KL (DEEMED TO BE UNIVERSITY)

NETWORK PROTOCOLS & SECURITY
23EC2210 R/A/E

Topic:

ROUTING ALGORITHMS: FLOODING, SHORTEST PATH

Session - 20

AIM OF THE SESSION

To familiarize students with the Static routing algorithms

INSTRUCTIONAL OBJECTIVES

This Session is designed to:

1. Describe the optimality principle of routing
2. Describe the routing process of Flooding algorithm
3. Explain the routing process of shortest path routing algorithm

LEARNING OUTCOMES

At the end of this session, you should be able to:

1. Compare static and dynamic routing.
2. Illustrate the working of Flooding algorithm.
3. Compute the shortest path using Dijkstra's algorithm.

SESSION INTRODUCTION

- The main function of the network layer is **routing packets** from the source machine to the destination machine. Packets will require **multiple hops** to make the journey.

- **Routing algorithm** is part of the network layer software responsible for deciding which output line an incoming packet should be transmitted on.

- Datagram network: **Routing Decision must be made anew for every arriving data packet** since the best route may have changed since last time.

- Virtual circuit Network: **Routing decisions are made only when a new virtual circuit is being set up**. Thereafter, data packets just follow the already established route.

- **When a router receives a packet, it handles two processes:**
  1. Forwarding process- Looking up the outgoing line to use for it in the routing table.
  2. Table Updating process- Responsible for filling in and updating the routing table.

Properties of Routing Algorithms…

- Objective of routing algorithms is to calculate \`good’ routes.

- Regardless of whether routes are chosen independently for each packet sent(Datagrams) or only when new connections are established(Virtual Circuits), certain properties are desirable in a routing algorithm.

  - **Correctness:** The routing should be done properly and correctly so that the packets may reach their proper destination.

  - **Simplicity:** The routing should be done in a simple manner so that the overhead is as low as possible.

  - **Robustness:** The algorithms designed for routing should be robust enough to handle hardware and software failures and should be able to cope with changes in the topology and traffic.

  - **Stability:** The routing algorithms should be stable under all possible circumstances.

  - **Fairness:** Every node connected to the network should get a fair chance of transmitting their packets. This is generally done on a first come first serve basis.

  - **Optimality:** The routing algorithms should be optimal in terms of throughput and minimizing mean packet delays.

Types of Routing Algorithms

- Routing algorithms can be grouped into two major classes:
  - Non-adaptive
  - Adaptive

Non-Adaptive:

- Routing decisions does not depend on measurements or estimates of the current topology and traffic.
- The route to travel from source to destination is computed in advance.
- This procedure is sometimes called **Static routing.**

Adaptive algorithms:

- Change their routing decisions to reflect changes in the topology, and sometimes changes in the traffic as well.
- Known as **Dynamic routing**.

List of Routing Algorithms

- The Optimality Principle
- Flooding
- Shortest Path Routing
- Distance Vector Routing
- Link State Routing
- Hierarchical Routing
- Broadcast Routing
- Multicast Routing

The Optimality Principle

- Optimality Principle states that

  " if router J is on the optimal path from router I to router K, then the optimal path from J to K also falls along the same route."

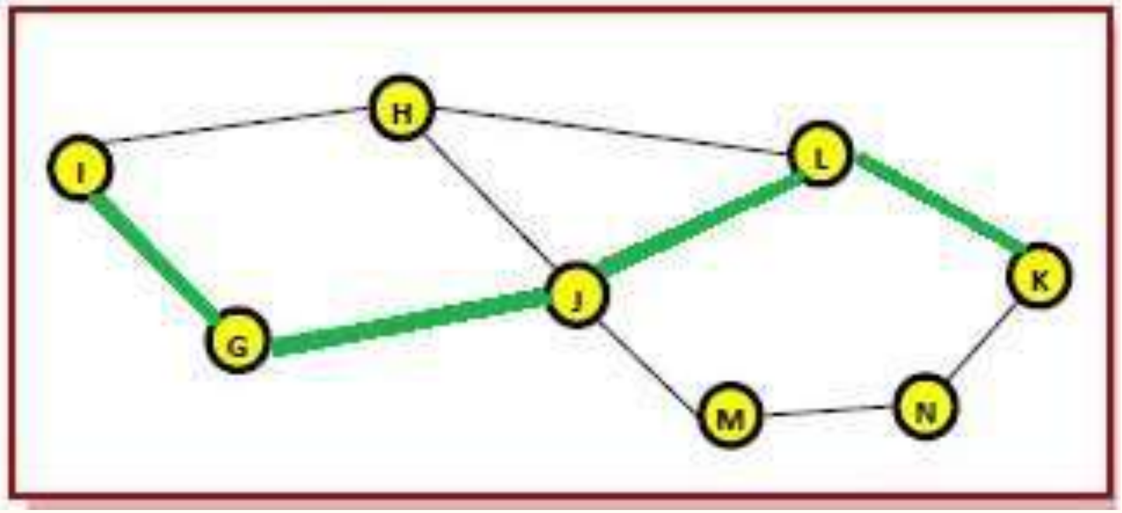
- Let us call the part of the route from *I* to *J as r*1 and the rest of the route as *r*2*.*

- If a route better than *r*2 existed from *J* to *K*, it could be concatenated with *r*1 to improve the route from *I* to *K*, contradicting our statement that *r*1*r*2 is optimal.

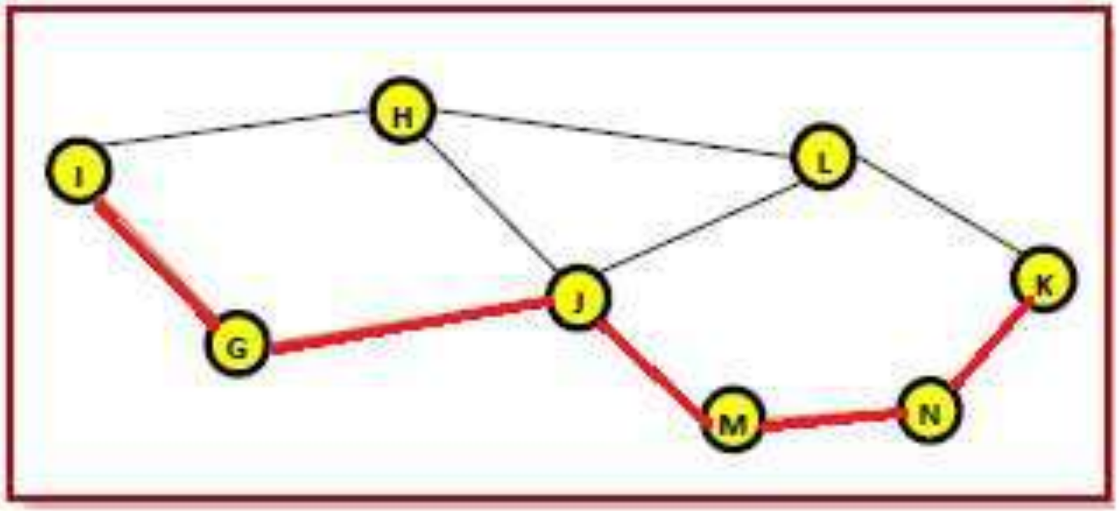
The Optimality principle Example...

Example

Consider a network of routers, {G, H, I, J, K, L, M, N} as shown in the figure. Let the optimal route from I to K be as shown via the green path, i.e. via the route I-G-J-L-K. According to the optimality principle, the optimal path from J to K with be along the same route, i.e. J-L-K.



Now, suppose we find a better route from J to K is found, say along J-M-N-K. Consequently, we will also need to update the optimal route from I to K as I-G-J-M-N-K. This new optimal path is shown as orange lines in the figure.



FLOODING

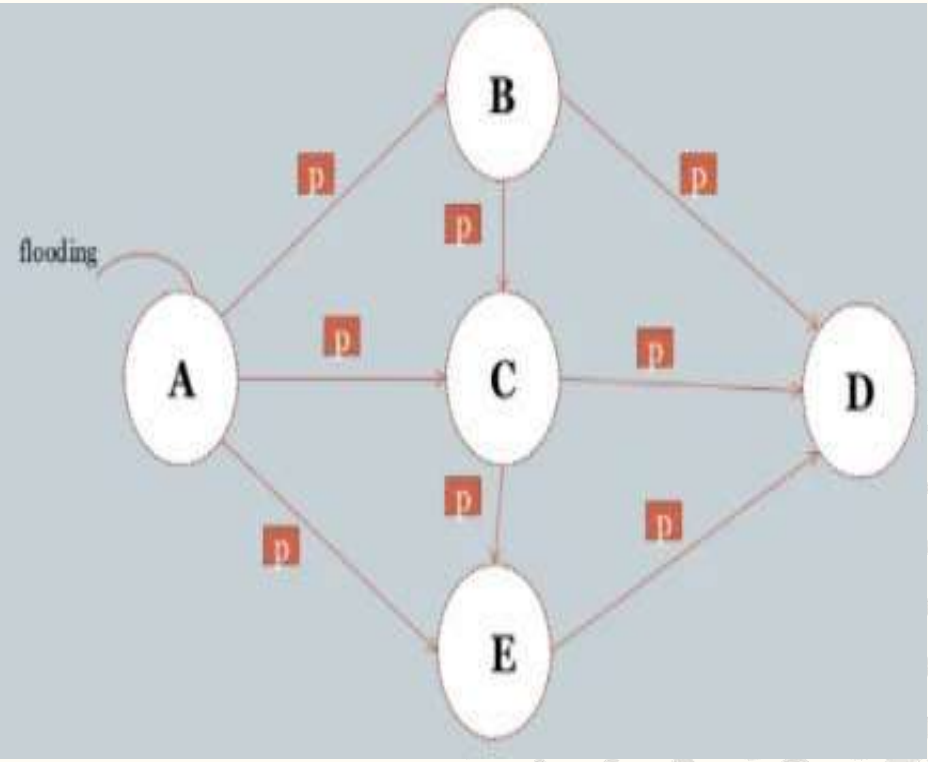
1. Flooding Algorithm

- Requires no network information like topology, load condition, cost of different paths, etc.

- Every incoming packet to a node is sent out on every outgoing line except the one it arrived on.

- Limitations –
  - Flooding generates vast number of duplicate packets

- Suitable damping mechanism must be used



Flooding…

- Flooding obviously generates vast numbers of duplicate packets, in fact, an infinite number unless some measures are taken to damp the process. One such measure is to have a hop counter.

Hop:

- A hop is a computer networking term that refers to the number of routers that a packet passes through from its source to its destination.

Hop-Count:

- A hop counter may be contained in the packet header which is decremented at each hop.
- The packet is discarded when the counter becomes zero.
- Ideally, the hop counter should be initialized to the length of the path from source to destination.
- If the sender does not know how long the path is, it can initialize the counter to the worst case, namely, the full diameter of the network.

Flooding…

Sequence Number:

- Flooding with a hop count can produce an exponential number of duplicate packets as the hop count grows and routers duplicate packets they have seen before.
- A better technique for damming the flood is to have routers keep track of which packets have been flooded, to avoid sending them out a second time.
- One way to achieve this goal is to have the source router put a **sequence number** in each packet it receives from its hosts.
- Each router then needs a list per source router telling which sequence numbers originating at that source have already been seen. If an incoming packet is on the list, it is not flooded.

Selective Flooding:

- Routers do not send every incoming packet out on every line, only on those lines that go in approximately in the direction of the destination.

SHORTEST PATH ROUTING

2. Shortest Path Routing Algorithm

- A graph for the subnet is built with each node of the graph representing a router and each arc of the graph representing communication line.

- The algorithm finds a shortest path from a node to all other nodes in the network.

- Dijkstra’s algorithm is used for solving the problem.

- Steps followed:
  - Dijkstra’s algorithm starts by assigning some initial values for the distance from node S to every other node in the network
  - At each step, the shortest distance from node S to another node is determined.

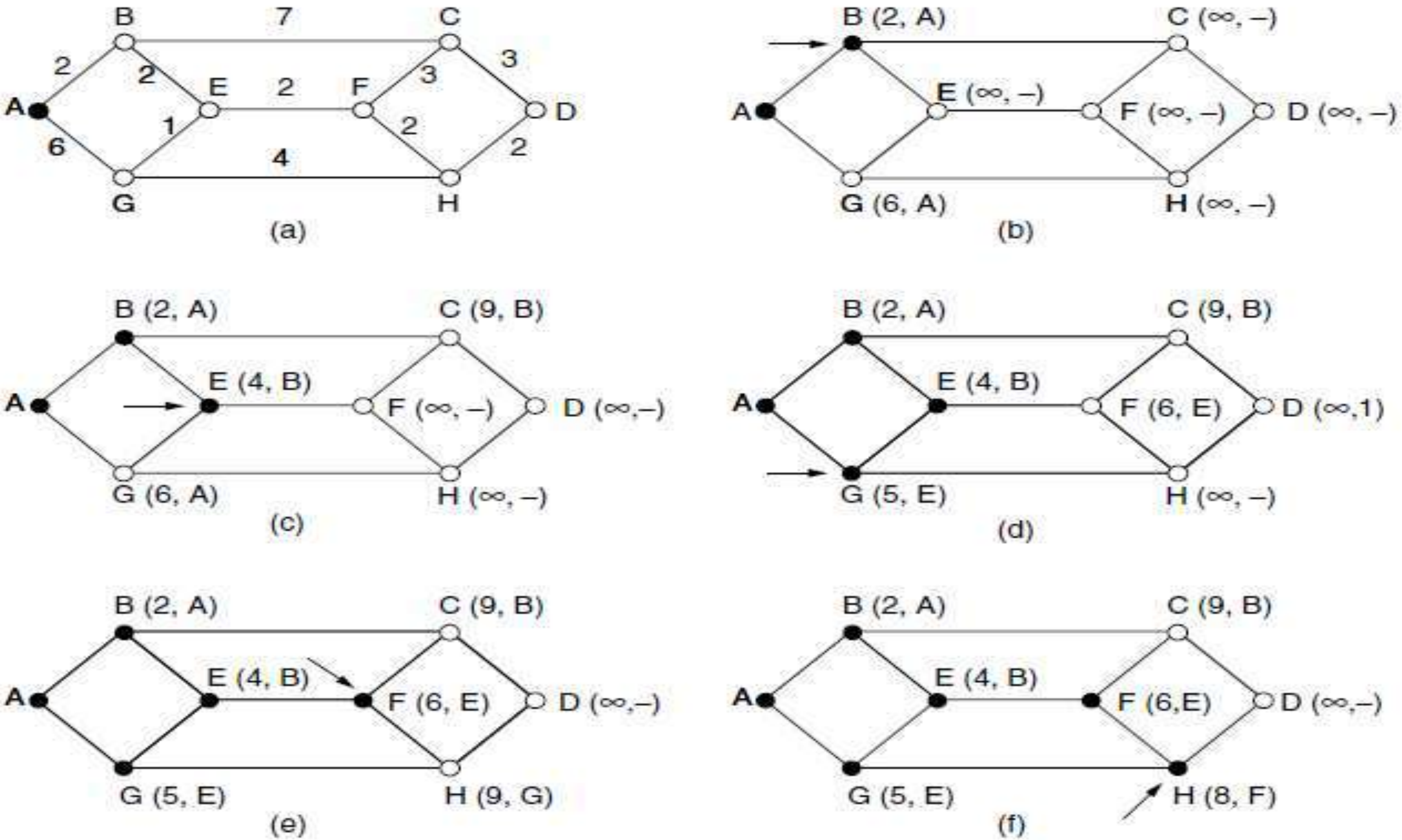
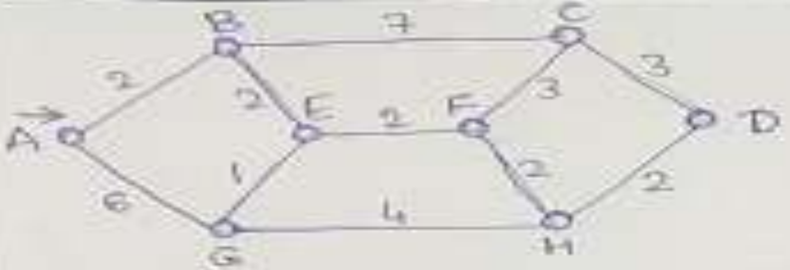
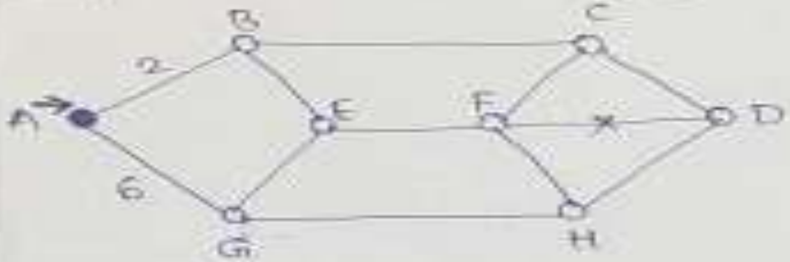


Figure 5-7. The first six steps used in computing the shortest path from *A* to *D*. The arrows indicate the working node.



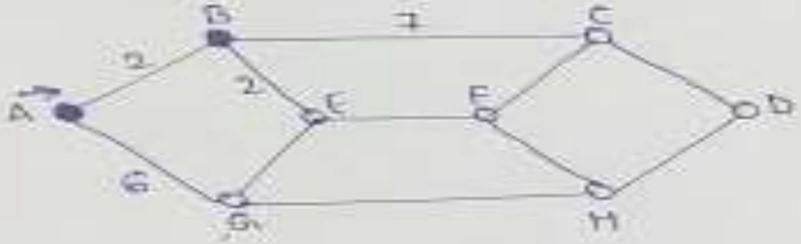
Dest	Cost	Predecessor	T/P
A	∞	—	T
B	∞	—	T
C	∞	—	T
D	∞	—	T
E	∞	—	T
F	∞	—	T
G	∞	—	T
H	∞	—	T

Step-1 : Source : A [Make A as permanent & identify adjacents to A]



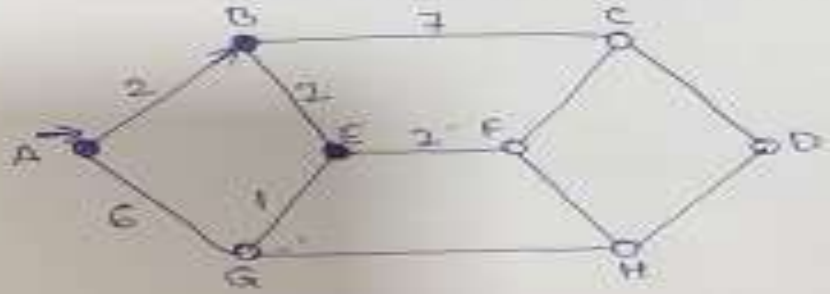
Dest	Cost	Predecessor	T/P
A	0	—	P
B	2	A	T
C	∞	—	T
D	∞	—	T
E	∞	—	T
F	∞	—	T
G	6	A	T
H	∞	—	T

Step-2 :- Out of all temporary nodes, B is having least distance/cost. So make B as Permanent & identify adjacents to B



Dest	Cost	Predecessor	T/P
A	0	—	P
B	2	A	P
C	2+7=9	B	T
D	∞	—	T
E	2+2=4	B	T
F	∞	—	T
G	6	A	T
H	∞	—	T

Step-3 :- Out of all temporary nodes, E is having least cost. So make E as Permanent & identify adjacents of E

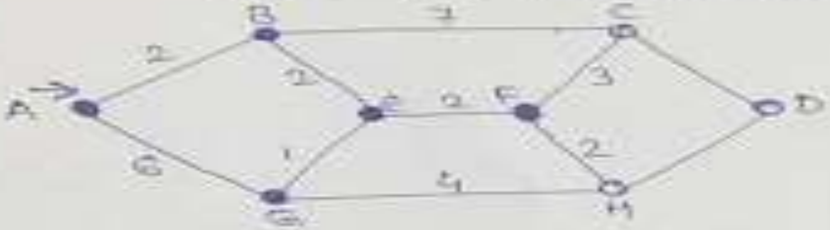


Dest	Cost	Predecessor	T/P
A	0	—	P
B	2	A	P
C	9	B	T
D	∞	—	T
E	4	B	P
F	4+2=6	E	T
G	~~6~~ 4+1=5	E	T
H	∞	—	T

Step-4: Out of all temporary nodes, G is having least cost, So make G as Permanent & identify adjacents of G

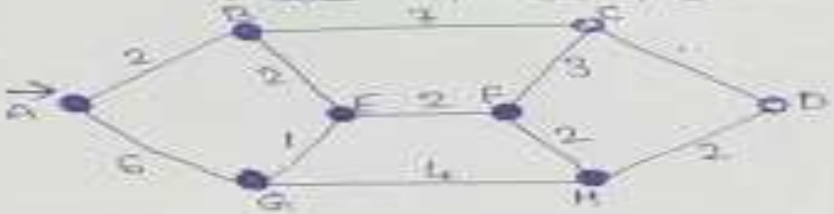
Dest	Cost	Predecessor	T/P
A	0	—	P
B	2	A	P
C	9	B	T
D	∞	—	T
E	4	B	P
F	6	E	P
G	5	E	P
H	5+4=9	G	T

Step-5: Out of all temporary nodes, F is having least cost, So make F as Permanent & identify adjacents of F



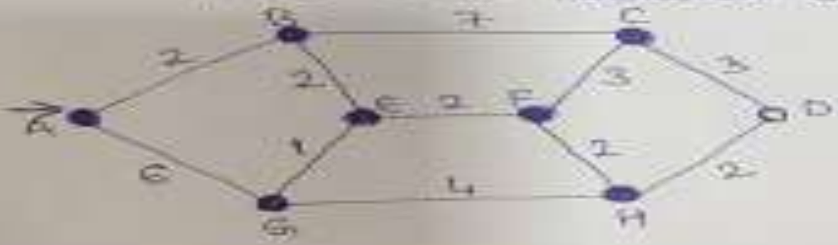
Dest	Cost	Predecessor	T/P
A	0	—	P
B	2	A	P
C	9	B	T
D	∞	—	T
E	4	B	P
F	6	E	P
G	5	E	P
H	~~9~~ 6+2=8	F	T

Step-6: Out of all temporary nodes, H is having least cost, So make H as Permanent & identify adjacents of H



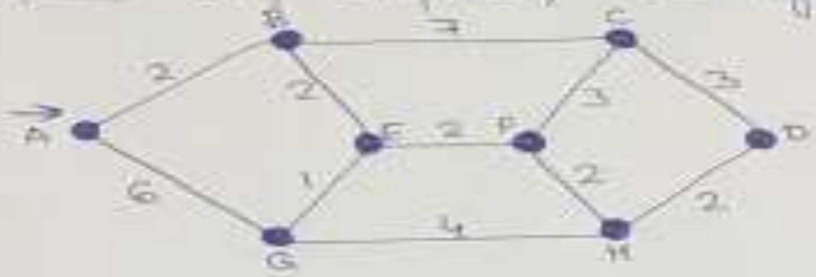
Dest	Cost	Predecessor	T/P
A	0	—	P
B	2	A	P
C	9	B	T
D	10	H	T
E	4	B	P
F	6	E	P
G	5	E	P
H	8	F	P

Step-7: Out of all temporary nodes, C is having least cost, So make C as Permanent & identify adjacents of C



Dest	Cost	Predecessor	T/P
A	0	—	P
B	2	A	P
C	9	B	P
D	10	H	T
E	4	B	P
F	6	E	P
G	5	E	P
H	8	F	P

Step-8: Only temporary node left is D. Make it as Permanent



Dest	Cost	Predecessor	T/P
A	0	–	P
B	2	A	P
C	9	B	P
D	10	H	P
E	4	B	P
F	6	E	P
G	5	E	P
H	8	F	P

Now the routing table represents the shortest paths from node A to all the other nodes.

~~Source~~	~~Routing Path~~	~~Destination~~	~~Dist~~
~~A~~	~~B ← A~~	~~B~~	~~2~~
~~A~~	~~C ← B ← A~~	~~C~~	~~9~~
~~A~~			

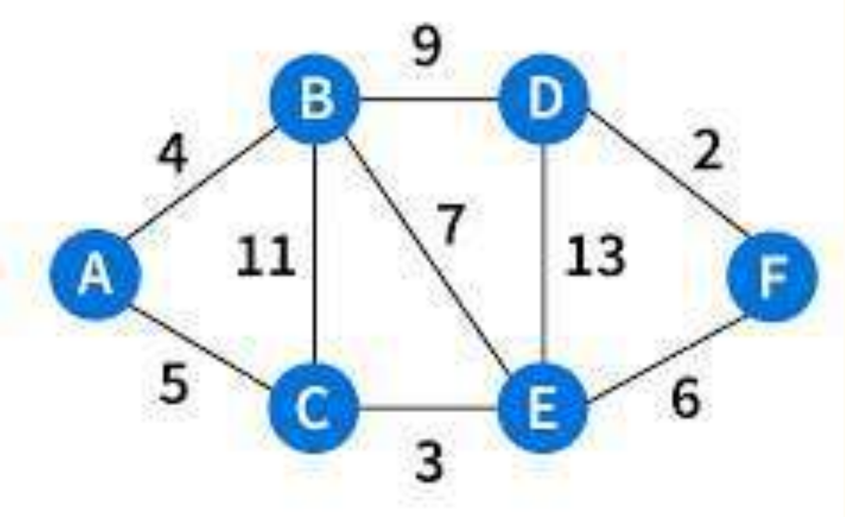
Source	Destination	Distance/cost	Routing Path
A	B	2	B ← A
A	C	9	C ← B ← A
A	D	10	D ← H ← F ← E ← B ← A
A	E	4	E ← B ← A
A	F	6	F ← E ← B ← A
A	G	5	G ← E ← B ← A
A	H	8	H ← F ← E ← B ← A

SUMMARY

- Optimality Principle
- Flooding algorithm
- Shortest Path Routing algorithm

TERMINAL QUESTIONS

1. Compare adaptive and non-adaptive routing algorithms.
2. Define optimality principle with an example.
3. Illustrate the routing process of flooding algorithm.
4. Mention the drawback of flooding algorithm and explain the methods to overcome the drawback.
5. Consider the network given. Compute shortest path from node A to all other nodes.



REFERENCES FOR FURTHER LEARNING OF THE SESSION

Reference Books:

1. A.S. Tanenbaum, David J. Wetheral “Computer Networks” Pearson, 5th Edition.
2. Behrouz A. Forouzan , “Data Communication and Networking”, TMH, 5th Edition, 2012.

Web Links:

1. https://www.tutorialspoint.com/the-optimality-principle-in-computer-networks

THANK YOU

Team – Network Protocols & Security