Tutorial N° 2
Dynamique routing & IPv6

Exercise 1

1. What is the main role of the network layer in a computer network?
   The main role of the network layer is to deliver packets from a source host to a destination host across multiple interconnected networks.

2. What are the key differences between routing and forwarding?
   Forwarding is about moving a packet from a router's input port to the appropriate output port. Routing is about determining the end-to-routes between sources and destinations.

3. Give two example computer applications for which connection-oriented service is appropriate. Now give two examples for which connectionless service is best.
   File transfer, remote login, and video on demand need connection-oriented service. On the other hand, credit card verification and other point-of-sale terminals, electronic funds transfer, and many forms of remote database access are inherently connectionless, with a query going one way and the reply coming back the other way.

4. A router has the following CIDR entries in its routing table.

Address/Mask	**Next Hop**
135.46.56.0/22	Interface 0
135.46.60.0/22	Interface 1
192.53.40.0/23	Router 1
default	Router 2

   For each of the following IP addresses, determine what the router does when a packet with that destination address arrives:

   (a) 135.46.63.10

   (b) 135.46.57.14

   (c) 135.46.52.2

   (d) 192.53.40.7

   (e) 192.53.56.7

   To forward a packet, the router compares the destination IP address with the prefixes stored in its routing table and selects the matching entry. If no specific entry matches, the default route is used.

   First, let us determine the address ranges covered by each prefix:

- **135.46.56.0/22**
  A /22 prefix corresponds to the mask `255.255.252.0`. Therefore, this entry covers addresses from `135.46.56.0` to `135.46.59.255`.
- **135.46.60.0/22**
  This entry covers addresses from `135.46.60.0` to `135.46.63.255`.
- **192.53.40.0/23**
  A /23 prefix corresponds to the mask `255.255.254.0`. Therefore, this entry covers addresses from `192.53.40.0` to `192.53.41.255`.

Now we examine each destination address:

(a) `135.46.63.10`
This address belongs to the range `135.46.60.0 - 135.46.63.255`. Therefore, the packet is forwarded through **Interface 1**.

(b) `135.46.57.14`
This address belongs to the range `135.46.56.0 - 135.46.59.255`. Therefore, the packet is forwarded through **Interface 0**.

(c) `135.46.52.2`
This address does not belong to either of the two `135.46.x.x` ranges defined above. Therefore, no specific route matches, and the router uses the **default route**, forwarding the packet to **Router 2**.

(d) `192.53.40.7`
This address belongs to the range `192.53.40.0 - 192.53.41.255`. Therefore, the packet is forwarded to **Router 1**.

(e) `192.53.56.7`
This address does not belong to the range `192.53.40.0 - 192.53.41.255`. Therefore, no specific route matches, and the router uses the **default route**, forwarding the packet to **Router 2**.

Hence, the final forwarding decisions are:

Destination IP Address	Router Action
135.46.63.10	Interface 1
135.46.57.14	Interface 0
135.46.52.2	Router 2 (default)
192.53.40.7	Router 1
192.53.56.7	Router 2 (default)

5. Compare and contrast link-state and distance-vector routing algorithms.
   Link state algorithms: Computes the least-cost path between source and destination using

complete, global knowledge about the network. Distance-vector routing: The calculation of the least-cost path is carried out in an iterative, distributed manner. A node only knows the neighbor to which it should forward a packet in order to reach given destination along the least-cost path, and the cost of that path from itself to the destination.

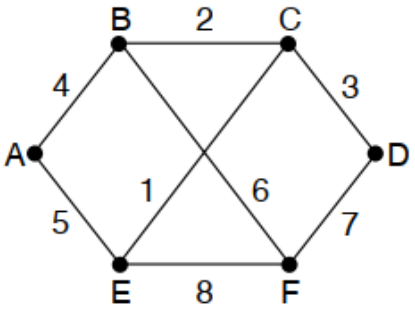
6. Is it necessary that every autonomous system use the same intra-AS routing algorithm? Why or why not?
   No, it is not necessary for all autonomous systems to use the same intra-AS routing algorithm. each autonomous system (AS) is independently managed by an organization (ISP, company, university, etc.). Therefore, each AS can choose the intra-domain routing protocol that best fits its needs, such as: OSPF, IS-IS, RIP ,EIGRP

7. True or false: When an OSPF route sends its link state information, it is sent only to those nodes directly attached neighbors. Explain.
   With OSPF, a router periodically broadcasts routing information to all other routers in the AS, not just to its neighboring routers. This routing information sent by a router has one entry for each of the router's neighbors; the entry gives the distance from the router to the neighbor. A RIP advertisement sent by a router contains information about all the networks in the AS, although this information is only sent to its neighboring routers.

8. BGP is a distance-vector routing protocol. Does it suffer from slow convergence like traditional distance-vector protocols?
   NO, unlike protocols such as RIP, BGP is a path vector protocol, meaning it **advertises the entire path (AS-PATH) to reach a destination**. This allows it to avoid routing loops and the count-to-infinity problem, which are the main causes of slow convergence in classical distance-vector protocols.

Exercise 2

Consider the network in the following figure.



Distance vector routing is used, and the following vectors have just come in to router C:

- from B: (5, 0, 8, 12, 6, 2)
- from D: (16, 12, 6, 0, 9, 10)

- from E: (7, 6, 3, 9, 0, 4).

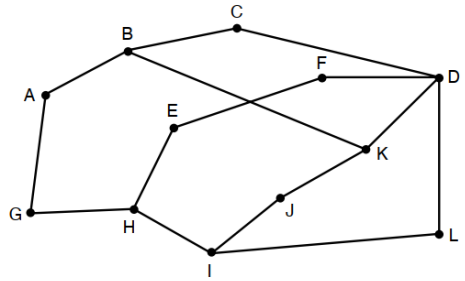
The cost of the links from C to B, D, and E, are 6, 3, and 5, respectively. What is C's new routing table? Give both the outgoing line to use and the cost.

- Going via B gives (11, 6, 14, 18, 12, 8).
- Going via D gives (19, 15, 9, 3, 9, 10).
- Going via E gives (12, 11, 8, 14, 5, 9).

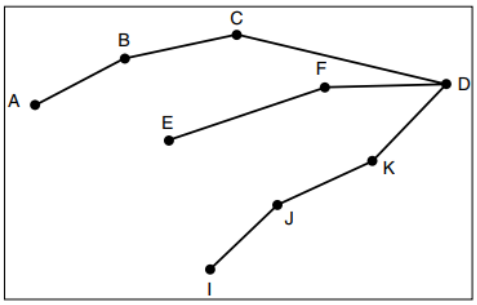
Taking the minimum for each destination except C gives (11, 6, 0, 3, 5, 8). The outgoing lines are (B, B, –, D, E, B).

Exercise 3

Compute a multicast spanning tree for router C in the following network for a group with members at routers A, B, C, D, E, F, I, and K



Multiple spanning trees are possible. One of them is:



Exercise 4

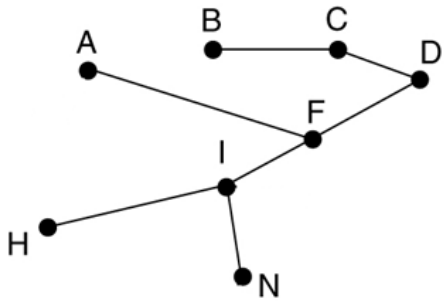
In the network shown in the figure, the spanning tree (b) is used to perform broadcast.
If node I broadcasts a message to all nodes in the network:

1. How many hops will this message take?
   In a spanning tree:
   Number of links = NumberofNodes 1 = 15 1 = 14
   During a broadcast, each link is used exactly once, so the message makes **14 hops**

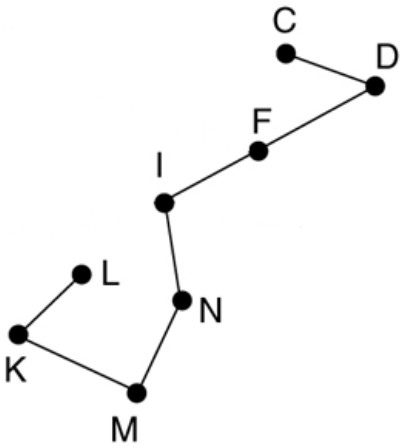
2. What do you think about this number of hops?
   Efficient: no loops, no duplicate transmissions
   Not optimal in distance: Some nodes receive the message through longer paths than necessary
   Conclusion: The number of hops is optimal for loop-free broadcast, but not for shortest-path delivery.

3. Draw the multicast trees computed by the root node I for the following groups:

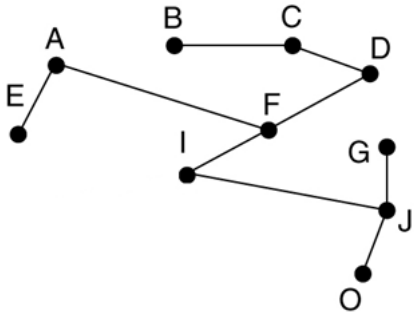
   - Group 1: A, B, C, D, F, I, H, N



   - Group 2: C, I, K, L, M, N



   - Group 3: I, B, E, O, G



4. Consider Group 2 from the previous question, calculate the number of hops taken by a message sent from node I to all members of the group, in the following cases:

- When the multicast tree is used
  In multicast each link is used only once, We count the links in the pruned tree: 7 hops
- When the message is sent individually to each member (using shortest-path routing in terms of hops) In Now we send separate messages to each node. Count hops for each destination: 11 hops
  Multicast is more efficient because it avoids sending duplicate data over the same links, while unicast may reuse the same links multiple times.

Exercise 5

Let us consider a network using **link-state routing**. Router *A* has just received the following link-state information packets:

B		**C**		**D**		**E**		**F**		**G**		**H**	
N	C	N	C	N	C	N	C	N	C	N	C	N	C
A	2	B	7	C	3	B	2	C	3	A	6	D	2
C	7	D	3	H	2	F	2	E	2	E	1	F	2
E	2	F	3	–	–	G	1	H	2	H	4	G	4

Table 1: Link-state information packets received by router *A* (N: Neighbor, C: Cost)

- Draw the graph representing the network.
- Compute and draw the routing table of router *A*, specifying for each destination:
  - The outgoing interface (next hop)
  - The total path cost

Exercise 6

Two routers **R1** and **R2** are connected on the same Ethernet segment.

Parameter	**R1**	**R2**
IP Address	10.1.1.1/24	10.1.1.2/24
Area ID	0	0
Hello Interval	10 s	5 s
Dead Interval	40 s	20 s
Authentication	None	None

1. Will R1 and R2 become OSPF neighbors? Justify your answer.
2. At which stage of the adjacency process will the failure occur?
3. What configuration changes are required to establish adjacency?

4. List and explain the sequence of OSPF states until FULL adjacency.
5. If Hello timers are correctly configured and:
   - R1 has RID = 1.1.1.1
   - R2 has RID = 2.2.2.2

   Which router becomes the **Master**? Justify.
6. Can two routers reach the **Two-Way** state but not reach the **Full** state? Explain when this happens.

Solution: Exercise 8

1. **No, R1 and R2 will NOT become neighbors.**

   This is because OSPF requires identical parameters, and here:
   - Hello intervals are different (10 s vs 5 s)
   - Dead intervals are different (40 s vs 20 s)
2. The failure occurs during the **Hello packet validation phase**, corresponding to the **Init state**.

   The routers receive Hello messages but reject them due to mismatched parameters.
3. To fix the issue, both routers must have identical timers:
   - Hello Interval = 10 s
   - Dead Interval = 40 s
4. The sequence of OSPF states is:

   Down → Init → Two-Way → ExStart → Exchange → Loading → Full

   Brief explanation:
   - **Down:** No Hellos received
   - **Init:** Hello received but no bidirectional communication yet
   - **Two-Way:** Bidirectional communication established
   - **ExStart:** Master/Slave election
   - **Exchange:** Database Description packets exchanged
   - **Loading:** Missing LSAs requested and received
   - **Full:** Full adjacency, synchronized LSDB

5. **R2 becomes the Master.**

   Master selection is based on the highest Router ID (RID):

   - R1 = 1.1.1.1
   - R2 = 2.2.2.2

   Therefore, R2 has the higher RID.

6. **Yes, it is possible.**

   In multi-access networks (e.g., Ethernet):

   - Routers form **Two-Way** adjacency with all neighbors
   - Only **Designated Router (DR)** and **Backup DR (BDR)** form **Full** adjacency

   Other routers remain in the Two-Way state.