CN-Advanced
L32

Distance Vector Routing

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Distance Vector Routing

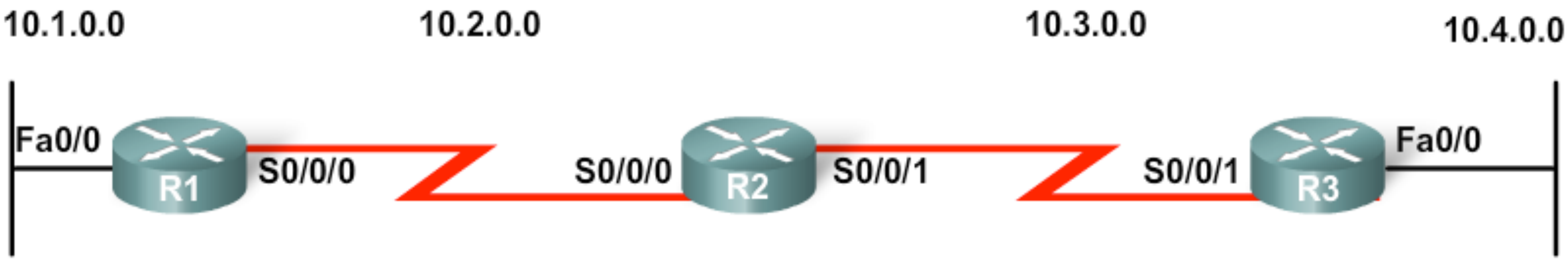
- Assumption
  - Each node knows cost of its directly connected link
  - A down (or non-existent) link cost is taken as infinity
- Distributed
  - Each node receives info from neighbors
  - Computes routing and distributes to neighbors
  - No central computation
- Iterative
  - Routing computation stops when no more info exchange
  - It is self terminating - no external control
- Asynchronous
  - Each node does not work in sync with others

Distance Vector Routing

- Does not allows a router to know exact topology
- Uses router as signposts along the path to dst^n
- Sends periodic updates
- Core of the DV protocol
  - Bellman Ford Algorithm
- Works best in following type of situations
  - Network is simple and flat
    - Does not require hierarchical design
  - Administrators do not have enough knowledge
    - Configure/troubleshoot link state protocols
  - Worst case **convergence** time is not a concern

DV Routing - Example

Initial Network



Network	Interface	Hop
10.1.0.0	Fa0/0	0
10.2.0.0	S0/0/0	0

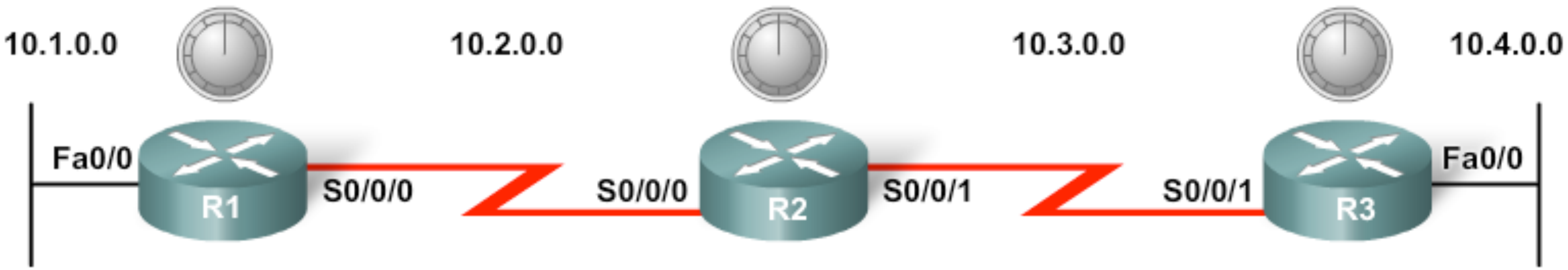
Network	Interface	Hop
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/1	0

Network	Interface	Hop
10.3.0.0	S0/0/0	0
10.4.0.0	Fa0/0	0

Src: CCNA Module 2

DV Routing - Example

- After the exchange of routing packets



Network	Interface	Hop
10.1.0.0	Fa0/0	0
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/0	1
10.4.0.0	S0/0/0	2

Network	Interface	Hop
10.2.0.0	S0/0/0	0
10.3.0.0	S0/0/1	0
10.1.0.0	S0/0/0	1
10.4.0.0	S0/0/1	1

Network	Interface	Hop
10.3.0.0	S0/0/1	0
10.4.0.0	Fa0/0	0
10.2.0.0	S0/0/1	1
10.1.0.0	S0/0/1	2

Src: CCNA Module 2

Distance vector algorithm

Bellman-Ford equation (dynamic programming)

let

$d_x(y)$:= cost of least-cost path from x to y

then

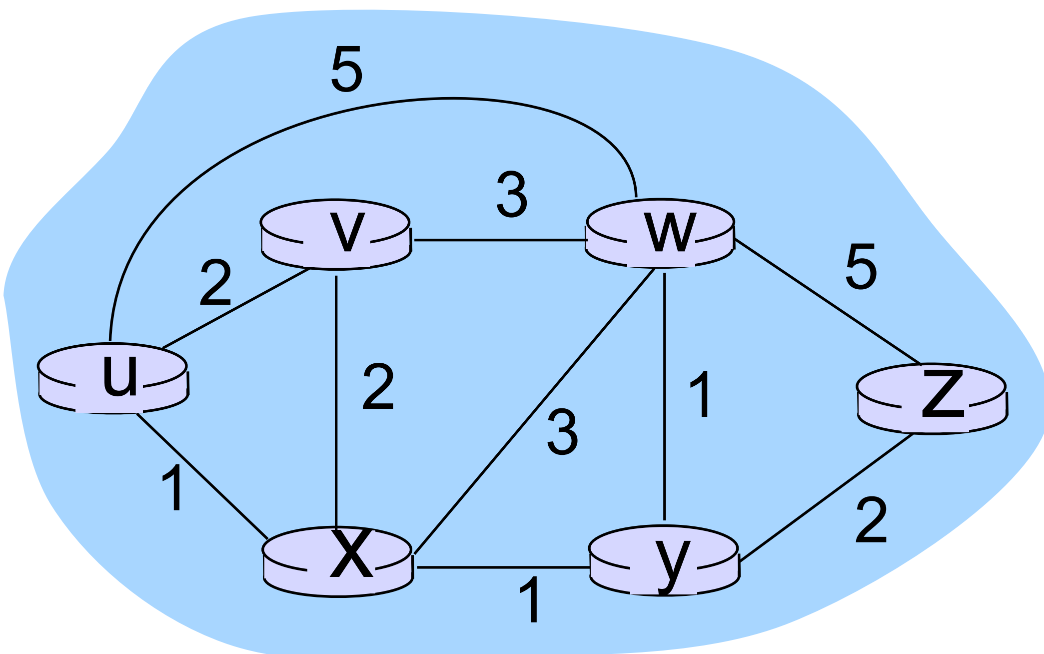
$$d_x(y) = \min_v \{c(x,v) + d_v(y)\}$$

cost from neighbor v to destination y

cost to neighbor v

min taken over all neighbors v of x

Bellman-Ford example



Compute $D_u(z)$:

For u's neighbors: v, x, w, we have

$d_v(z) = ?$, $d_x(z) = ?$, $d_w(z) = ?$

$d_v(z) = 5$, $d_x(z) = 3$, $d_w(z) = 3$

B-F equation says:

$$d_u(z) = \min \{ c(u,v) + d_v(z), \; c(u,x) + d_x(z), \; c(u,w) + d_w(z) \}$$

$$= \min \{2 + 5, \; 1 + 3, \; 5 + 3\}$$

$$= 4$$

node achieving minimum is next hop in shortest path, used in forwarding table

Distance vector algorithm

- $D_x(y)$ = estimate of least cost from x to y
    - actual least cost from x to y is represented as $d_x(y)$
  - node x maintains distance vector
    - $\mathbf{D_x} = [D_x(y): y \in N]$
- Node x:
  - knows cost to each neighbor v: $c(x,v)$
  - maintains its neighbors' distance vectors.
  - For each neighbor v, it maintains $\mathbf{D_v} = [D_v(y): y \in N]$

Distance vector algorithm

key idea:

- From time-to-time, each node sends its own distance vector estimate to neighbors
- When `x` receives new DV estimate from neighbor `v`, it updates its own DV using B-F equation:

$$D_x(y) \leftarrow \min_v\{c(x,v) + D_v(y)\} \quad \text{for each node } y \in N$$

- Under minor, natural conditions, the estimate $D_x(y)$ *converges to the actual least cost* $d_x(y)$

Distance vector algorithm

iterative, asynchronous:
each local iteration caused by:

- local link cost change
- DV update message from neighbor

distributed:

- each node notifies neighbors *only* when its DV changes
  - neighbors then notify their neighbors if necessary

each node:

initialize $D_x(y) = c(x,y)$

wait for (change in local link cost or msg from neighbor)

↓

recompute estimates

↓

if DV to any dest has changed, *notify* neighbors

DV Algorithm

/* Initialisation - for each node x */

for all destinations y in N:

$D_x(y) = c(x,y)$ /* $c(x,y) = \infty$ for non neighbour */

for each neighbor w

$D_w(y)$ = ? for all destinations y in N

for each neighbour w

send distance vector $D_x = [D_x(y)$: y in N] to w

DV Algorithm

Loop /* for each node x */

wait for (change in local link cost
or msg from neighbor)

for each y in N:

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

if Dx(y) changed for any destination y

send $D_x = [D_x(y): y \text{ in } N]$ to all neighbour

Forever

node x table

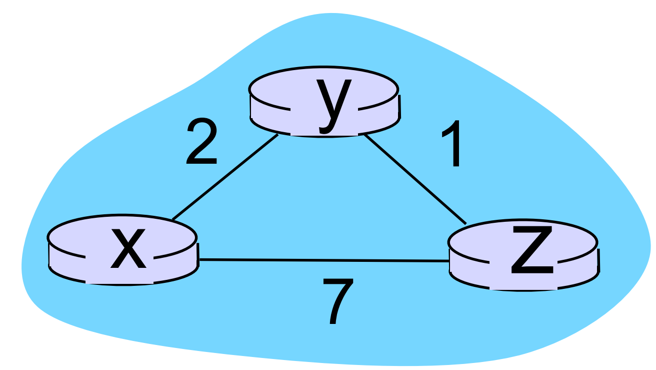
from \ cost to	x	y	z
x	0	2	7
y	∞	∞	∞
z	∞	∞	∞

node y table

from \ cost to	x	y	z
x	∞	∞	∞
y	2	0	1
z	∞	∞	∞

node z table

from \ cost to	x	y	z
x	∞	∞	∞
y	∞	∞	∞
z	7	1	0



time

$$D_x(y) = \min\{c(x,y) + D_y(y),\ c(x,z) + D_z(y)\}$$
$$= \min\{2+0\ ,\ 7+1\} = 2$$

$$D_x(z) = \min\{c(x,y) + D_y(z),\ c(x,z) + D_z(z)\}$$
$$= \min\{2+1\ ,\ 7+0\} = 3$$

node x table

from \ cost to	x	y	z
x	0	2	7
y	∞	∞	∞
z	∞	∞	∞

from \ cost to	x	y	z
x	0	2	3
y	2	0	1
z	7	1	0

node y table

from \ cost to	x	y	z
x	∞	∞	∞
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node z table

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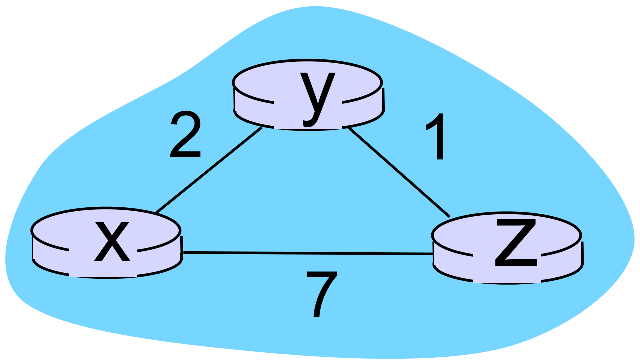
time



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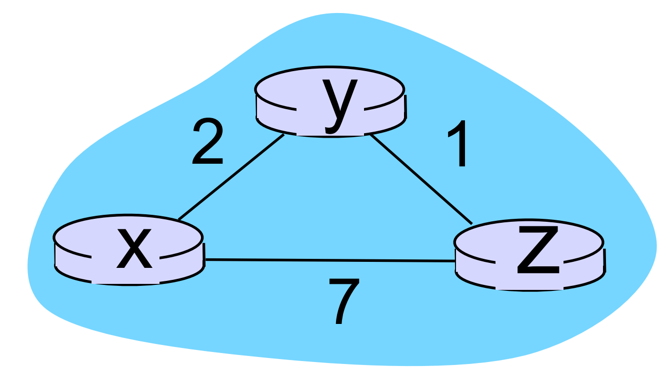

time

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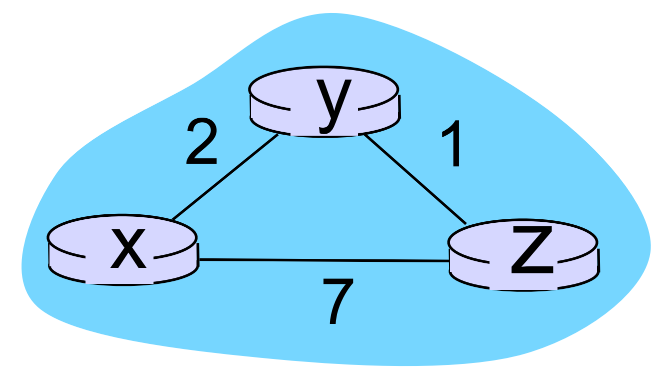

time

DV Routing

- Issues
  - Routing Loop
  - Count to Infinity
  - Slow Convergence
    - link cost changes (increases)

Summary

- Each node knows only its neighbours
- Each node knows cost to all nodes
  - A node does not know the topology of the network
- A node receives cost of all nodes from its neighbours