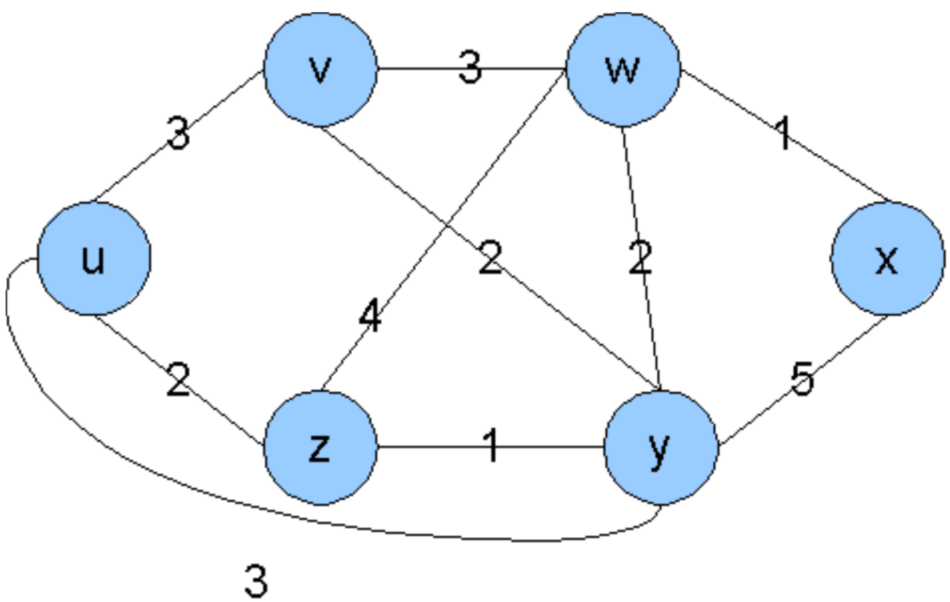
Homework #5

Narisu Tao
narisu.tao@informatik.uni-goettingen.de

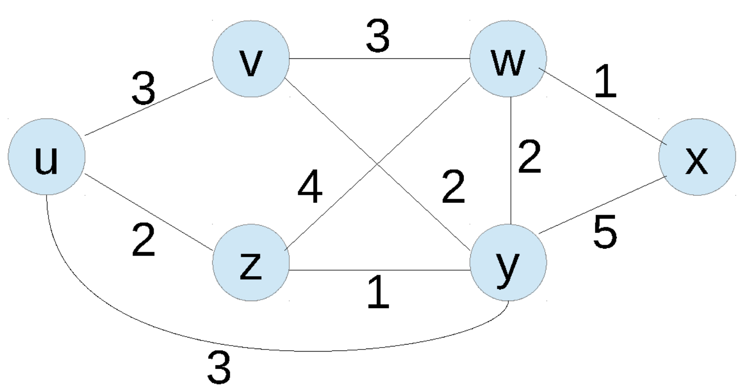
Dijkstra's algorithm

Q1: Given the following network, use Dijkstra's algorithm to find the least cost paths from node u. Please provide a table showing the steps of the algorithm, a graph showing the resulting shortest-path tree from u and the final forwarding table of u.



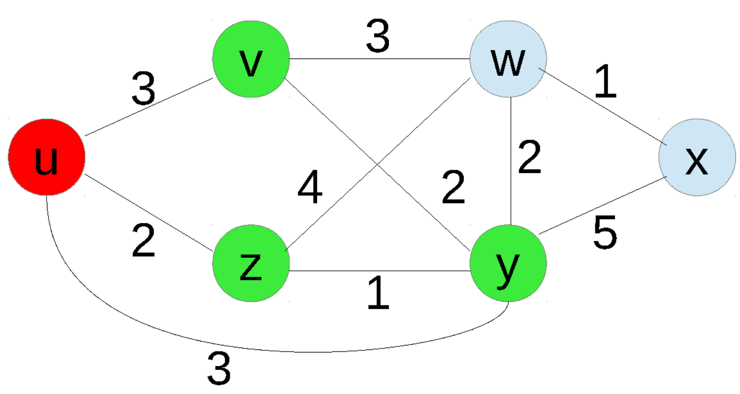
Dijkstra's algorithm (cont’d)

Step	N'	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)



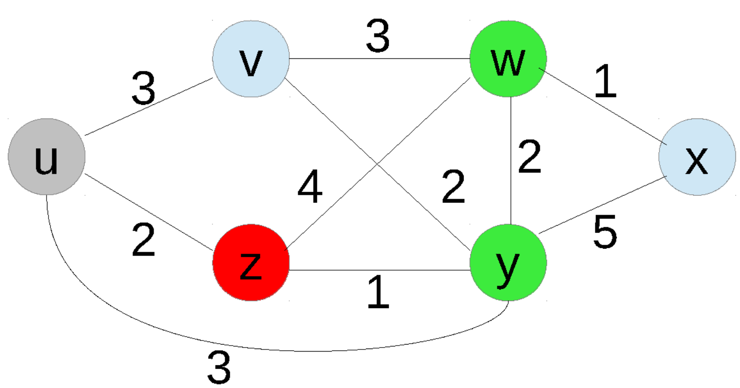
Dijkstra's algorithm (cont’d)

Step	N'	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)
0	u	3,u	∞	∞	3,u	2,u



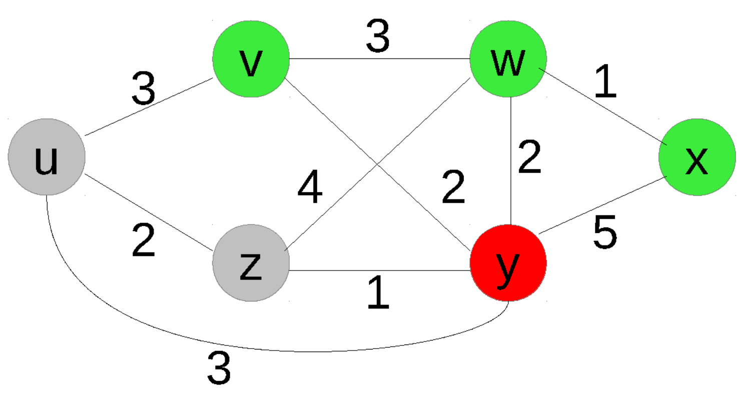
Dijkstra's algorithm (cont’d)

Step	N'	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)
0	u	3,u	∞	∞	3,u	2,u
1	uz	3,u	6,z	∞	3,u	



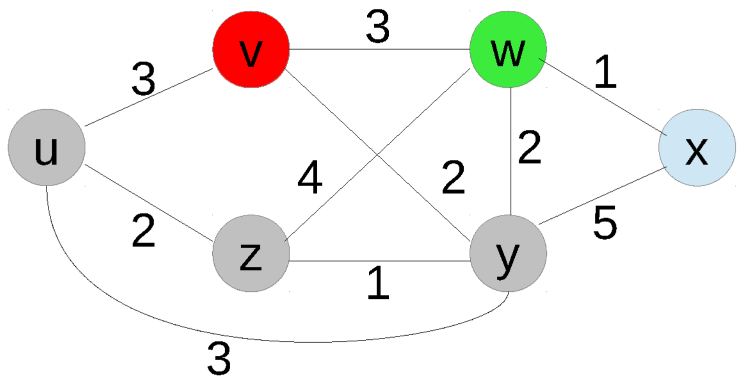
Dijkstra's algorithm (cont'd)

Step	N'	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)
0	u	3,u	∞	∞	3,u	2,u
1	uz	3,u	6,z	∞	3,u	
2	uzy	3,u	5,y	8,y		



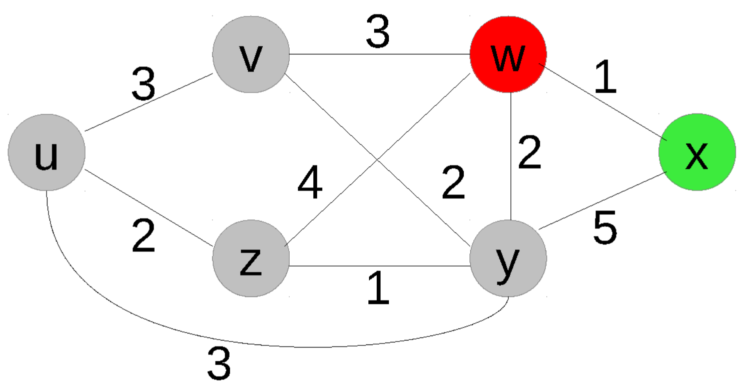
Dijkstra's algorithm (cont’d)

Step	N'	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)
0	u	3,u	∞	∞	3,u	2,u
1	uz	3,u	6,z	∞	3,u	
2	uzy	3,u	5,y	8,y		
3	uzyv		5,y	8,y		



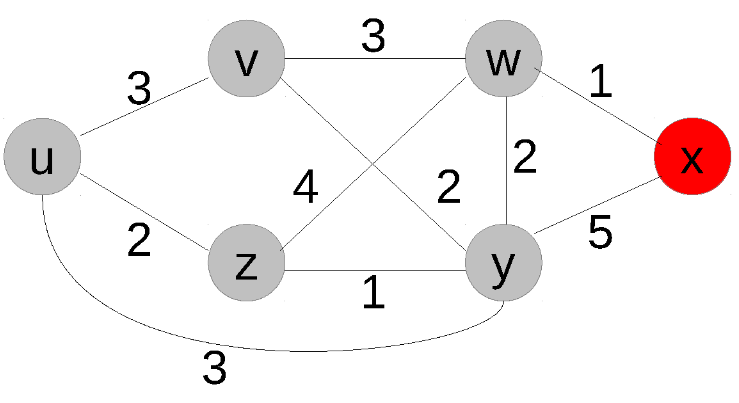
Dijkstra's algorithm (cont'd)

Step	N'	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)
0	u	3,u	∞	∞	3,u	2,u
1	uz	3,u	6,z	∞	3,u	
2	uzy	3,u	5,y	8,y		
3	uzyv		5,y	8,y		
4	uzyvw			6,w		



Dijkstra's algorithm (cont’d)

Step	N'	D(v), p(v)	D(w), p(w)	D(x), p(x)	D(y), p(y)	D(z), p(z)
0	u	3,u	∞	∞	3,u	2,u
1	uz	3,u	6,z	∞	3,u	
2	uzy	3,u	5,y	8,y		
3	uzyv		5,y	8,y		
4	uzyvw			6,w		
5	uzyvwx					



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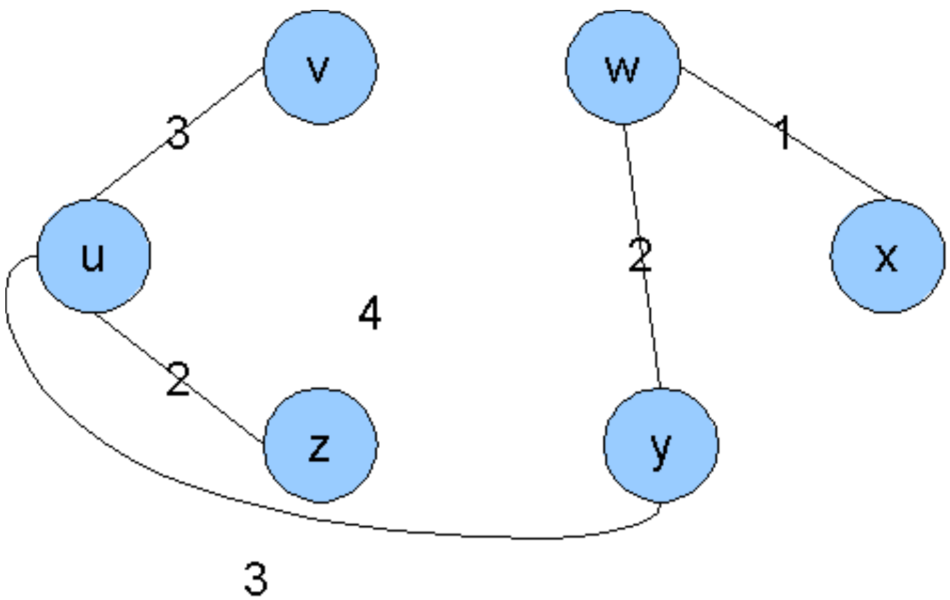
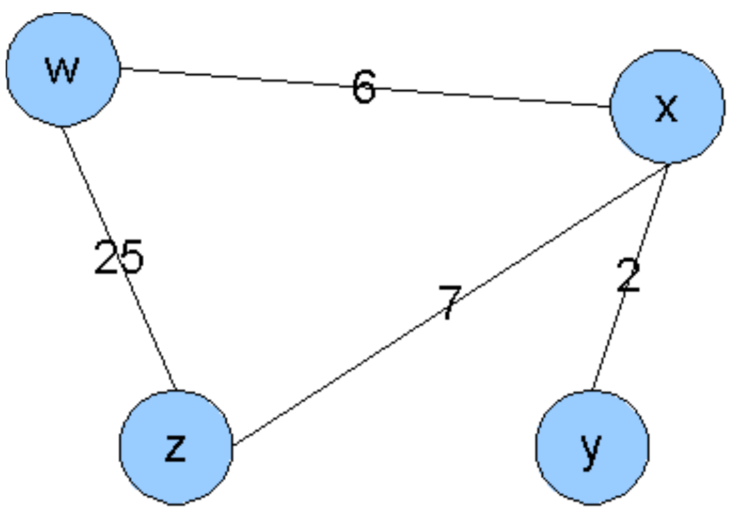
Dijkstra's algorithm (cont'd)



Dest.	Link.
z	z
y	y
v	v
w	y
x	y

Distance Vector algorithm

Q2: Given the following network, use the Distance Vector algorithm to find the least cost paths for all nodes. Fill the provided tables and indicate with arrows between the tables when a node sends a distance vector to another node.



Distance Vector algorithm

Node w		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node w		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node w		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node w		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node x		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node x		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node x		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node x		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node y		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node y		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node y		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node y		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node z		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node z		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node z		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node z		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Distance Vector algorithm

Node w		cost to			
		w	x	y	z
from	w	**0**	**6**	∞	**25**
	x	∞	∞	∞	∞
	y	∞	∞	∞	∞
	z	∞	∞	∞	∞

Node w		cost to			
		w	x	y	z
from	w	**0**	**6**	**8**	**13**
	x	6	0	2	7
	y	∞	∞	∞	∞
	z	25	7	∞	0

Node w		cost to			
		w	x	y	z
from	w	0	6	8	13
	x	6	0	2	7
	y	∞	∞	∞	∞
	z	13	7	9	0

Node w		cost to			
		w	x	y	z
from	w				3
	x				
	y				
	z				

Node x		cost to			
		w	x	y	z
from	w	∞	∞	∞	∞
	x	**6**	**0**	**2**	**7**
	y	∞	∞	∞	∞
	z	∞	∞	∞	∞

Node x		cost to			
		w	x	y	z
from	w	0	6	∞	25
	x	6	0	2	7
	y	∞	2	0	∞
	z	25	7	∞	0

Node x		cost to			
		w	x	y	z
from	w	0	6	8	13
	x	6	0	2	7
	y	8	2	0	9
	z	13	7	9	0

Node x		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node y		cost to			
		w	x	y	z
from	w	∞	∞	∞	∞
	x	∞	∞	∞	∞
	y	∞	**2**	**0**	∞
	z	∞	∞	∞	∞

Node y		cost to			
		w	x	y	z
from	w	∞	∞	∞	∞
	x	6	0	2	7
	y	**8**	**2**	**0**	**9**
	z	∞	∞	∞	∞

Node y		cost to			
		w	x	y	z
from	w	∞	∞	∞	∞
	x	6	0	2	7
	y	8	2	0	9
	z	∞	∞	∞	∞

Node y		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

Node z		cost to			
		w	x	y	z
from	w	∞	∞	∞	∞
	x	∞	∞	∞	∞
	y	∞	∞	∞	∞
	z	**25**	**7**	∞	**0**

Node z		cost to			
		w	x	y	z
from	w	0	6	∞	25
	x	6	0	2	7
	y	∞	∞	∞	∞
	z	**13**	**7**	**9**	**0**

Node z		cost to			
		w	x	y	z
from	w	0	6	8	13
	x	6	0	2	7
	y	∞	∞	∞	∞
	z	13	7	9	0

Node z		cost to			
		w	x	y	z
from	w				
	x				
	y				
	z				

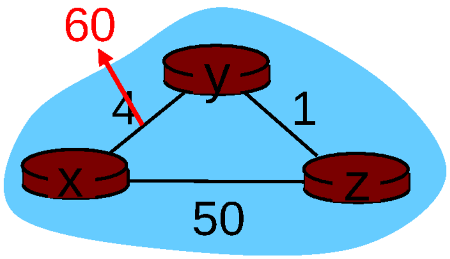
Comparison LV vs. DV

Q3: Compare Link State routing algorithms to Distance Vector algorithms in terms of scalability and robustness.

- Scalability
  - LS uses broadcasts to disseminate complete knowledge about all links to entire network
  - DV only sends (local) information to neighboring nodes. Convergence time and DV size still increase with network size
- Robustness
  - LS: every router does its own calculations
  - DV: wrong DV will be used by neighboring nodes and further
  - propagate the error

Count-to-infinity problem

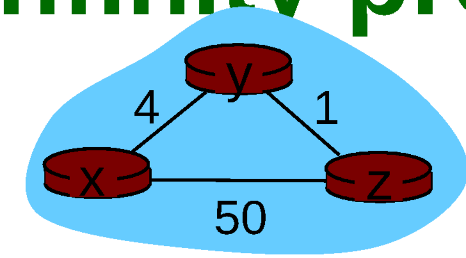
Q4: Explain the count-to-infinity problem. using a simple example. How can this problem be avoided?



When Link cost of edge x to y changes from 4 to 60,

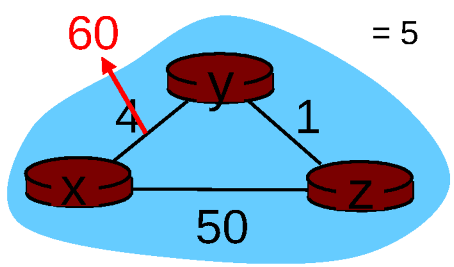
44 iterations before algorithm stabilizes.

Count-to-infinity problem (con't)



Dy(x) = min(c(y,x) + Dx(x), c(y,z)+Dz(x))
= min(4 + 0 ,1 + 5)
= min(4 , 6)
= 4

Dz(x) = min(c(z,x) + Dx(x), c(z,y)+Dy(x))
= min(50 + 0 , 1 + 4)
= min(50 , 5)
= 5



Dy(x) = min(c(y,x) + Dx(x), c(y,z)+Dz(x))
= min(60 + 0, 1 + 5)
= min(60 , 6)
= 6

Dy(x) = min(c(y,x) + Dx(x), c(y,z)+Dz(x))
= min(60 + 0, 1 + 7)
= min(60 , 8)
= 8

Dz(x) = min(c(z,x) + Dx(x), c(z,y)+Dy(x))
= min(50 + 0 , 1 + 6)
= min(50 , 7)
= 7

Dz(x) = min(c(z,x) + Dx(x), c(z,y)+Dy(x))
= min(50 + 0 , 1 + 8)
= min(50 , 9)
= 9

Count-to-infinity problem (con't)

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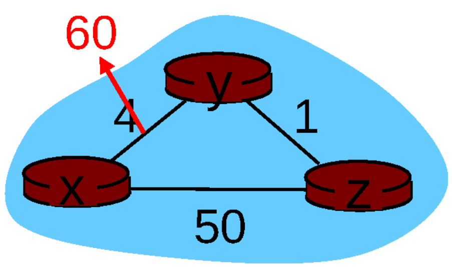

Dy(x) = min(c(y,x) + Dx(x), c(y,z)+Dz(x))

= min(60 + 0, 1 + 49)

= min(60 , 50)

= 50

Dy(x) = min(c(y,x) + Dx(x), c(y,z)+Dz(x))

= min(60 + 0, 1 + 50)

= min(60 , 51)

= 51

Dz(x) = min(c(z,x) + Dx(x), c(z,y)+Dy(x))

= min(50 + 0 , 1 + 50)

= min(50 , 51)

= 50

Dz(x) = min(c(z,x) + Dx(x), c(z,y)+Dy(x))

= min(50 + 0 , 1 + 51)

= min(50 , 52)

= 50

Count-to-infinity problem (con't)

- Count-to-infinitiy problem can be avoided using the poisoned reverse technique.
  - Router A will advertise a distance as infinite to Router B if Router B is on the advertised path
  - In the example: In its advertisements to Router B, Router C will advertise the cost to reach Router A as infinite as long as it routes packets to A via B
  - Poisoned reverse will only prevent routing loops that involve just two gateways. It is still possible to end up with patterns in which three gateways are engaged in mutual deception. E.g. A may believe it has a route through B, B through C, and C through A.

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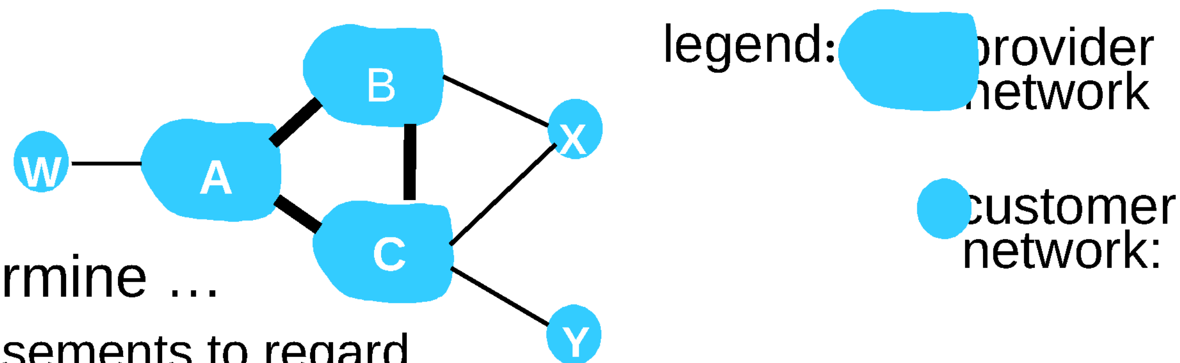
Routing policies

Q5: How are routing policies used in BGP. Give one example.



- Routing policies determine …
  - … which BGP advertisements to regard
  - … which routes to advertise
- Example
  - AS x is connected to AS B and AS C
  - Policy : AS x does not want AS B to route traffic via AS x to AS C
  - Therefore, AS x does not advertise any route to reach AS C to AS B

Intra- vs. inter-AS routing

Q6: Why are different inter-AS and intra-AS protocols used in the Internet?

- Different policies
  - Inter-AS: control over how (foreign) traffic is routed via the own network
  - Intra-AS: control over how traffic is routed within the the own network
- Scale
  - Hierarchical routing saves table size, reduced update traffic

Thank you

Any questions?