CSCI 466: Networks

Network Layer – Routing (Control Plane)

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Fall 2022

Announcements

NO CLASS on Monday (10/24)

- Email/DM me if you need to chat or have questions

PA2 due **tonight*** at 11:59 PM

→ You can submit it any time this weekend without a late pass and you won't lose points ☺

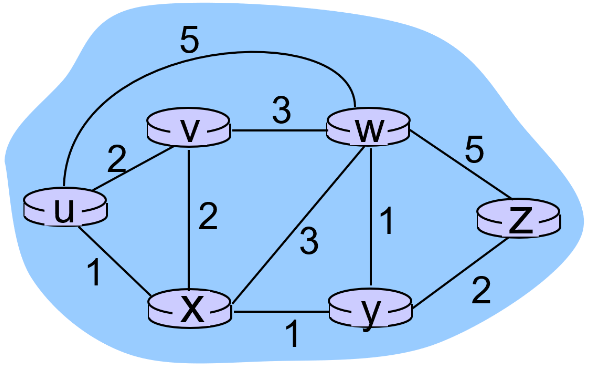
HW2 Released. Due one week from today (10/28)

Forwarding refers to moving packets from a **router's input** to appropriate **router output**, and is implemented in the data plane.

Address range	Interface (output link)
128.11.52.0 – 128.11.52.255	1
153.90.2.0 – 153.90.2.255	2
153.90.2.87 – 153.90.2.89	3

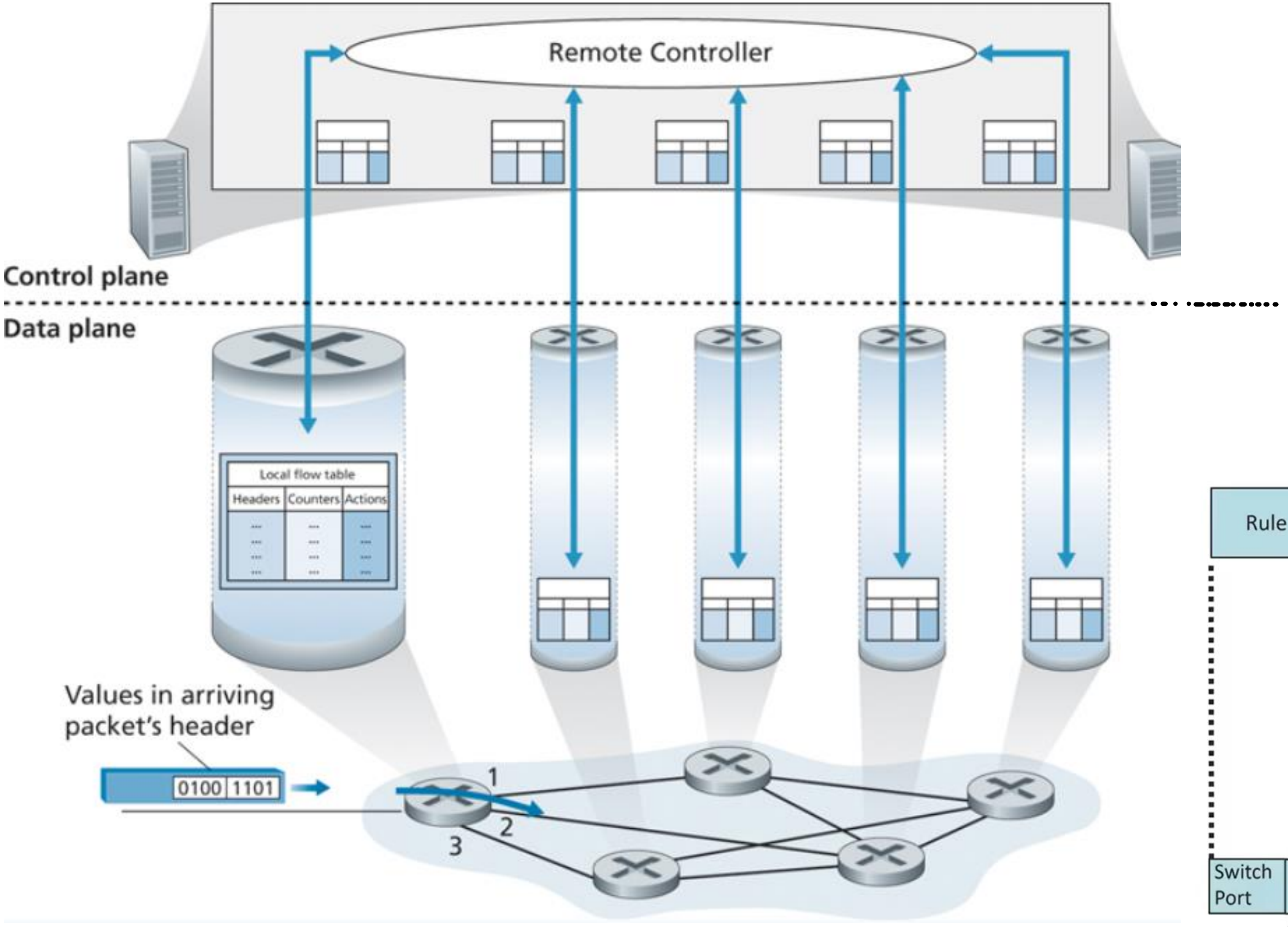
Ideally, this output links are the most optimal path to get to the destination

Routing refers to determining the route taken by packets from **source** to **destination**, and is implemented in the control plane.

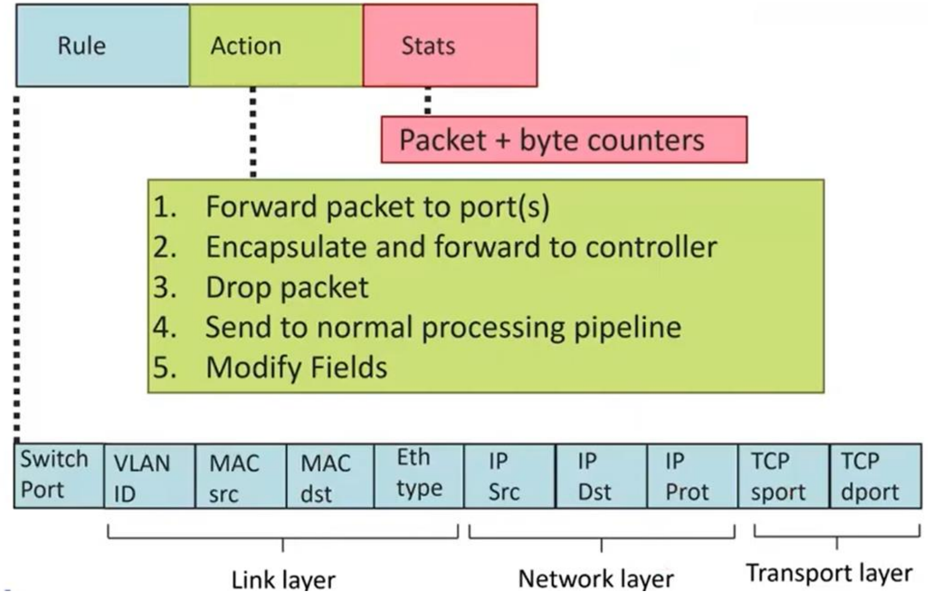


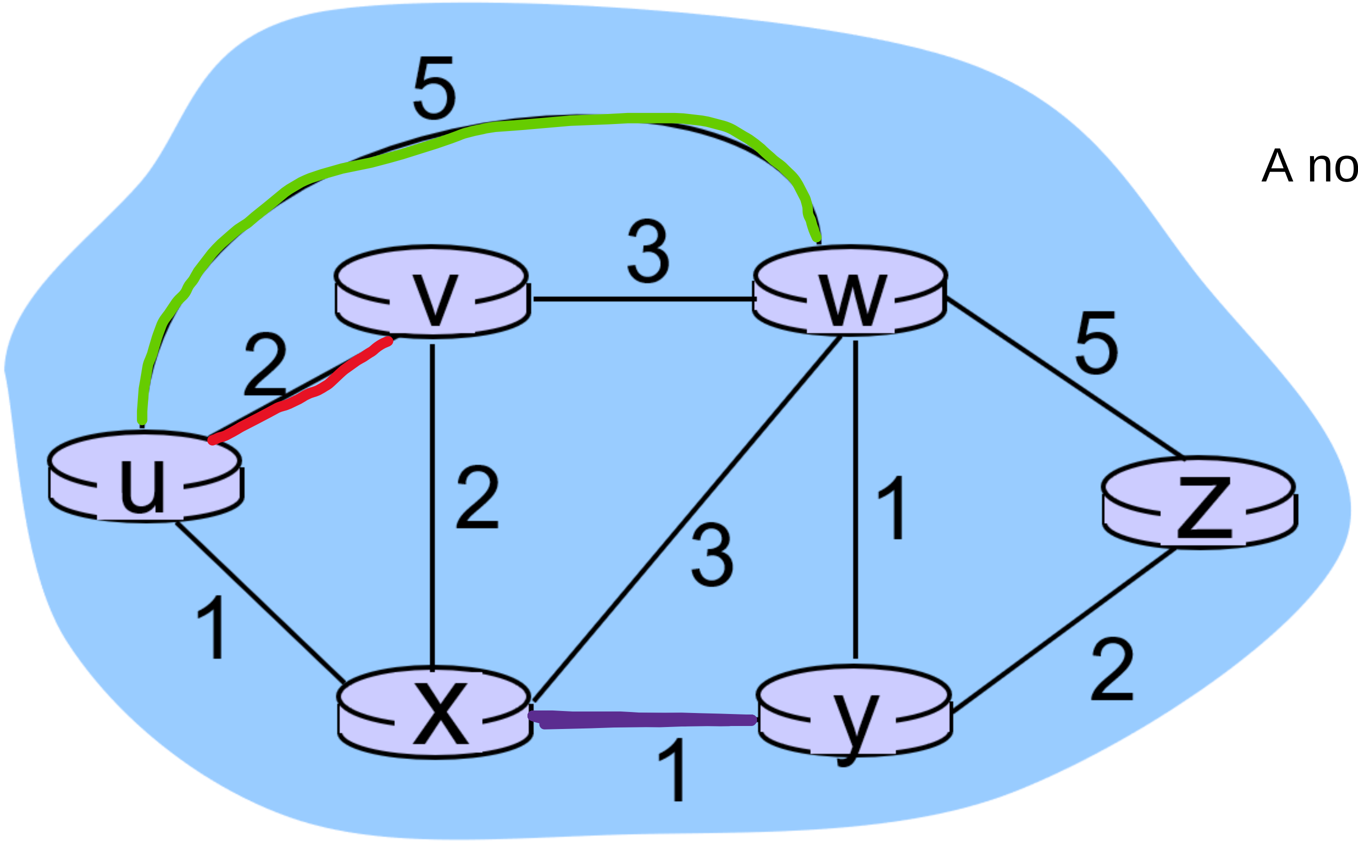
What is the best way to get from **u** to **z**?

Generalized Forwarding and Software Defines Network (SDN)



Control Plane and Data Plane need to work together in order to create efficient routing tables





An example network with 6 hosts/routers

What do the costs represent??

A graph G consists of N nodes

N = { u v x w y z }

A node could be a host, a router, or a smaller network!

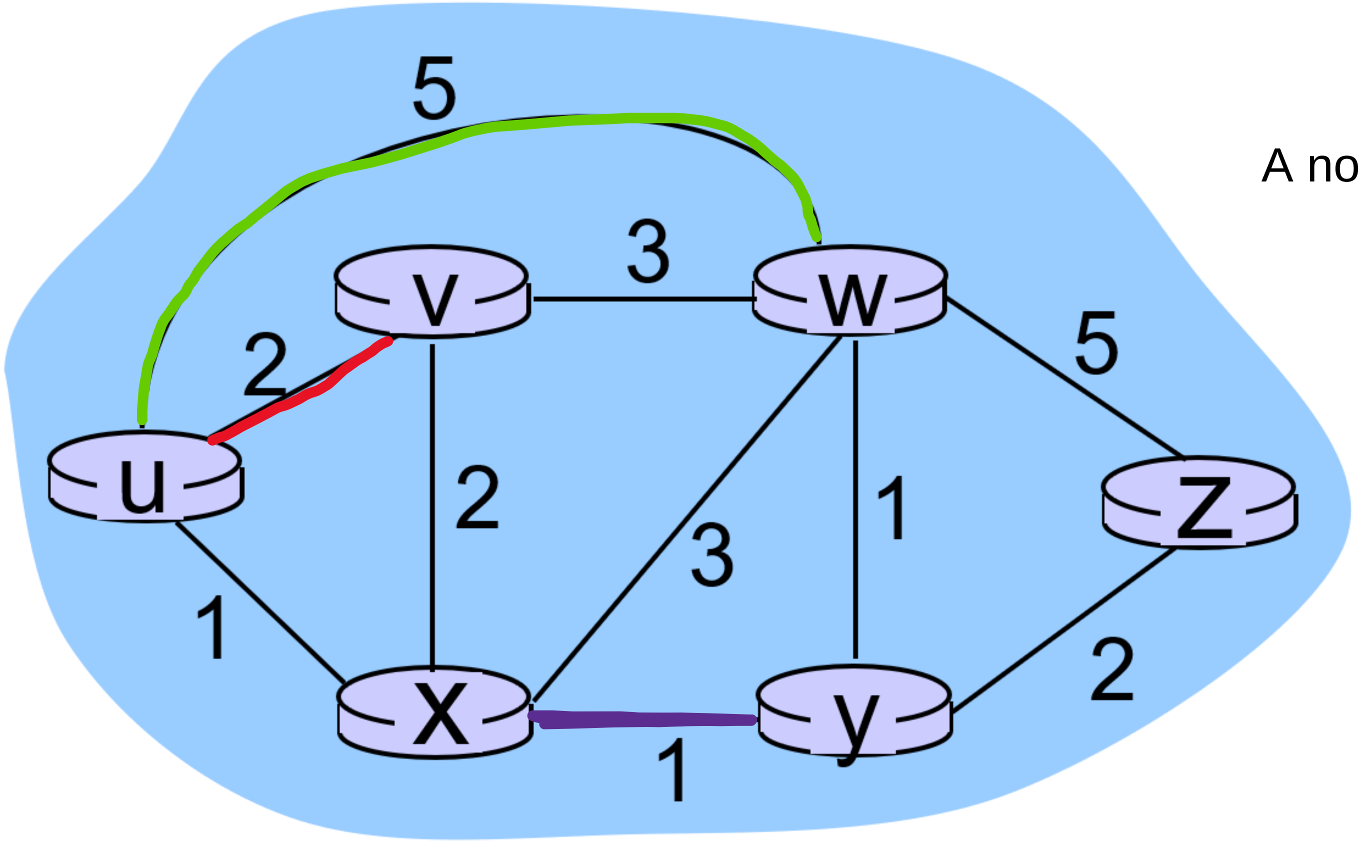
A graph consists of edges E

E_1 (u,v) = 2

E_2 (u,w) = 5

E_6 (x,y) = 1

In most cases, edges will also have a **cost**



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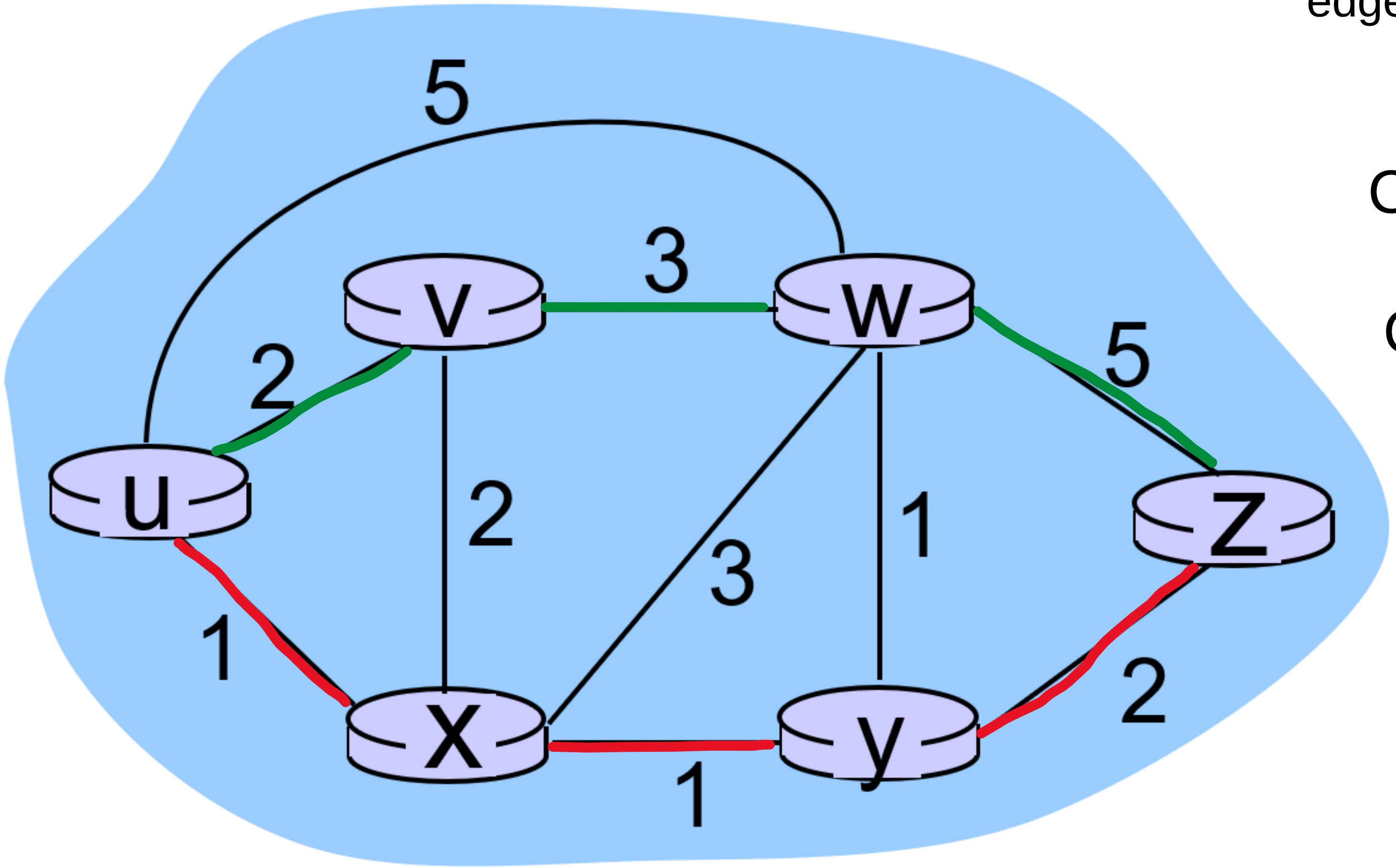
What do the costs represent?? Physical distance, time needed, bandwidth, delay

Network as a Graph



The cost from A to B is the **sum** of the edge weights of the path taken

C(u,z) = 1 + 1 + 2 = 4

C(u,z) = 2 + 3 + 5 = 10

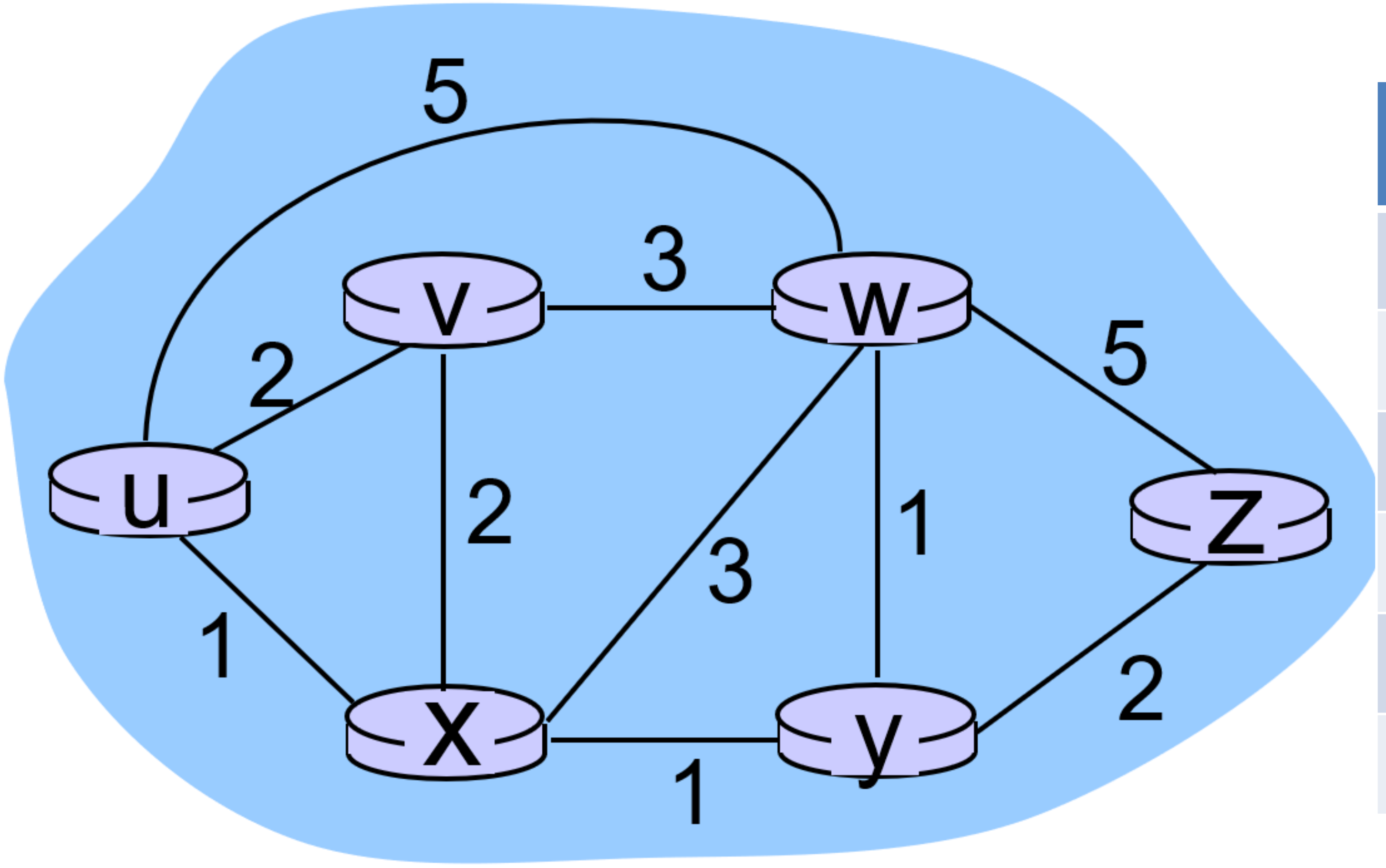
If a packet needs to go from U to Z, we want it to take the most optimal path!

Routing algorithm: algorithm that finds the least cost path

Do you know any? 👀

Link-state Algorithm (Dijkstra's algorithm)

Dijkstra's algorithm is a shortest path algorithm that is guaranteed to find a solution



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	N/A	N/A
1						
2						
3						
4						
5						

Goal: Find shortest path from u to z

N' is our current optimal path. We must start at u obviously

Link-state Algorithm (Dijkstra's algorithm)

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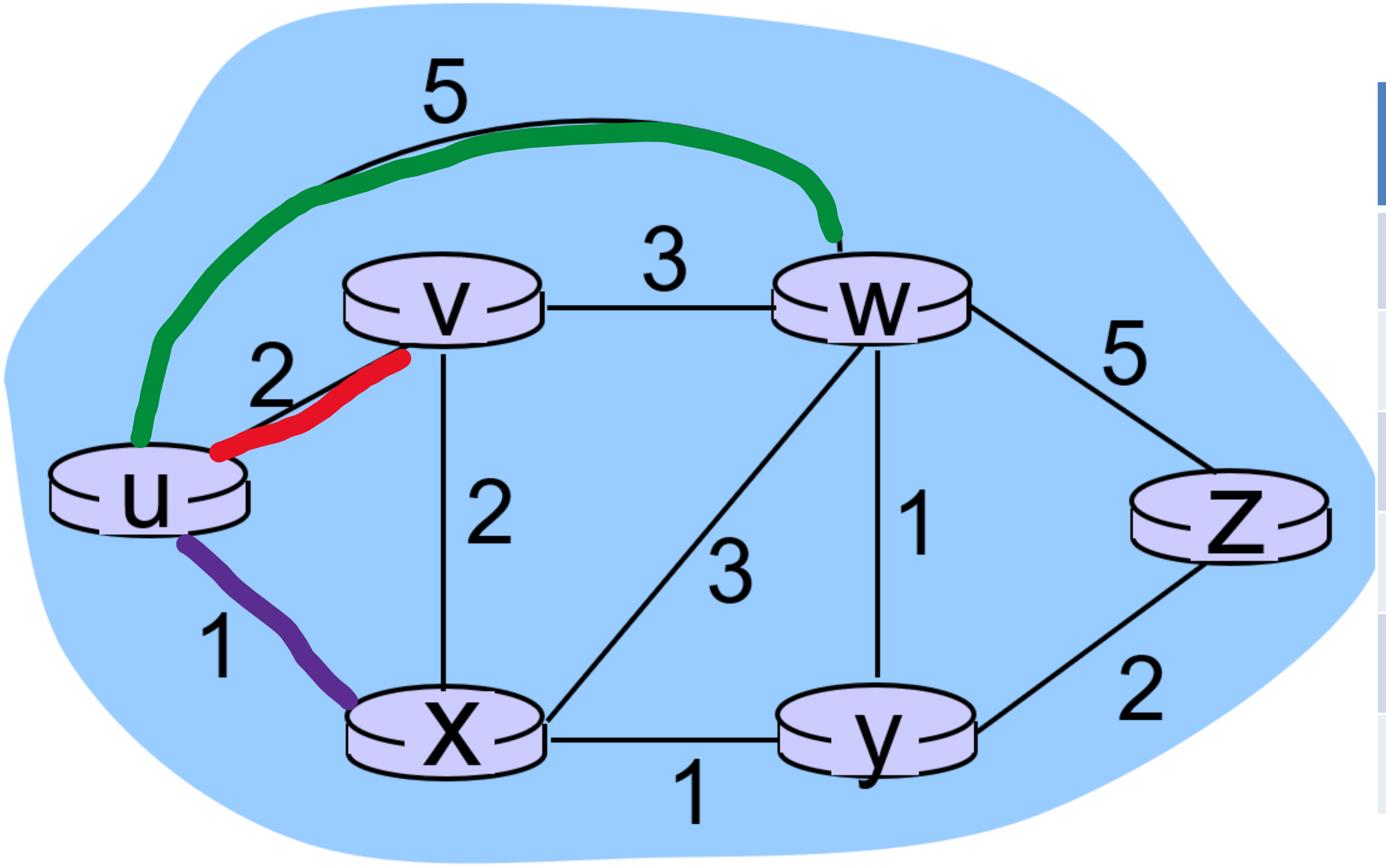

step	N'	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)
0	u	2, u	5, u	1, u	N/A	N/A
1						
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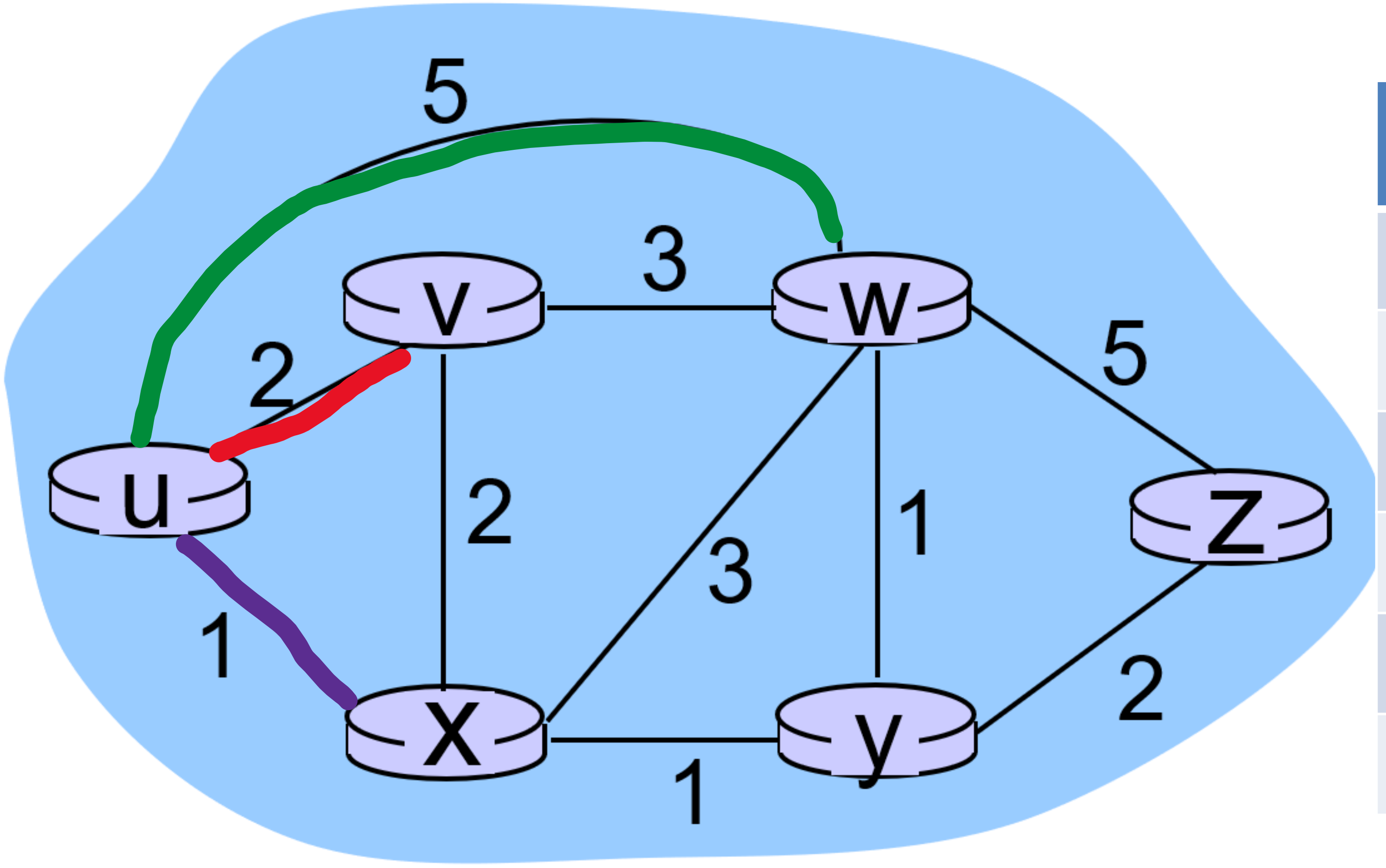
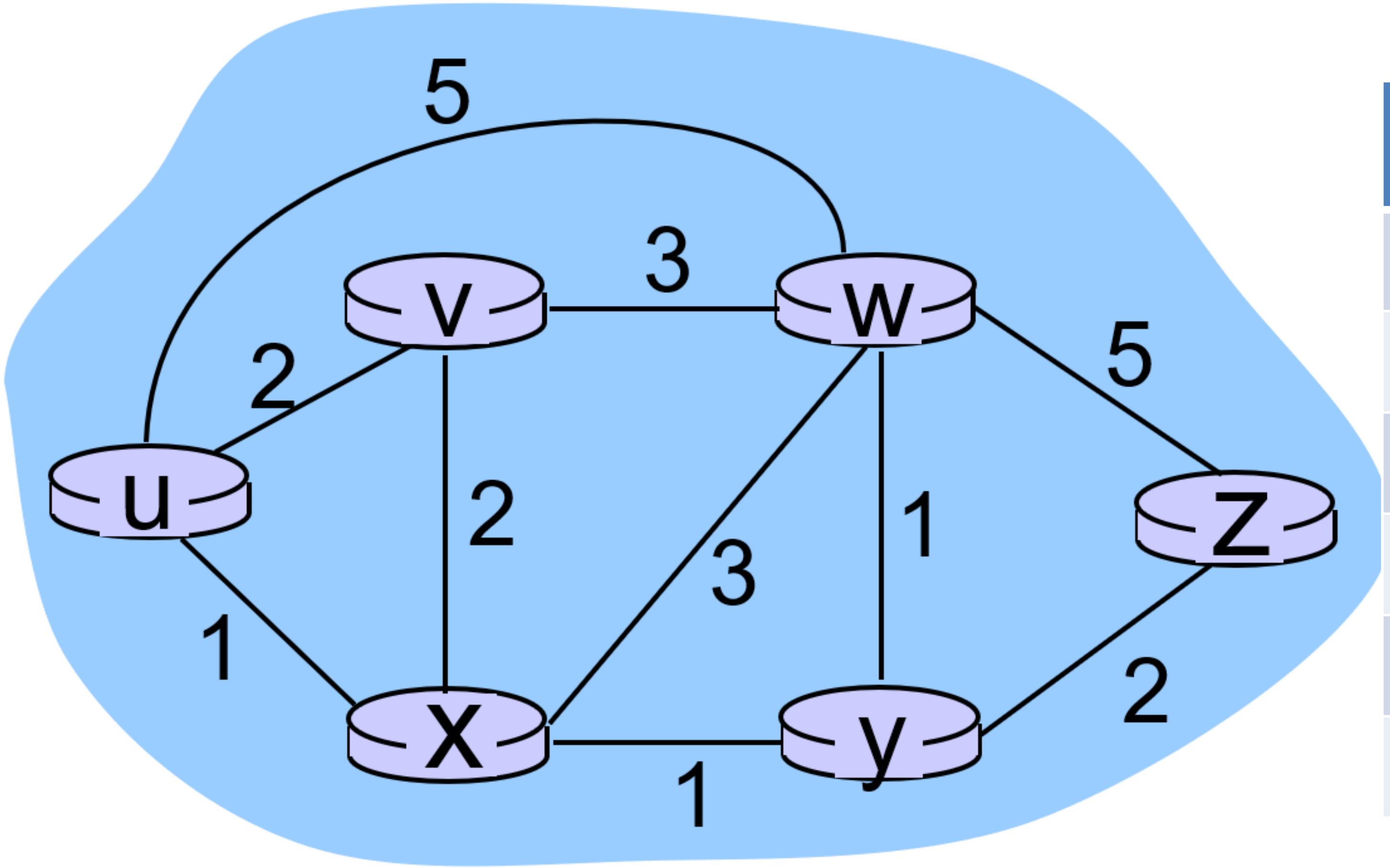


step	N'	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)
0	u	2, u	5, u	1, u	N/A	N/A
1						
2						
3						
4						
5						

The path with the least cost is to X, so x will get added onto our path!

Goal: Find shortest path from u to z

Link-state Algorithm (Dijkstra's algorithm)



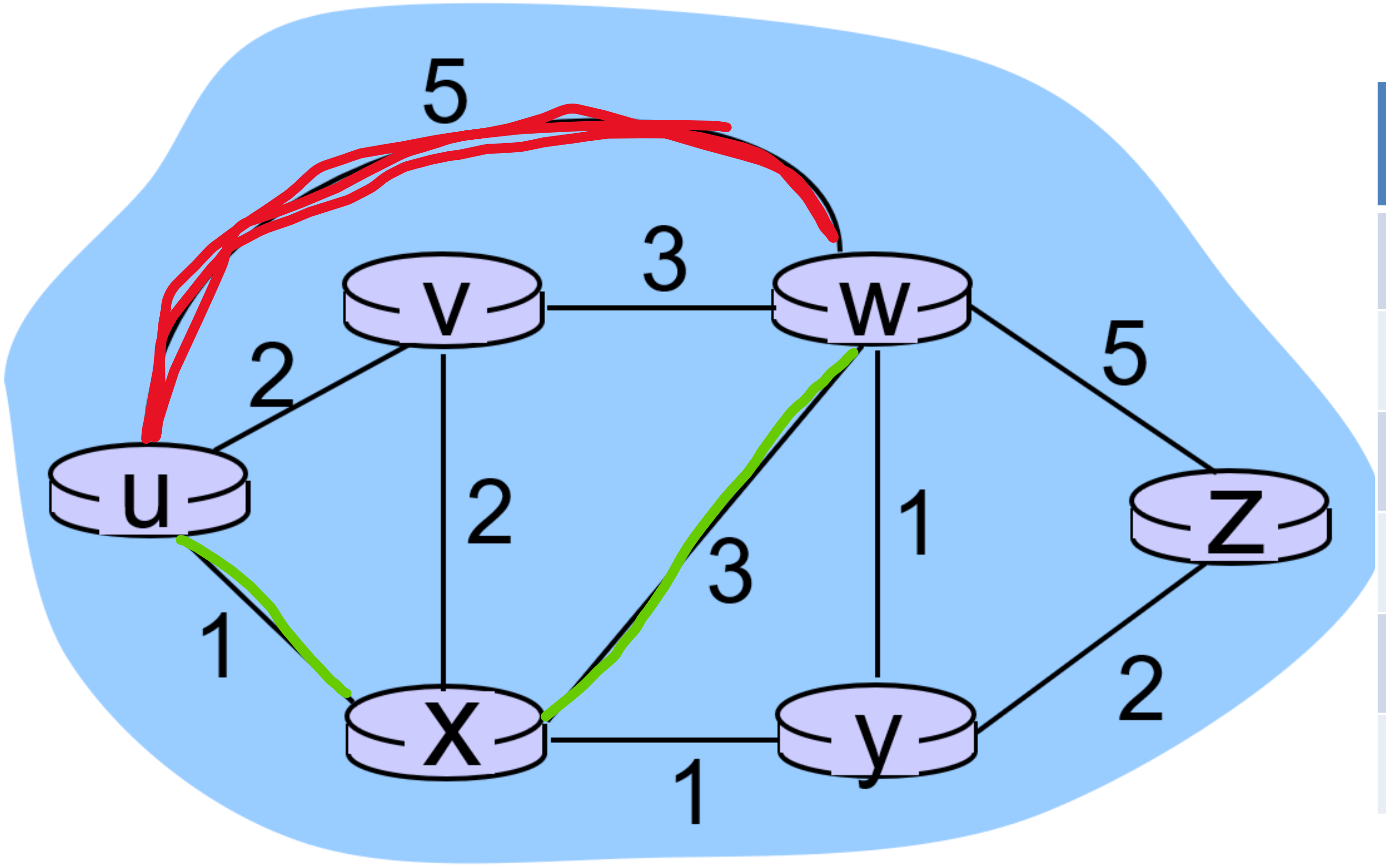
Goal: Find shortest path from u to z

Dijkstra's algorithm is a shortest path algorithm that is guaranteed to find a solution

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	N/A	N/A
1	ux					
2						
3						
4						
5						

Link-state Algorithm (Dijkstra's algorithm)

Dijkstra's algorithm is a shortest path algorithm that is guaranteed to find a solution



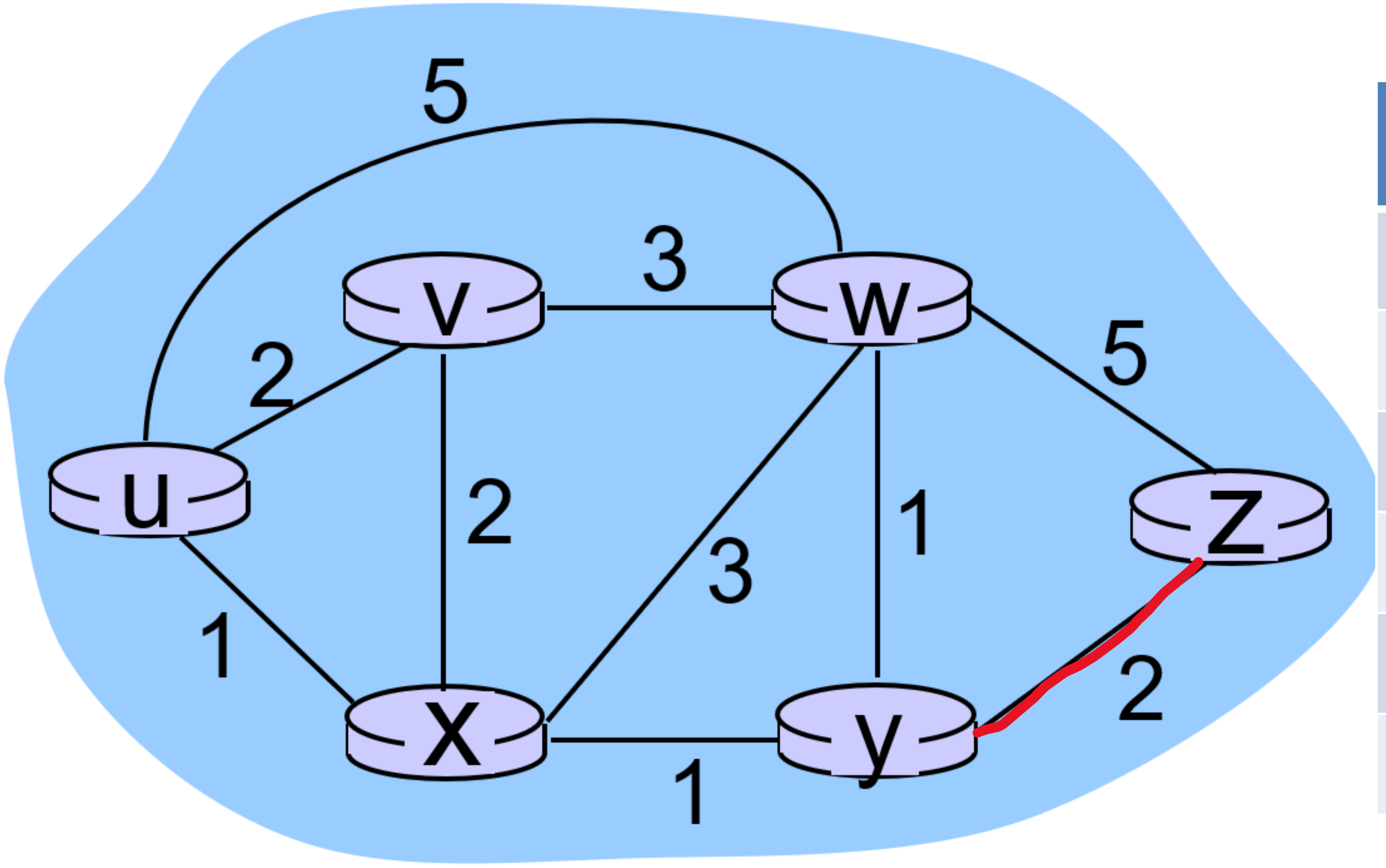
step	N'	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)
0	u	2, u	~~5, u~~	1, u	N/A	N/A
1	ux	2, u	4, x ✓		2, x	N/A
2						
3						
4						
5						

The shortest path from u to v is still the same

The shortest path from u to w is now 4 (travel through x) instead of taking the 4 cost path

Goal: Find shortest path from u to z

Link-state Algorithm (Dijkstra's algorithm)



Goal: Find shortest path from u to z

Dijkstra's algorithm is a shortest path algorithm that is guaranteed to find a solution

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	N/A	N/A
1	ux	2, u	4, x		2, x	N/A
2	uxy	2, u	3, y			4,y
3						
4						
5						

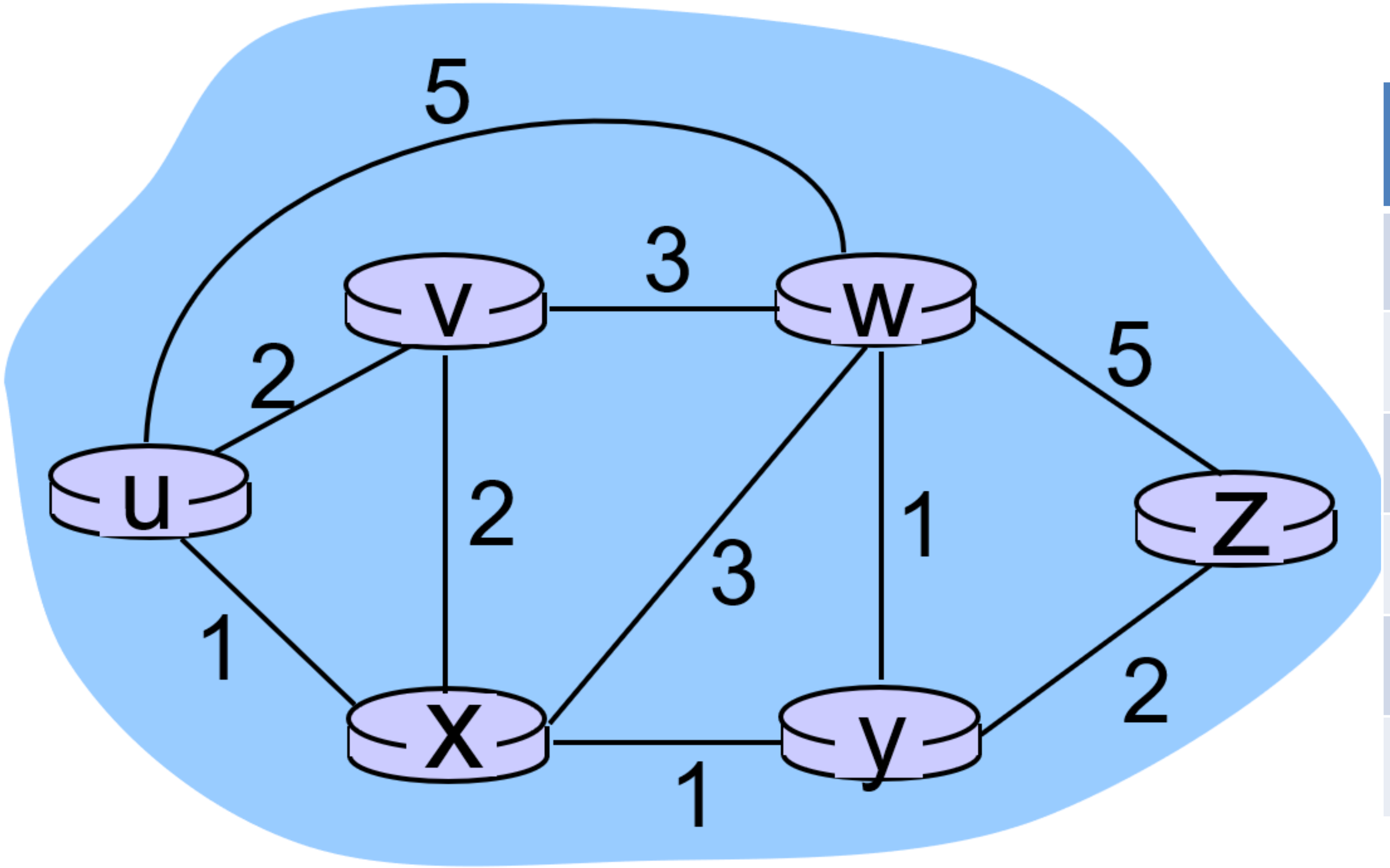
We also have a more optimal path to W now

Now that y is on our path, we can now reach z!

Path(u,z) = uxyz
Cost = 1 +1 + 2 = **4**

Link-state Algorithm (Dijkstra's algorithm)

Dijkstra's algorithm is a shortest path algorithm that is guaranteed to find a solution

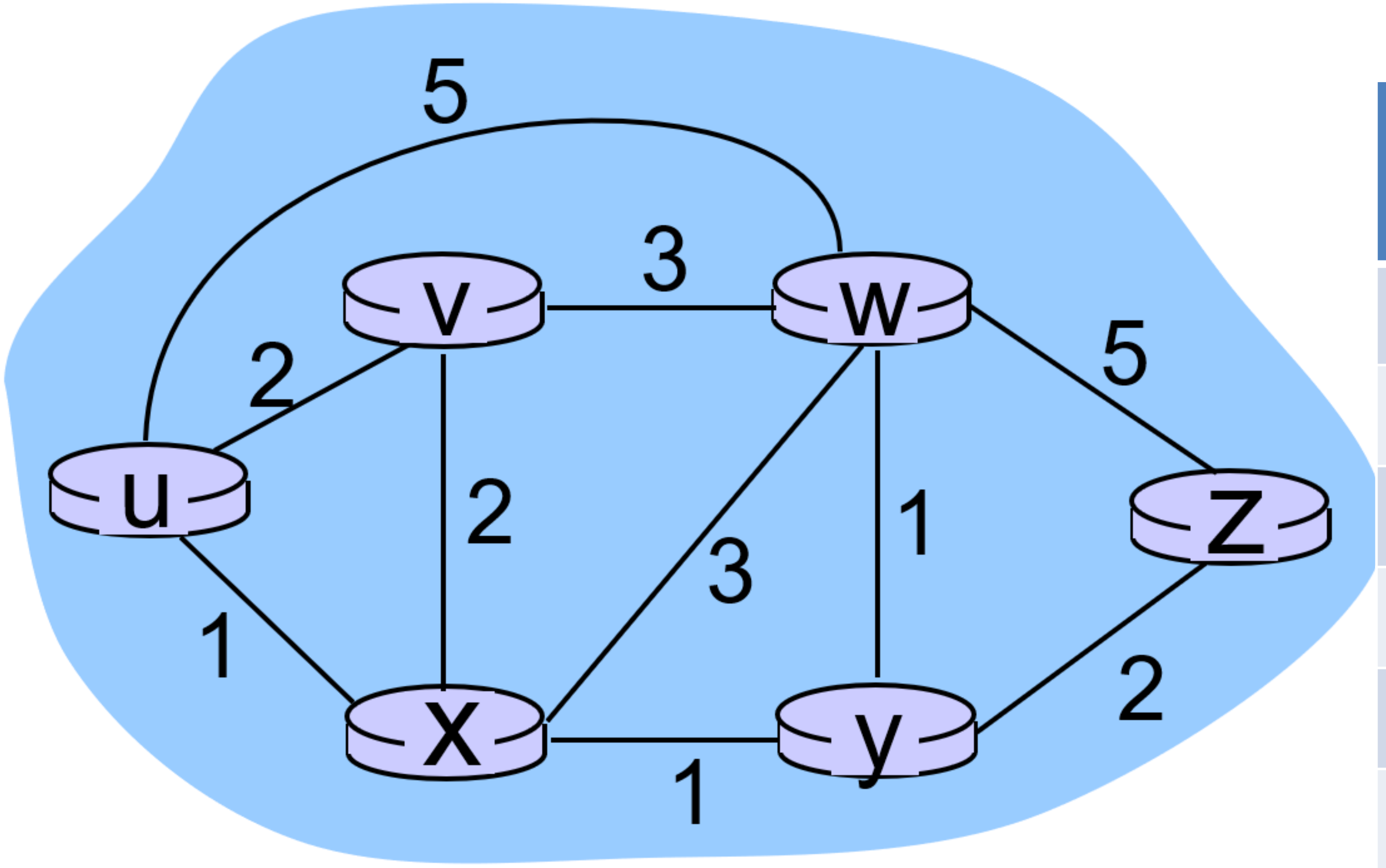


step	N'	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)
0	u	2, u	5, u	1, u	N/A	N/A
1	ux	2, u	4, x		2, x	N/A
2	uxy	2, u	3, y			4,y
3	uxyv		3,y			4,y
4						
5						

NEW Goal: Find shortest path from u to any node

Link-state Algorithm (Dijkstra's algorithm)

Dijkstra's algorithm is a shortest path algorithm that is guaranteed to find a solution



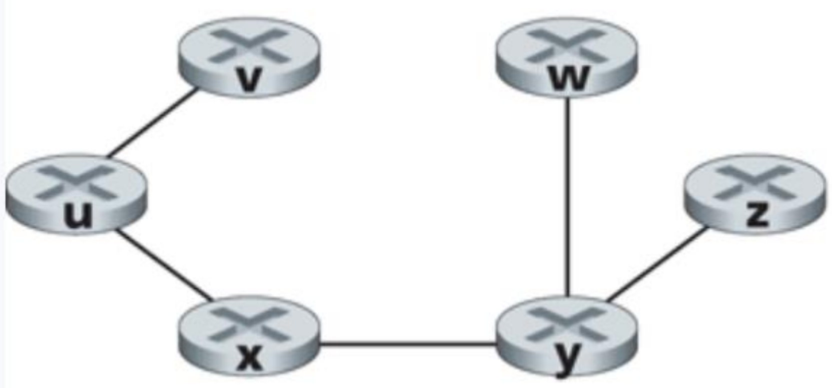
step	N'	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)
0	u	2, u	5, u	1, u	N/A	N/A
1	ux	2, u	4, x		2, x	N/A
2	uxy	2, u	3, y			4,y
3	uxyv		3,y			4,y
4	uxyvw					4,y
5	uxyvwz					

NEW Goal: Find shortest path from u to any node

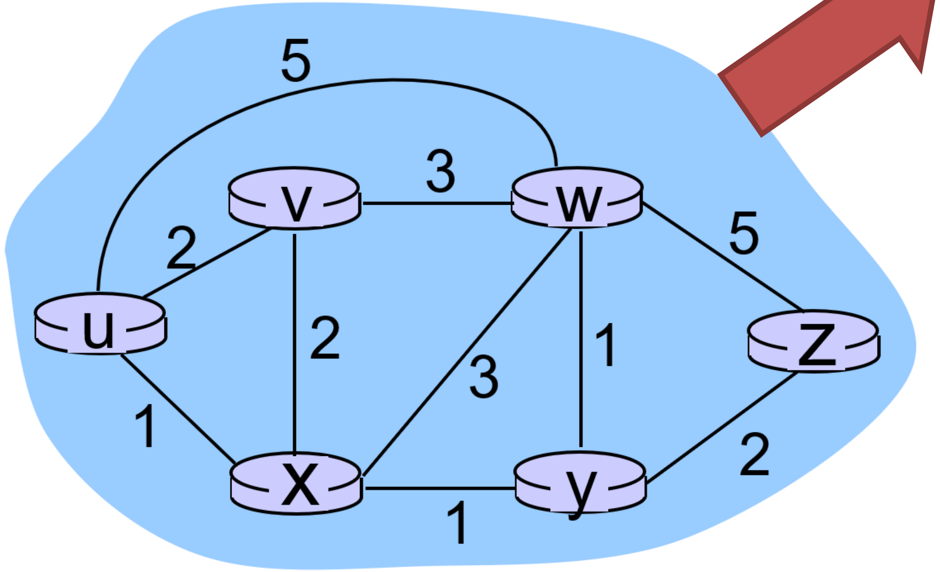
Link-state Algorithm (Dijkstra's algorithm)

LS complexity = **O(N^2)**

Issues? Concerns?



Destination	Link
v	(u, v)
w	(u, x)
x	(u, x)
y	(u, x)
z	(u, x)



Routing table for node u

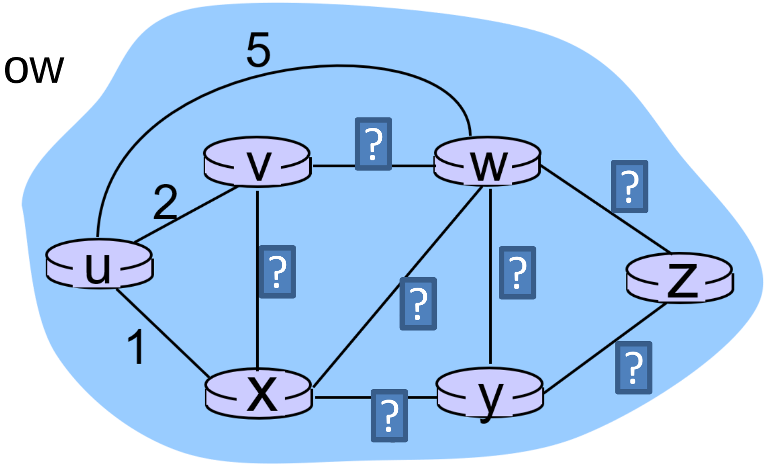
We will then run the same algorithm on each node to create its forwarding table!

Link-state Algorithm (Dijkstra's algorithm)

LS is a **centralized** routing algorithm, which means it has global knowledge about all the edge of the network!

However, it is very likely we will not know information about the network beforehand!

Additionally, path costs can frequently change based on network congestion



Have a good weekend