Distance-Vector Routing

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Outline

- Recap on link-state routing
- Distance-vector routing
- Bellman-Ford equation
- Distance-vector algorithm
- Examples

Recap on Routing

- Goal: each router u must be able to compute, for each other router v, the next-hop neighbor x that is on the least-cost path from u to v

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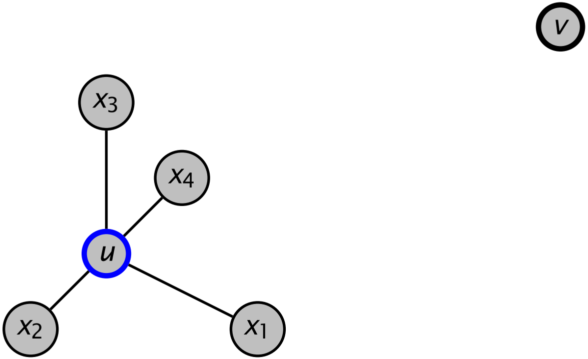

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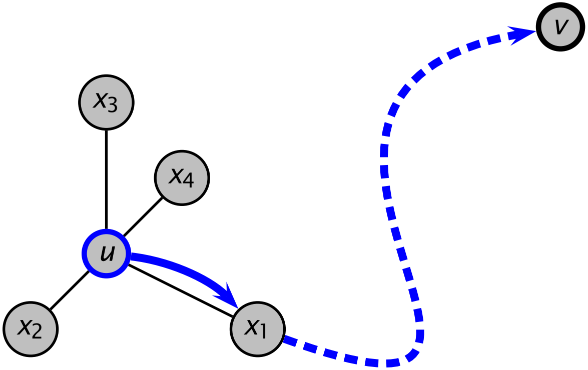

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- With a complete knowledge of the network topology, routers perform a local computation (Dijkstra's algorithm) to find the least-cost paths to every other router

- In essence
  - *broadcast transmission of topology information*
  - *global knowledge of the network*
  - *local computation*

Changes in Link Costs

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- Changes in link costs are propagated quickly to all routers

- Routers can then react by recomputing paths and by updating their forwarding tables accordingly
  - in fact, this “reaction” is not different from the normal behavior of the protocol

Distance-Vector Routing

Distance-Vector Routing

- Every router u maintains a *"distance vector"*
  - v is a destination node in the network
  - $D_u[v]$ is the best known distance between u and v
  - $n_u[v]$ is the next-hop router on the best known path to v

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- After a number of iterations, *the algorithm converges to a point where every router has a minimal distance vector*

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- Local knowledge of the network
  - router u knows its distance $D_u[v]$ and the first step along that path
  - router u does not know about any link cost except its adjacent links
- Global computation
  - the computation is actually distributed

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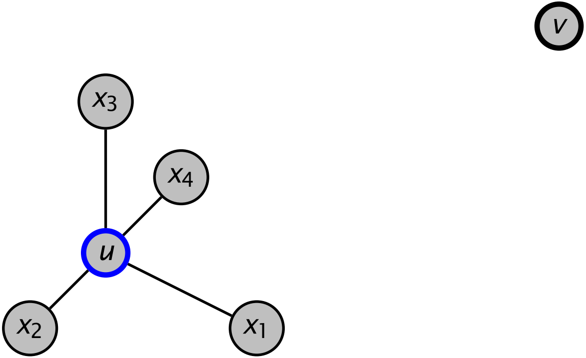

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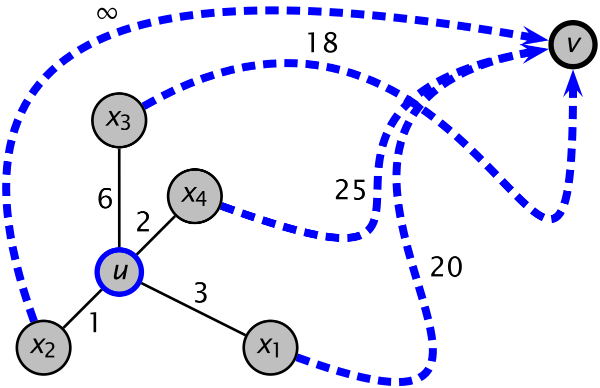

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  - $n_u[v]$, next-hop node (neighbor of u) on the least-cost path from u to v

Distance-Vector Algorithm

- Executing locally at node u
- Variables storing values known at each iteration
  - $D_u[v]$, cost of the least-cost path from u to v (distance vector)
  - $n_u[v]$, next-hop node (neighbor of u) on the least-cost path from u to v
  - $D_x[v]$, distance vectors of every neighbor node x

Distance-Vector Algorithm: Initialization

```
▷ Initialization
for v ∈ V
      do if v ∈ neighbors(u)
            then D_u[v] ← c(u, v)
                 n_u[v] ← v
            else D_u[v] ← ∞
for x ∈ neighbors(u)
      do for v ∈ V
            do D_x[v] ← ∞
send D_u to all neighbor nodes
```

Distance-Vector Algorithm: Loop

when D'_x is received from neighbor x
    do $D_x \leftarrow D'_x$
        for $v \in N$
            do $D_u[v] \leftarrow \min_{x \in neighbors(u)}(c(u,x) + D_x[v])$
        if D_u was updated
          then send D_u to all neighbor nodes

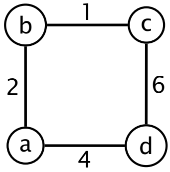
when link cost $c(u,x)$ changes
    do for $v \in N$
            do $D_u[v] \leftarrow \min_{x \in neighbors(u)}(c(u,x) + D_x[v])$
        if D_u was updated
          then send D_u to all neighbor nodes

Distance-Vector Algorithm: D_u Update

▷ updating D_u:
▷ $\forall v \in N : D_u[v] \leftarrow \min_{x \in neighbors(u)}(c(u,x) + D_x[v])$

updated $\leftarrow$ false
for $v \in N$
    do for $x \in neighbors(u)$
        do if $D_u[v] > c(u,x) + D_x[v]$
            then $D_u[v] \leftarrow c(u,x) + D_x[v]$
                $n_u[v] \leftarrow x$
                updated $\leftarrow$ true

Example



Example

(a)	a	b	c	d
D_a	0	2	∞	4
D_b	∞	∞	∞	∞
D_d	∞	∞	∞	∞

(b)	a	b	c	d
D_b	2	0	1	∞
D_a	∞	∞	∞	∞
D_c	∞	∞	∞	∞

(c)	a	b	c	d
D_c	∞	1	0	6
D_b	∞	∞	∞	∞
D_d	∞	∞	∞	∞

(d)	a	b	c	d
D_d	4	∞	6	0
D_a	∞	∞	∞	∞
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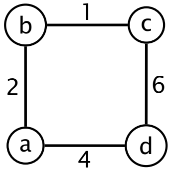

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a	a	b	c	d
D_a	0	2	∞	4
D_b	∞	∞	∞	∞
D_d	∞	∞	∞	∞

b	a	b	c	d
D_b	2	0	1	∞
D_a	∞	∞	∞	∞
D_c	∞	∞	∞	∞

c	a	b	c	d
D_c	∞	1	0	6
D_b	∞	∞	∞	∞
D_d	∞	∞	∞	∞

d	a	b	c	d
D_d	4	∞	6	0
D_a	∞	∞	∞	∞
D_c	∞	∞	∞	∞

a	a	b	c	d
D_a	0	2	**3**	4
D_b	2	0	1	∞
D_d	4	∞	6	0

b	a	b	c	d
D_b	2	0	1	**6**
D_a	0	2	∞	4
D_c	∞	1	0	6

c	a	b	c	d
D_c	**3**	1	0	6
D_b	2	0	1	∞
D_d	4	∞	6	0

d	a	b	c	d
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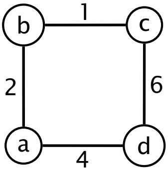

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D_a	∞	∞	∞	∞
D_c	∞	∞	∞	∞

(c)	a	b	c	d
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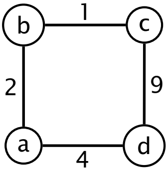

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D_c	∞	∞	∞	∞

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D_b	∞	∞	∞	∞
D_d	∞	∞	∞	∞

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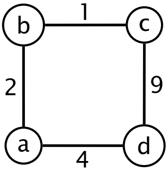

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D_a	∞	∞	∞	∞
D_c	∞	∞	∞	∞

(c)	a	b	c	d
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D_d	∞	∞	∞	∞

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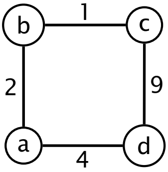

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D_c	3	1	0	9

(c)	a	b	c	d
D_c	3	1	0	**7**
D_b	2	0	1	6
D_d	4	6	9	0

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