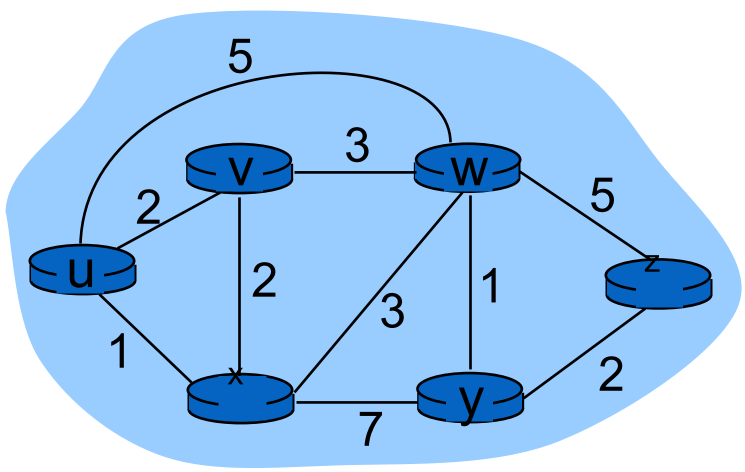
CNT 5106

Spring 2023

Homework 5

1. Describe how a link state routing protocol works. Name a link state routing protocol. Give the pseudo code of the Dijkstra's algorithm. Based on the network topology below, produce a shortest path tree from the Dijkstra's algorithm with u being the source node. Construct a forwarding table from the shortest path tree.



In a link state routing protocol, every node constructs a map of the connectivity to the network, in the form of a graph, showing which nodes are connected to which other nodes. Each node then independently calculates the next best logical path from it to every possible destination in the network. Each collection of best paths will then form each node's routing table. A link state routing protocols include OSPF.

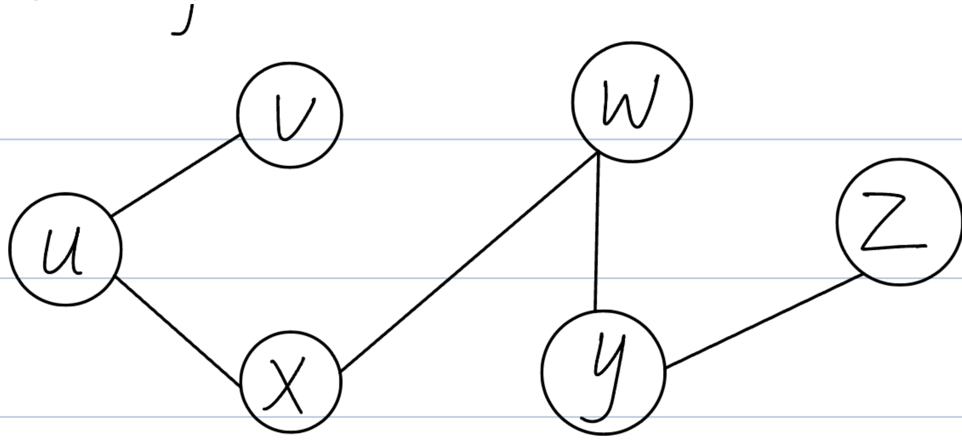
```
Initialization:
N' = {u}
for all nodes v
if v adjacent to u
then D(v) = c(u,v), p(v) = u
else D(v) = ∞, p(v) = nil

Loop
find x not in N' with smallest D(x)
add x to N'
update D(v) for all v adjacent to x and not in N' :
```

```
D(v) = min( D(v), D(x) + c(x,v) ) , p(v) = x if D(x) + c(x, v) is smaller
/* new cost to v is either old cost to v or known
shortest path cost to x plus cost from x to v */
until all nodes in N'
```

Step	N'	D(v).p(v)	D(w).p(w)	D(x).p(x)	D(y).p(y)	D(z).p(z)
0	u	2.u	5.u	1,u	∞	∞
1	ux	2,u	4,x		8,x	∞
2	uxv		4,x		8,x	∞
3	uxvw				5,w	9,w
4	uxvwy					7.y
5	uxvwyz					

resulting shortest-path tree from u:



resulting forwarding table in u:

destination	link
v	(u,v)
x	(u,x)
w	(u,x)
y	(u,x)
z	(u,x)

2. Describe how a distance vector routing protocol works. Name a distance vector routing protocol. Give the pseudo code of the Bellman-Ford algorithm. Suppose a router x has two neighbors, u and v. Suppose cost(x, u) = 1 and cost(x, v) = 5. Update the distance vector at x based on the distance vectors of u and v below.

   At u,

Destination	distance
x	1
y	4
z	9
u	0
v	6
w	10

   At v,

Destination	distance
x	5
y	14
z	2
u	6
v	0
w	5

Distance vector routing protocols work by each router maintaining a table of the best-known distance to each destination in the network, based on periodic exchanges of distance vectors with neighboring routers. The routing table is then used to determine the best next-hop router for each destination. Examples of distance vector protocols include RIP and BGP.

```
//V is the number of vertices in the graph
for v in V:
   v.distance = infinity
   v.p = None     //path for v
source.distance = 0
for i from 1 to |V| - 1:
for each edge (u, v) in E:
    if v.distance > u.distance + weight(u, v):
         v.distance = u.distance + weight(u, v)
      v.p = u
for (u, v) in E:
   if v.distance > u.distance + weight(u, v):
      print "A negative weight cycle exists"
```

$$D_x(y) = \min_v \{c(x,v) + D_v(y)\}$$

$$D_x(u) = \min\{1 + D_u(u), 5 + D_v(u)\}$$
$$= \min\{1+0, 5+6\} = 1$$

$$D_x(v) = \min\{1 + D_u(v), 5 + D_v(v)\}$$
$$= \min\{1+6, 5+0\} = 5$$

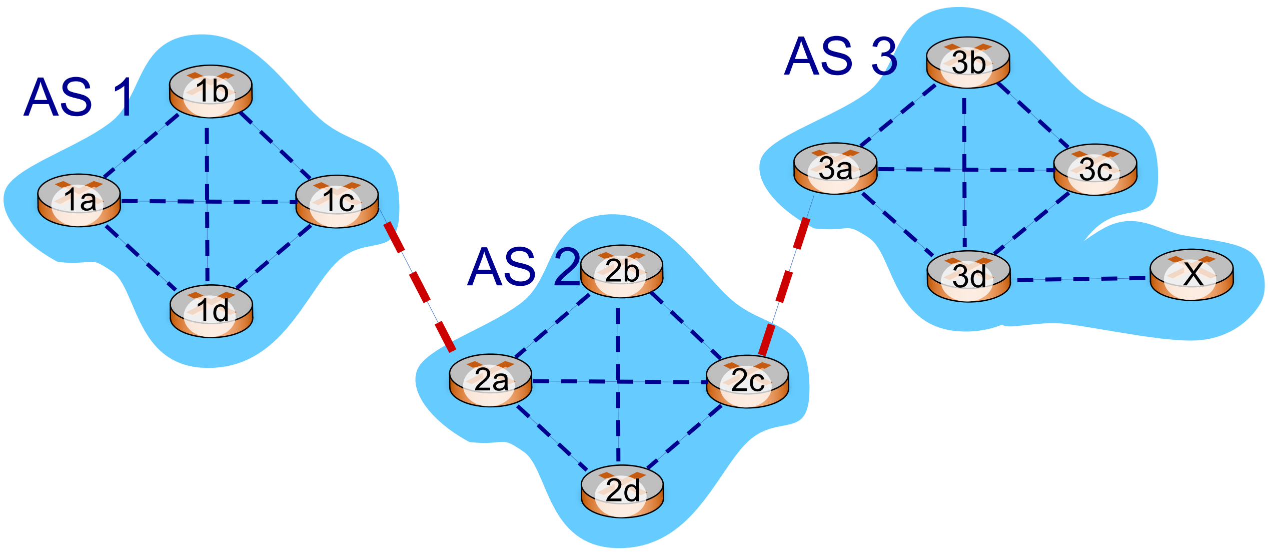
$$D_x(w) = \min\{1 + D_u(w), 5 + D_v(w)\}$$
$$= \min\{1+10, 5+5\} = 10$$

$$D_x(y) = \min\{1 + D_u(y), 5 + D_v(y)\}$$
$$= \min\{1+4, 5+14\} = 5$$

$$D_x(z) = \min\{1 + D_u(z), 5 + D_v(z)\}$$
$$= \min\{1+9, 5+2\} = 7$$

Destination	At x, distance
x	0
y	5
z	7
u	1
v	5
w	10

3. How does router 1a learns the existence of X? How does router 2d build its forwarding table that includes both internal address prefixes within its AS and external address prefixes in other ASes?



AS2 router 2c receives path advertisement (AS3,X) (via eBGP) from AS3 router 3a, based on AS2 policy, AS2 router 2c accepts path (AS3,X), propagates (via iBGP) to all AS2 routers, based on AS2 policy, AS2 router 2a advertises (via eBGP) path (AS2, AS3, X) to AS1 router 1c, then 1a learn about destination X via iBGP from 1c: "path to X goes through 1c".

For internal address prefixes within AS2, router 2d learns about them through interior gateway protocols (IGP) such as OSPF or IS-IS. For external address prefixes in other ASes, router 2d learns about them through BGP advertisements received from 2a and 2c.

4. In hierarchical OSPF, describe how each area border router builds a forwarding table that includes both address prefixes in its local area and address prefixes in other areas.

For the local area, an ABR builds its forwarding table using the shortest path first (SPF) algorithm based on the link-state database it has received from all routers in its own area. It considers only routes within the same area and does not consider routes from other areas.

For external prefixes in other areas, an ABR builds its forwarding table using Type 3 LSAs received from other areas. Type 3 LSAs describe the routing information for other areas within this AS. The ABR uses this information to build a forwarding table that includes both local and remote routes.

5. Name one advantage of software-defined networking v.s. traditional router design.

One of advantage of SDN is the ability to centralize network management and control, in the traditional router design, each router maintains its own forwarding table and control plane, which can result in inconsistent configurations and difficulty in managing the network as a whole.