Chapter5 Network Layer(1)

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Communication & Computer Network key-Lab of GD

Main object of the chapter5

- How packets transport from source to destination?
- How to select a path?
  - Routing protocol, Router
  - Routed protocol: IPv4,IPv6
  - Others

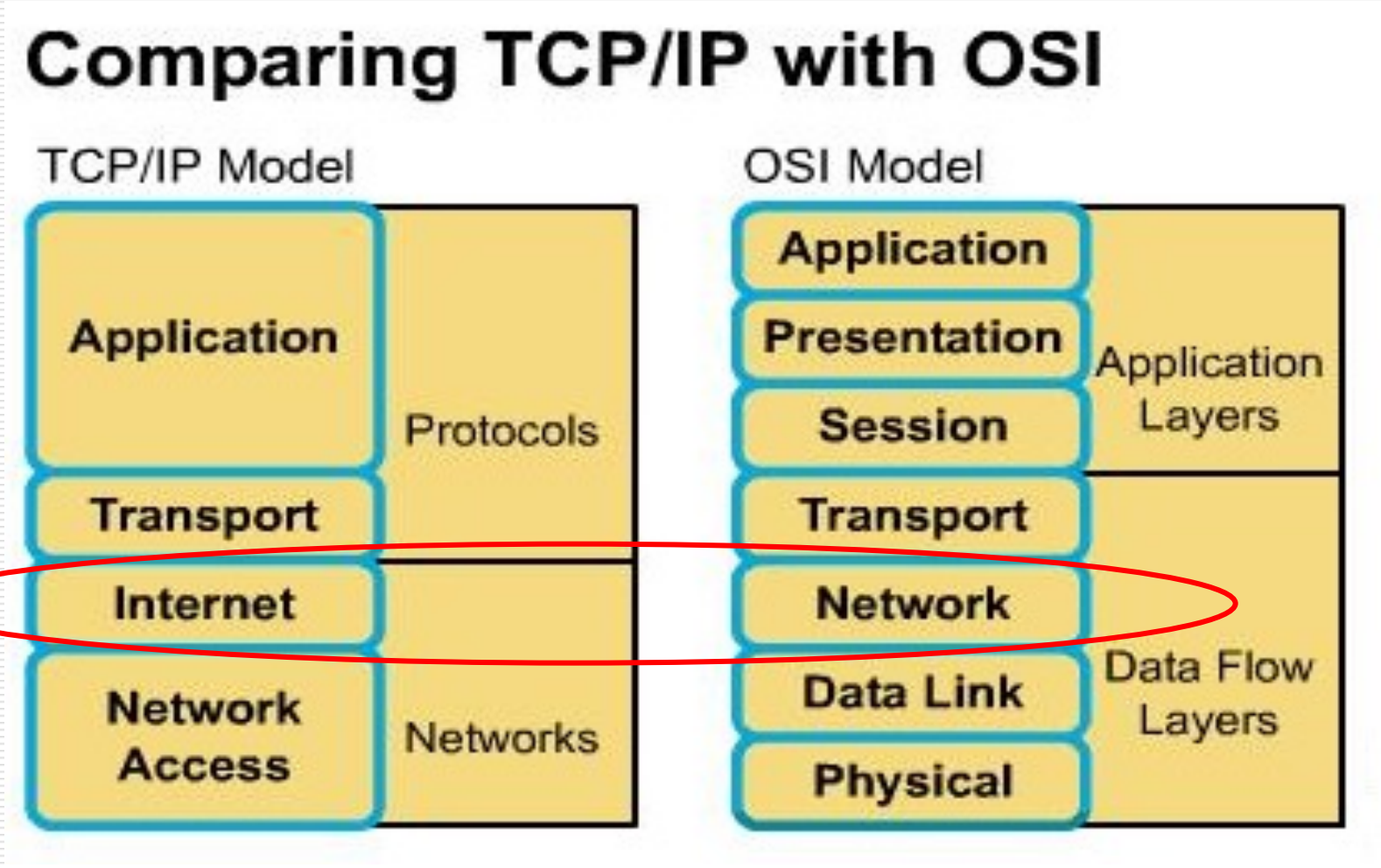
Contents of the first part(5.1~5.3)

- Outline of network layer
- Outline of Routing algorithm
- Learn Dijkstra algorithm
- Distance-vector algorithm： Rip
- Link state routing algorithm： OSPF
- Multi-level routing, broadcast routing, mobile routing, adhoc routing, p2p, and et al.

Outline of the lecture

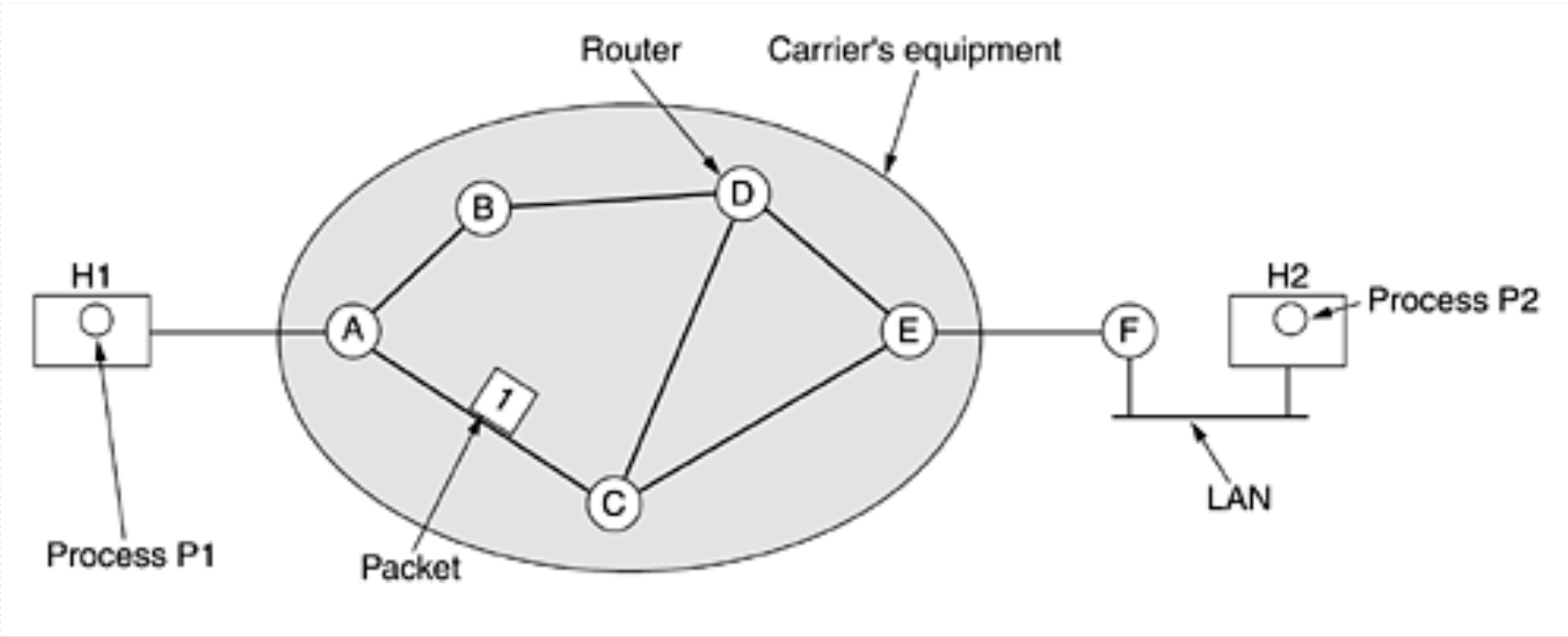
- Main function of network layer
- Routing algorithm
  - Static routing algorithm
    - Dijkstra
    - flooding
  - Dynamic routing algorithm
    - DV
    - LS
- Learn Dijkstra algorithm

Position of network layer



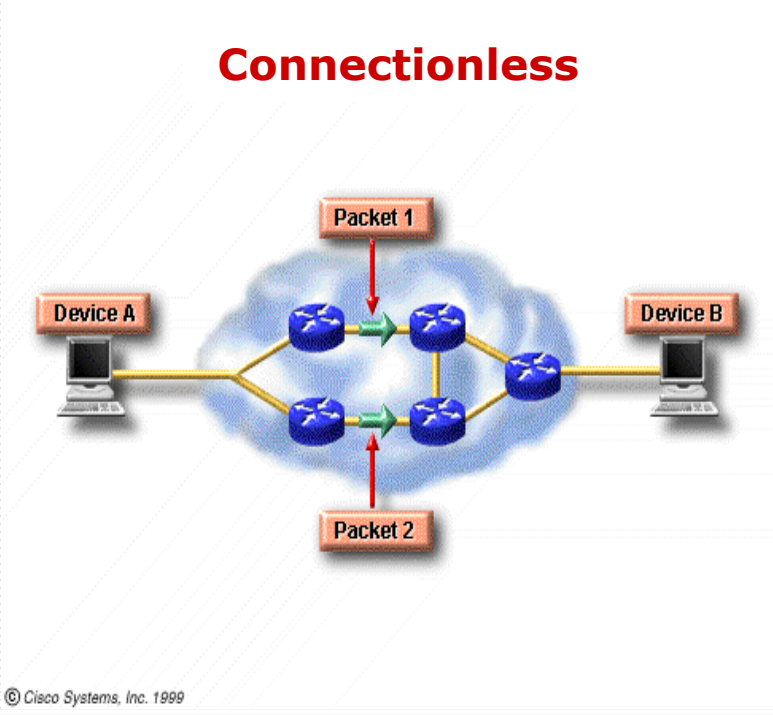
Main function of network layer

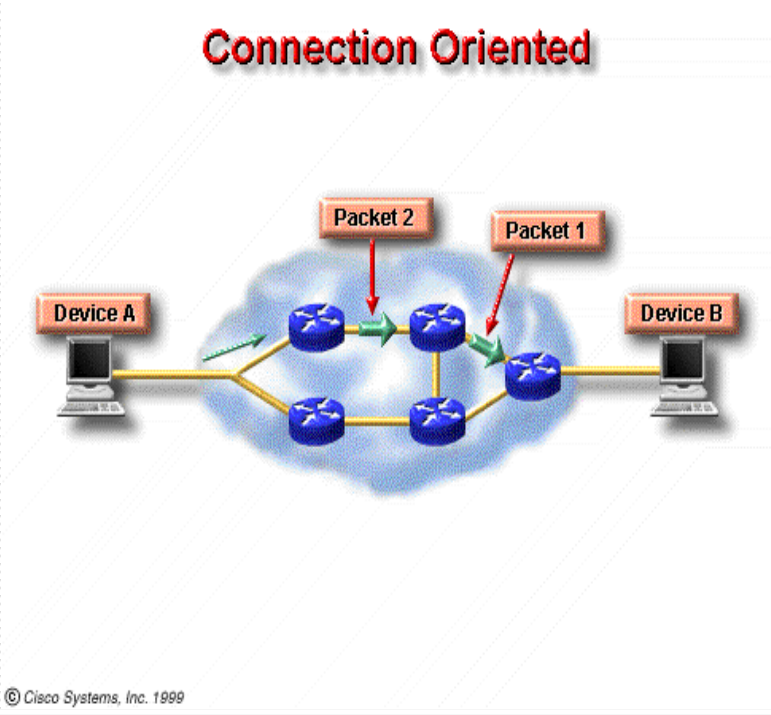
- **Main function is: transport packet from source to destination all the way.**



Service types provided by network layer

- Connection oriented service：X.25, ATM
- Connectionless service：IP

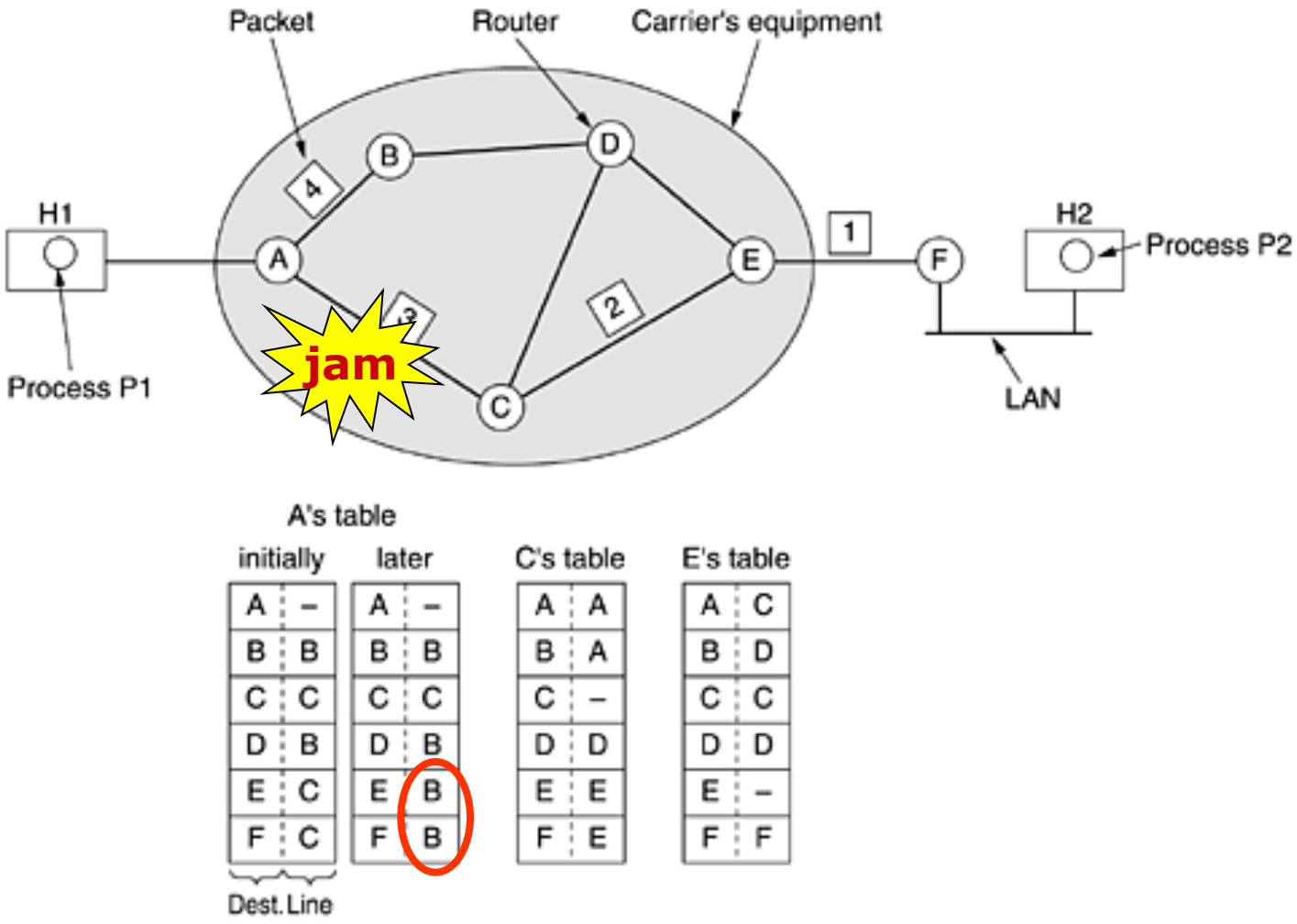




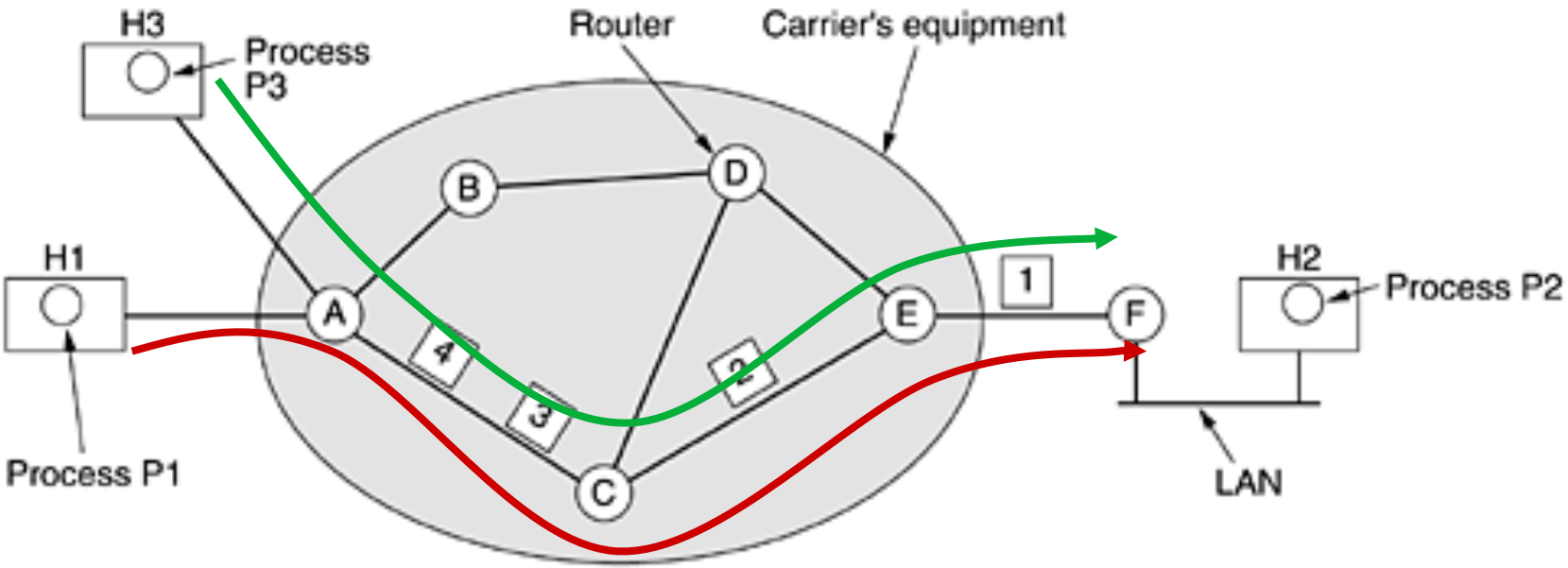
Structure of communication subnet

- **Virtual-circuit subnet**
  - **Select a path when connection is established**
  - **Each packet has a connection-number**
  - **Connection is removed when communication is over**
- **Datagram subnet**
  - **Each datagram has destination-address**
  - **Each datagram look for path independently**

Connectionless service—datagram subnet



Connection-oriented Serv.-virtual circuit Subnet



A's table

In		Out	
H1	1	C	1
H3	1	C	2

C's table

A	1	E	1
A	2	E	2

E's table

C	1	F	1
C	2	F	2

Issue	Datagram subnet	Virtual-circuit subnet
Circuit setup	Not needed	Required
Addressing	Each packet contains the full source and destination address	Each packet contains a short VC number
State information	Routers do not hold state information about connections	Each VC requires router table space per connection
Routing	Each packet is routed independently	Route chosen when VC is set up; all packets follow it
Effect of router failures	None, except for packets lost during the crash	All VCs that passed through the failed router are terminated
Quality of service	Difficult	Easy if enough resources can be allocated in advance for each VC
Congestion control	Difficult	Easy if enough resources can be allocated in advance for each VC

Question

- **Does virtual-circuit subnet not need path-select (routing algorithm)?**

(是否虚电路子网不需要路由选择算法？)

How is routing table set up?

- Static routing
  - Configured by administrator: ip route
- Dynamic routing
  - Routing algorithm
    - Distance vector routing（D-V）
    - Link state routing（L-S）

Static routing and dynamic routing

- **Routing table entry that is configured by administrator is called static routing**
  - **Fit for small, stable network，cost less**
  - **Default routing：both of destination network address and subnet mask is 0.0.0.0，as:**

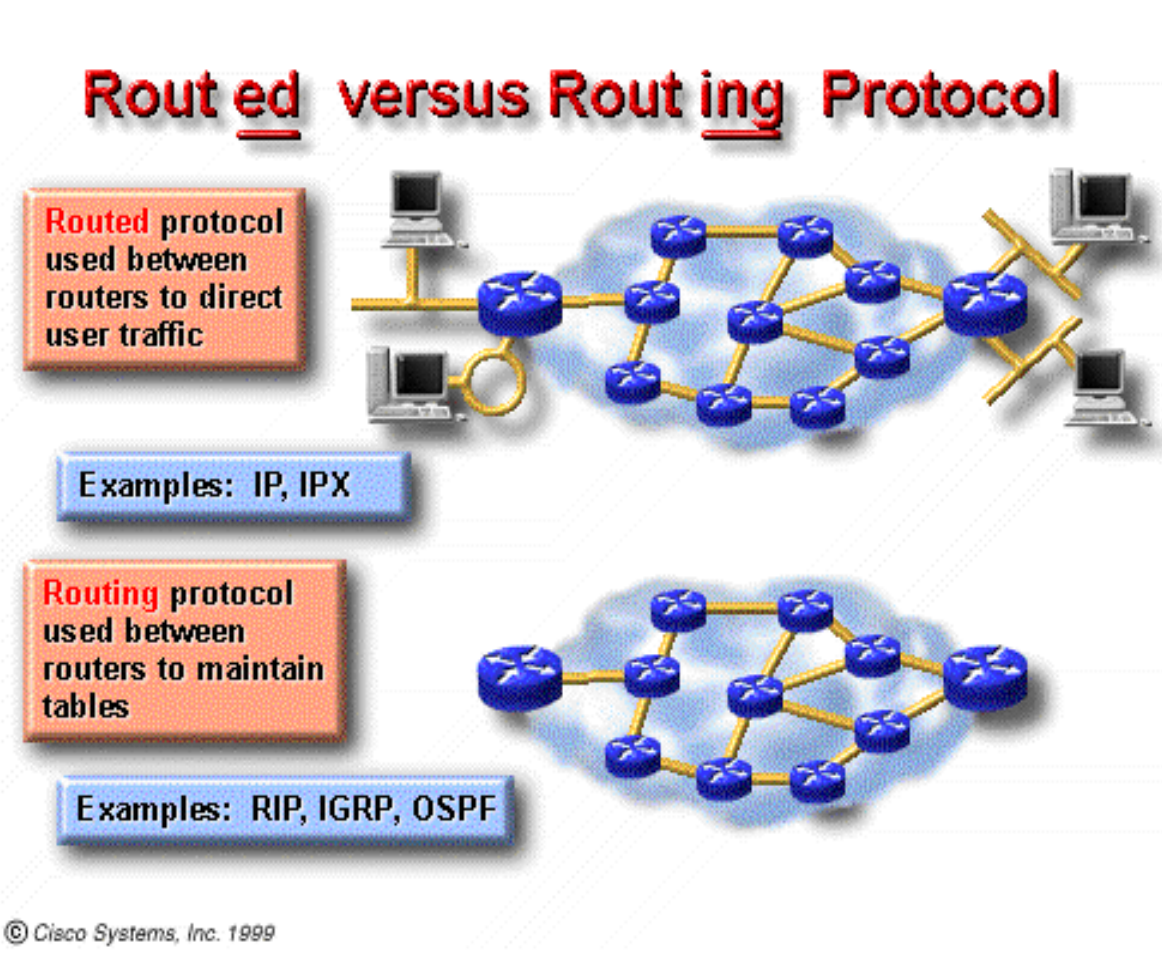
网络	网络地址	网络掩码	网关	接口	跳数
	0.0.0.0	0.0.0.0	203.74.205.1	203.74.205.1	1

  - **Can use Windows route print, check routing table**
- **Routing table entry that is obtained by routing protocol is called dynamic routing**
  - **Fit for big, variational network，cost more**

Routing protocol classification

- **Routed protocol**
  - **example：IP、IPX**
- **Routing protocol**
  - **Distance vector routing**
  - **Link state routing**
  - **Hybrid routing**

Routed protocol VS. routing protocol



Routing algorithm

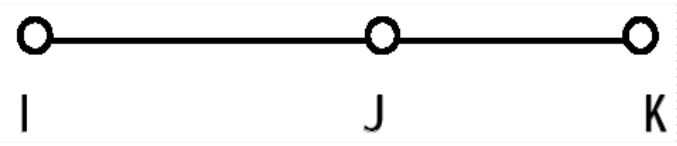
- What is routing algorithm?
- Routing algorithm design must consider following issue:
  - Correctness, simplicity, robustness, stability, fairness, and optimality (contradictory、trade-off)
- Classification of routing algorithm
  - Static algorithm（not self-adaptive）
  - Dynamic algorithm（ self-adaptive ）

Metric in routing algorithm

- Alias：cost，量度、代价、开销、成本
- Common metric
  - Path length：hop (跳数)
  - reliability：error rate on line
  - delay
  - bandwidth
  - Load of router
  - Communication cost

Optimization principle（最优化原理）

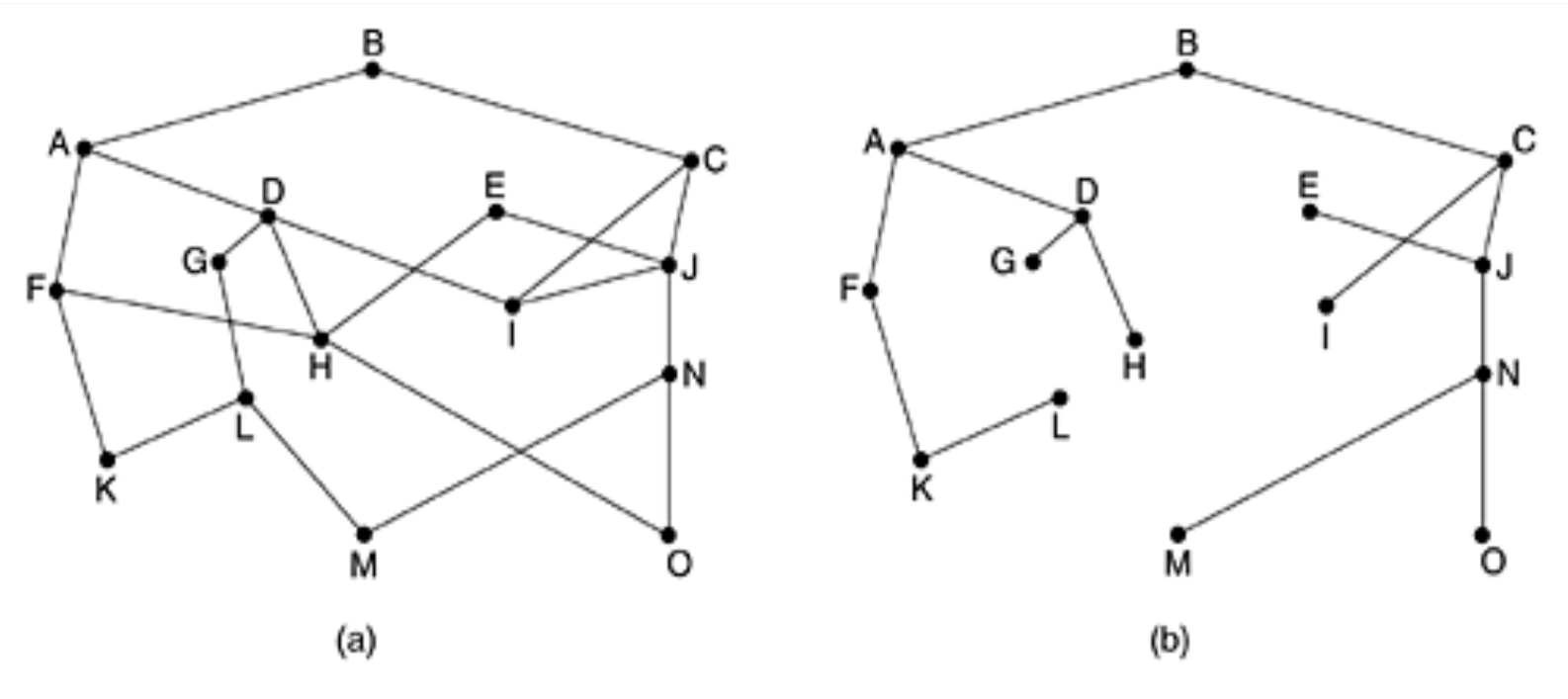
- if router J is on the optimal path from router I to router K, then the optimal path from J to K also falls along the same route



- the set of optimal routes from all sources to a given destination form a tree (called sink tree) rooted at the destination

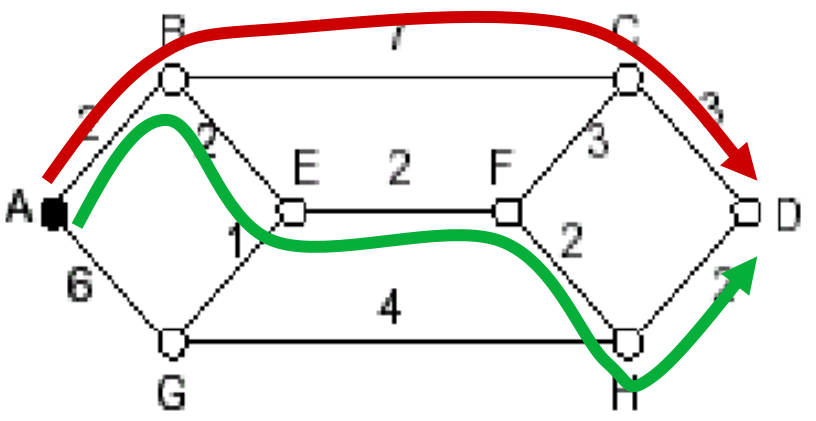
Sink tree(汇集树)

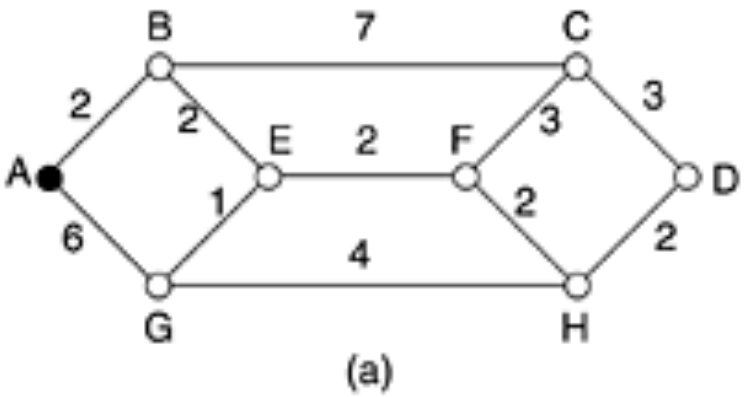
- a sink tree is not necessarily unique
- The goal of all routing algorithms is to discover and use the sink trees for all routers

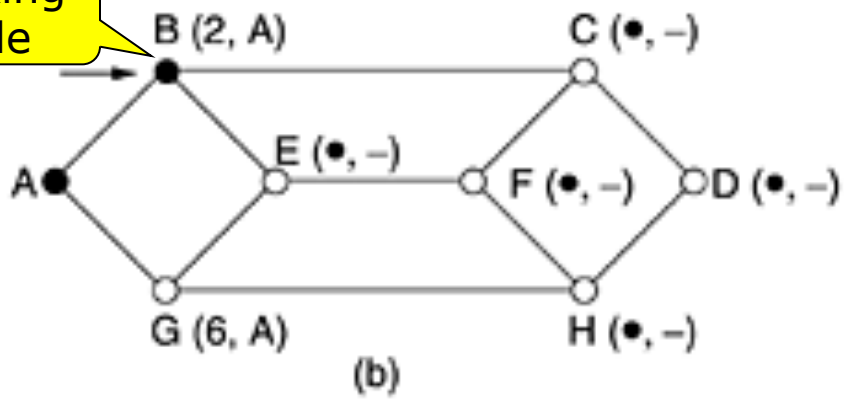


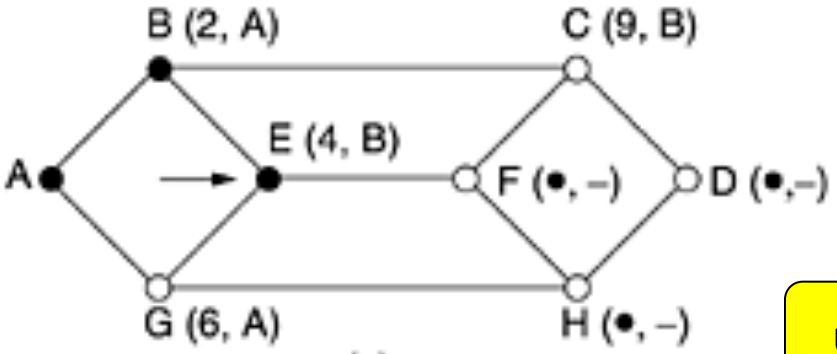
Shortest path routing

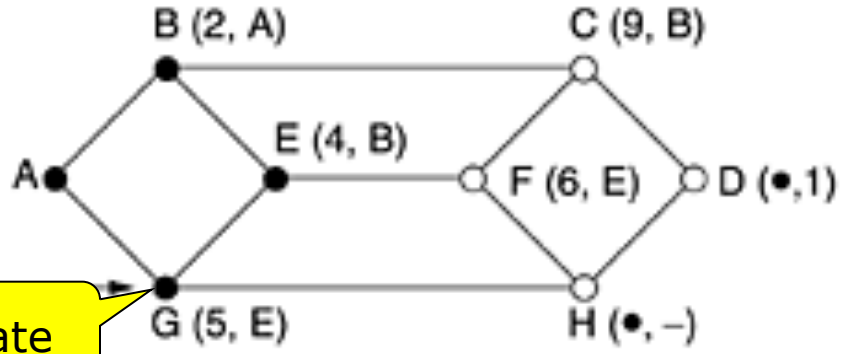
- **Dijkstra algorithm（1959）： compute shortest path using weight on communication-line**
- **Pay attention：**
  - **path with lest line may not be shortest path**
  - **The shortest path may be the fastest one**

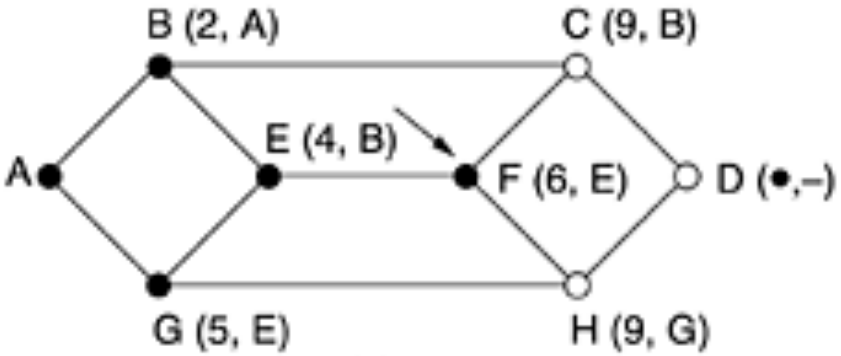


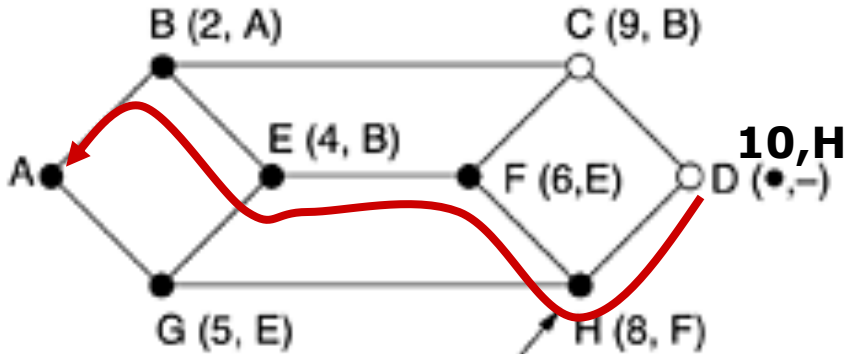

B
7
C
2
2
E
2
F
3
3
A
D
1
2
6
4
2
G
H
(a)


Working node
B (2, A)
C (•, –)
E (•, –)
A
F (•, –)
D (•, –)
G (6, A)
H (•, –)
(b)


B (2, A)
C (9, B)
E (4, B)
A
F (•, –)
D (•,–)
G (6, A)
H (•, –)
(c)


B (2, A)
C (9, B)
E (4, B)
A
F (6, E)
D (•,1)
update
G (5, E)
H (•, –)
(d)


B (2, A)
C (9, B)
E (4, B)
A
F (6, E)
D (•,–)
G (5, E)
H (9, G)
(e)


B (2, A)
C (9, B)
E (4, B)
10,H
A
F (6,E)
D (•,–)
G (5, E)
H (8, F)
(f)

Dijkstra algorithm steps（1/2）

- **1. Initialization**

Suppose node i is source node, N = {i}， for all nodes which is not included in collection:

$$D(v) = \begin{cases} l(i,v) & \text{若v与i直接连接} \\ \infty & \text{若v与i不直接相连} \end{cases}$$

“∞” can be replaced by “any number bigger more than path ”, such as 10^9

Dijkstra algorithm steps (1/2)

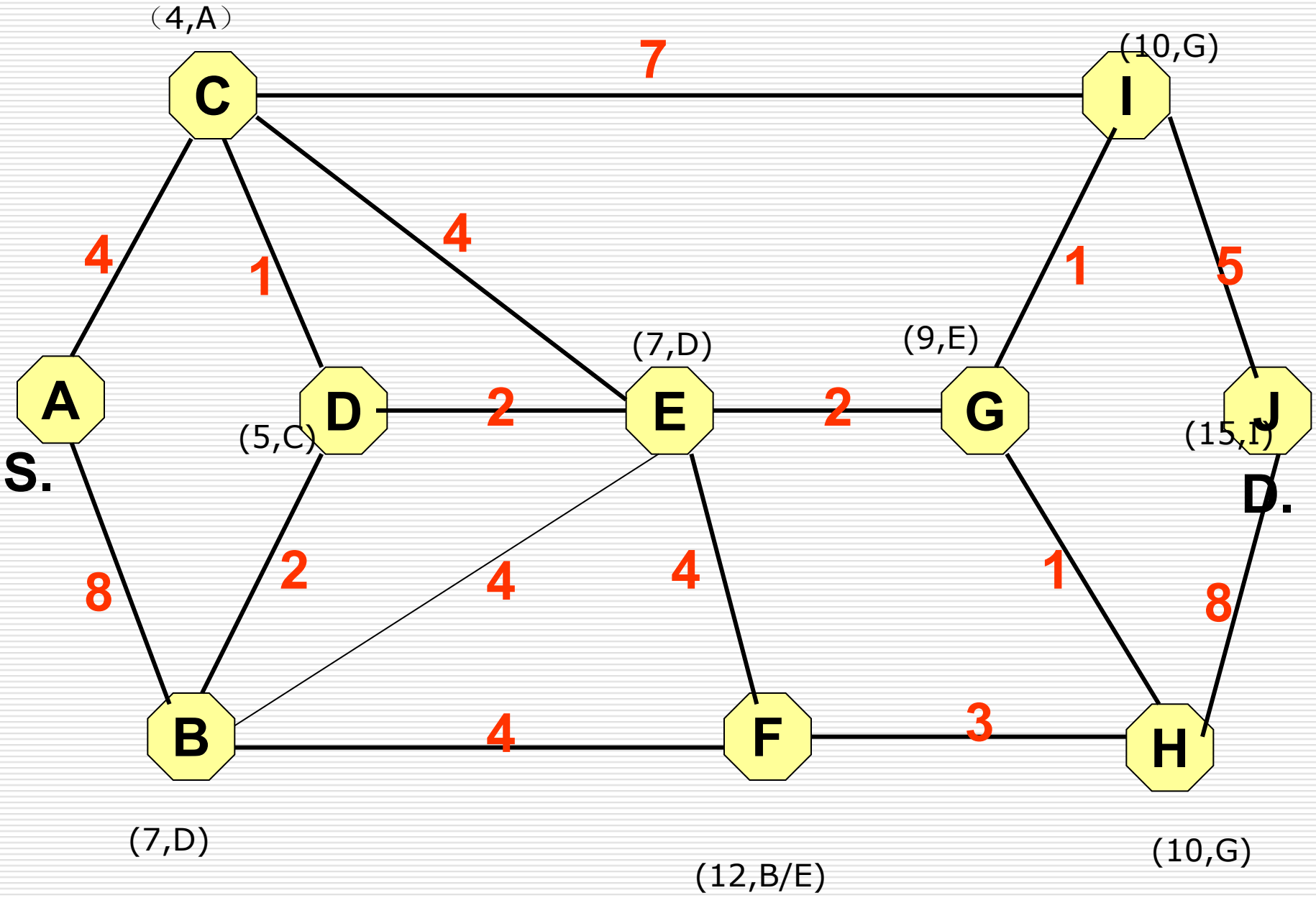
- 2. look for a node w which is not included in collection N，whose D(w) is lest，and put w into N; Then for all nodes which are not included in N，using min[D(v)，D(w) + l(w,v)] to replace D(v):

$$D(v) \leftarrow \min [\, D(v),\ D(w)+l(w,v) \,]$$

- 3.repeat step 2，until all nodes are included in collection N

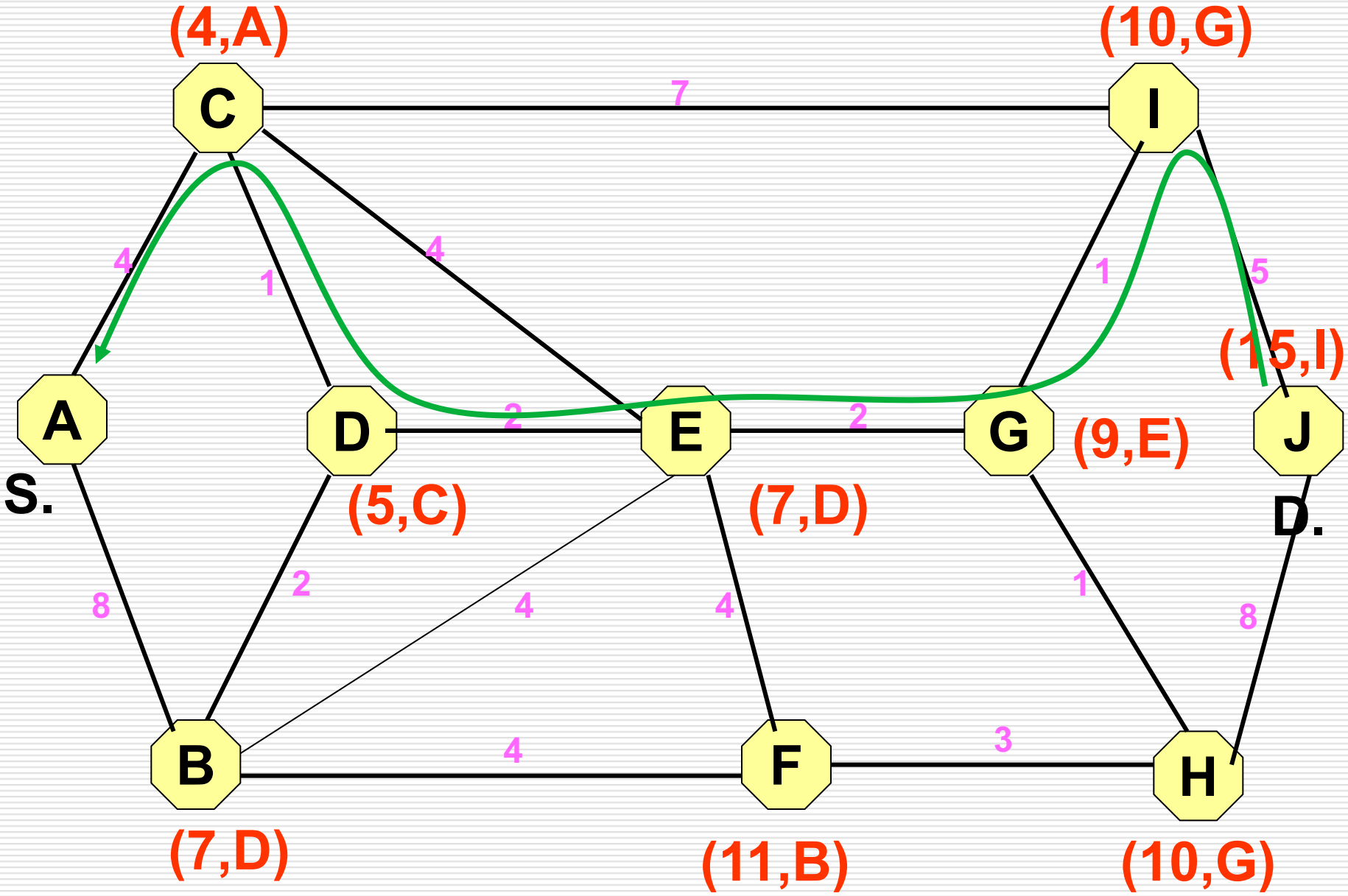
Do exercise

- According to following figure，try to select a shortest path from A to J using Dijkstra algorithm：
  - Write each working node in turn
  - Answer the shortest path from A to J and cost (metric)
  - Lable each node after the finish


（4,A）
C
7
I
(10,G)
4
1
4
1
5
A
D
E
G
J
(7,D)
(9,E)
(5,C)
(15,I)
2
2
S.
D.
8
2
4
4
1
8
B
F
H
4
3
(7,D)
(12,B/E)
(10,G)

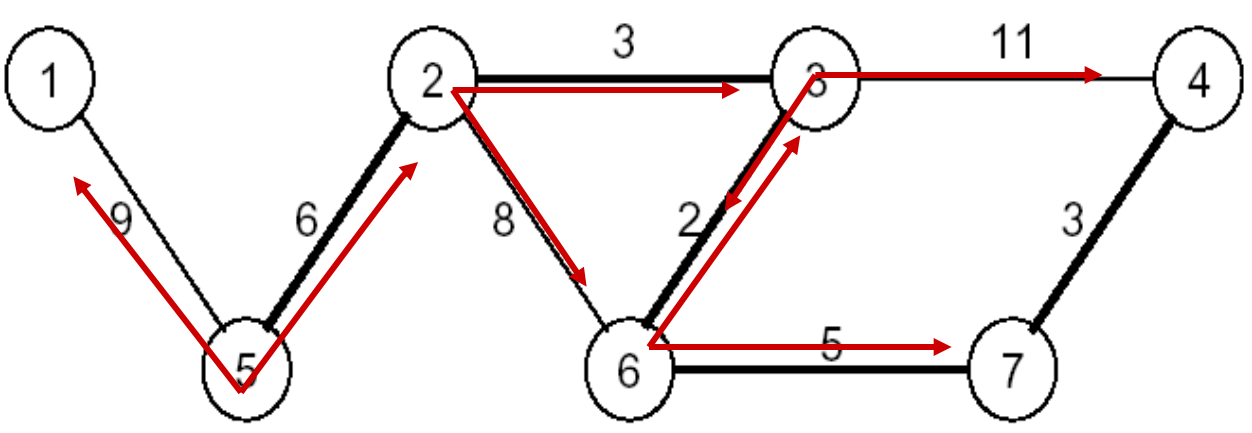
Reference key

- **Working node:**
  - **A、C、D、BE、EB、G、IH、HI、F、J**
- **Shortest path and cost:**
  - **ACDEGIJ，and cost is 15**
- **Labels are following:**


(4,A)
(10,G)
C
7
I
4
4
1
1
5
(15,I)
A
D
2
E
2
G
(9,E)
J
S.
(5,C)
(7,D)
D.
8
2
4
4
1
8
B
4
F
3
H
(7,D)
(11,B)
(10,G)

Flooding(1/2)

- Every incoming packet is sent out on every outgoing line except the one it arrived on(不计算路径，有路就走)



- For example, from 5 to 4：packet from 5→1,2；2→3,6；3→6,4；6→3,7；7→4
- problem：duplicate packets，such as 3，6

Flooding(2/2)

- **Resolution:**
  - **Add a counter in packet-header， reduce 1 when pass a node，packet is discarded when counter is zero**
  - **Each node set up a register table, packet is discarded when it arrives a node again**
  - **Flooding selectively**
- **disadvantage：duplicate packets are two many，waste bandwidth**
- **advantage：reliability high，path short，use in military affairs frequently**

Summary of the lecture

- **Main function of network layer**
  - **Transport packets (path selection)**
  - **Service provide to transport-layer**
- **Routing protocol**
  - **Routing-table**
- **Static routing algorithm**
  - **Dijkstra algorithm**
  - **flooding**

Thank you all !