Unit-6

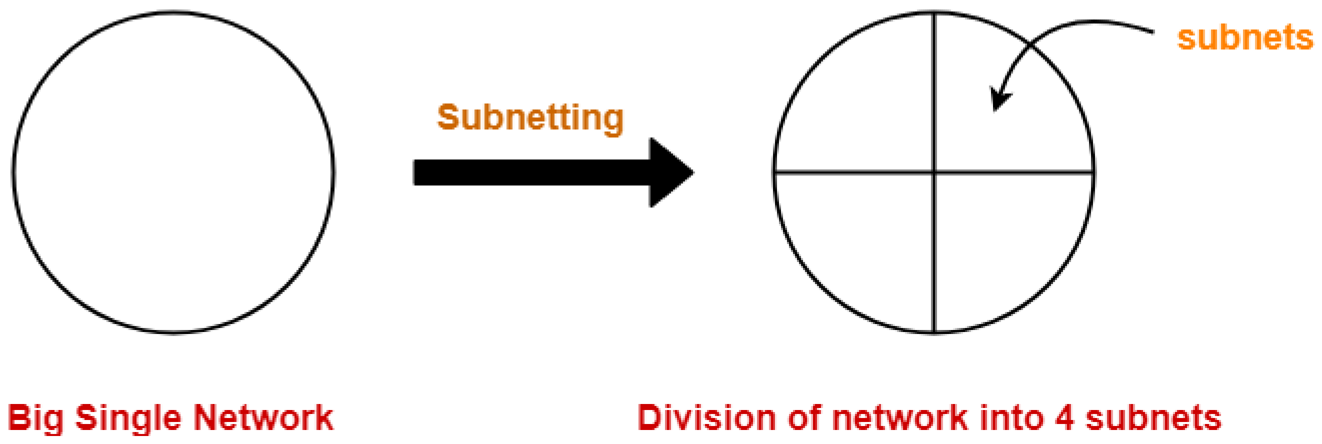
Subnetting

In networking,

- The process of dividing a single network into multiple sub networks is called as **subnetting**.
- The sub networks so created are called as **subnets**.

Example-

Following diagram shows the subnetting of a big single network into 4 smaller subnets-



Advantages-

The two main advantages of subnetting a network are-

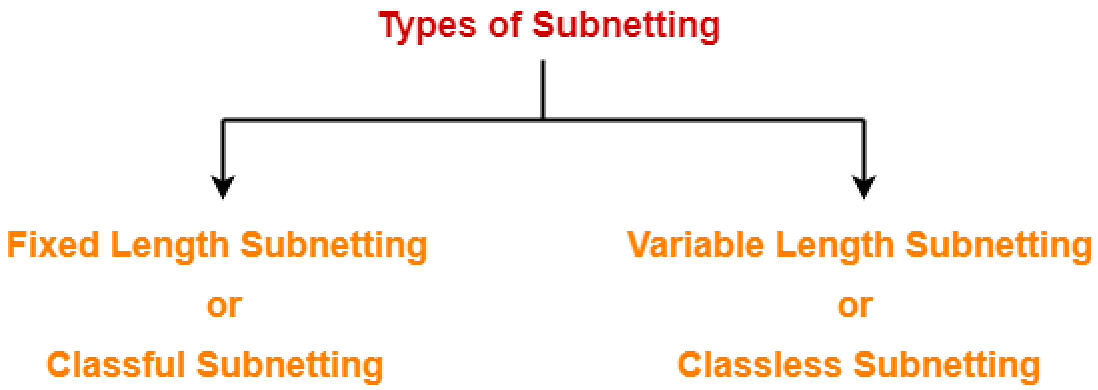
- It improves the security.
- The maintenance and administration of subnets is easy.

Subnet ID-

- Each subnet has its unique network address known as its **Subnet ID**.
- The subnet ID is created by borrowing some bits from the Host ID part of the IP Address.
- The number of bits borrowed depends on the number of subnets created.

Types of Subnetting-

Subnetting of a network may be carried out in the following two ways-



1. Fixed Length Subnetting
2. Variable Length Subnetting

1. Fixed Length Subnetting-

Fixed length subnetting also called as **classful subnetting** divides the network into subnets where-

- All the subnets are of same size.
- All the subnets have equal number of hosts.
- All the subnets have same subnet mask.

2. Variable Length Subnetting-

Variable length subnetting also called as **classless subnetting** divides the network into subnets where-

- All the subnets are not of same size.
- All the subnets do not have equal number of hosts.
- All the subnets do not have same subnet mask.

Subnetting Examples-

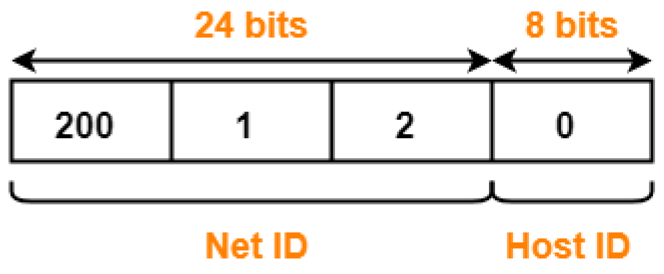
Now, we shall discuss some examples of subnetting a network-

Example-01:

Consider-

- We have a big single network having IP Address 200.1.2.0.
- We want to do subnetting and divide this network into 2 subnets.

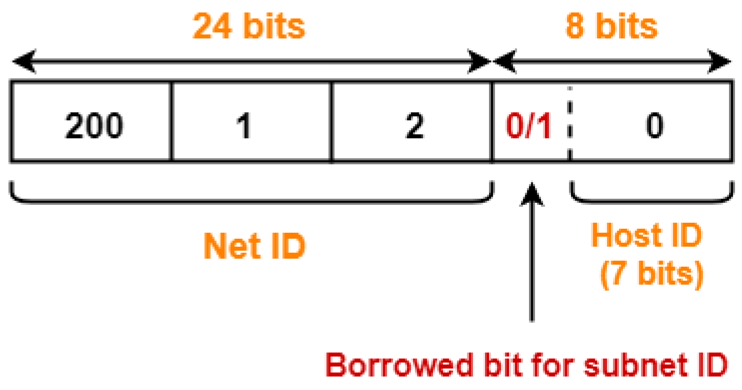
Clearly, the given network belongs to class C.



For creating two subnets and to represent their subnet IDs, we require 1 bit.

So,

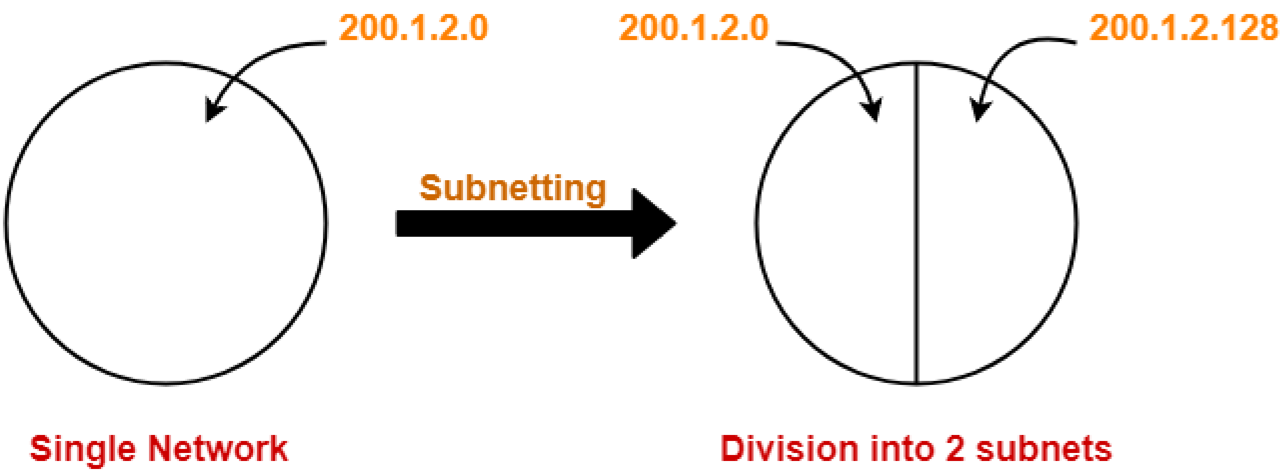
- We borrow one bit from the Host ID part.
- After borrowing one bit, Host ID part remains with only 7 bits.



- If borrowed bit = 0, then it represents the first subnet.
- If borrowed bit = 1, then it represents the second subnet.

IP Address of the two subnets are-

- 200.1.2.**0**0000000 = 200.1.2.0
- 200.1.2.**1**0000000 = 200.1.2.128



For 1st Subnet-

- IP Address of the subnet = 200.1.2.0
- Total number of IP Addresses = 2^7 = 128
- Total number of hosts that can be configured = 128 – 2 = 126
- Range of IP Addresses = [200.1.2.**0**0000000, 200.1.2.**0**1111111] = [200.1.2.0, 200.1.2.127]
- Direct Broadcast Address = 200.1.2.**0**1111111 = 200.1.2.127
- Limited Broadcast Address = 255.255.255.255

For 2nd Subnet-

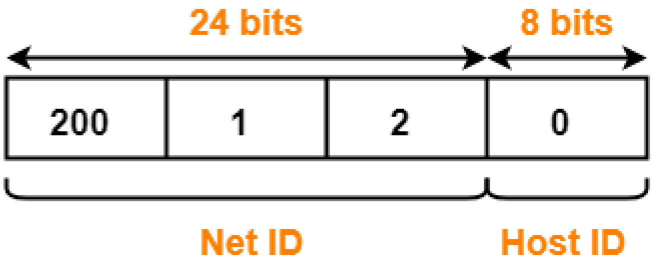
- IP Address of the subnet = 200.1.2.128
- Total number of IP Addresses = 2^7 = 128
- Total number of hosts that can be configured = 128 – 2 = 126
- Range of IP Addresses = [200.1.2.**1**0000000, 200.1.2.**1**1111111] = [200.1.2.128, 200.1.2.255]
- Direct Broadcast Address = 200.1.2.**1**1111111 = 200.1.2.255
- Limited Broadcast Address = 255.255.255.255

Example-02:

Consider-

- We have a big single network having IP Address 200.1.2.0.
- We want to do subnetting and divide this network into 4 subnets.

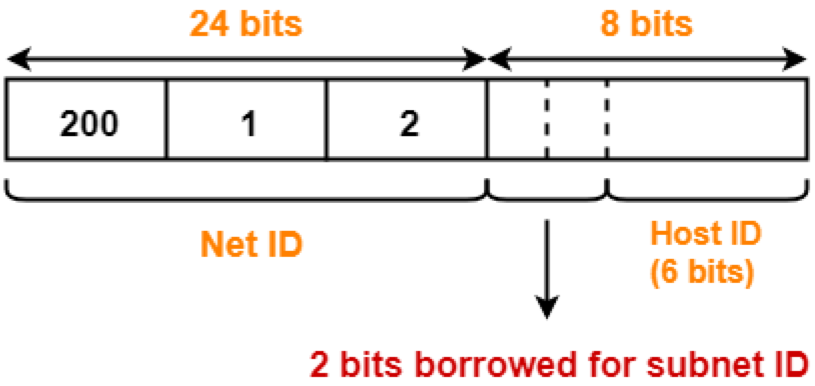
Clearly, the given network belongs to class C.



For creating four subnets and to represent their subnet IDs, we require 2 bits.

So,

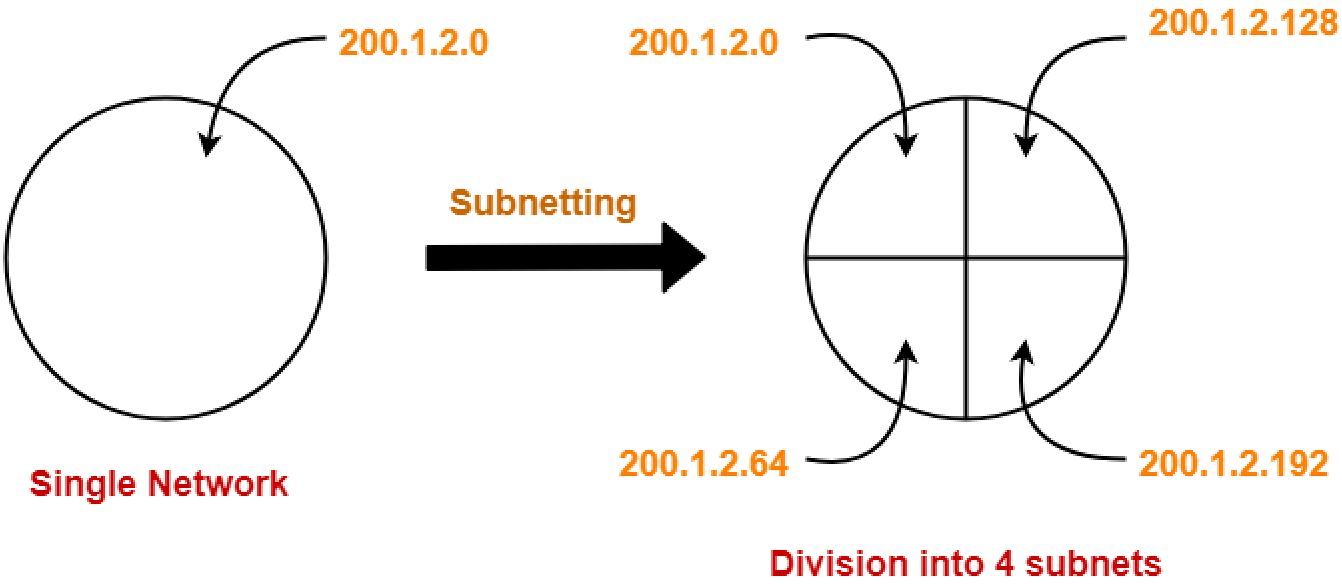
- We borrow two bits from the Host ID part.
- After borrowing two bits, Host ID part remains with only 6 bits.



- If borrowed bits = 00, then it represents the 1st subnet.
- If borrowed bits = 01, then it represents the 2nd subnet.
- If borrowed bits = 10, then it represents the 3rd subnet.
- If borrowed bits = 11, then it represents the 4th subnet.

IP Address of the four subnets are-

- 200.1.2.**00**000000 = 200.1.2.0
- 200.1.2.**01**000000 = 200.1.2.64
- 200.1.2.**10**000000 = 200.1.2.128
- 200.1.2.**11**000000 = 200.1.2.192



For 1st Subnet-

- IP Address of the subnet = 200.1.2.0
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.**00**000000, 200.1.2.**00**111111] = [200.1.2.0, 200.1.2.63]
- Direct Broadcast Address = 200.1.2.**00**111111 = 200.1.2.63
- Limited Broadcast Address = 255.255.255.255

For 2nd Subnet-

- IP Address of the subnet = 200.1.2.64
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.**01**000000, 200.1.2.**01**111111] = [200.1.2.64, 200.1.2.127]
- Direct Broadcast Address = 200.1.2.**01**111111 = 200.1.2.127
- Limited Broadcast Address = 255.255.255.255

For 3rd Subnet-

- IP Address of the subnet = 200.1.2.128
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.**10**000000, 200.1.2.**10**111111] = [200.1.2.128, 200.1.2.191]

- Direct Broadcast Address = 200.1.2.**10**111111 = 200.1.2.191
- Limited Broadcast Address = 255.255.255.255

For 4th Subnet-

- IP Address of the subnet = 200.1.2.192
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.**11**000000, 200.1.2.**11**111111] = [200.1.2.192, 200.1.2.255]
- Direct Broadcast Address = 200.1.2.**11**111111 = 200.1.2.255
- Limited Broadcast Address = 255.255.255.255

Example-03:

Consider-

- We have a big single network having IP Address 200.1.2.0.
- We want to do subnetting and divide this network into 3 subnets.

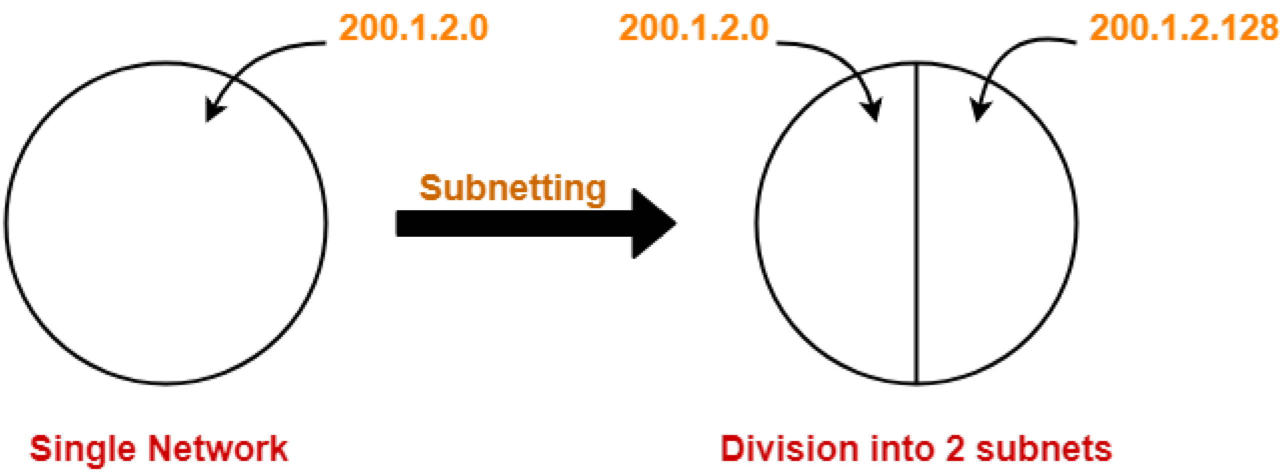
Here, the subnetting will be performed in two steps-

1. Dividing the given network into 2 subnets
2. Dividing one of the subnets further into 2 subnets

Step-01: Dividing Given Network into 2 Subnets-

The subnetting will be performed exactly in the same way as performed in Example-01.

After subnetting, we have-



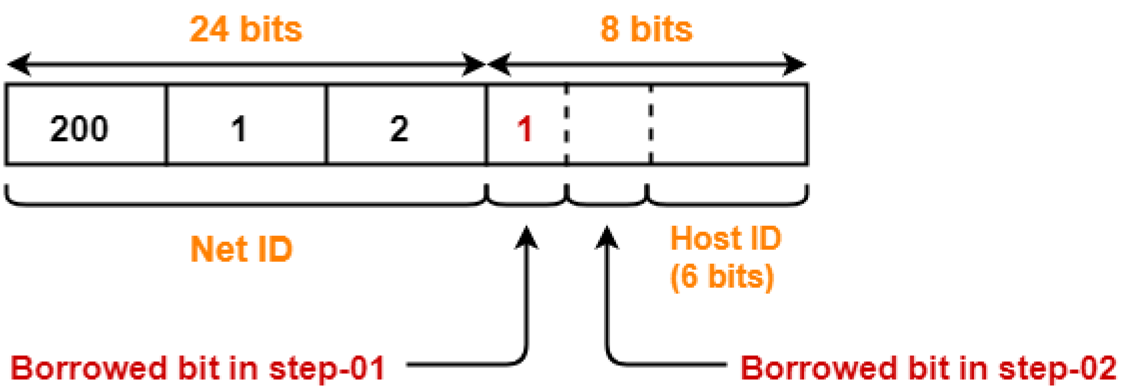
Step-02: Dividing One Subnet into 2 Subnets-

- We perform the subnetting of one of the subnets further into 2 subnets.
- Consider we want to do subnetting of the 2nd subnet having IP Address 200.1.2.128.

For creating two subnets and to represent their subnet IDs, we require 1 bit.

So,

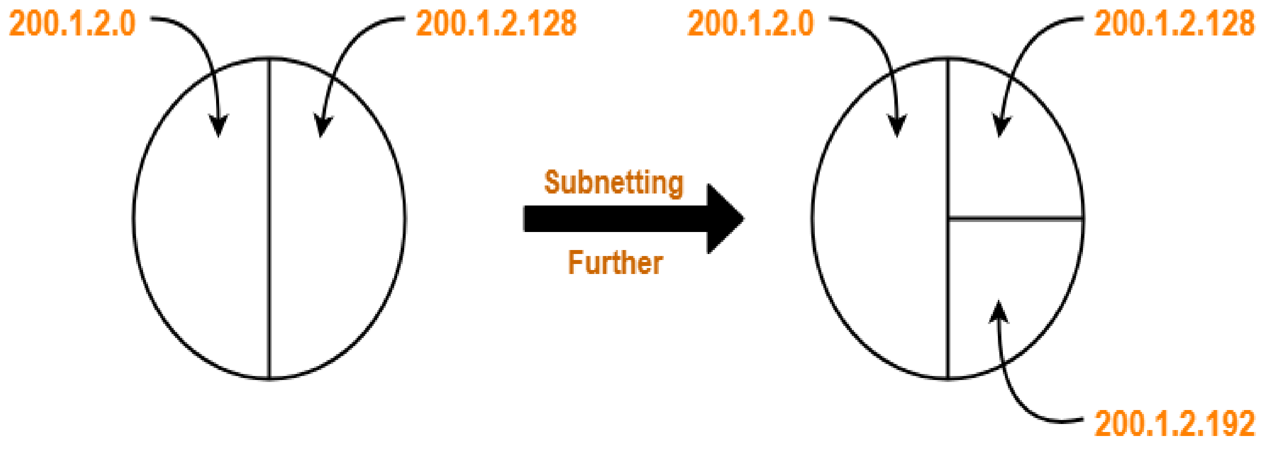
- We borrow one more bit from the Host ID part.
- After borrowing one bit, Host ID part remains with only 6 bits.



- If 2nd borrowed bit = 0, then it represents one subnet.
- If 2nd borrowed bit = 1, then it represents the other subnet.

IP Address of the two subnets are-

- 200.1.2.**10**000000 = 200.1.2.128
- 200.1.2.**11**000000 = 200.1.2.192



Finally, the given single network is divided into 3 subnets having IP Address-

- 200.1.2.0
- 200.1.2.128
- 200.1.2.192

For 1st Subnet-

- IP Address of the subnet = 200.1.2.0
- Total number of IP Addresses = 2^7 = 128
- Total number of hosts that can be configured = 128 – 2 = 126
- Range of IP Addresses = [200.1.2.**0**0000000, 200.1.2.**0**1111111] = [200.1.2.0, 200.1.2.127]
- Direct Broadcast Address = 200.1.2.**0**1111111 = 200.1.2.127
- Limited Broadcast Address = 255.255.255.255

For 2nd Subnet-

- IP Address of the subnet = 200.1.2.128
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.**10**000000, 200.1.2.**10**111111] = [200.1.2.128, 200.1.2.191]
- Direct Broadcast Address = 200.1.2.**10**111111 = 200.1.2.191
- Limited Broadcast Address = 255.255.255.255

For 3rd Subnet-

- IP Address of the subnet = 200.1.2.192
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.**11**000000, 200.1.2.**11**111111] = [200.1.2.192, 200.1.2.255]
- Direct Broadcast Address = 200.1.2.**11**111111 = 200.1.2.255
- Limited Broadcast Address = 255.255.255.255

Disadvantages of Subnetting-

Point-01:

Subnetting leads to loss of IP Addresses.

During subnetting,

- We have to face a loss of IP Addresses.
- This is because two IP Addresses are wasted for each subnet.
- One IP address is wasted for its network address.
- Other IP Address is wasted for its direct broadcasting address.

Point-02:

Subnetting leads to complicated communication process.

After subnetting, the communication process becomes complex involving the following 4 steps-

1. Identifying the network
2. Identifying the sub network
3. Identifying the host
4. Identifying the process

PRACTICE PROBLEMS BASED ON SUBNETTING IN NETWORKING-

Problem-01:

Suppose a network with IP Address 192.16.0.0. is divided into 2 subnets, find number of hosts per subnet.

Also for the first subnet, find-

1. Subnet Address
2. First Host ID
3. Last Host ID
4. Broadcast Address

Solution-

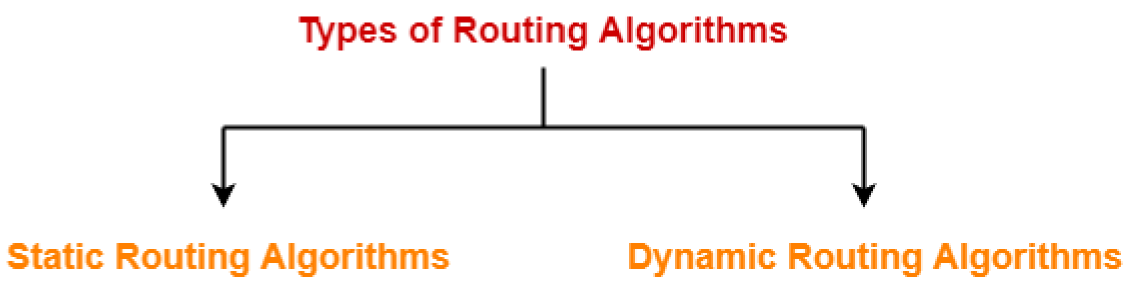
- Given IP Address belongs to class C.
- So, 24 bits are reserved for the Net ID.
- The given network is divided into 2 subnets.
- So, 1 bit is borrowed from the host ID part for the subnet IDs.
- Then, Number of bits remaining for the Host ID = 7.
- Thus, Number of hosts per subnet = 2^7 = 128.

For 1st Subnet-

- Subnet Address = First IP Address = 192.16.0.**0**0000000 = 172.16.0.0
- First Host ID = 192.16.0.**0**0000001 = 192.16.0.1
- Last Host ID = 192.16.0.**0**1111110 = 192.16.0.126
- Broadcast Address = Last IP Address = 192.16.0.**0**1111111 = 172.16.0.127

Routing Algorithms-

- Routing algorithms are meant for determining the routing of packets in a node.
- Routing algorithms are classified as-



1. Static Routing Algorithms
2. Dynamic Routing Algorithms

Distance Vector Routing Algorithm-

Distance Vector Routing is a dynamic routing algorithm.

It works in the following steps-

Step-01:

Each router prepares its routing table. By their local knowledge. Each router knows about-

- All the routers present in the network
- Distance to its neighboring routers

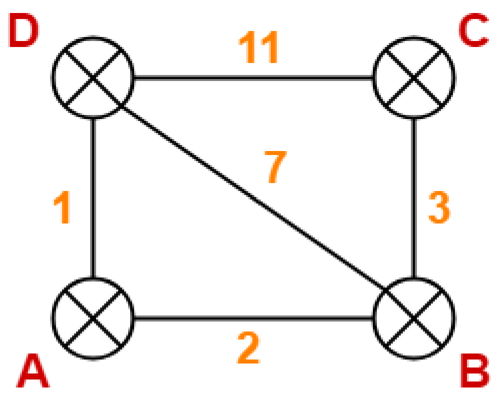
Step-02:

- Each router exchanges its distance vector with its neighboring routers.
- Each router prepares a new routing table using the distance vectors it has obtained from its neighbors.
- This step is repeated for (n-2) times if there are n routers in the network.
- After this, routing tables converge / become stable.

Distance Vector Routing Example-

Consider-

- There is a network consisting of 4 routers.
- The weights are mentioned on the edges.
- Weights could be distances or costs or delays.



Step-01:

Each router prepares its routing table using its local knowledge.

Routing table prepared by each router is shown below-

At Router A-

Destination	Distance	Next Hop
A	0	A
B	2	B
C	∞	–
D	1	D

At Router B-

Destination	Distance	Next Hop
A	2	A

B	0	B
C	3	C
D	7	D

At Router C-

Destination	Distance	Next Hop
A	∞	–
B	3	B
C	0	C
D	11	D

At Router D-

Destination	Distance	Next Hop
A	1	A
B	7	B
C	11	C
D	0	D

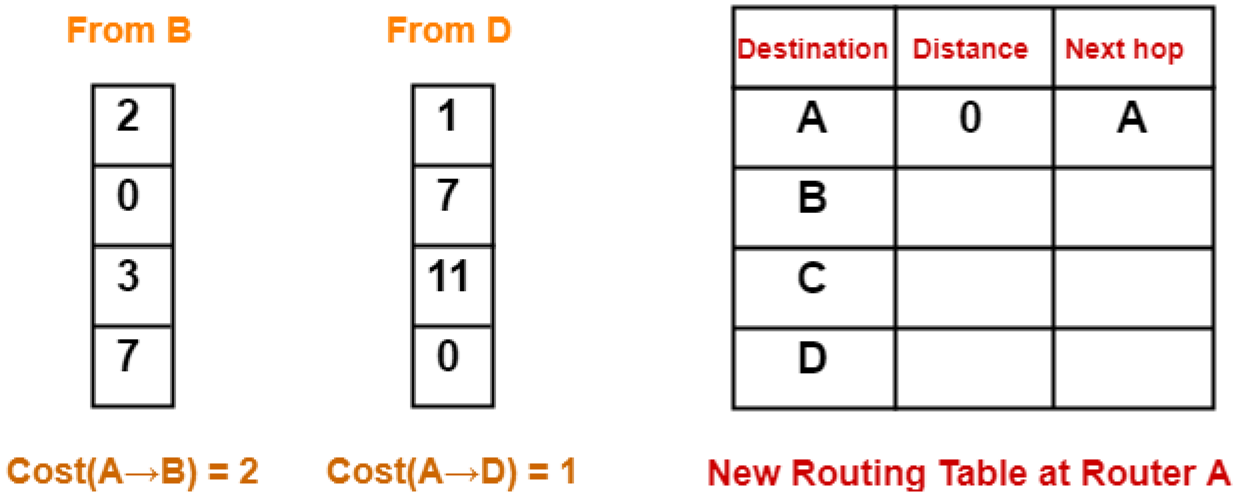
Step-02:

- Each router exchanges its distance vector obtained in Step-01 with its neighbors.
- After exchanging the distance vectors, each router prepares a new routing table.

This is shown below-

At Router A-

- Router A receives distance vectors from its neighbors B and D.
- Router A prepares a new routing table as-



- Cost of reaching destination B from router A = min { 2+0 , 1+7 } = 2 via B.
- Cost of reaching destination C from router A = min { 2+3 , 1+11 } = 5 via B.
- Cost of reaching destination D from router A = min { 2+7 , 1+0 } = 1 via D.

Explanation For Destination B

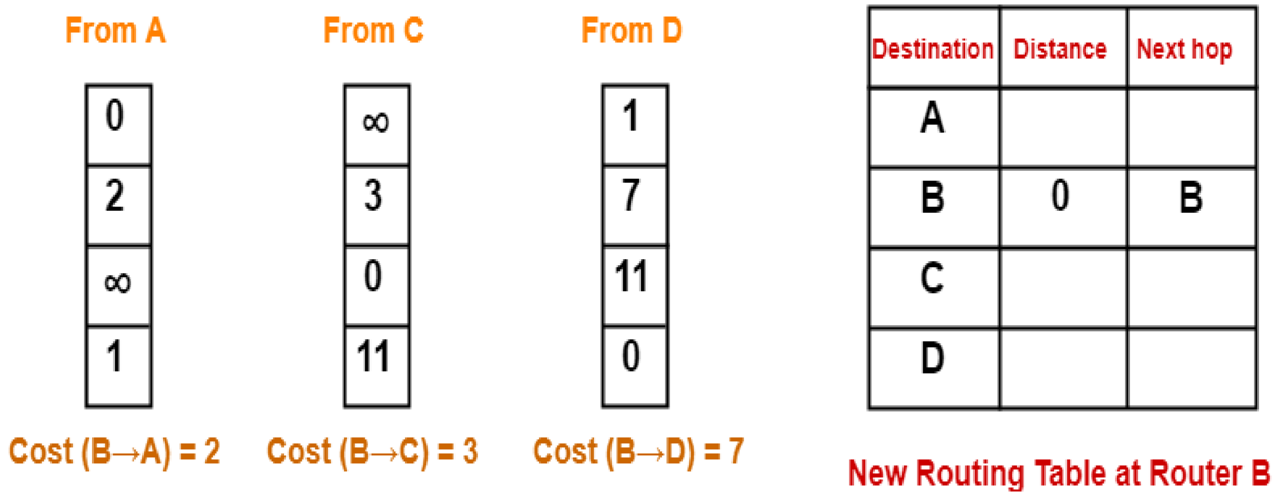
- Router A can reach the destination router B via its neighbor B or neighbor D.
- It chooses the path which gives the minimum cost.
- Cost of reaching router B from router A via neighbor B = Cost (A→B) + Cost (B→B)= **2 + 0** = 2
- Cost of reaching router B from router A via neighbor D = Cost (A→D) + Cost (D→B) = **1 + 7** = 8
- Since the cost is minimum via neighbor B, so router A chooses the path via B.
- It creates an entry (2, B) for destination B in its new routing table.
- Similarly, we calculate the shortest path distance to each destination router at every router.

Thus, the new routing table at router A is-

Destination	**Distance**	**Next Hop**
A	0	A
B	2	B
C	5	B
D	1	D

At Router B-

- Router B receives distance vectors from its neighbors A, C and D.
- Router B prepares a new routing table as-



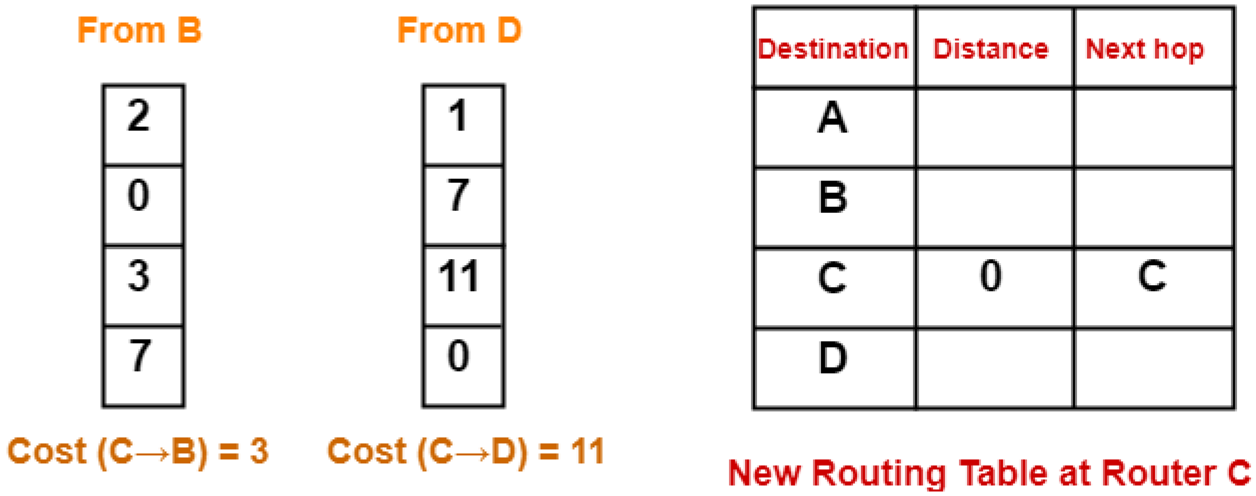
- Cost of reaching destination A from router B = min { 2+0 , 3+∞ , 7+1 } = 2 via A.
- Cost of reaching destination C from router B = min { 2+∞ , 3+0 , 7+11 } = 3 via C.
- Cost of reaching destination D from router B = min { 2+1 , 3+11 , 7+0 } = 3 via A.

Thus, the new routing table at router B is-

Destination	Distance	Next Hop
A	2	A
B	0	B
C	3	C
D	3	A

At Router C-

- Router C receives distance vectors from its neighbors B and D.
- Router C prepares a new routing table as-



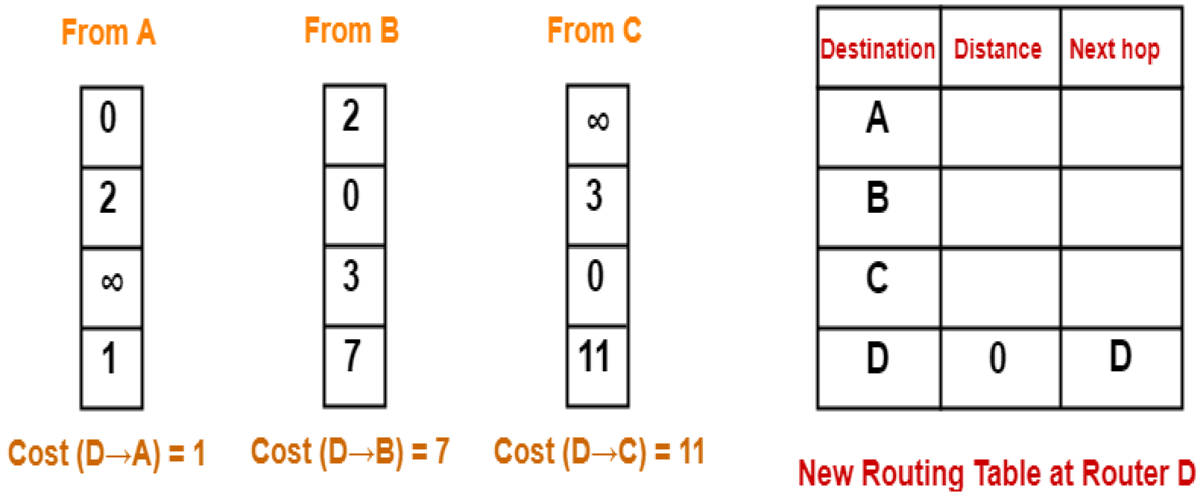
- Cost of reaching destination A from router C = min { 3+2 , 11+1 } = 5 via B.
- Cost of reaching destination B from router C = min { 3+0 , 11+7 } = 3 via B.
- Cost of reaching destination D from router C = min { 3+7 , 11+0 } = 10 via B.

Thus, the new routing table at router C is-

Destination	**Distance**	**Next Hop**
A	5	B
B	3	B
C	0	C
D	10	B

At Router D-

- Router D receives distance vectors from its neighbors A, B and C.
- Router D prepares a new routing table as-



- Cost of reaching destination A from router D = min { 1+0 , 7+2 , 11+∞ } = 1 via A.
- Cost of reaching destination B from router D = min { 1+2 , 7+0 , 11+3 } = 3 via A.
- Cost of reaching destination C from router D = min { 1+∞ , 7+3 , 11+0 } = 10 via B.

Thus, the new routing table at router D is-

Destination	Distance	Next Hop
A	1	A
B	3	A
C	10	B
D	0	D

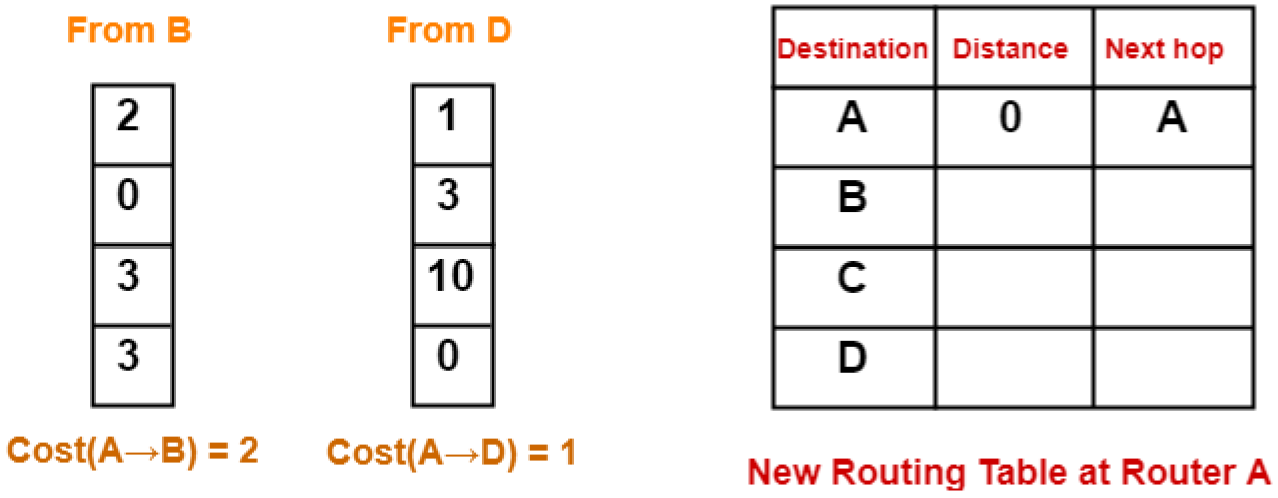
Step-03:

- Each router exchanges its distance vector obtained in Step-02 with its neighboring routers.
- After exchanging the distance vectors, each router prepares a new routing table.

This is shown below-

At Router A-

- Router A receives distance vectors from its neighbors B and D.
- Router A prepares a new routing table as-



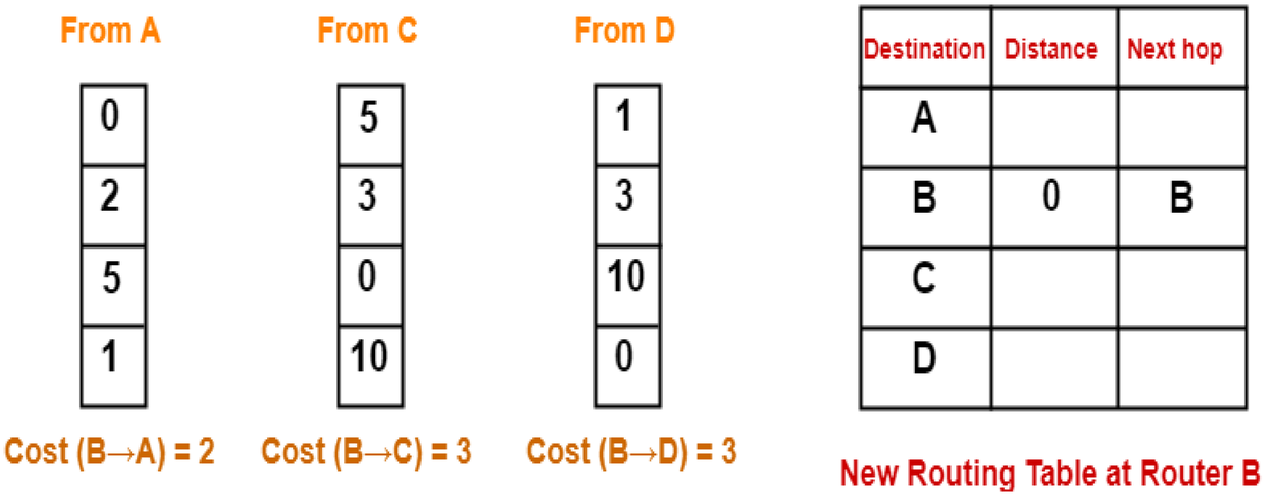
- Cost of reaching destination B from router A = min { 2+0 , 1+3 } = 2 via B.
- Cost of reaching destination C from router A = min { 2+3 , 1+10 } = 5 via B.
- Cost of reaching destination D from router A = min { 2+3 , 1+0 } = 1 via D.

Thus, the new routing table at router A is-

Destination	Distance	Next Hop
A	0	A
B	2	B
C	5	B
D	1	D

At Router B-

- Router B receives distance vectors from its neighbors A, C and D.
- Router B prepares a new routing table as-



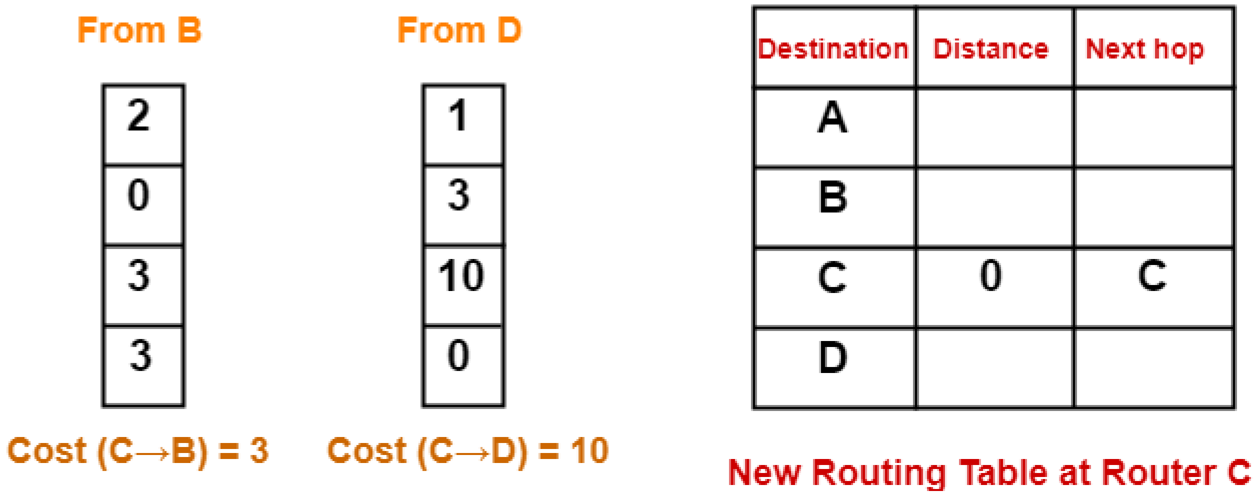
- Cost of reaching destination A from router B = min { 2+0 , 3+5 , 3+1 } = 2 via A.
- Cost of reaching destination C from router B = min { 2+5 , 3+0 , 3+10 } = 3 via C.
- Cost of reaching destination D from router B = min { 2+1 , 3+10 , 3+0 } = 3 via A.

Thus, the new routing table at router B is-

Destination	Distance	Next Hop
A	2	A
B	0	B
C	3	C
D	3	A

At Router C-

- Router C receives distance vectors from its neighbors B and D.
- Router C prepares a new routing table as-



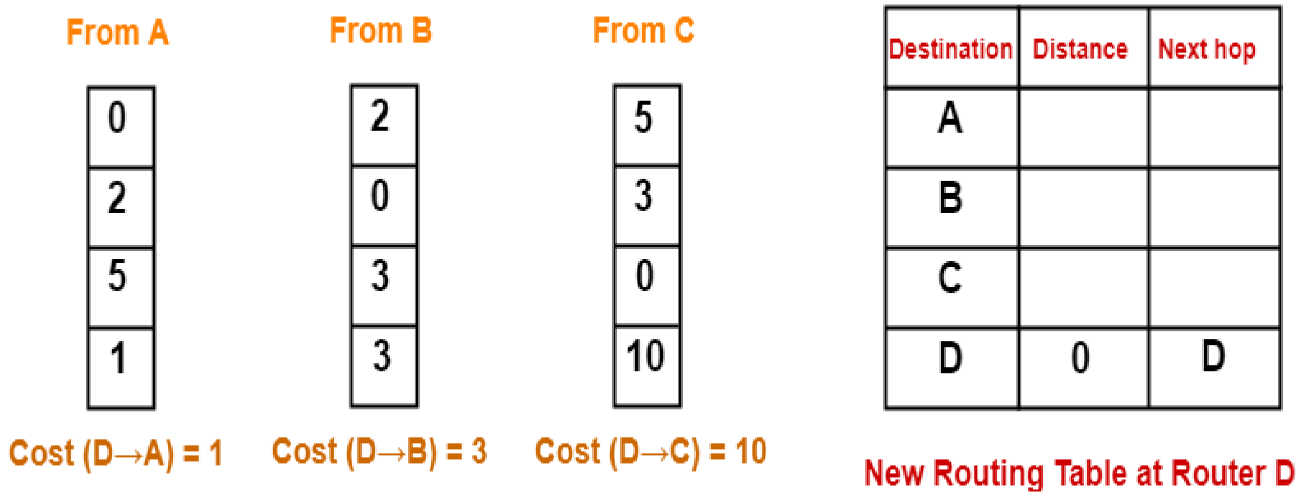
- Cost of reaching destination A from router C = min { 3+2 , 10+1 } = 5 via B.
- Cost of reaching destination B from router C = min { 3+0 , 10+3 } = 3 via B.
- Cost of reaching destination D from router C = min { 3+3 , 10+0 } = 6 via B.

Thus, the new routing table at router C is-

Destination	**Distance**	**Next Hop**
A	5	B
B	3	B
C	0	C
D	6	B

<u>At Router D-</u>

- Router D receives distance vectors from its neighbors A, B and C.
- Router D prepares a new routing table as-



- Cost of reaching destination A from router D = min { 1+0 , 3+2 , 10+5 } = 1 via A.
- Cost of reaching destination B from router D = min { 1+2 , 3+0 , 10+3 } = 3 via A.
- Cost of reaching destination C from router D = min { 1+5 , 3+3 , 10+0 } = 6 via A.

Thus, the new routing table at router D is-

Destination	Distance	Next Hop
A	1	A
B	3	A
C	6	A
D	0	D

These will be the final routing tables at each router.

Identifying Unused Links-

After routing tables converge (becomes stable),

- Some of the links connecting the routers may never be used.
- In the above example, we can identify the unused links as-

We have-

- The value of next hop in the final routing table of router A suggests that only edges AB and AD are used.
- The value of next hop in the final routing table of router B suggests that only edges BA and BC are used.
- The value of next hop in the final routing table of router C suggests that only edge CB is used.
- The value of next hop in the final routing table of router D suggests that only edge DA is used.

Thus, edges BD and CD are never used.

Important Notes-

Note-01:

In Distance Vector Routing,

- Only distance vectors are exchanged.
- "Next hop" values are not exchanged.
- This is because it results in exchanging the large amount of data which consumes more bandwidth.

Note-02:

While preparing a new routing table-

- A router takes into consideration only the distance vectors it has obtained from its neighboring routers.
- It does not take into consideration its old routing table.

Note-03:

The algorithm is called so because-

- It involves exchanging of distance vectors between the routers.
- Distance vector is nothing but an array of distances.

Note-04:

- The algorithm keeps on repeating periodically and never stops.
- This is to update the shortest path in case any link goes down or topology changes.

Note-05:

- Distance Vector Routing suffers from count to infinity problem.
- Distance Vector Routing uses UDP at transport layer