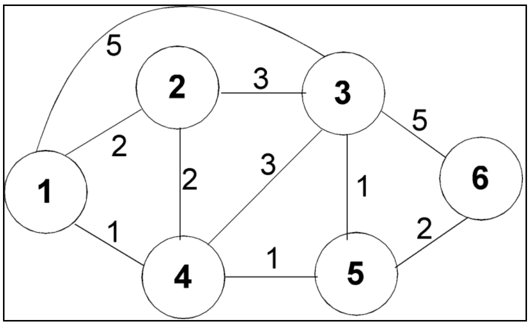
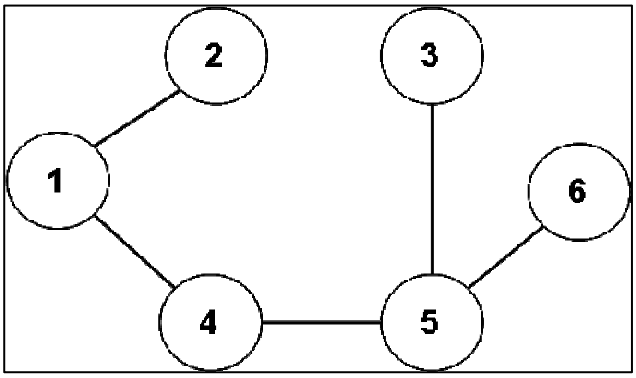
Network



Routing Table for node 1

Destination	Next Hop	Cost
2	2	…
3	4	…
4	4	…
5	4	…
6	4	…

Tree



Cost Matrix *C*

c_{iJ} represents costs between nodes *i* and *j*

- $c_{ij} = 0$, for all *i*
- $c_{iJ} = \infty$, if node *i* and node *j* are not adjacent

$$C = \begin{vmatrix} 0 & 2 & 5 & 1 & \infty & \infty \\ 2 & 0 & 3 & 2 & \infty & \infty \\ 5 & 3 & 0 & 3 & 1 & 5 \\ 1 & 2 & 3 & 0 & 1 & \infty \\ \infty & \infty & 1 & 1 & 0 & 2 \\ \infty & \infty & 5 & \infty & 2 & 0 \end{vmatrix}$$

Bellman's Equation

$D_i = min_{\text{all } J} \ (D_J + c_{iJ})$

BELLMAN-FORD-MOORE ALGORITHM (BFMA)

Node **1** is the source node.
D_i - distance along the optimal path from Node **1** to Node **i** ($D_1 = 0$).
c_{iJ} - distance (cost) between nodes **i** and **j**

$$\text{Bellman equation: } D_i = \min_J [D_j + c_{Ji}] \qquad (1)$$

D_i^h - length of the shortest path from Node **1** to Node **i** containing no more than *h* hops

BFMA:

I. *h* = 0.

Let $D_1^0 = 0$. Let $D_i^0 = \infty$, for each $i \neq 1$.

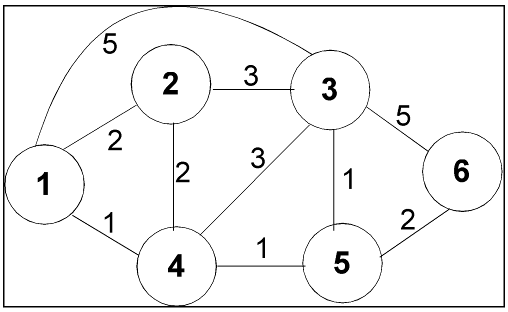
II. For each successive h > 0. For each $i \neq 1$ let

$$D_i^{h+1} = \min_J [D_J^h + c_{Ji}]$$

Connect **i** with predecessor node **j**, for which the minimum is obtained. Eliminate any connection of **i** with a different predecessor.

Labeling algorithm

label (p,d): p - current predecessor, d - current distance from the source node **1**
Q - queue of potential predecessors nodes



Step		Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Q
1		-1 , 0	-1 , ∞	-1 , ∞	-1 , ∞	-1 , ∞	-1 , ∞	1
2	j=1	-1 , 0	1, 2	1 , 5	1 , 1	-1 , ∞	-1 , ∞	2, 3, 4
3	j=2	-1 , 0	1, 2	1 , 5	1 , 1	-1 , ∞	-1 , ∞	3, 4
4	j=3	-1 , 0	1, 2	1 , 5	1 , 1	3 , 6	3 , 10	4, 5, 6
5	j=4	-1 , 0	1, 2	4 , 4	1 , 1	4 , 2	3 , 10	5, 6, 3
6	j=5	-1 , 0	1, 2	5 , 3	1 , 1	4 , 2	5 , 4	6, 3
7	j=6	-1 , 0	1, 2	5 , 3	1 , 1	4 , 2	5 , 4	3
8	j=3	-1 , 0	1, 2	5 , 3	1 , 1	4 , 2	5 , 4	{ }

DIJKSTRA ALGORITHM (DA)

Unlike BFMA, which iterates on a number of hops, DA iterates on length.
Node **1** is the source node.
D_i - current estimate of the distance between Node **1** and Node **i**.
N - set of nodes currently connected with source

DA:

I. N = {1}. $D_1 = 0$. $D_i = \infty$, for each **i** $\neq 1$.

II. Updating labels. For each **j**$\notin \mathbf{N}$ set

$$D_J = \min_{i \in \mathbf{N}} \; [D_J \, , \, D_i + c_{iJ} \,]$$

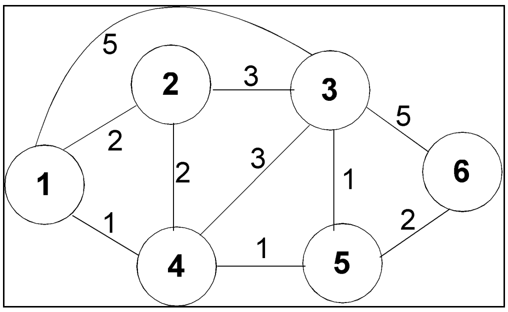
If minimum is equal to previous D_J, leave the connection to **j** and predecessor unchanged. Otherwise, change connection **j** with predecessor **i**, for which the minimum is obtained.
III. Finding the next closest node. Find **i**$\notin \mathbf{N}$ for which

$$D_i = \min_{J \notin \mathbf{N}} \; D_J$$

Set **N** = **N**$\cup${**i**} and permanently connect **i** to the corresponding predecessor.
IV. If **N** contains all network nodes, algorithm si completed.
Otherwise repeat steps **II** and **III.**

Labeling algorithm

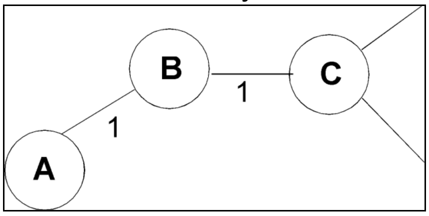
label (p,d): p - current predecessor, d - current distance from the source node **1**



Step	Node 2	Node 3	Node 4	Node 5	Node 6	N
1	-1 , ∞	-1 , ∞	-1 , ∞	-1 , ∞	-1 , ∞	1
2	1, 2	1 , 5	***1 , 1***	-1 , ∞	-1 , ∞	1, 4
3	***1, 2***	4 , 4	1 , 1	4 , 2	-1 , ∞	1,4,2
4	1, 2	4 , 4	1 , 1	***4 , 2***	-1 , ∞	1,4,2,5
5	1, 2	***5 , 3***	1 , 1	4 , 2	5 , 4	1,4,2,5,3
6	1, 2	5 , 3	1 , 1	4 , 2	***5 , 4***	1,4,2,5,3,6

DISTRIBUTED ASYNCHRONOUS BFMA

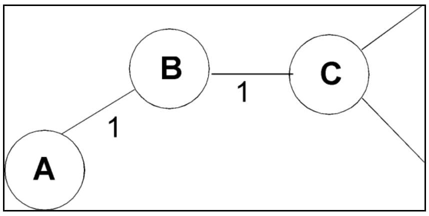
Good news travel quickly, bad news travel slowly.



Routing tables:

	Node A			Node B			Node C		
	Dest.	Next Hop	Cost	Dest.	NextHop	Cost	Dest.	NextHop	Cost
1	down			A	-1	∞	A	-1	∞
2	up			A	A	1	A	-1	∞
3	A	A	0	A	A	1	A	B	2
…									

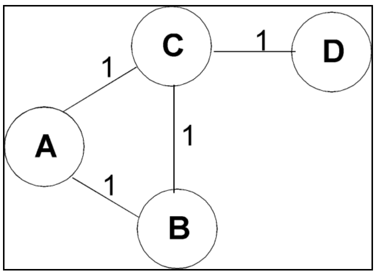
Count to infinity problem.



Routing tables:

	Node A			Node B			Node C		
	Dest.	Next Hop	Cost	Dest.	NextHop	Cost	Dest.	NextHop	Cost
1	A	A	0	A	A	1	A	B	2
2	down			A	C	3	A	B	2
3	down			A	C	3	A	B	4
4	down			A	C	5	A	B	4
…	down			A		∞	A		∞

Split horizon problem.



Routing tables:

	NodeD	Node A			Node B			Node C		
		Dest	Next Hop	Cost	Dest	NextHop	Cost	Dest	NextHop	Cost
1	up	D	C	2	D	C	2	D	D	1
2	down	D	C	2	D	C	2	D	-1	∞
3	down	D	B	3	D	-1	∞	D	-1	∞
4	down	D	B	3	D	-1	∞	D	A	4
5	down	D	-1	∞	D	C	5	D	A	4
…										