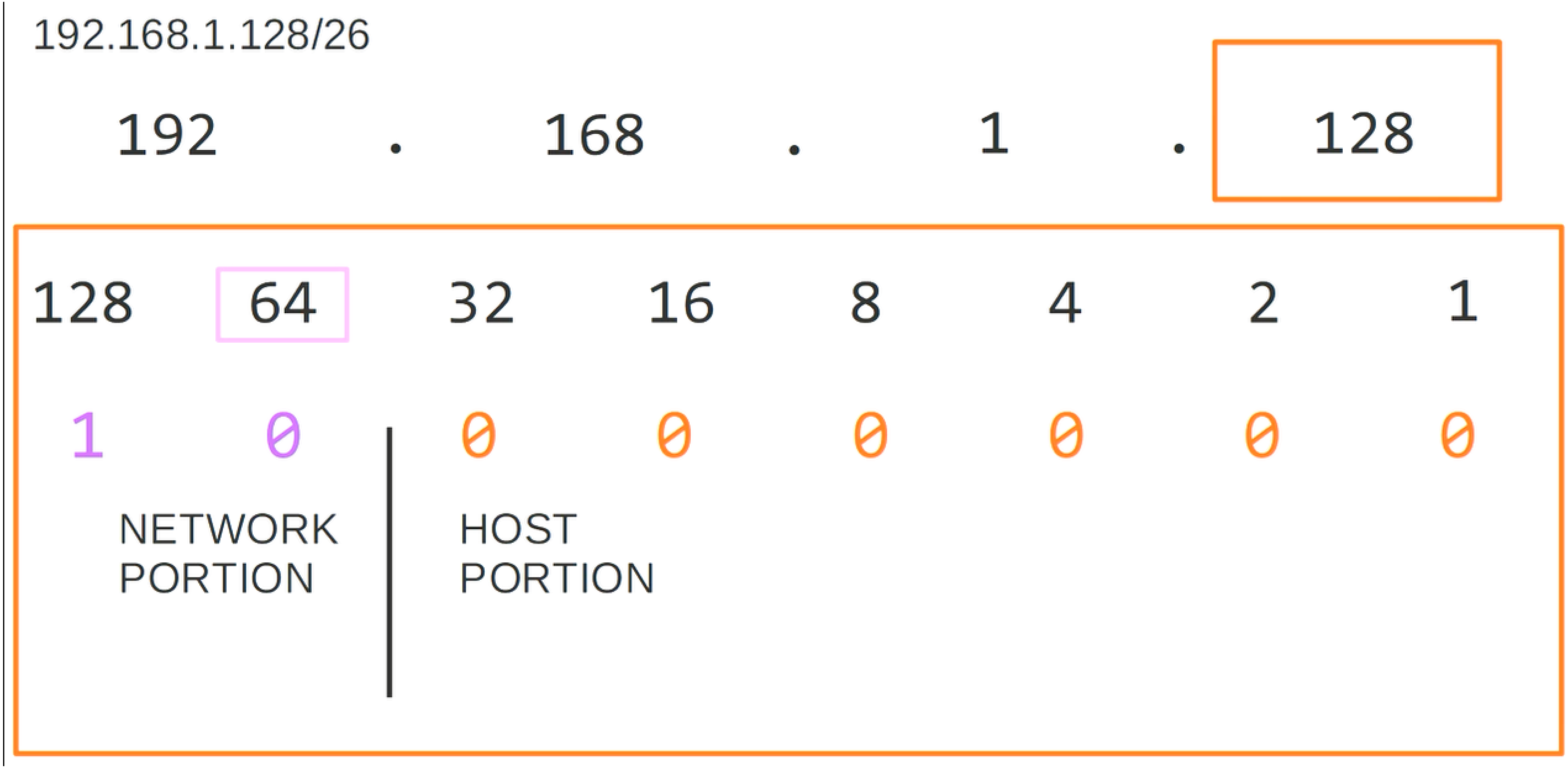
192 . 168 . 1 . 0

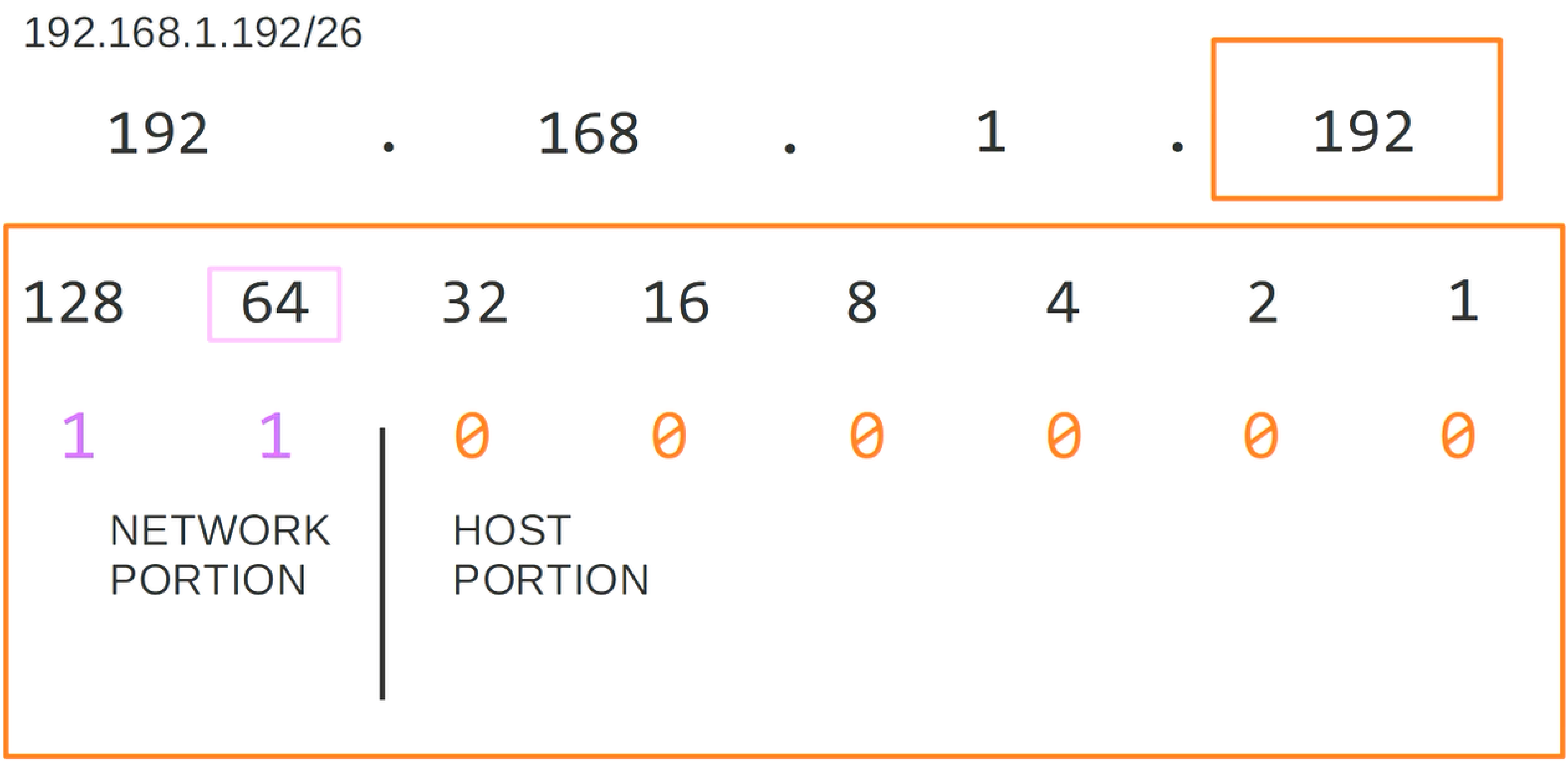
128	64	32	16	8	4	2	1
0	0	0	0	0	0	0	0

NETWORK PORTION | HOST PORTION

192.168.1.64/26

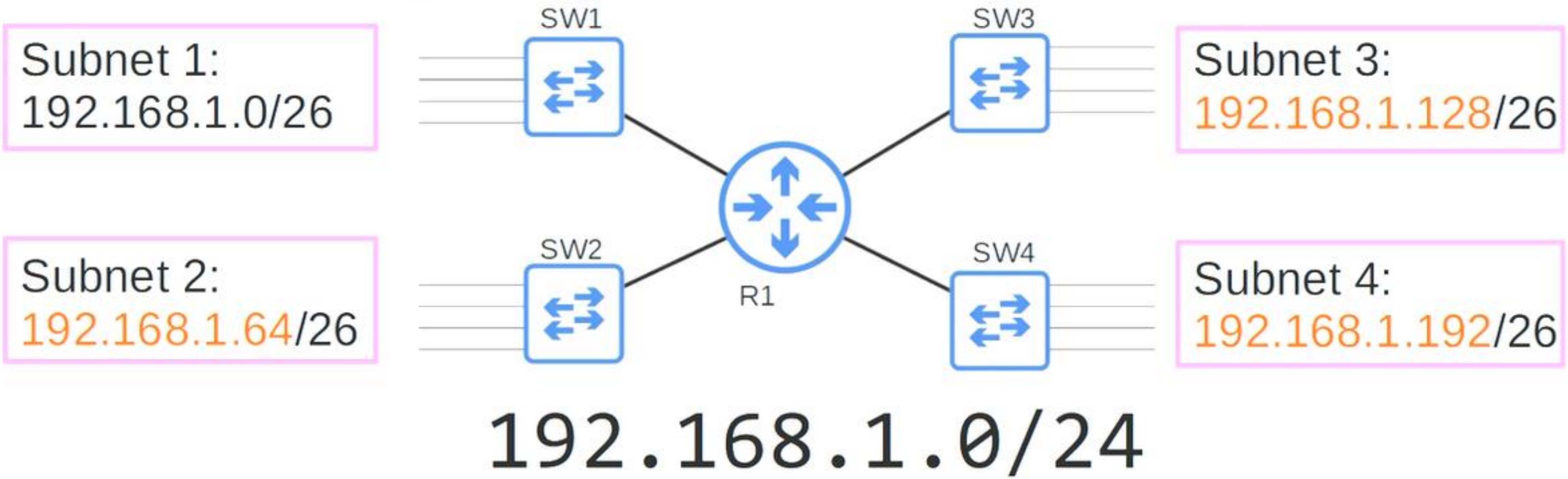



192.168.1.128/26
192
.
168
.
1
.
128
128
64
32
16
8
4
2
1
1
0
0
0
0
0
0
0
NETWORK PORTION
HOST PORTION


192.168.1.192/26
192 . 168 . 1 . 192
128 64 32 16 8 4 2 1
1 1 0 0 0 0 0 0
NETWORK PORTION
HOST PORTION

The first subnet (Subnet 1) is 192.168.1.0/26. What are the remaining subnets?

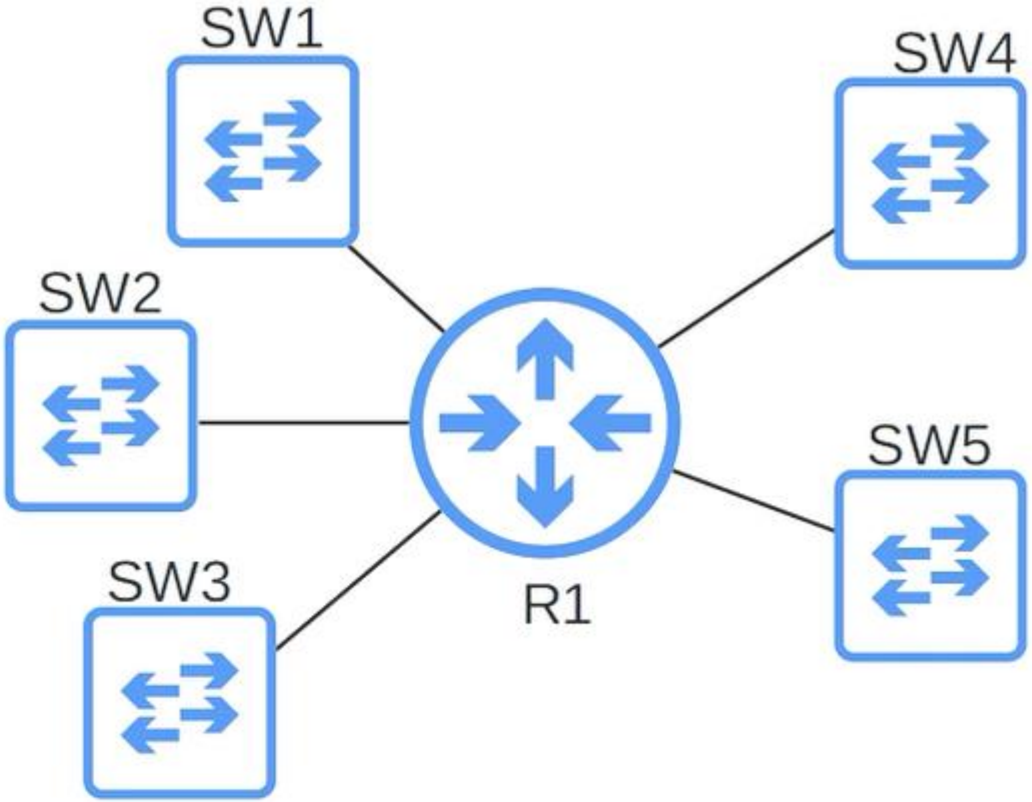
HINT: Find the broadcast address of Subnet 1. The next address is the network address of Subnet 2. Repeat the process for Subnets 3 and 4.



Subnet 1:

Subnet 2:

Subnet 3:



Subnet 4:

Subnet 5:

192.168.255.0/24

Divide the **192.168.255.0/24** *network into five subnets of equal size. Identify the five subnets.*

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0

192 . 168 . 255 . 0

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 1 1 1 1 1 1 1 1 . 1 0 0 0 0 0 0 0

192 . 168 . 255 . 128

Borrowing 1 bit = can make 2 subnets

2^x = number of subnets
(x = number of ‘borrowed’ bits)

$2^n - 2$ = number of hosts
(n = number of host bits)

Subnet 1:

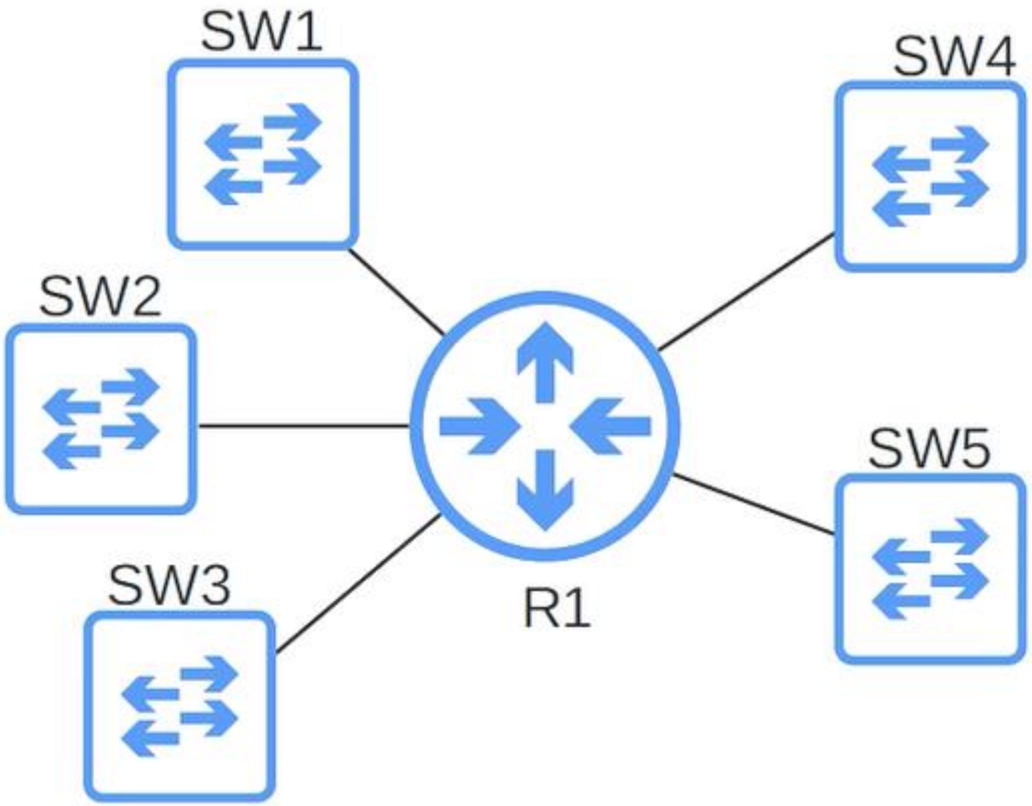
192.168.255.0/27

Subnet 2:

192.168.255.32/27

Subnet 3:

192.168.255.64/27



Subnet 4:

192.168.255.96/27

Subnet 5:

192.168.255.128/27

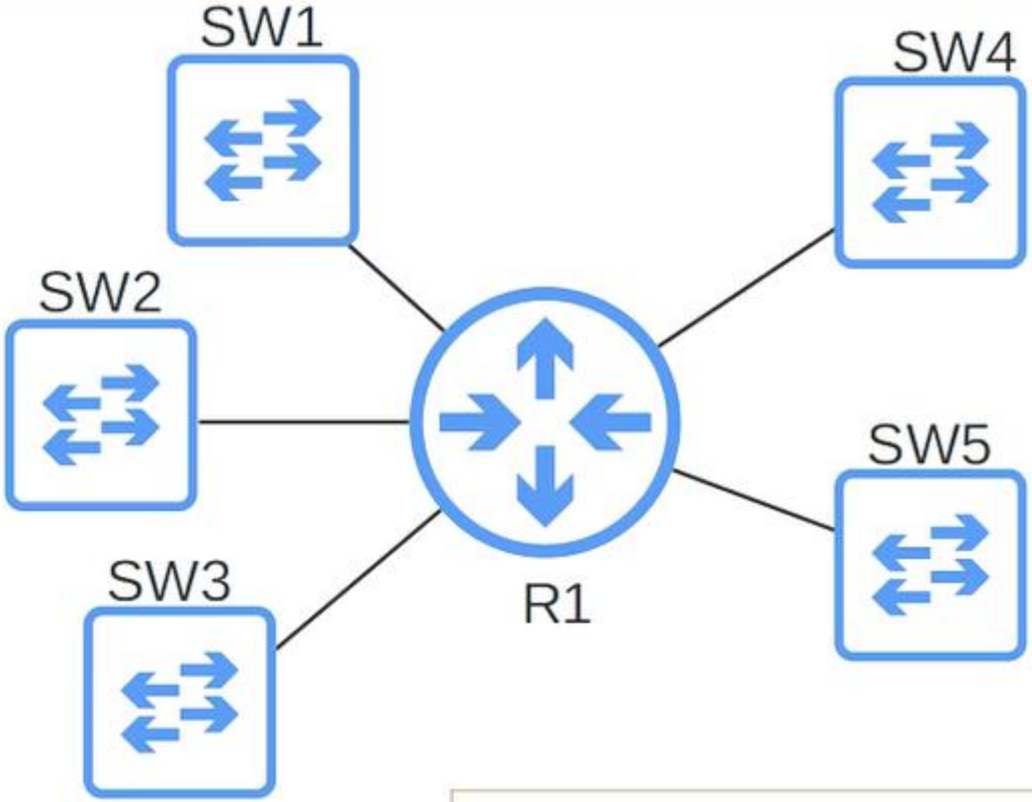
192.168.255.0/24

Divide the **192.168.255.0/24** network into five subnets of equal size. Identify the five subnets.

Subnet 1:
192.168.255.0/27

Subnet 2:
192.168.255.32/27

Subnet 3:
192.168.255.64/27



Subnet 4:
192.168.255.96/27

Subnet 5:
192.168.255.128/27

Subnet 6: 192.168.255.160/27
Subnet 7: 192.168.255.192/27
Subnet 8: 192.168.255.224/27

192.168

Divide the **192.168.255.0/** *f*

equal size. Identify the five subnets.

Requirements:

1) Create 3 Sub-networks
2) Use a Class C IP address: 192.168.1.0
3) Determine the Network Id and Broadcast Id of all the subnets

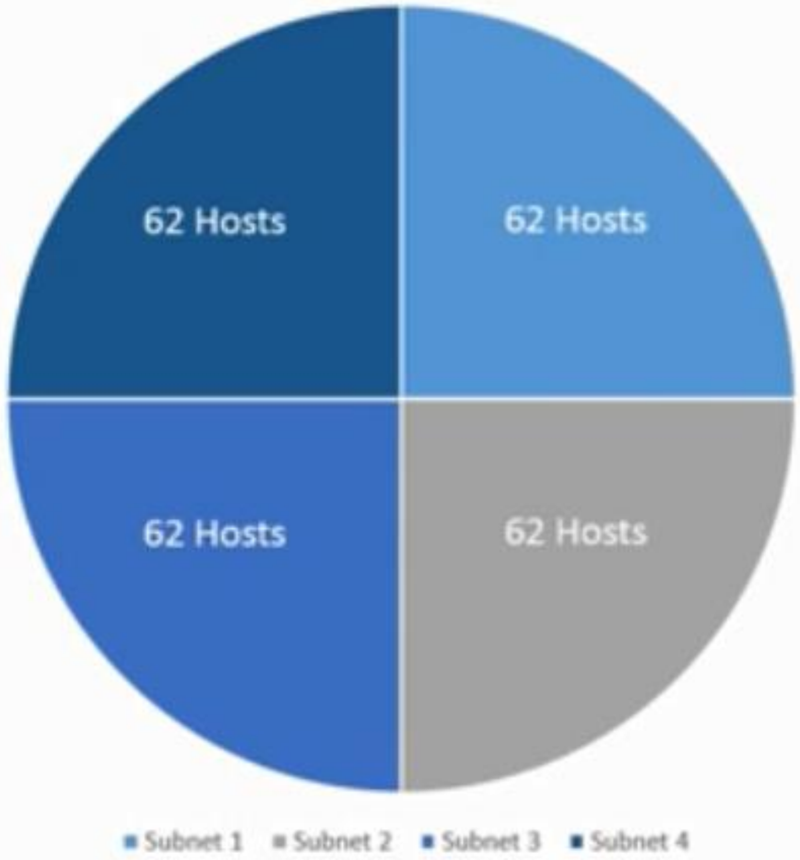
Subnet	1	2	4	8	16	32	64	128	256
Host	256	128	64	32	16	8	4	2	1
Subnet Mask	/24	/25	/26	/27	/28	/29	/30	/31	/32

Requirements:

1) Create 3 Sub-networks
2) Use a Class C IP address: 192.168.1.0
3) Determine the Network Id and Broadcast Id of all the subnets

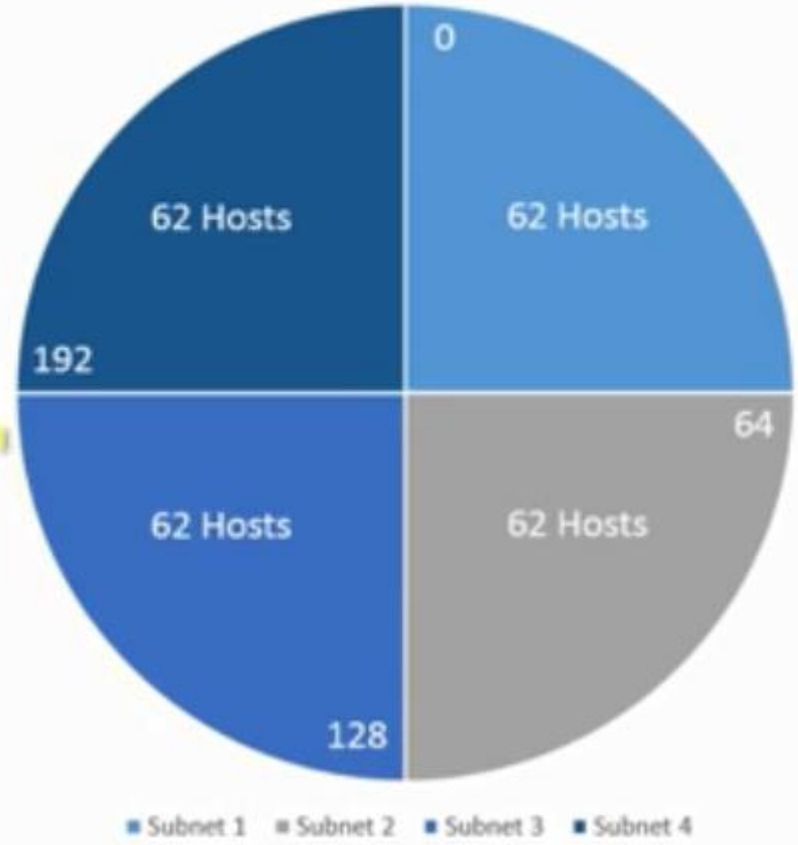
128	64	32	16	8	4	2	1
1	1	0	0	0	0	0	0

Network



Requirements:

1) Create 3 Sub-networks
2) Use a Class C IP address: 192.168.1.0
3) Determine the Network Id and Broadcast Id of all the subnets

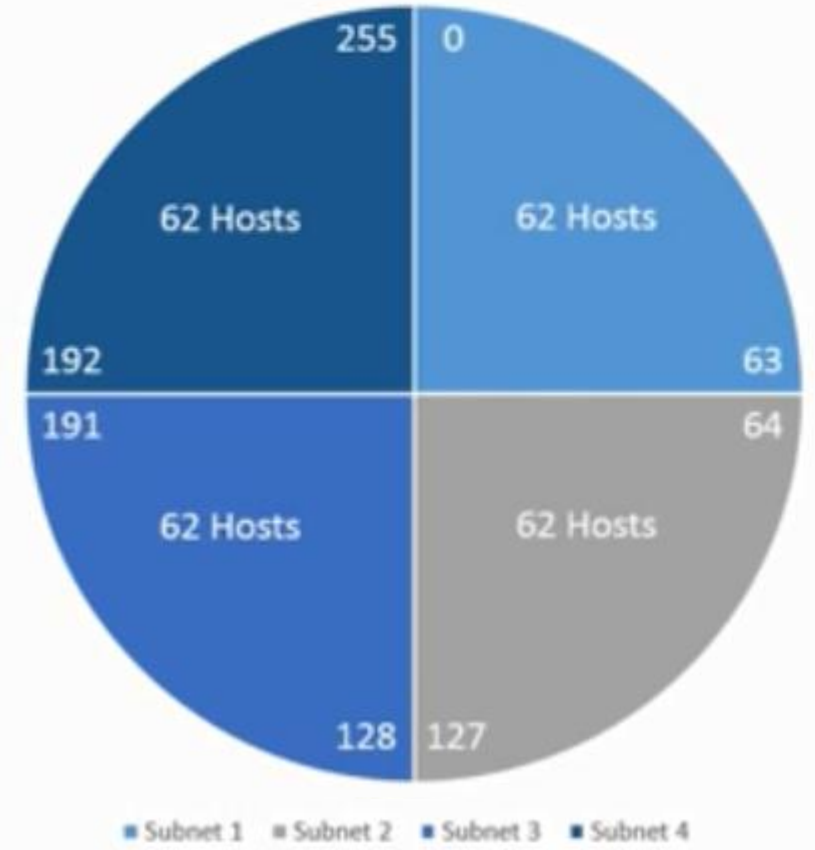


128	64	32	16	8	4	2	1
1	1	0	0	0	0	0	0

Network

Requirements:

1) Create 3 Sub-networks
2) Use a Class C IP address: 192.168.1.0
3) Determine the Network Id and Broadcast Id of all the subnets



128	64	32	16	8	4	2	1
1	1	0	0	0	0	0	0

Network

Question:

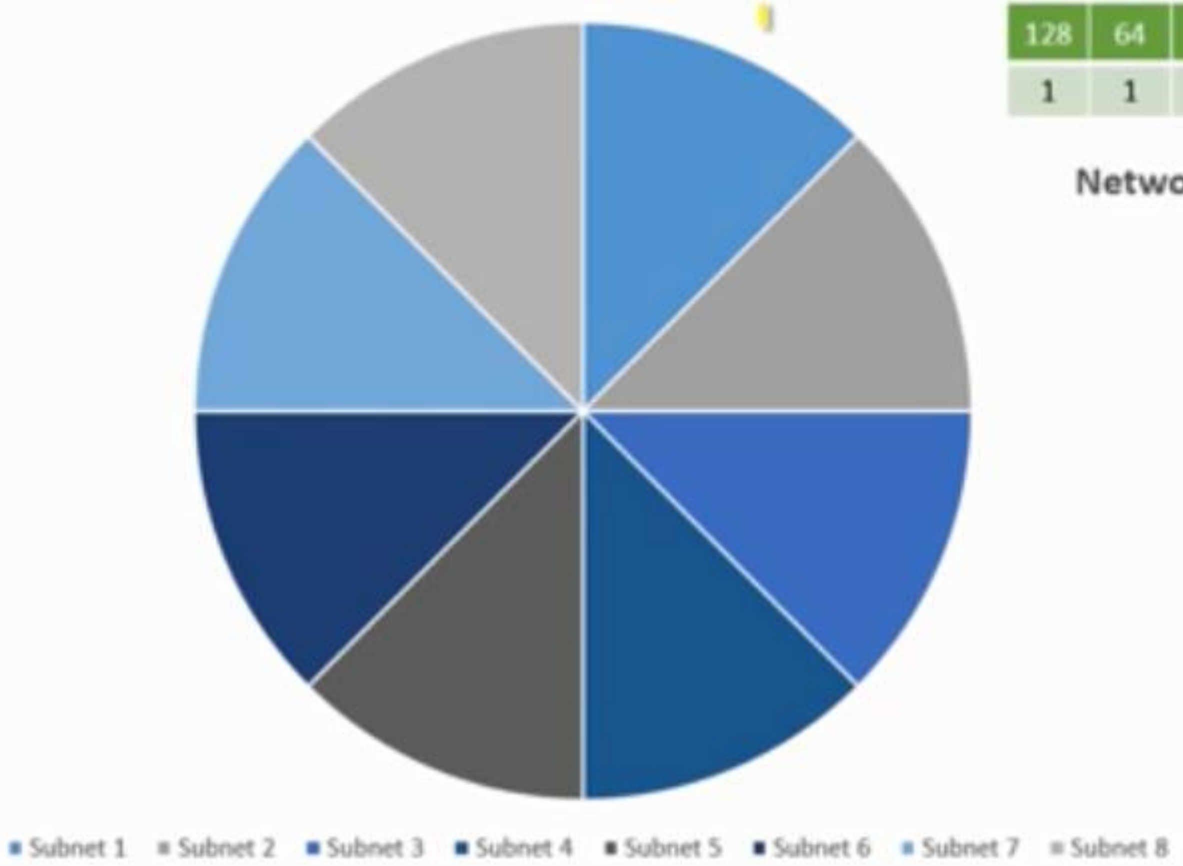
Find the Network Id and Broadcast Id of this IP Address

192.168.225.212/27

<u>Question:</u>

Find the Network Id and Broadcast Id of this IP Address

192.168.225.212/27



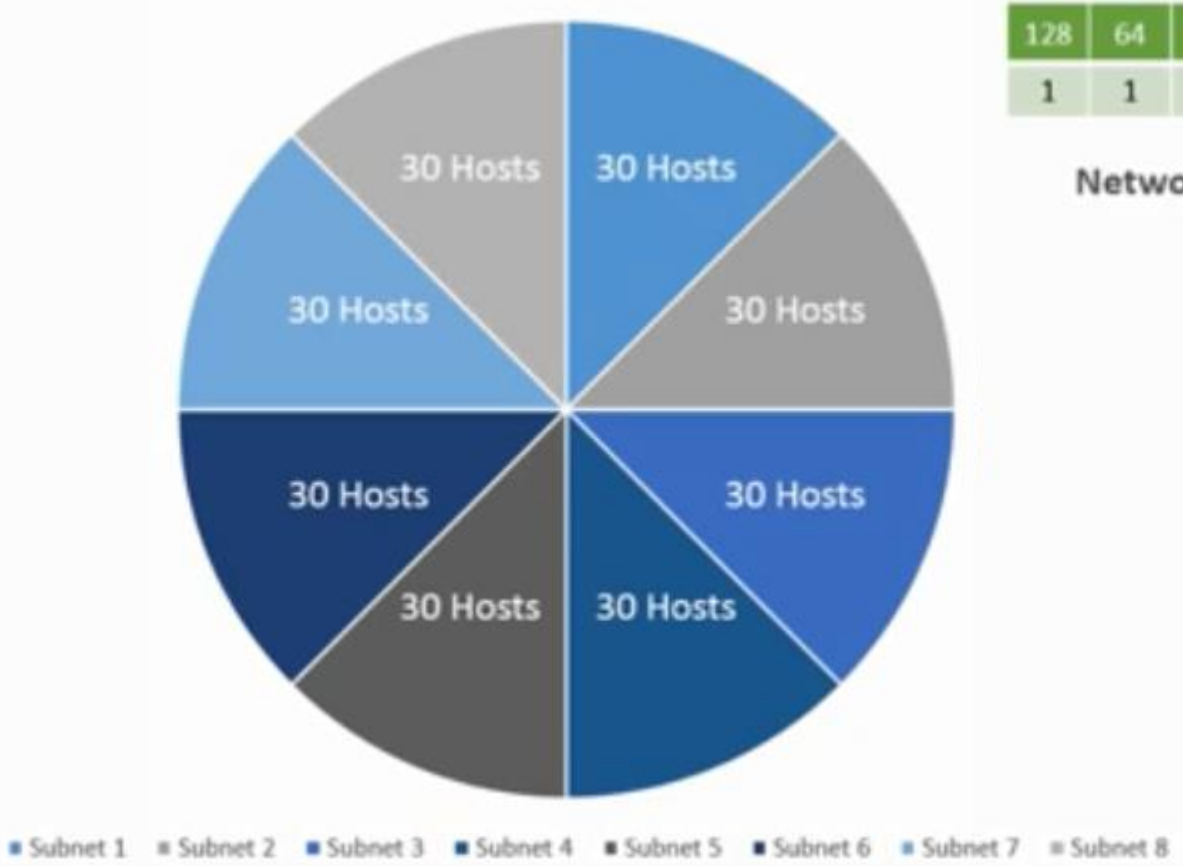
128	64	32	16	8	4	2	1
1	1	1	0	0	0	0	0

Network

Question:

Find the Network Id and Broadcast Id of this IP Address

192.168.225.212/27



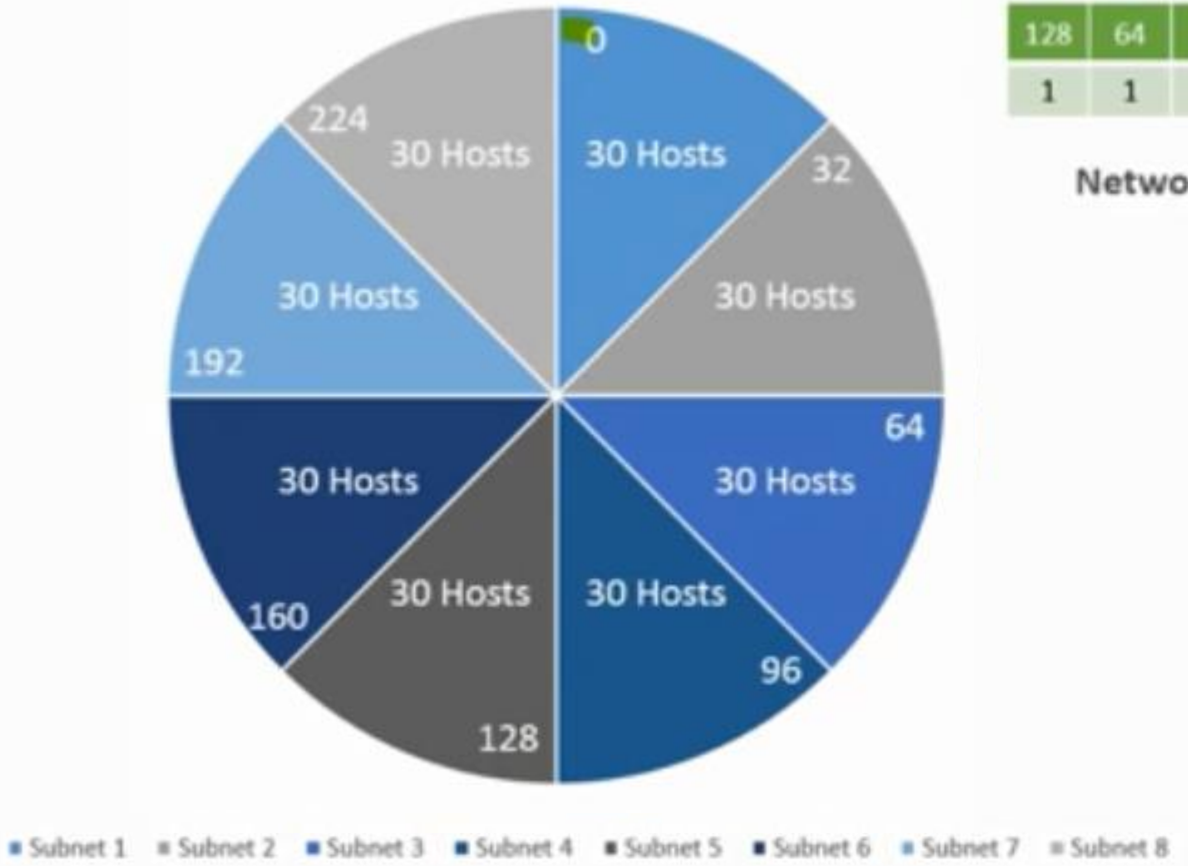
128	64	32	16	8	4	2	1
1	1	1	0	0	0	0	0

Network

Question:

Find the Network Id and Broadcast Id of this IP Address

192.168.225.212/27



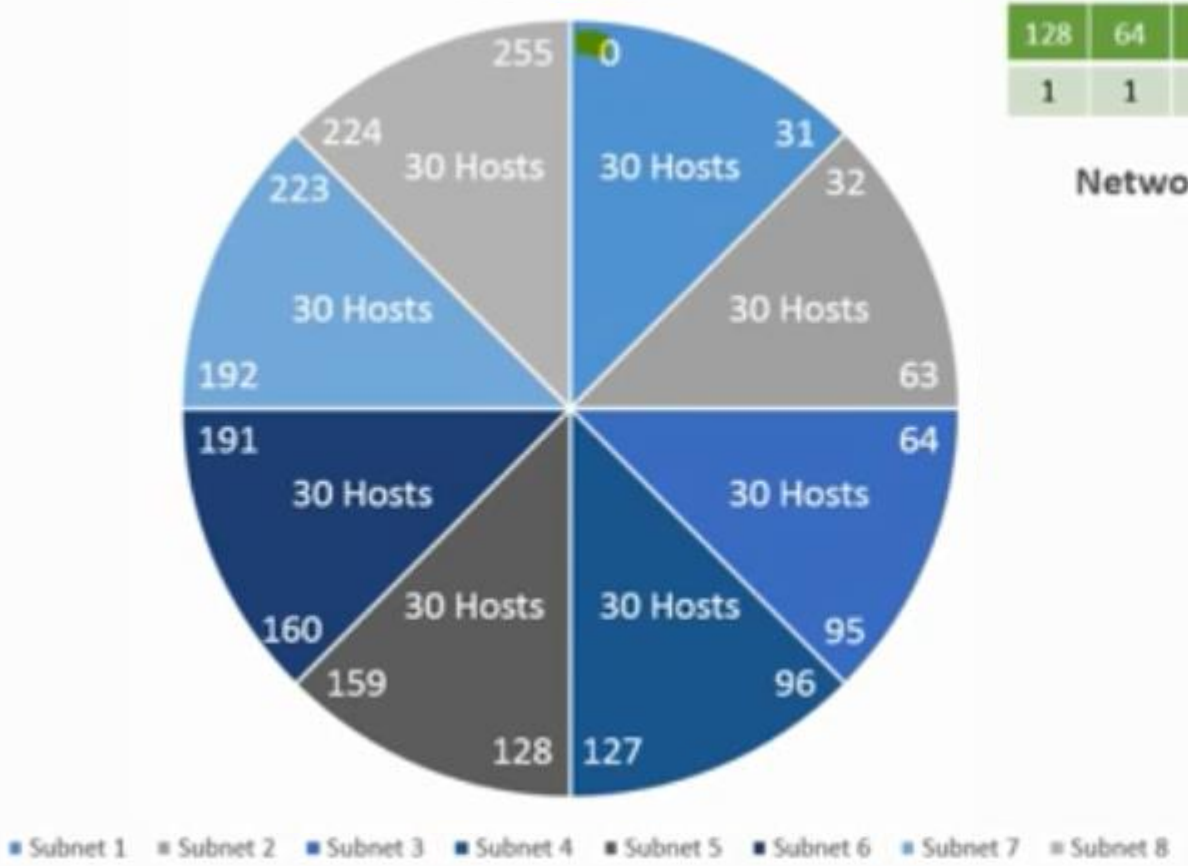
128	64	32	16	8	4	2	1
1	1	1	0	0	0	0	0

Network

Question:

Find the Network Id and Broadcast Id of this IP Address

192.168.225.212/27

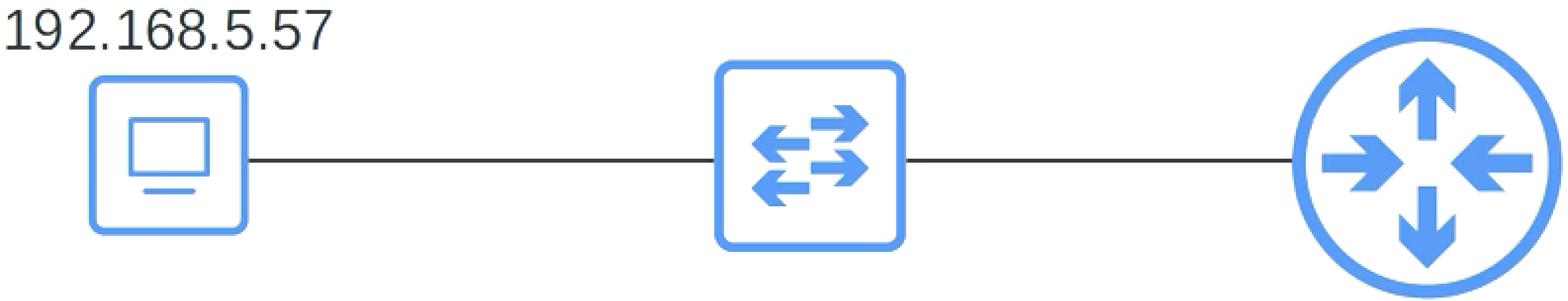


128	64	32	16	8	4	2	1
1	1	1	0	0	0	0	0

Network

What subnet does host **192.168.5.57/27** belong to?

Subnet ID: _______________/27



1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 1 0 1 . 0 0 1 1 1 0 0 1

192 . 168 . 5 . 57

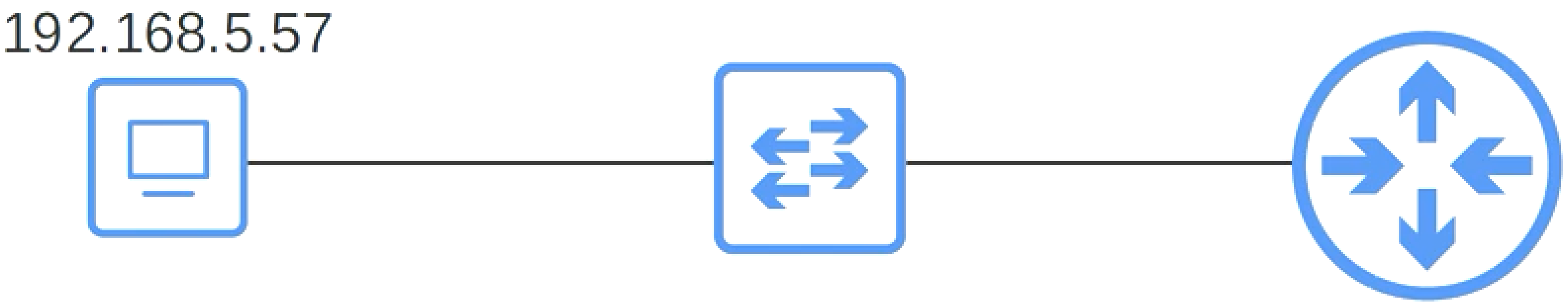
↓

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 0 0 1 0 1 . 0 0 1 0 0 0 0 0

192 . 168 . 5 . 32

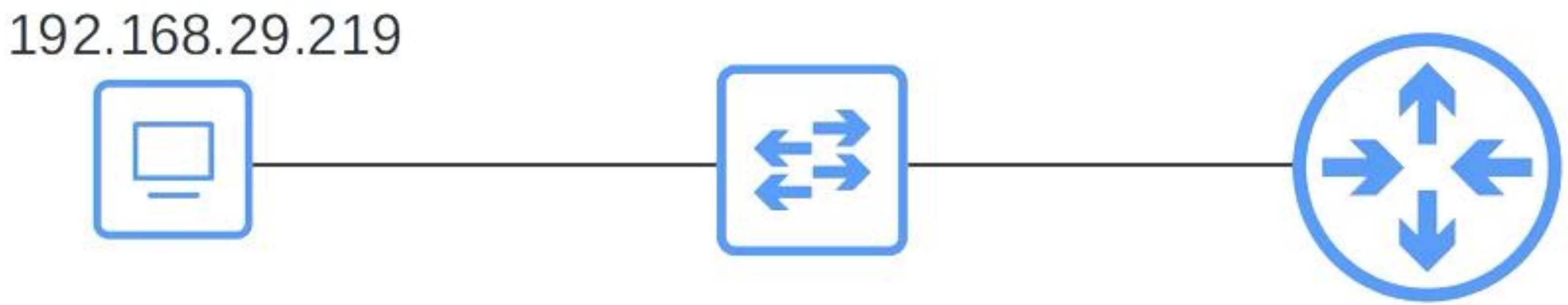
What subnet does host **192.168.5.57/27** *belong to?*

Subnet ID: _192.168.5.32_/27



What subnet does host **192.168.29.219/29** belong to?

Subnet ID: _______________/29



1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 1 1 1 0 1 . 1 1 0 1 1 0 1 1

192 . 168 . 29 . 219

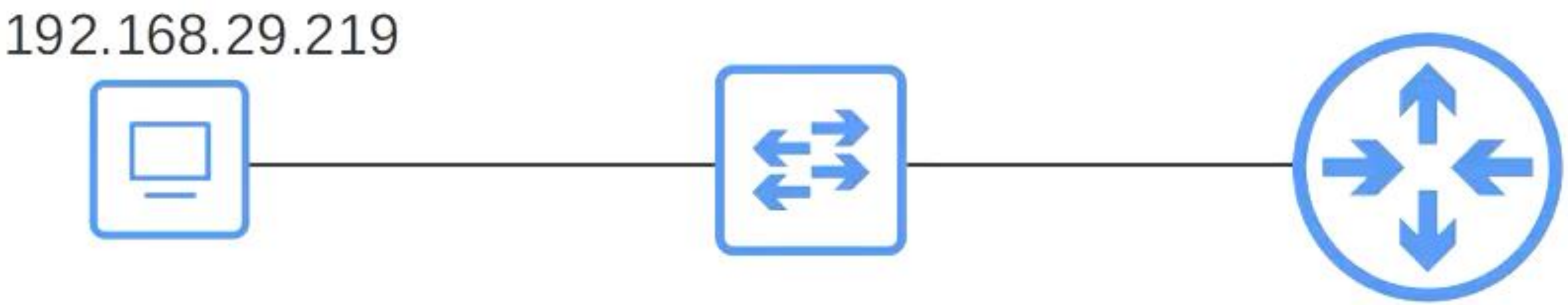
↓

1 1 0 0 0.0.0.0 . 1 0 1 0 1 0 0 0 . 0 0 0 1 1 1 0 1 . 1 1 0 1 1 0 0 0

192 . 168 . 29 . 216

What subnet does host **192.168.29.219/29** belong to?

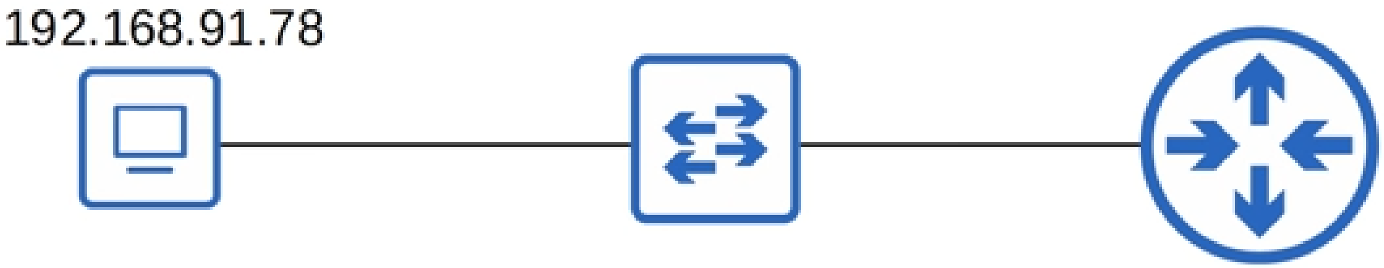
Subnet ID: 192.168.29.216/29



What is the **broadcast address** of the network

192.168.91.78/26 belongs to?

Broadcast address: _______________/26



What is the **broadcast address** of the network

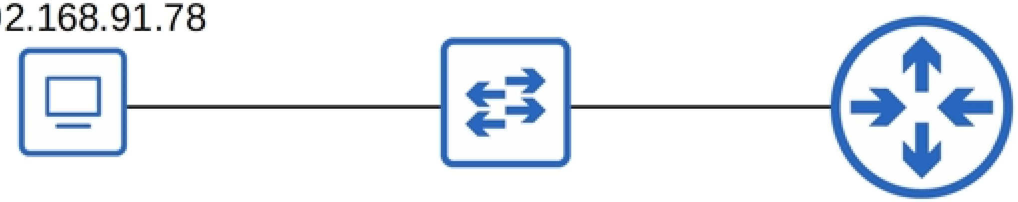
192.168.91.78/26 belongs to?

```
1 1 0 0 0 0 0 0 . 1 0 1 0 1 0 0 0 . 0 1 0 1 1 0 1 1 . 0 1 0 0 1 1 1 0
      192       .       168       .        91       .       78
                                  ↓
1 1 0 0 0 0 0 0 . 1 0 1 0 1 0 0 0 . 0 1 0 1 1 0 1 1 . 0 1 1 1 1 1 1 1
      192       .       168       .        91       .       127
```

What is the **broadcast address** of the network

192.168.91.78/26 belongs to?

Broadcast address: 192.168.91.127 /26



Prefix Length	Number of Subnets	Number of Hosts
/17	2	32766
/18	4	16382
/19	8	8190
/20	16	4094
/21	32	2044
/22	64	1022
/23	128	510
/24	256	254

Prefix Length	Number of Subnets	Number of Hosts
/25	512	126
/26	1024	62
/27	2048	30
/28	4096	14
/29	8192	6
/30	16384	2
/31	32768	0 (2)
/32	65536	0 (1)

You have been given the 10.0.0.0/8 network. You must create 2000 subnets which will be distributed to various enterprises.

What prefix length must you use?

How many host addresses (usable addresses) will be in each subnet?

Subnetting Class B Networks

/8

0 0 0 0 1 0 1 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

10 . 0 . 0 . 0

Subnet mask:

1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

255 . 0 . 0 . 0

Subnetting Class B Networks

/8

0 0 0 0 1 0 1 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

10 . 0 . 0 . 0

Borrowing 0 bits = can't make any subnets

Subnet mask:

1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

255 . 0 . 0 . 0

Subnetting Class A Networks

$2^{what?}$ = at least 2000

Subnetting Class A Networks

$2^{what?}$ = at least 2000

$2^{11} = 2048$

Subnetting Class B Networks

/19

0 0 0 0 1 0 1 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

10 . 0 . 0 . 0

Subnet mask:

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 0 0 0 0 0 . 0 0 0 0 0 0 0 0

255 . 255 . 224 . 0

Subnetting Class B Networks

/19

0 0 0 0 1 0 1 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

10 . 0 . 0 . 0

13 host bits = $2^{13} - 2$ = 8190 hosts per subnet

Subnet mask:

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 0 0 0 0 0 . 0 0 0 0 0 0 0 0

255 . 255 . 224 . 0

You have been given the 10.0.0.0/8 network. You must create 2000 subnets which will be distributed to various enterprises.

What prefix length must you use? /19

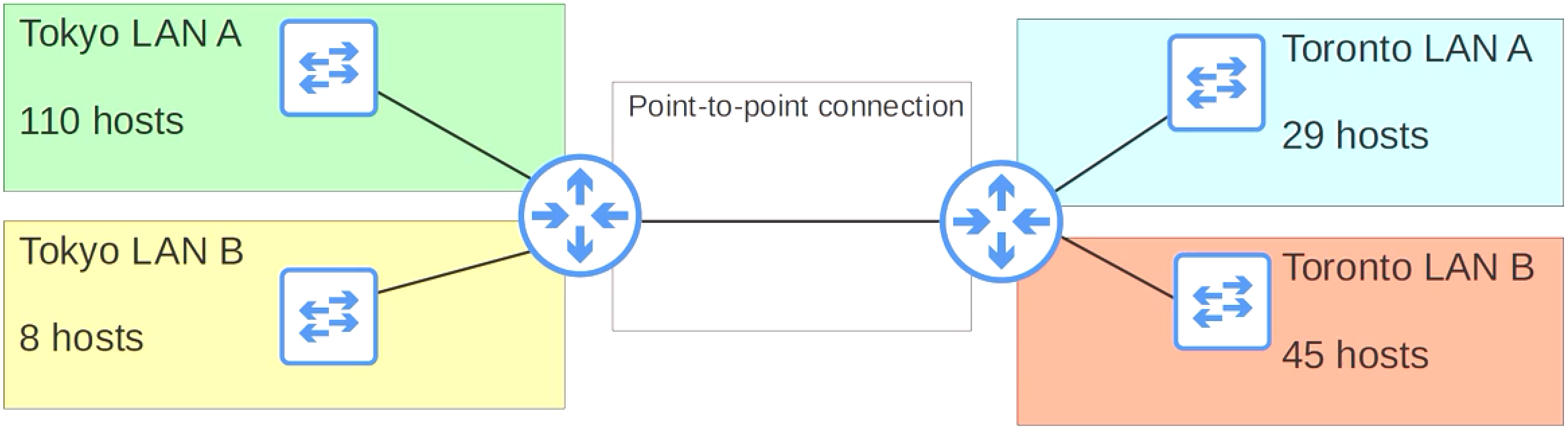
How many host addresses (usable addresses) will be in each subnet? 8190

Variable-Length Subnet Masks

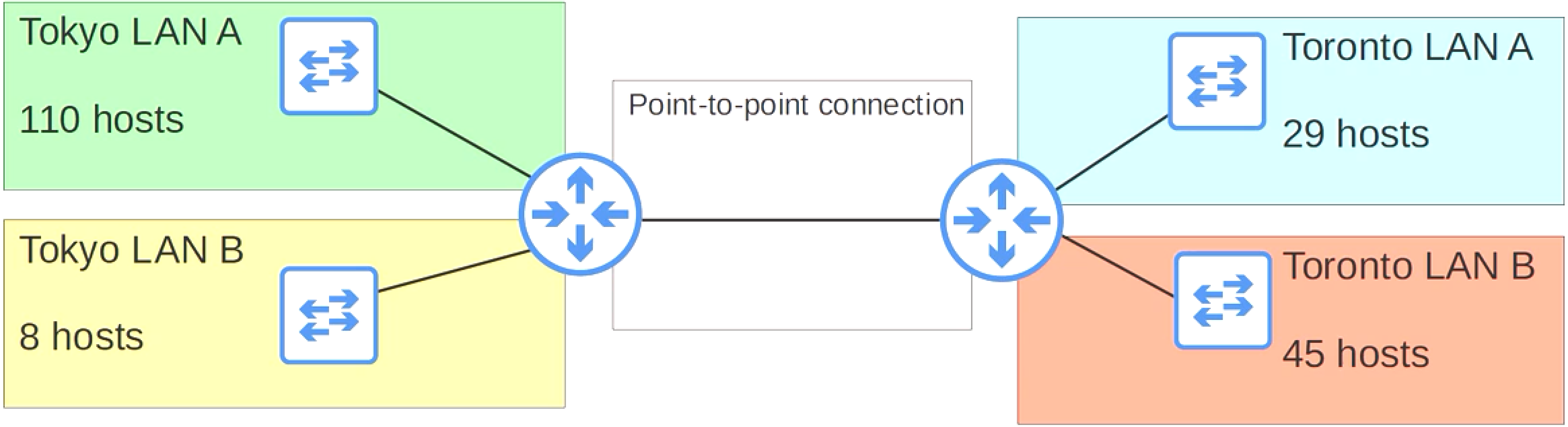
- Until now, we have practiced subnetting used FLSM (Fixed-Length Subnet Masks).
- This means that all of the subnets use the same prefix length (ie. subnetting a class C network into 4 subnets using /26).

- VLSM (Variable-Length Subnet Masks) is the process of creating subnets of different sizes, to make your use of network addresses more efficient.

- VLSM is more complicated than FLSM, but it’s easy if you follow the steps correctly.


Tokyo LAN A
110 hosts
Tokyo LAN B
8 hosts
Point-to-point connection
Toronto LAN A
29 hosts
Toronto LAN B
45 hosts

192.168.1.0/24

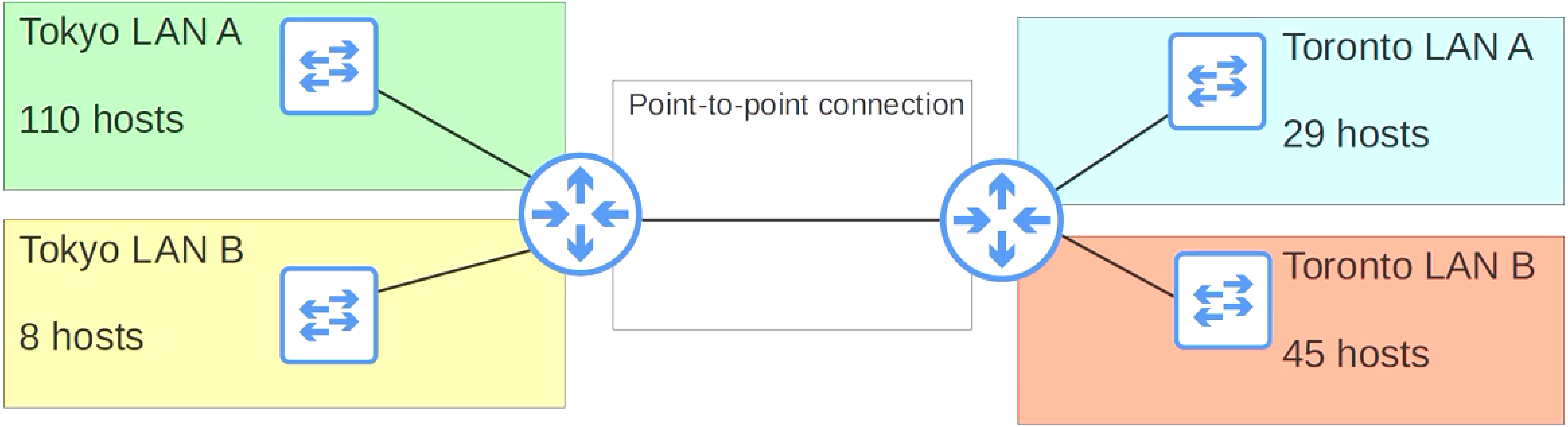


192.168.1.0/24

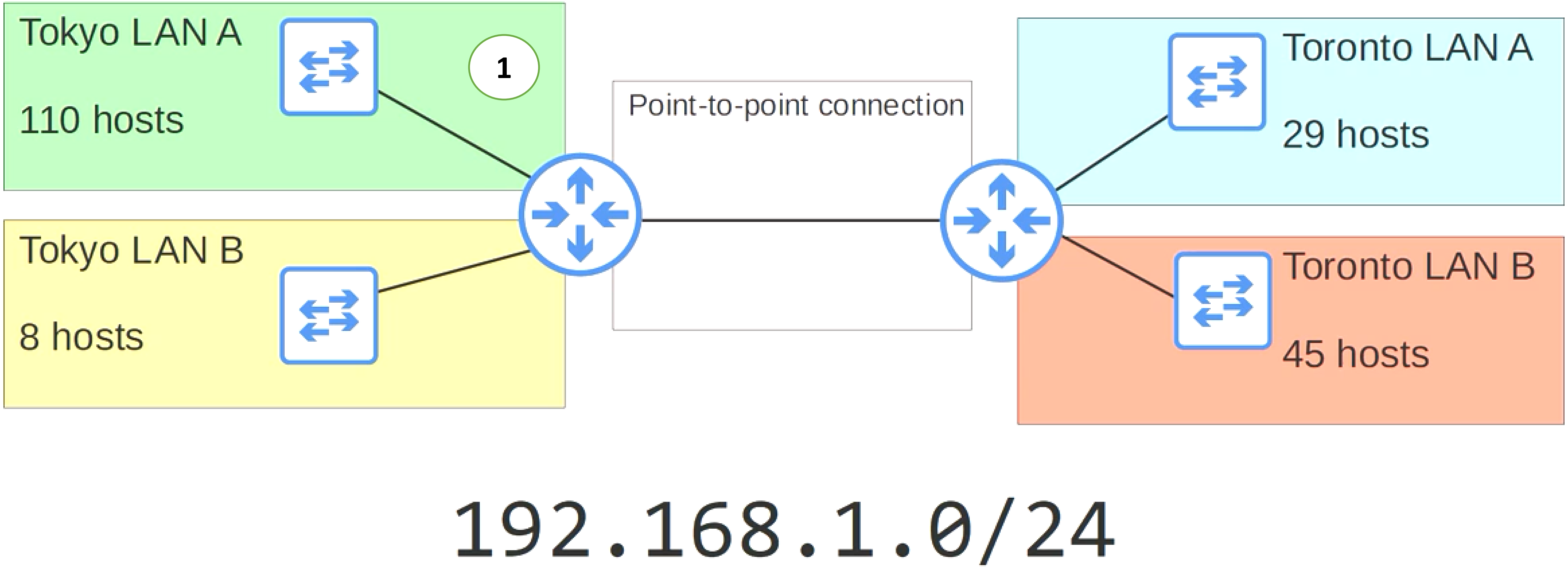
1) Assign the largest subnet at the start of the address space.

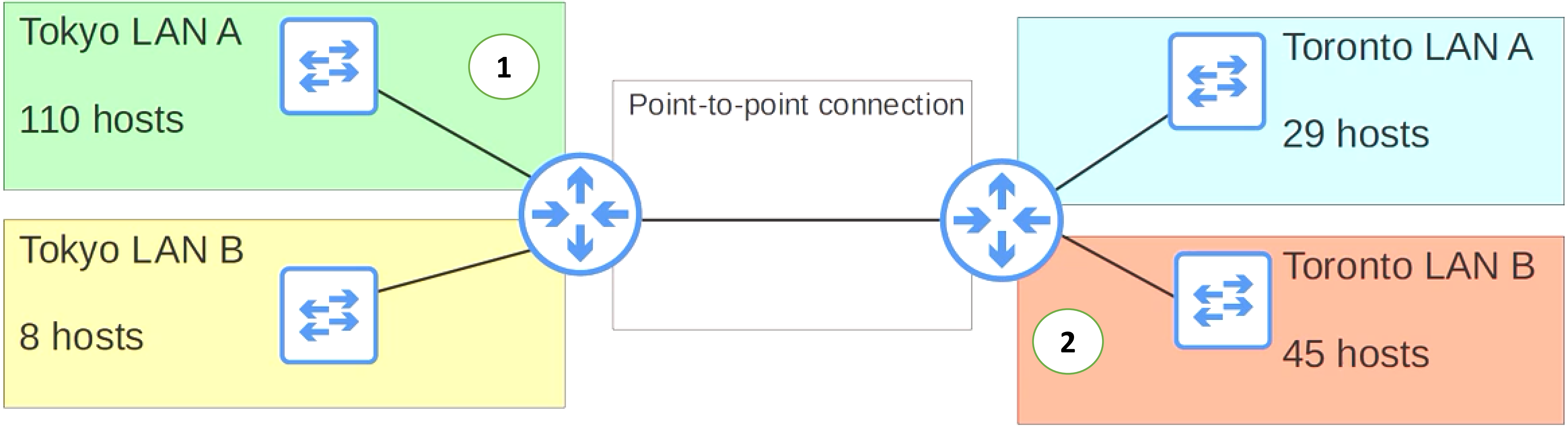
2) Assign the second-largest subnet after it.

3) Repeat the process until all subnets have been assigned.

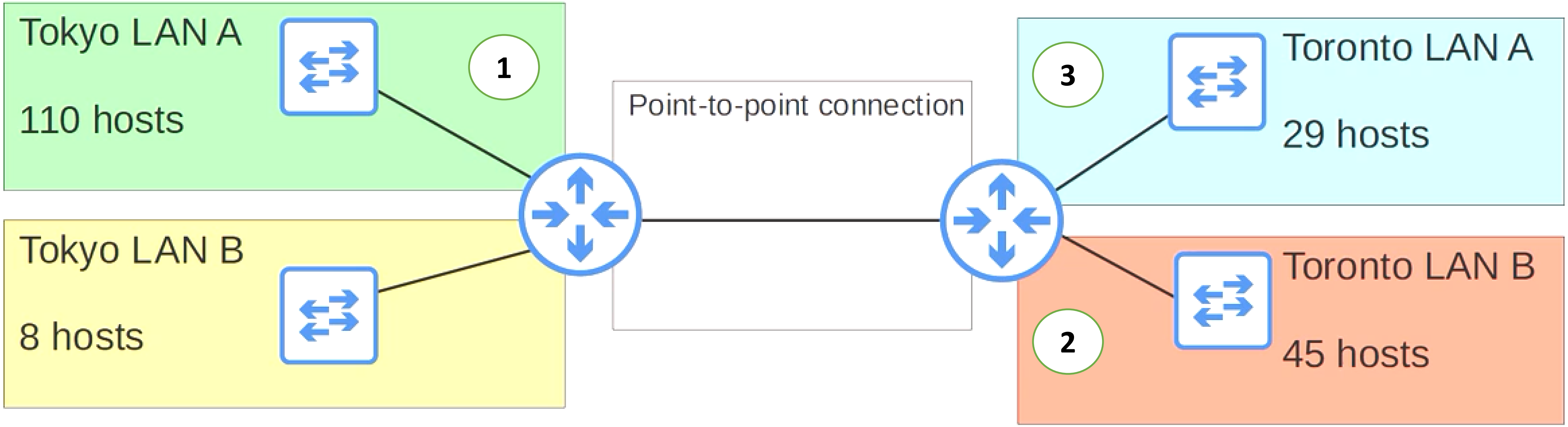

Tokyo LAN A
110 hosts
Tokyo LAN B
8 hosts
Point-to-point connection
Toronto LAN A
29 hosts
Toronto LAN B
45 hosts

192.168.1.0/24

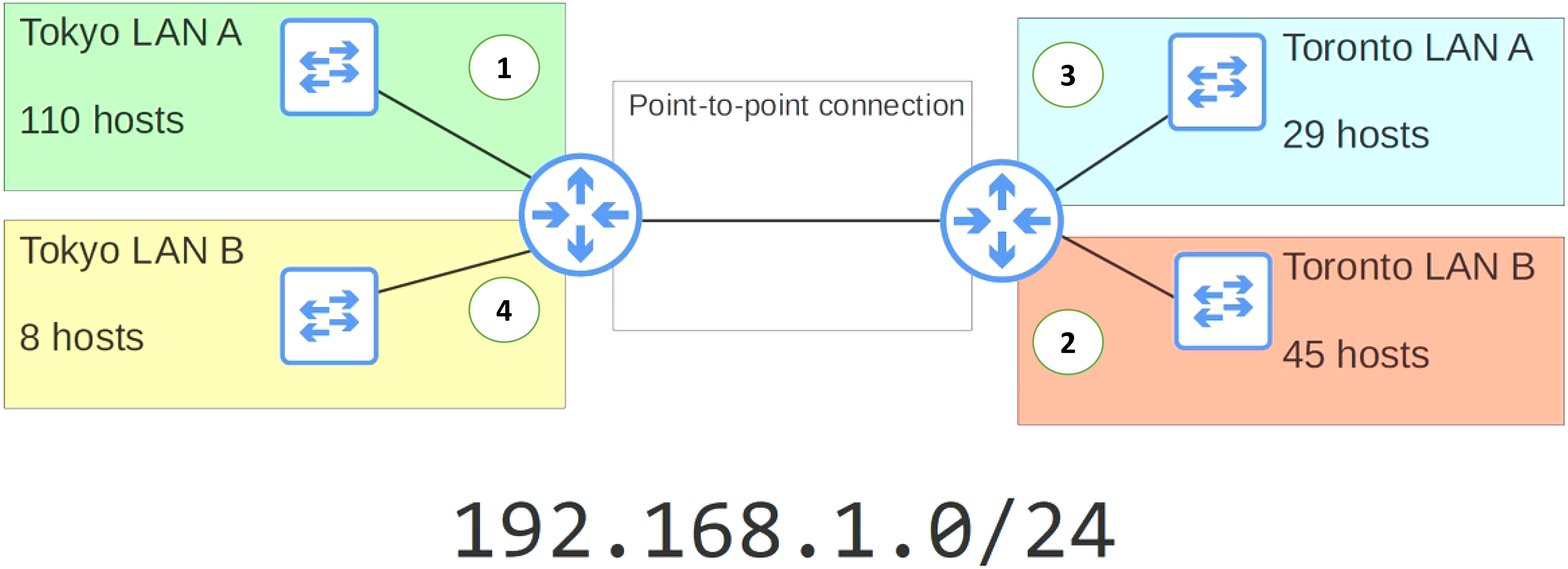

Tokyo LAN A
110 hosts
1
Tokyo LAN B
8 hosts
Point-to-point connection
Toronto LAN A
29 hosts
Toronto LAN B
45 hosts
192.168.1.0/24

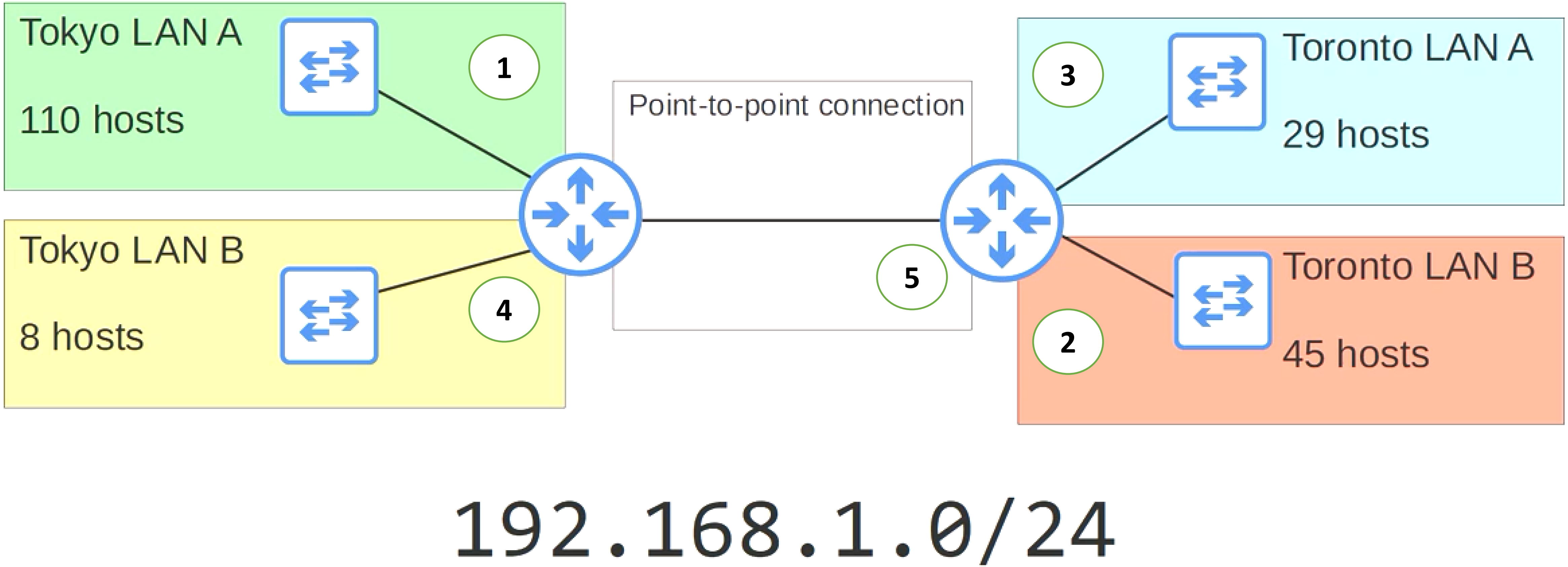

Tokyo LAN A
110 hosts
1
Tokyo LAN B
8 hosts
Point-to-point connection
Toronto LAN A
29 hosts
Toronto LAN B
45 hosts
2

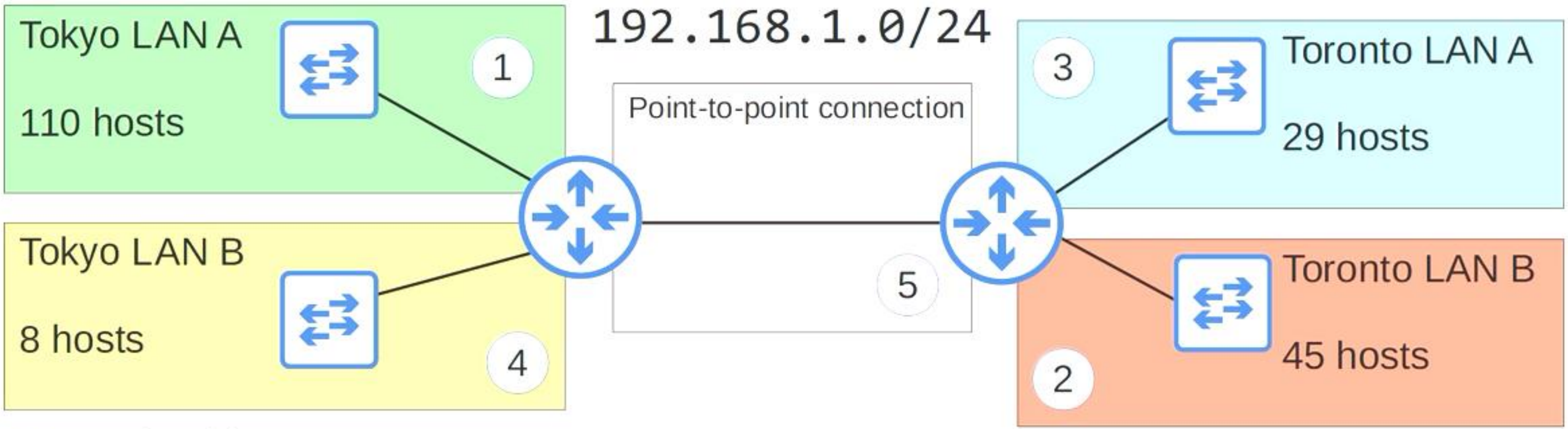
192.168.1.0/24


Tokyo LAN A
110 hosts
1
Tokyo LAN B
8 hosts
Point-to-point connection
3
Toronto LAN A
29 hosts
Toronto LAN B
45 hosts
2

192.168.1.0/24


Tokyo LAN A
110 hosts
1
Tokyo LAN B
8 hosts
4
Point-to-point connection
Toronto LAN A
29 hosts
3
Toronto LAN B
45 hosts
2
192.168.1.0/24


Tokyo LAN A
110 hosts
1
Tokyo LAN B
8 hosts
4
Point-to-point connection
5
Toronto LAN A
29 hosts
3
Toronto LAN B
45 hosts
2
192.168.1.0/24



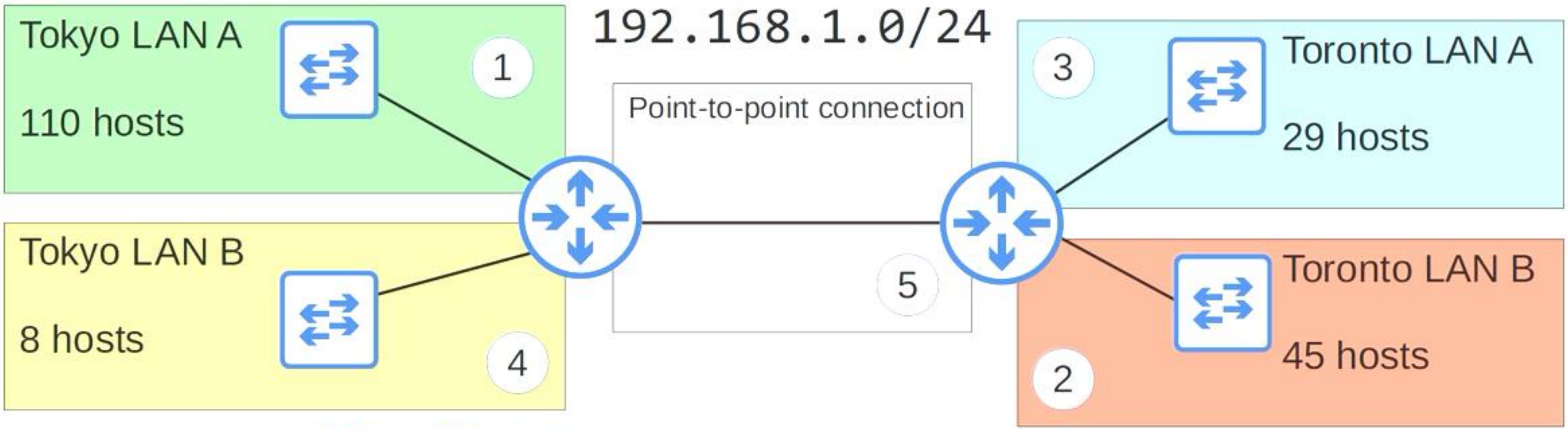
Network address:

Broadcast address:

First usable address:

Last usable address:

Total number of usable host addresses:



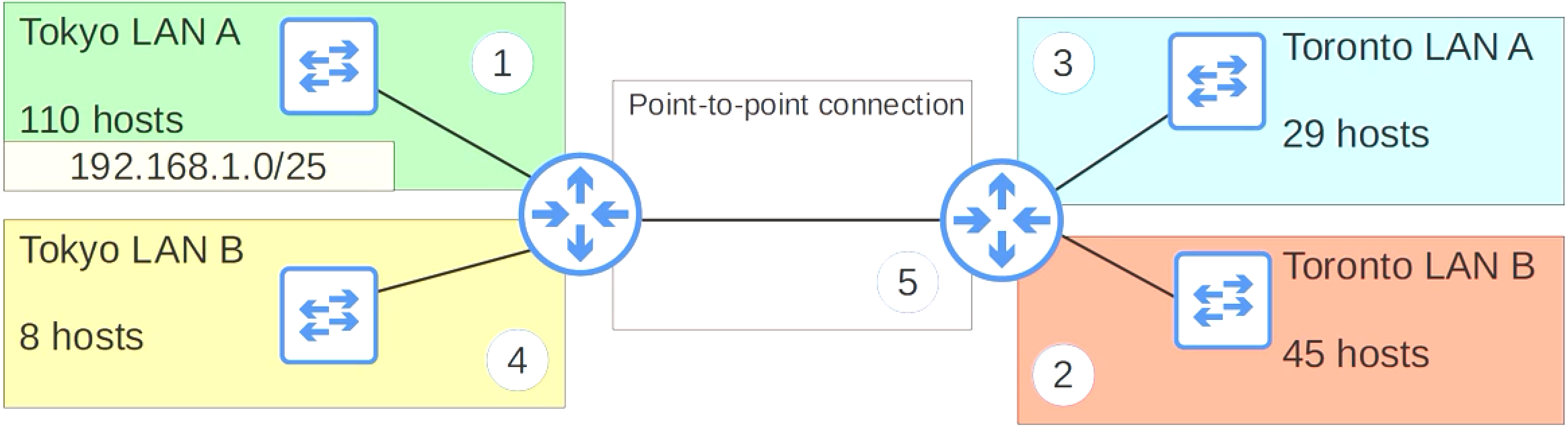
Network address: 192.168.1.0/25

Broadcast address: 192.168.1.127/25

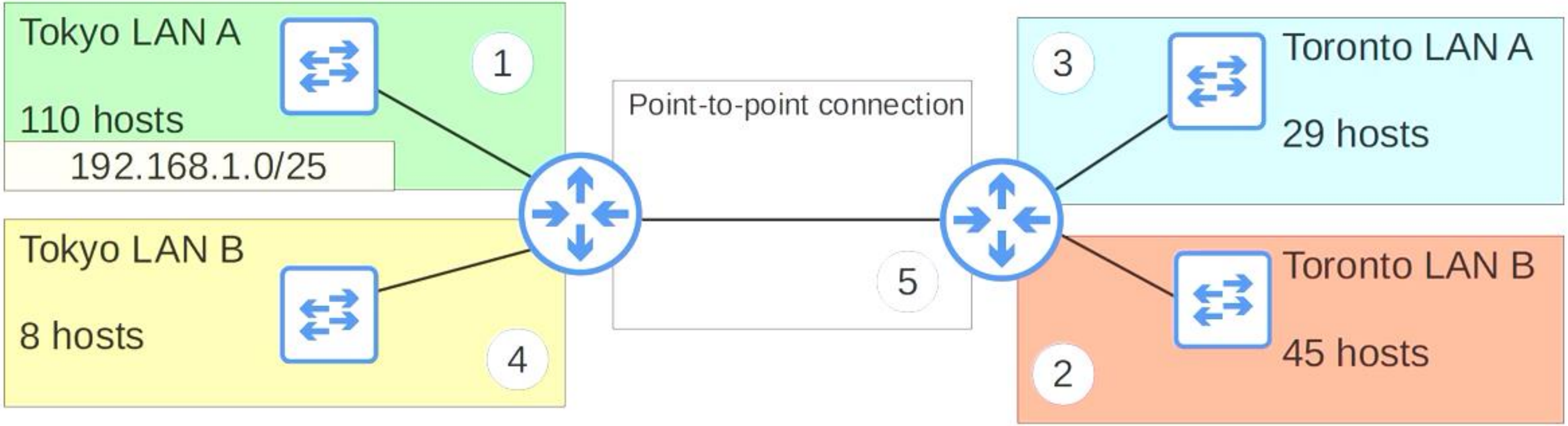
First usable address: 192.168.1.1/25

Last usable address: 192.168.1.126/25

Total number of usable host addresses: 126


Tokyo LAN A
110 hosts
192.168.1.0/25
1
Tokyo LAN B
8 hosts
4
Point-to-point connection
5
3
Toronto LAN A
29 hosts
Toronto LAN B
45 hosts
2

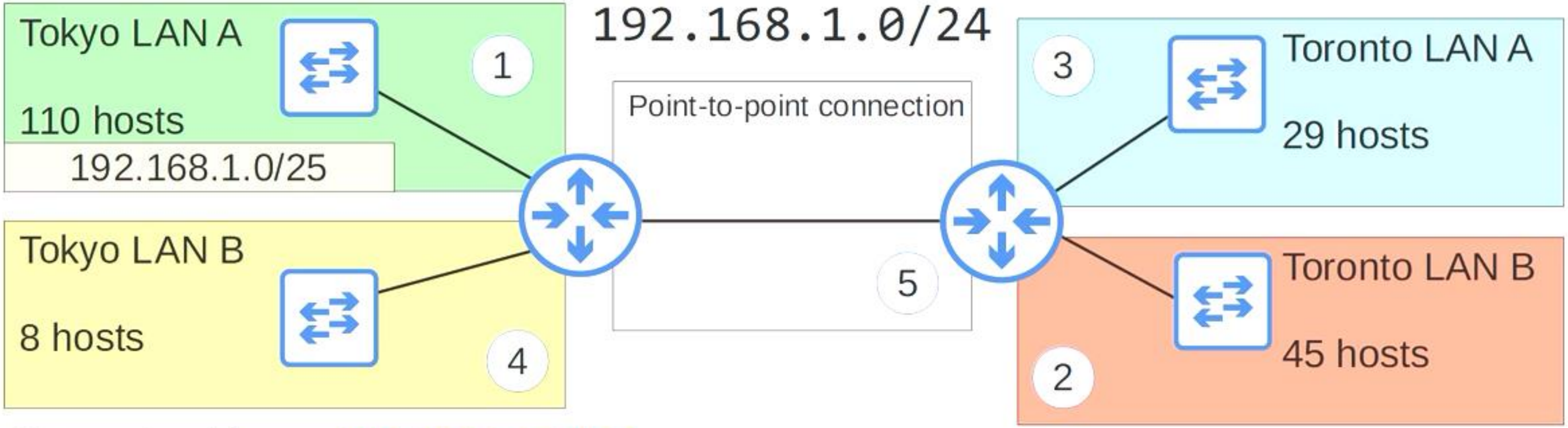
192.168.1.0/24



192.168.1.0/24

192.168.1.127 = broadcast address of Tokyo LAN A

192.168.1.128 = network address of Toronto LAN B



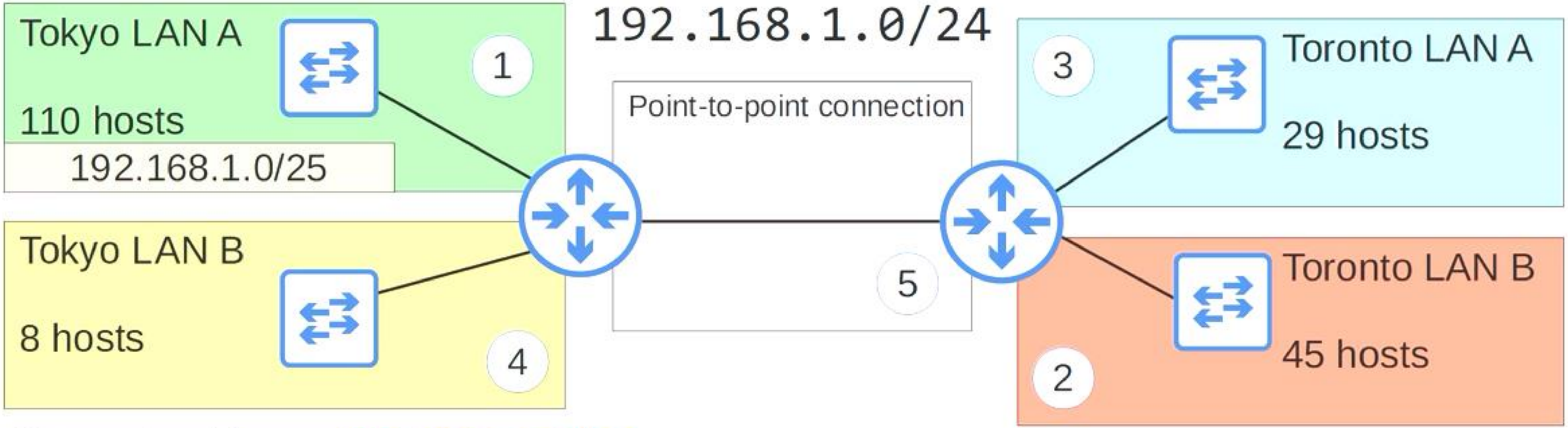
Network address: 192.168.1.128/??

Broadcast address:

First usable address:

Last usable address:

Total number of usable host addresses:



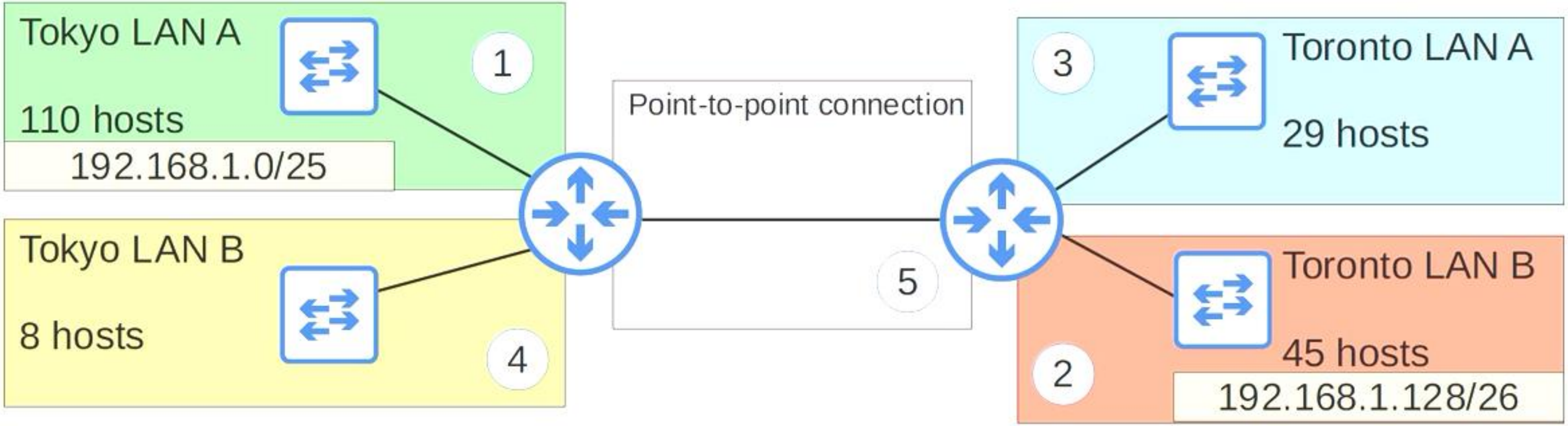
Network address: 192.168.1.128/26

Broadcast address: 192.168.1.191/26

First usable address: 192.168.1.129/26

Last usable address: 192.168.1.190/26

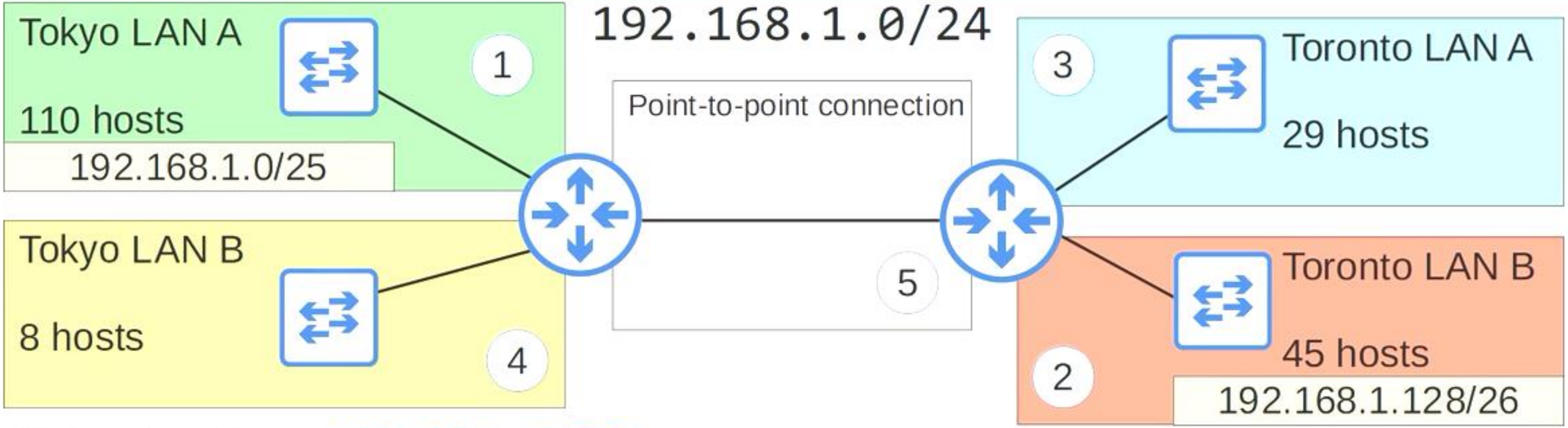
Total number of usable host addresses: 62



192.168.1.0/24

192.168.1.191 = broadcast address of Toronto LAN B

192.168.1.192 = network address of Toronto LAN A



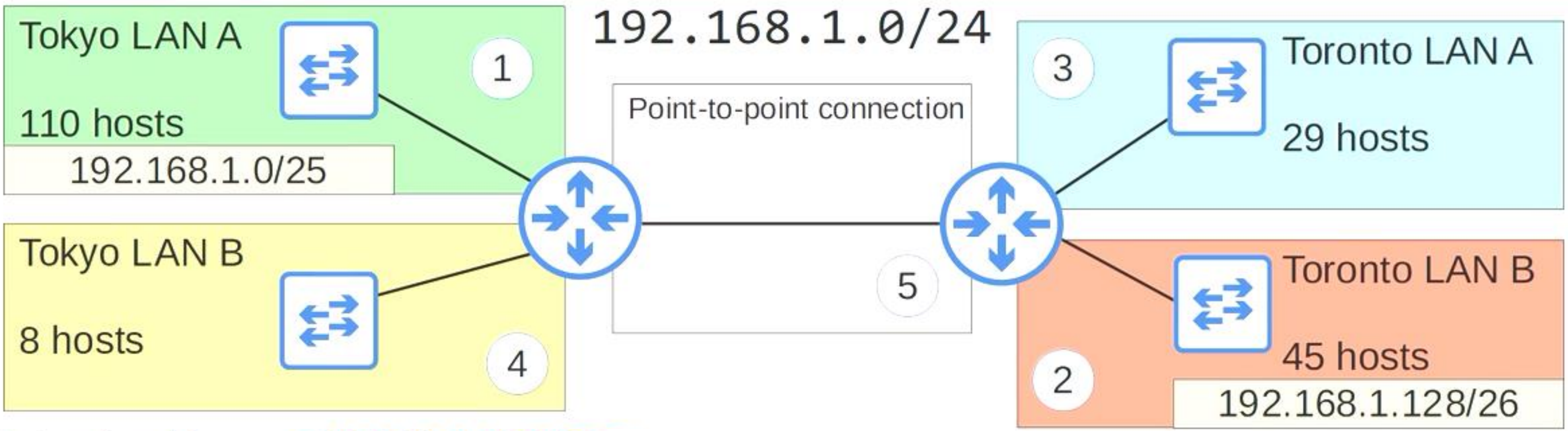
Network address: 192.168.1.192/??

Broadcast address:

First usable address:

Last usable address:

Total number of usable host addresses:



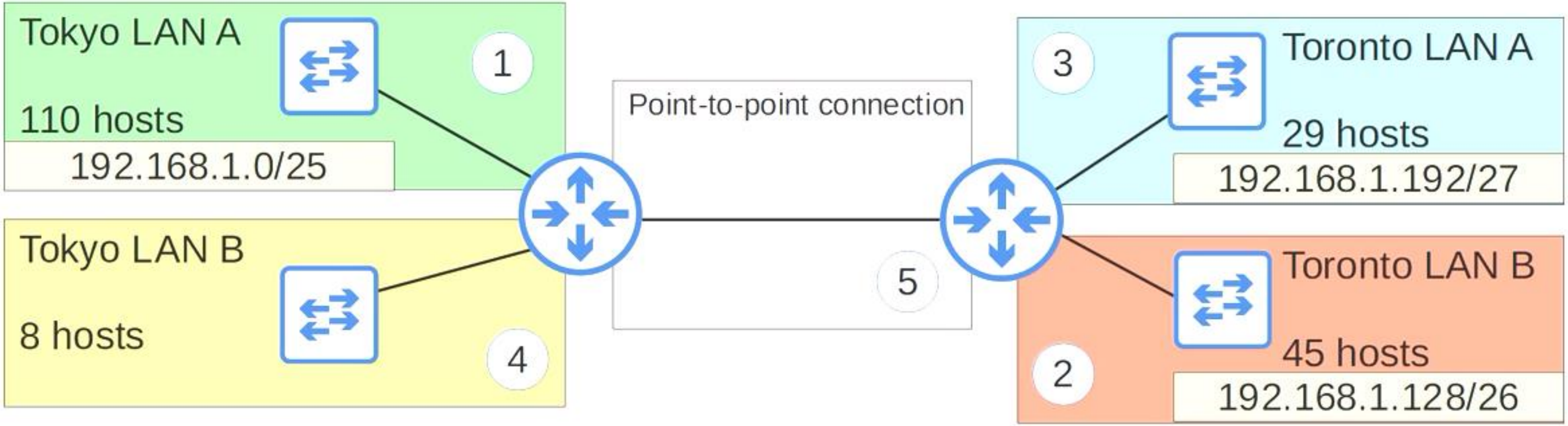
Network address: 192.168.1.192/27

Broadcast address: 192.168.1.223/27

First usable address: 192.168.1.193/27

Last usable address: 192.168.1.222/27

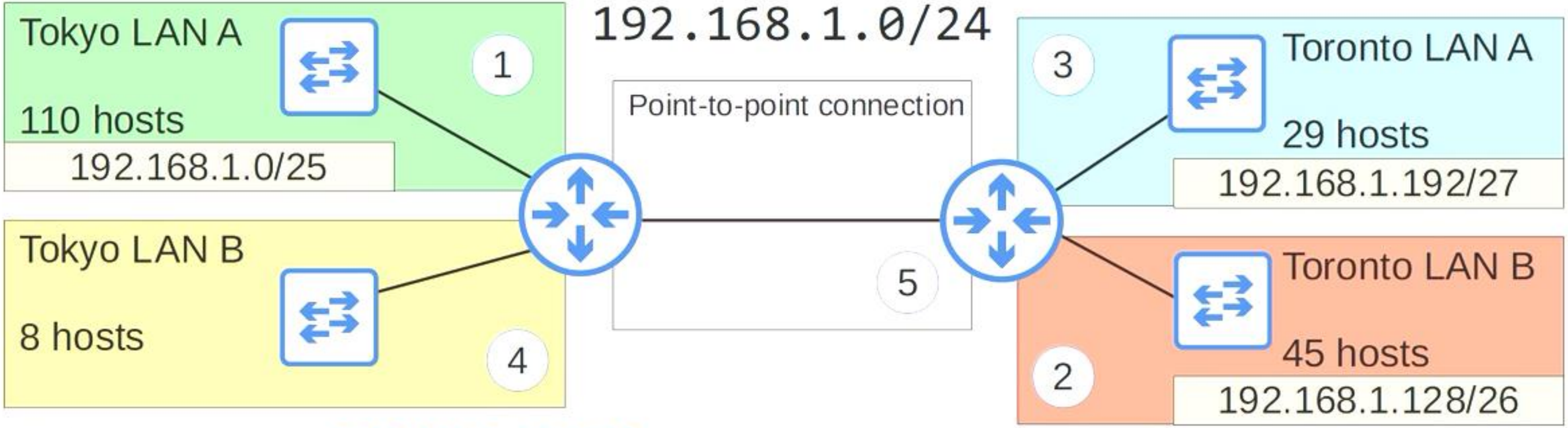
Total number of usable host addresses: 30



192.168.1.0/24

192.168.1.223 = broadcast address of Toronto LAN A

192.168.1.224 = network address of Tokyo LAN B



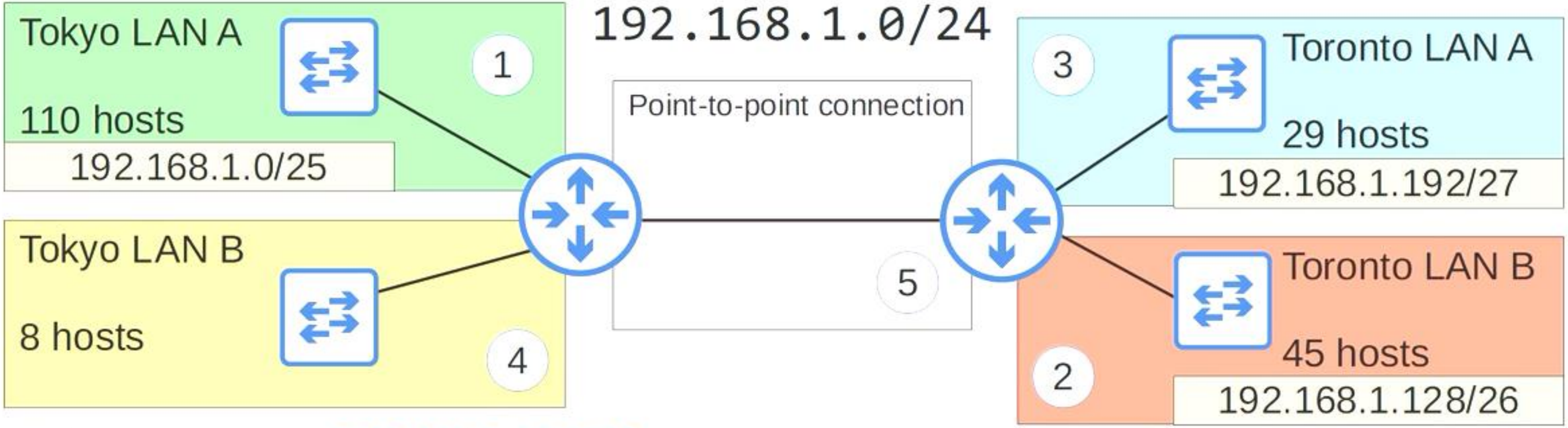
Network address: 192.168.1.224/??

Broadcast address:

First usable address:

Last usable address:

Total number of usable host addresses:



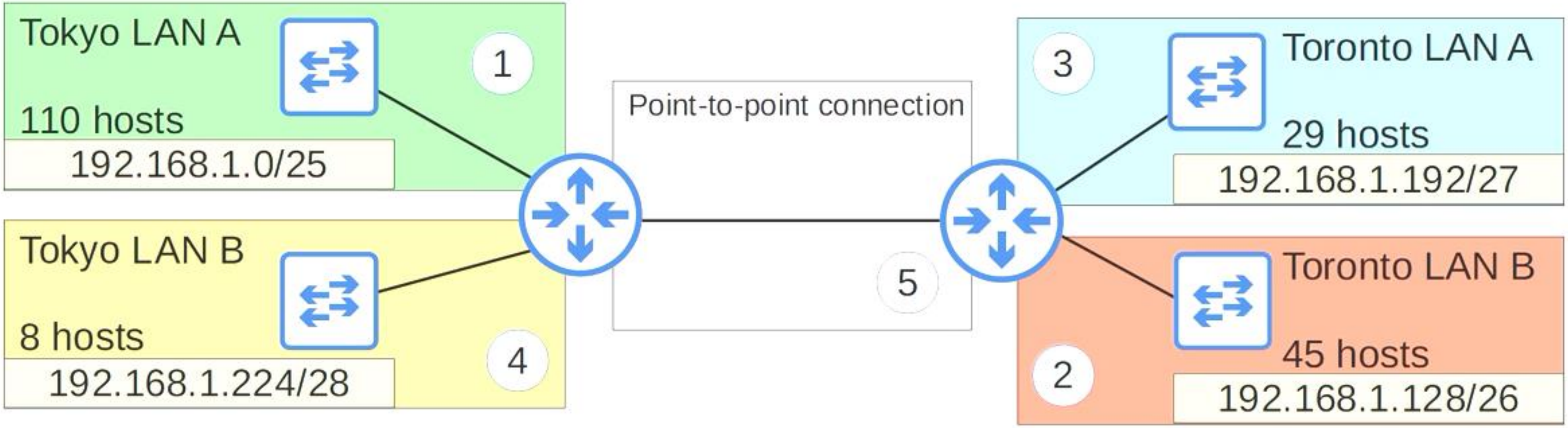
Network address: 192.168.1.224/28

Broadcast address: 192.168.1.239/28

First usable address: 192.168.1.225/28

Last usable address: 192.168.1.238/28

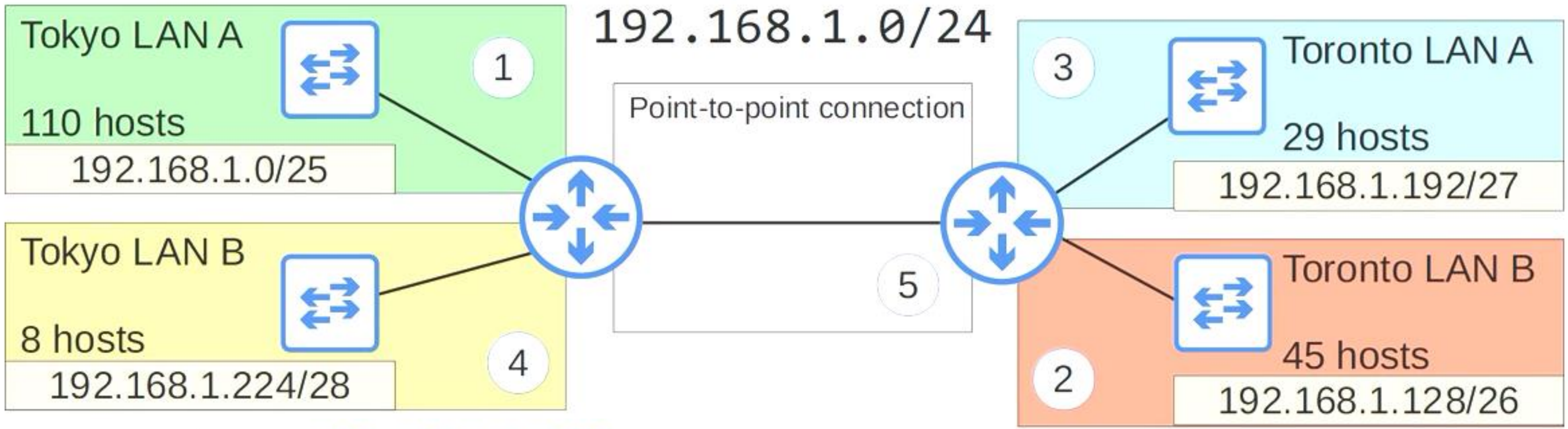
Total number of usable host addresses: 14



192.168.1.0/24

192.168.1.239 = broadcast address of Tokyo LAN B

192.168.1.240 = network address of point-to-point connection



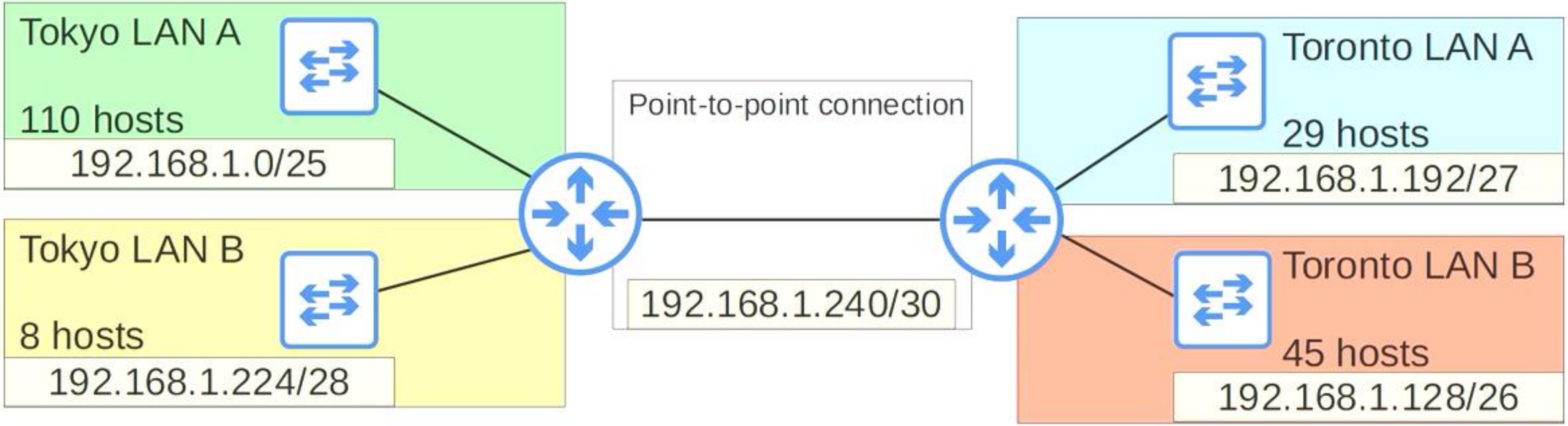
Network address: 192.168.1.240/30

Broadcast address: 192.168.1.243/30

First usable address: 192.168.1.241/30

Last usable address: 192.168.1.242/30

Total number of usable host addresses: 2


Tokyo LAN A
110 hosts
192.168.1.0/25
Tokyo LAN B
8 hosts
192.168.1.224/28
Point-to-point connection
192.168.1.240/30
Toronto LAN A
29 hosts
192.168.1.192/27
Toronto LAN B
45 hosts
192.168.1.128/26

192.168.1.0/24

Requirements:

1) Design a network with 3 Networks: Marketing, Sales, Management
2) Marketing requires 60 computers; Sales requires 100 computers
3) Management requires 34 computers

Requirements:

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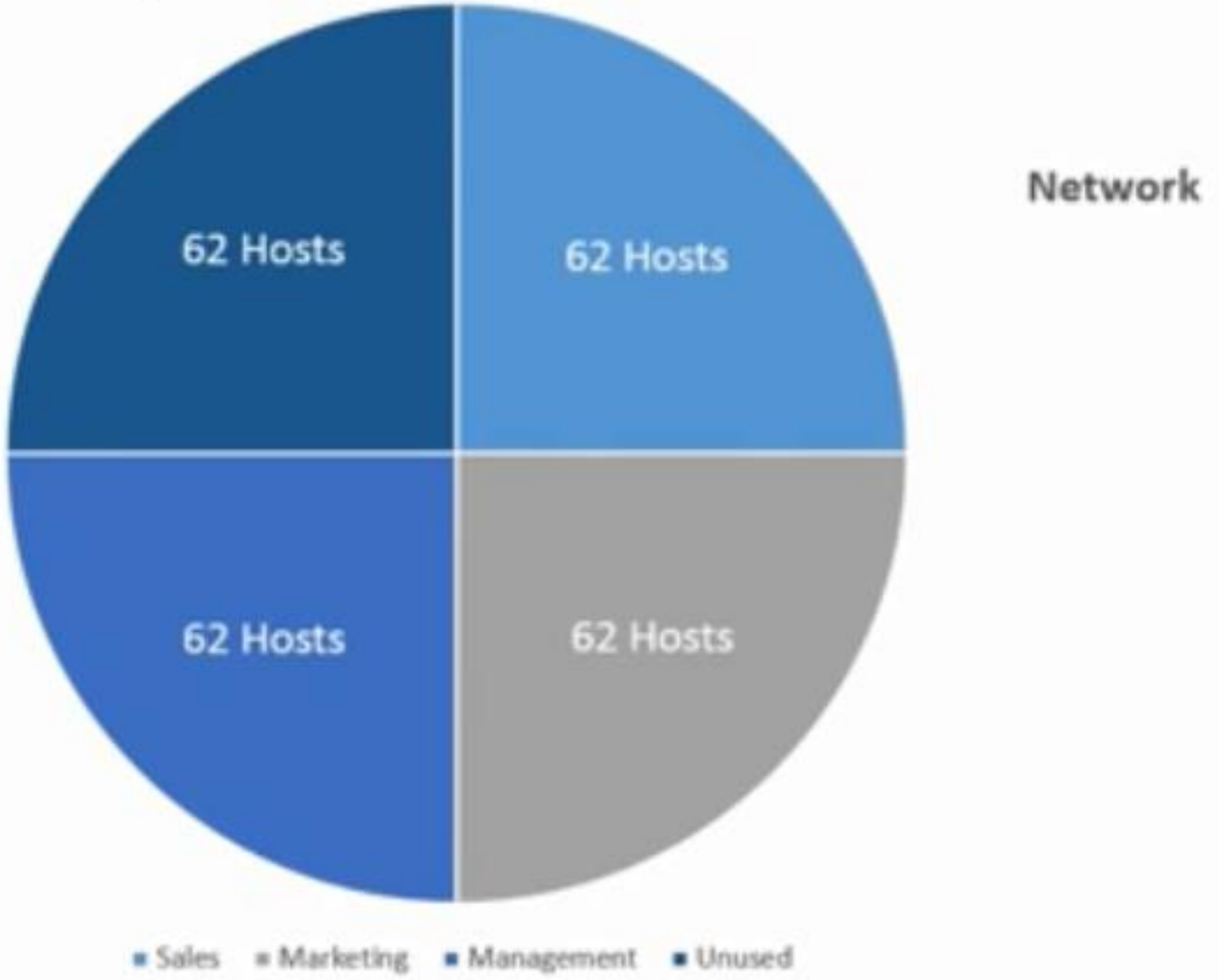

Requirements:

1) Design a network with 3 Networks: Marketing, Sales, Management
2) Marketing requires 60 computers; Sales requires 100 computers
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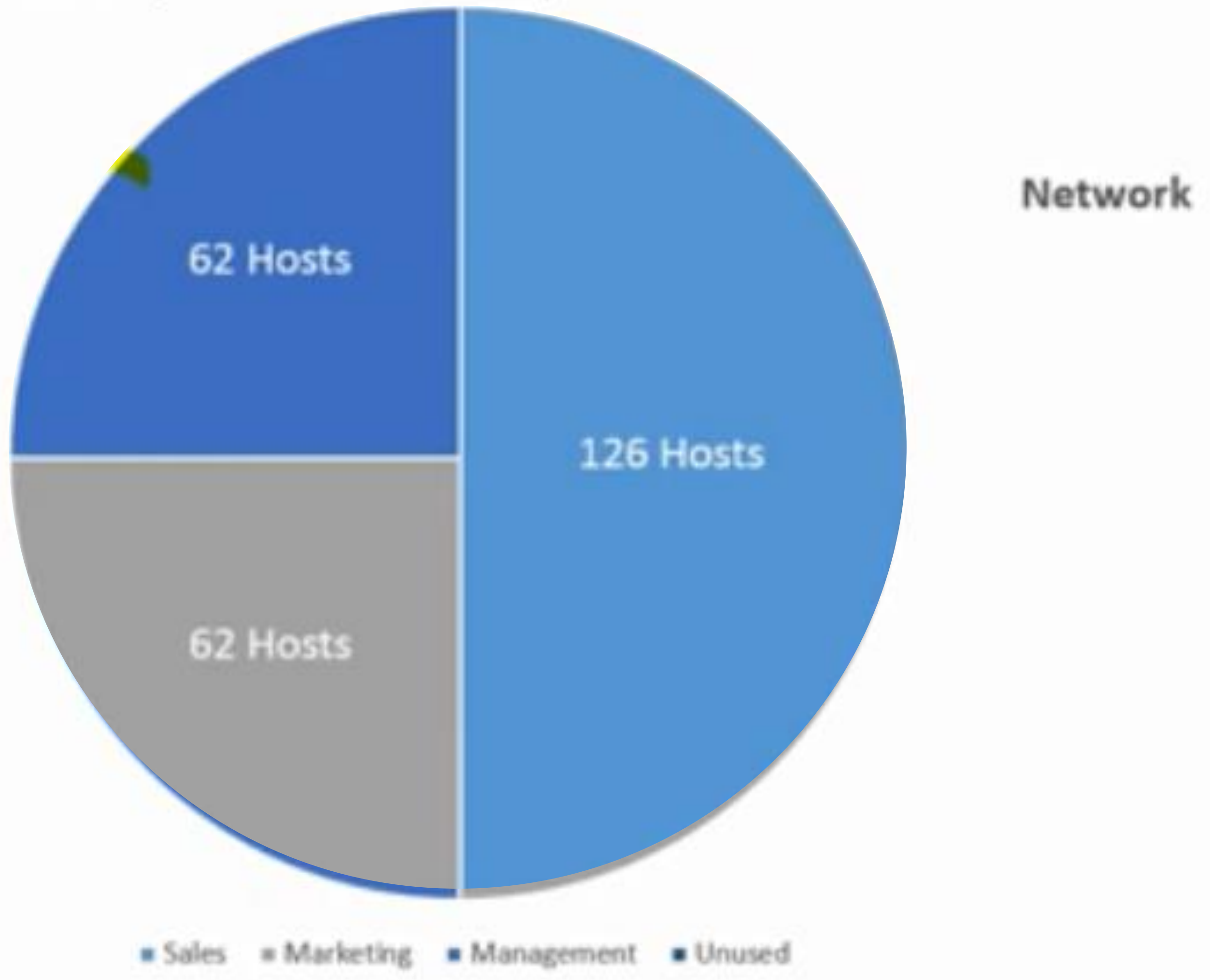
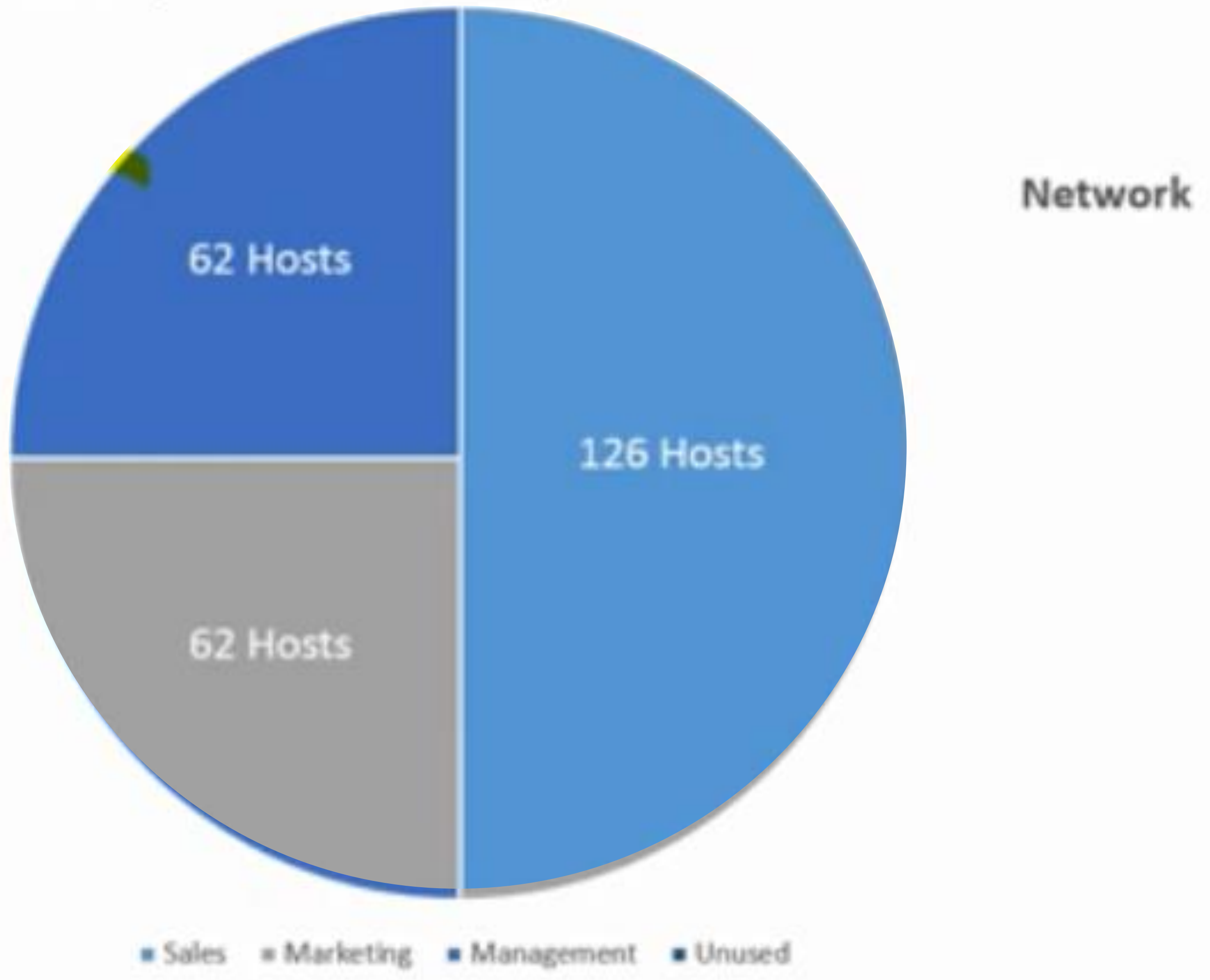


Requirements: **Variable Length Subnet Mask (VLSM)**

1) Design a network with 3 Networks: Marketing, Sales, Management
2) Marketing requires 60 computers; Sales requires 100 computers
3) Management requires 34 computers

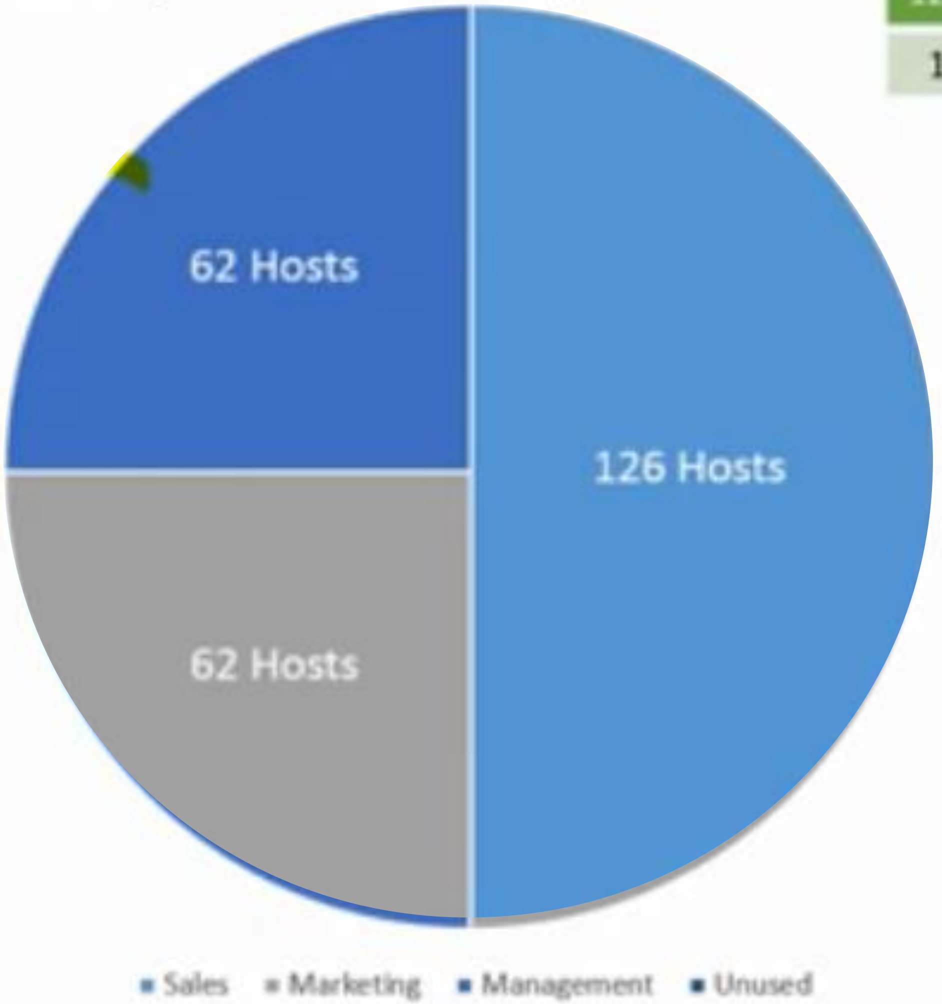


Requirements: **Variable Length Subnet Mask (VLSM)**

1) Design a network with 3 Networks: Marketing, Sales, Management
2) Marketing requires 60 computers; Sales requires 100 computers
3) Management requires 34 computers

128	64	32	16	8	4	2	1
1	0	0	0	0	0	0	0

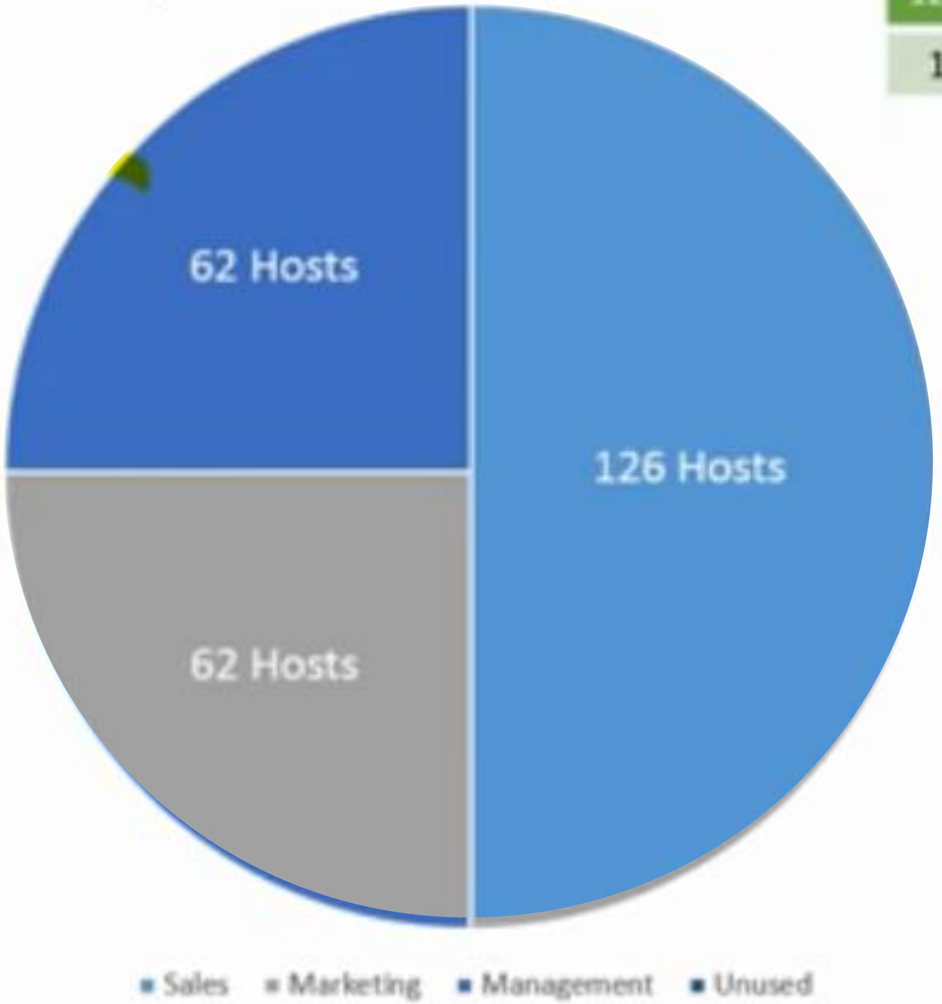
Network



Requirements: Variable Length Subnet Mask (VLSM)

1) Design a network with 3 Networks: Marketing, Sales, Management
2) Marketing requires 60 computers; Sales requires 100 computers
3) Management requires 34 computers

128	64	32	16	8	4	2	1
1	0	0	0	0	0	0	0



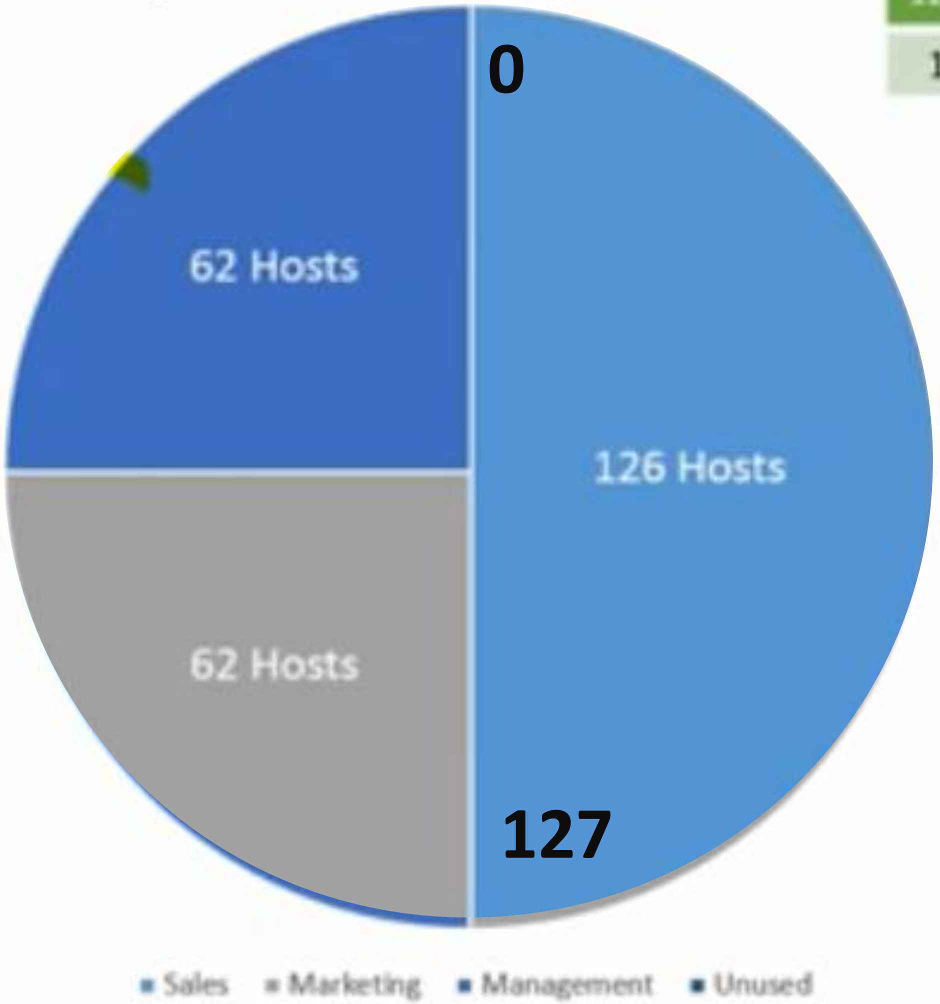
Network

Network ID: 192.168.1.0/25
Broadcast ID: 192.168.1.127/25

Requirements: **Variable Length Subnet Mask (VLSM)**

1) Design a network with 3 Networks: Marketing, Sales, Management
2) Marketing requires 60 computers; Sales requires 100 computers
3) Management requires 34 computers

128	64	32	16	8	4	2	1
1	0	0	0	0	0	0	0



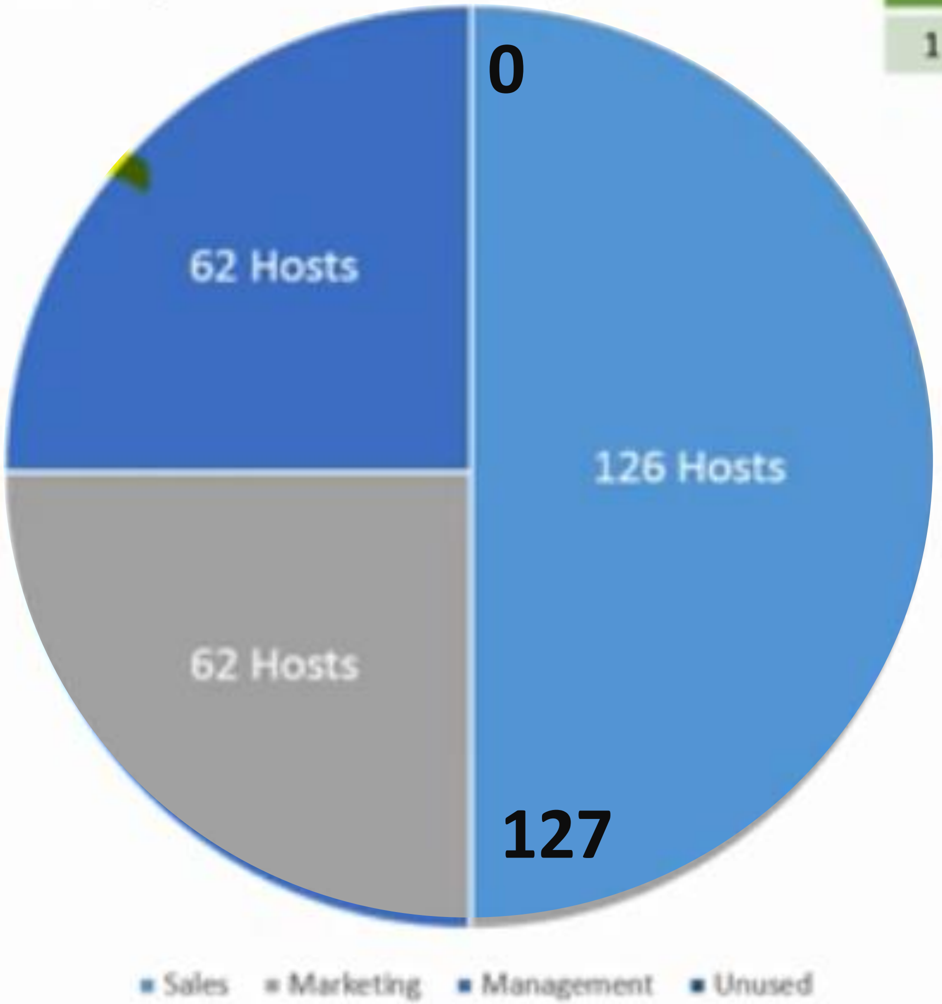
Network

Network ID: 192.168.1.0/25
Broadcast ID: 192.168.1.127/25

<u>Requirements:</u> Variable Length Subnet Mask (VLSM)

1) Design a network with 3 Networks: Marketing, Sales, Management
2) Marketing requires 60 computers; Sales requires 100 computers
3) Management requires 34 computers

128	64	32	16	8	4	2	1
1	1	0	0	0	0	0	0



Network

Network ID: 192.168.1.0/25
Broadcast ID: 192.168.1.127/25

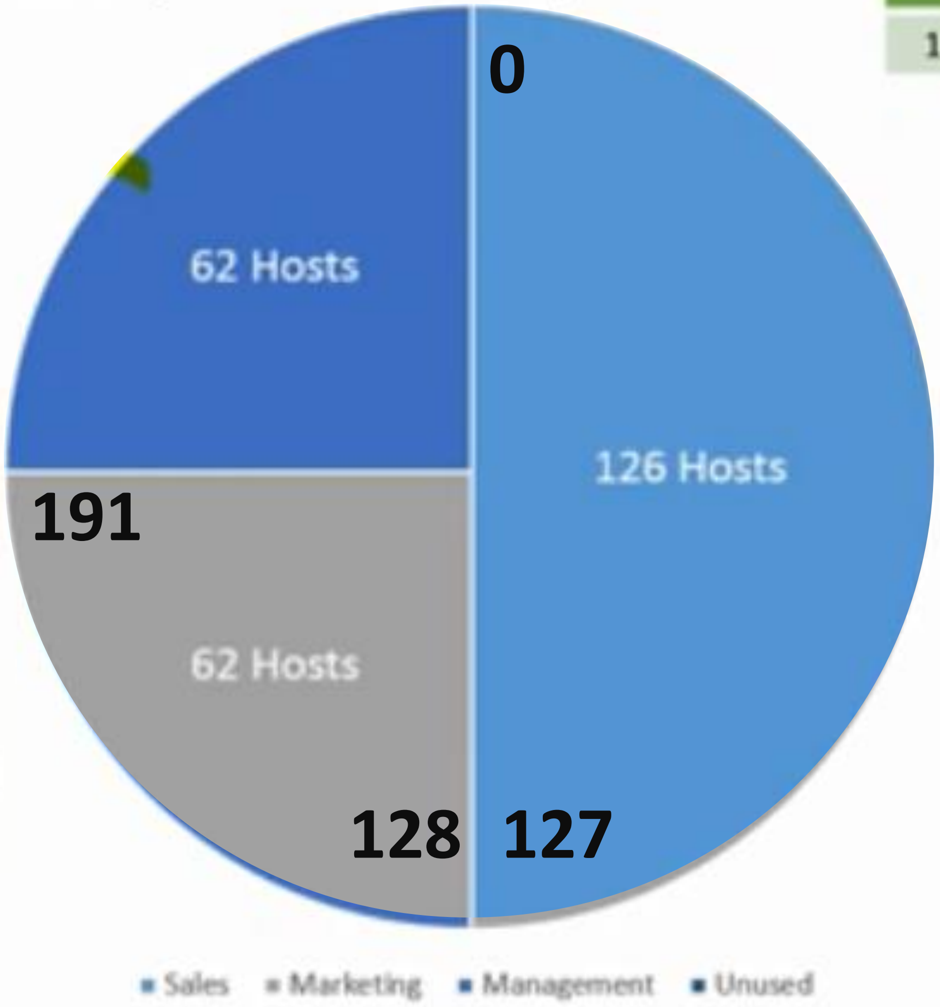
Requirements: **Variable Length Subnet Mask (VLSM)**

1) Design a network with 3 Networks: Marketing, Sales, Management
2) Marketing requires 60 computers; Sales requires 100 computers
3) Management requires 34 computers

128	64	32	16	8	4	2	1
1	1	0	0	0	0	0	0

Network

Network ID: 192.168.1.0/25
Broadcast ID: 192.168.1.127/25



Network ID: 192.168.1.128/26
Broadcast ID: 192.168.1.191/26

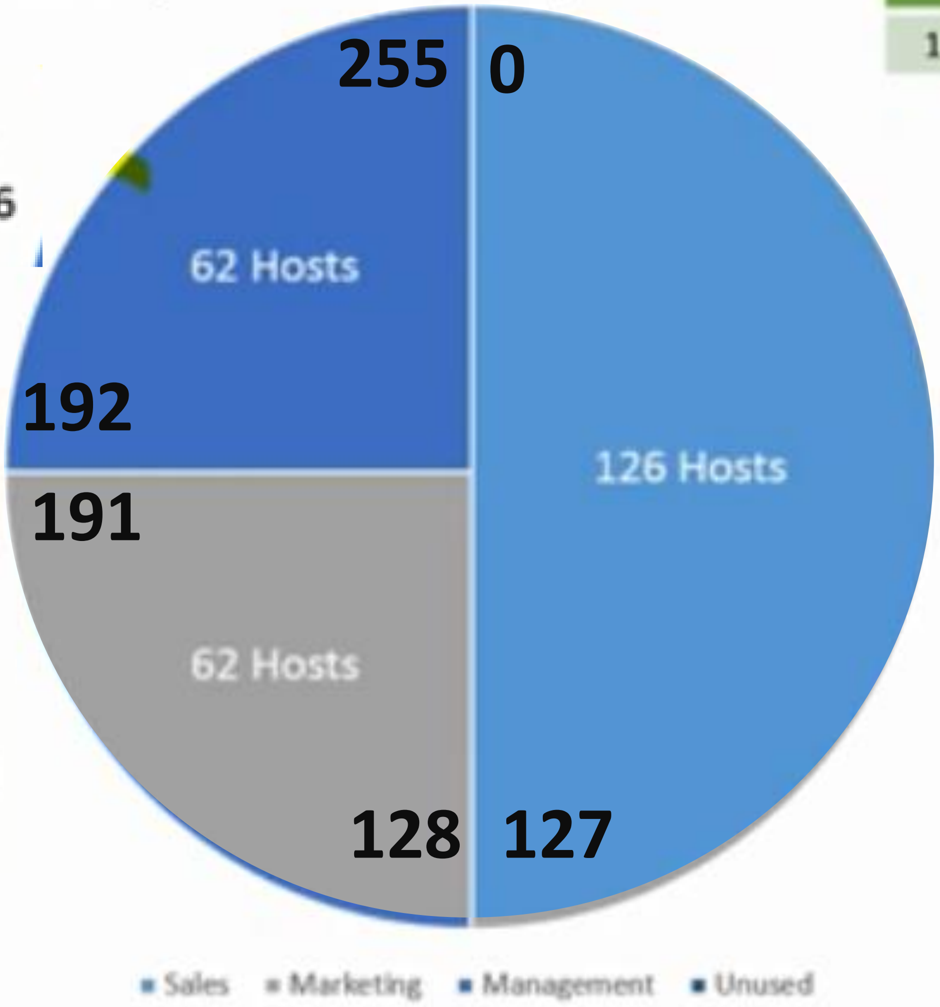
Requirements: Variable Length Subnet Mask (VLSM)

1) Design a network with 3 Networks: Marketing, Sales, Management
2) Marketing requires 60 computers; Sales requires 100 computers
3) Management requires 34 computers

128	64	32	16	8	4	2	1
1	1	0	0	0	0	0	0

Network

Network ID: 192.168.1.192/26
Broadcast ID: 192.168.1.255/26



Network ID: 192.168.1.0/25
Broadcast ID: 192.168.1.127/25

Network ID: 192.168.1.128/26
Broadcast ID: 192.168.1.191/26

	PUBLIC	PRIVATE
A	1.0.0.0 - 126.255.255.255 SUBNET: 255.0.0.0	10.0.0.0 - 10.255.255.255
B	128.0.0.0 - 191.255.255.255 SUBNET: 255.255.0.0	172.16.0.0 - 172.31.255.255
C	192.0.0.0 - 223.255.255.255 SUBNET: 255.255.255.0	192.168.0.0 - 192.168.255.255

Rules for assigning Host ID:

- Host ID’s are used to identify a host within a network. The host ID are assigned based on the following rules:
    - Within any network, the host ID must be unique to that network.
    - Host ID in which all bits are set to 0 cannot be assigned because this host ID is used to represent the network ID of the IP address.
    - Host ID in which all bits are set to 1 cannot be assigned because this host ID is reserved as a broadcast address to send packets to all the hosts present on that particular network.

Rules for assigning Network ID:

- Hosts that are located on the same physical network are identified by the network ID, as all host on the same physical network is assigned the same network ID. The network ID is assigned based on the following rules:
  - The network ID cannot start with 127 because 127 belongs to class A address and is reserved for internal loop-back functions.
  - All bits of network ID set to 1 are reserved for use as an IP broadcast address and therefore, cannot be used.
  - All bits of network ID set to 0 are used to denote a specific host on the local network and are not routed and therefore, aren’t used.

Subnetting for Class B network

The range of ip address in a class B network is from 128.0.0.0 to 191.255.255.255. The subnet mask is fixed 255.255.0.0 for a classfull class B IP address. In this IP address we have only 16 bits for host. For creating subnetting we have only 16 bits to manipulate.

A /16 Class B network

Network ID		Host ID	
11111111	**11111111**	**00000000**	**00000000**
255	255	0	0

To create subnet we need to take borrow from host ID to network ID

Denoting the IP address for subnetting

Here we denote the subnet mask by a fix number. We know that subnet mask is or 32 bits. When we assign subnet mask to a host we write full figure like “255.0.0.0”, “255.255.0.0” etc. Actually 1 bits denote the network ID only and remaining 0 bits used for host ID. We can write the **subnet mask 255.0.0.0 like /8**. **the subnet mask 255.255.0.0 as /16** . the subnet mask **255.255.255.0 like /24**. Here the number after / shows the on bits for network ID. These numbers known as CIDR.

In class B the subnet is 255.255.0.0 or we can say /16. Here first 16 bits remain on always. We have only remaining 16 bits for creating subnetting. So the subnets will be /17 , /18 , /19 , /20 etc. For each subnet the number of Hosts became less. For /17 subnet we have on 15 bits for hosts. Keep in mind that total number of network and hosts always remains 32.

Factors to know before creating subnetting

1. **The number of subnets required**. How many networks you want to create. In a subnet mask the masked bits are use to know the subnets. For example in a class B address for /17 mask we have 1 bit on and remaining 15 bits are available for hosts. Here number of subnets is $2^1=2$. It means if we use first bit of host we can create 2 subnets. Similarly for a /18 mask we have 2 bits masked. For /18 we have $2^2=4$ subnets.

2. **The numbers of hosts in each subnet**. In above para you know the valid subnets by using the masked bits. Similarly to know the numbers of hosts in each subnet can be calculated by using hosts bits. For example for a /17 mask we have only 15 bits for hosts. So here the numbers of hosts ID is $2^{15}=32768$. we have to leave 2 ID for network ID and broadcast ID. So in a /17 mask $2^{15}-2= 32766$ hosts per subnet are available.

3. **The numbers of valid subnets known as block size**. A simple formula is used to get the valid subnets or block size is 256-subnet mask= valid subnets. For a mask /17 the decimal value is “255.255.128.0”. Here the block size will be 256-128=128. So the block size of a /17 mask is 128.

4. **The number of valid hosts in each subnet**. The simple formula to know the valid host in a subnet is Block size-2= valid hosts. In a 32768 block size the valid hosts are only 32766 in each subnet. Remaining 2 ID will be used for subnet ID and Broadcast ID.

5. **The broadcast address or each subnet**. The last address in each subnet will be broadcast address. For a /17 mask the first broadcast address is 127.255.

Subnetting of Class B /17 network

- It is clear that a /17 mask provides remaining 15 bits for host ID and first bit is reserved for network. Out of 15 bits last octate bits remain unchanged. The third octate of /17 is like 10000000 the subnet mask looks like 255.255.128.0. Calculate the five terms discussed above for /17 masked network. Number of subnets are 2^1=2.
- It means there will be only two subnets created by class B /17 mask. Number of hosts per subnet are 215-2=32766 . The valid subnets or block size is 256-128=128. The valid subnet Id are 0.0 and 128.0 here. The broadcast ID for each subnet is the last ID of subnet. Here for first block the broadcast ID is 127.255 and for second block broadcast ID is 255.255. conclusion for /17 mask subnetting is that /17 subnet have two blocks.

	Block 1 or subnet 1	Block 2 or subnet 2
Subnet ID	0.0	128.0
First host ID	1.1	129.1
Last host ID	127.254	255.254
Broadcast ID	127.255	255.255

Subnetting of Class B /18 network

- It is clear that a /18 mask provides remaining 14 bits for host ID and first 2 bits are reserved for network. The third octate of /18 is like 11000000 the subnet mask looks like 255.255.192.0. The calculation for /18 masked network. Number of subnets are 2^2=4. It means there will be only 4 subnets created by /18 mask. Number of hosts per subnet are 2^{14}-2=16384.
- The valid subnets or block size is 256-192=64. The valid subnet Id are 0.0,64.0,128.0 and 192.0 here. The broadcast ID for each subnet is the last ID of subnet. Here for first block the broadcast ID is 63.255 and for second block broadcast ID is 127.255 for last block 255.255. conclusion for /18 mask subnetting is that /18 subnet have four blocks.

Subnetting of Class B /18 network

- It is clear that a /18 mask provides remaining 14 bits for host ID and first 2 bits are reserved for network. The third octate of /18 is like 11000000 the subnet mask looks like 255.255.192.0. The calculation for /18 masked network. Number of subnets are 2^2=4. It means there will be only 4 subnets created by /18 mask. Number of hosts per subnet are 2^{14}-2=16384.
- The valid subnets or block size is 256-192=64. The valid subnet Id are 0.0,64.0,128.0 and 192.0 here. The broadcast ID for each subnet is the last ID of subnet. Here for first block the broadcast ID is 63.255 and for second block broadcast ID is 127.255 for last block 255.255. conclusion for /18 mask subnetting is that /18 subnet have four blocks.

	Block 1 or subnet 1	Block 2 or subnet 2	Block 3 or subnet 3	Block 4 or subnet 4
Subnet ID	0.0	64.0	128.0	192.0
First host ID	0.1	64.1	128.1	192.1
Last host ID	63.254	127.254	191.254	255.254
Broadcast ID	63.255	127.255	191.255	255.255

Class	Leading bits	Size of *network number* bit field	Size of *rest* bit field	Number of networks	Addresses per network
Class A	0	8	24	128 (2^7)	16,777,216 (2^{24})
Class B	10	16	16	16,384 (2^{14})	65,536 (2^{16})
Class C	110	24	8	2,097,152 (2^{21})	256 (2^8)

You have been given the 172.16.0.0/16 network. You are asked to create 80 subnets for your company’s various LANs. What prefix length should you use?

```
172.16.0.0/16
```

1 0 1 0 1 1 0 0 . 0 0 0 1 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

172 . 16 . 0 . 0

Borrowing 1 bit = 2 subnets

Subnet mask:

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

255 . 255 . 128 . 0

1 0 1 0 1 1 0 0 . 0 0 0 1 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

172 . 16 . 0 . 0

Borrowing 2 bits = 4 subnets

Subnet mask:

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

255 . 255 . 192 . 0

Subnetting Class B Networks

/23

1 0 1 0 1 1 0 0 . 0 0 0 1 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

172 . 16 . 0 . 0

Borrowing 7 bits = 128 subnets

Subnet mask:

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 0 . 0 0 0 0 0 0 0 0

255 . 255 . 254 . 0

You have been given the 172.22.0.0/16 network. You are required to divide the network into 500 separate subnets. What prefix length should you use?

172.22.0.0/16

You have been given the 172.22.0.0/16 network. You are required to divide the network into 500 separate subnets. What prefix length should you use?

Subnetting Class B Networks

/25

1 0 1 0 1 1 0 0 . 0 0 0 1 0 1 1 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

172 . 22 . 0 . 0

Borrowing 9 bits = 512 subnets

You have been given the 172.18.0.0/16 network. Your company requires 250 subnets with the same number of hosts per subnet. What prefix length should you use?

172.18.0.0/16

Subnetting Class B Networks

/24

1 0 1 0 1 1 0 0 . 0 0 0 1 0 0 1 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

172 . 18 . 0 . 0

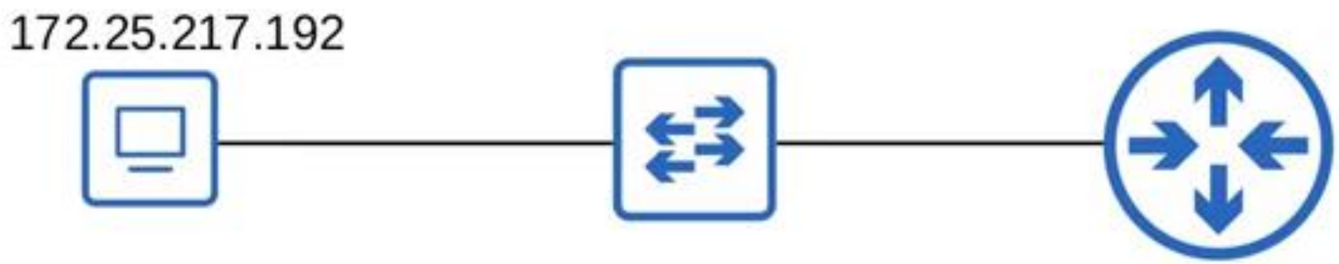
Borrowing 8 bits = 256 subnets

8 host bits = 254 hosts per subnet

Identify the subnet

What subnet does host **172.25.217.192/21** belong to?

Subnet ID: ______________/21



1 0 1 0 1 1 0 0 . 0 0 0 1 1 0 0 1 . 1 1 0 1 1 0 0 1 . 1 1 0 0 0 0 0 0

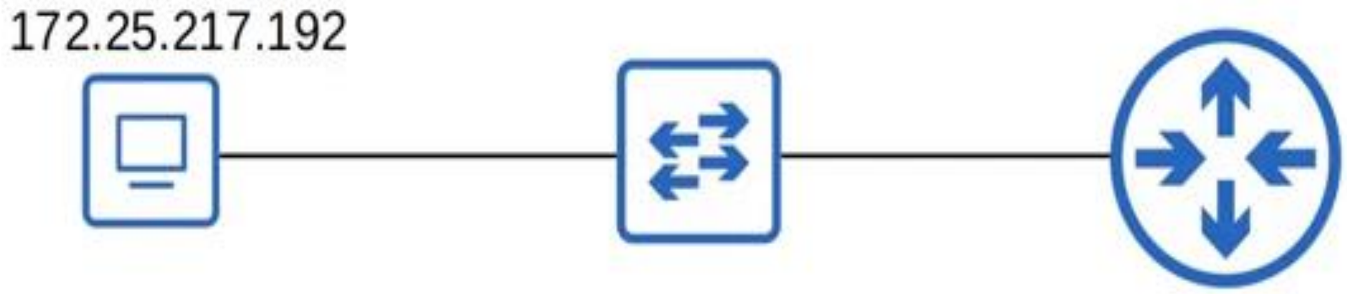
172 . 25 . 217 . 192

1 0 1 0 1 1 0 0 . 0 0 0 1 1 0 0 1 . 1 1 0 1 1 0 0 0 . 0 0 0 0 0 0 0 0

172 . 25 . 216 . 0

What subnet does host **172.25.217.192/21** belong to?

Subnet ID: _172.25.216.0_ /21



You have been given the 172.30.0.0/16 network. Your company requires 100 subnets with at least 500 hosts per subnet. What prefix length should you use?

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Borrowed bits:	1	2	3	4	5	6	7
Num. of subnets:	2	4	8	16	32	64	128

QUIZ QUESTION 1

/23

1 0 1 0 1 1 0 0 . 0 0 0 1 1 1 1 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

172 . 30 . 0 . 0

Subnet mask:

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 0 . 0 0 0 0 0 0 0 0

255 . 255 . 254 . 0

QUIZ QUESTION 1

/23

1 0 1 0 1 1 0 0 . 0 0 0 1 1 1 1 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

172 . 30 . 0 . 0

9 host bits = 2^9- 2 = 510 usable addresses

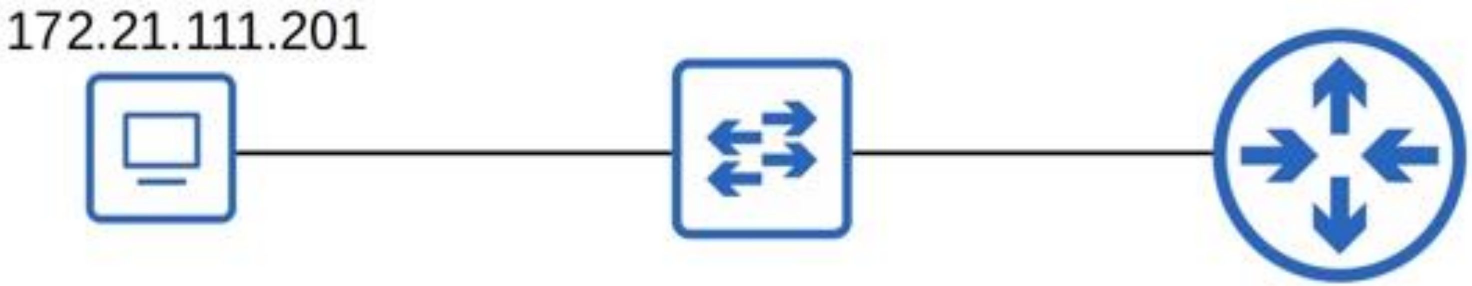
Subnet mask:

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 0 . 0 0 0 0 0 0 0 0

255 . 255 . 254 . 0

What subnet does host **172.21.111.201/20** belong to?

Subnet ID: ______________/20



What subnet does host **172.21.111.201/20** belong to?

```
1 0 1 0 1 1 0 0 . 0 0 0 1 0 1 0 1 . 0 1 1 0 1 1 1 1 . 1 1 0 0 1 0 0 1
      172       .       21        .       111       .       201

1 0 1 0 1 1 0 0 . 0 0 0 1 0 1 0 1 . 0 1 1 0 0 0 0 0 . 0 0 0 0 0 0 0 0
      172       .       21        .        96       .        0
```

What subnet does host **172.21.111.201/20** belong to?