EXHIBIT B

United States Patent [19]

Humblet

[11] Patent Number: 4,987,536

[45] Date of Patent: Jan. 22, 1991

[54] COMMUNICATION SYSTEM FOR SENDING AN IDENTICAL ROUTING TREE TO ALL CONNECTED NODES TO ESTABLISH A SHORTEST ROUTE AND TRANSMITTING MESSAGES THEREAFTER

[75] Inventor: Pierre A. Humblet, Cambridge, Mass.

[73] Assignee: Codex Corporation, Mansfield, Mass.

[21] Appl. No.: 193,391

[22] Filed: May 12, 1988

[51] Int. Cl.⁵ G06F 13/38
[52] U.S. Cl. 364/200; 364/242.94; 364/261.2; 364/260.1; 370/60
[58] Field of Search ... 364/200MS File, 900 MS File, 364/514; 370/60, 94, 16, 94.2, 94.3

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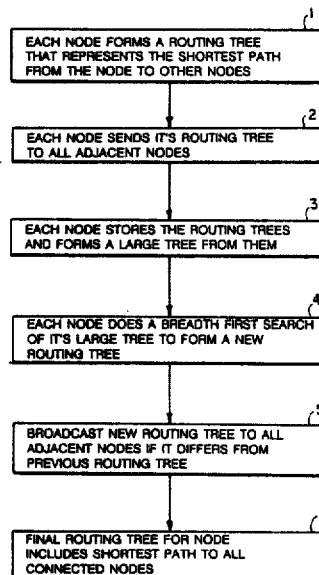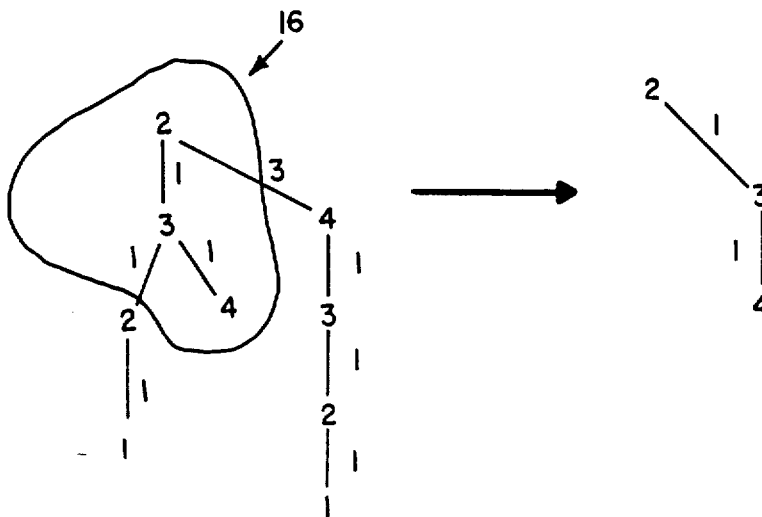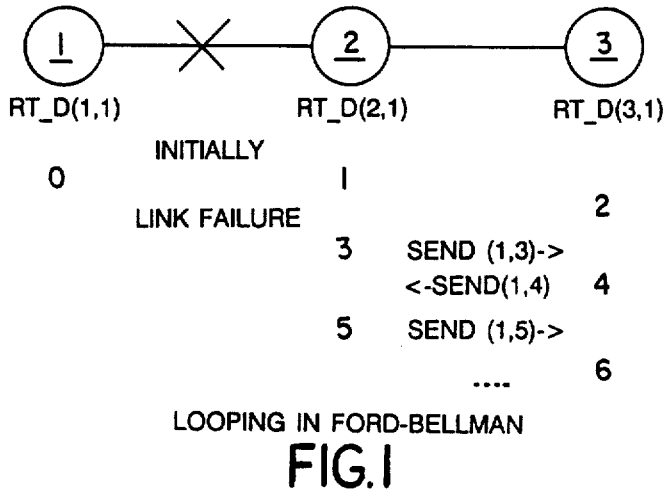|			
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Primary Examiner—Thomas C. Lee

[57] ABSTRACT

The communications network includes a plurality of interconnected nodes and communication links between nodes. Computing apparatus in provided for determining a shortest path from a starting node to a destination node. The computing apparatus is adapted so that each node forms a routing tree having nodes with indentities, branches with weights, and a distinguished node called a root. The routing tree is the estimated shortest path to all of the nodes and each node communicates its routing tree to each adjacent node. Upon receipt of a routing tree by a reference node from an adjacent node, the reference node stores the routing tree and produces a large tree having roots and branches by placing the reference node as the root of the large tree and creating branches from the reference node to the roots of the routing trees of the adjacent nodes. The lengths of the branches are equal to the lengths of the links from the reference node to the adjacent nodes. A breadth first search of the large tree is performed to determine a connected subset of the large tree where each node identity appears only once. The connected subset forms the new routing tree for the reference node. If the new routing tree differs from the previous routing tree, the new routing tree is broadcast to all adjacent nodes and the procedure is repeated until no new tree differs from a previous tree, thereby defining a final routing tree. The final routing tree includes the shortest path from the reference node to all connected nodes.

15 Claims, 3 Drawing Sheets

INITIALLY

LINK FAILURE

SEND (1,3)->
<-SEND(1,4)
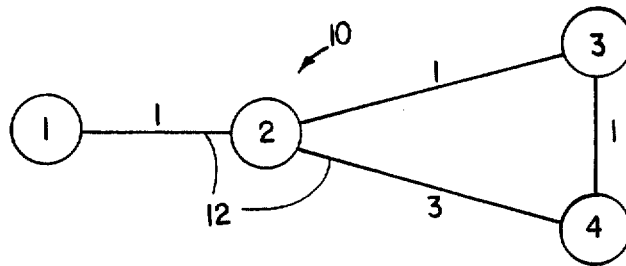SEND (1,5)->
....

LOOPING IN FORD-BELLMAN

FIG.I

BUILDING THE ROUTING TREE AT NODE 2 AFTER FAILURE OF LINK (1,2)
NODE 2 REALIZES AT ONCE THERE IS NO PATH TO NODE 1

RECONFIGURATION FOLLOWING A TOPOLOGY CHANGE
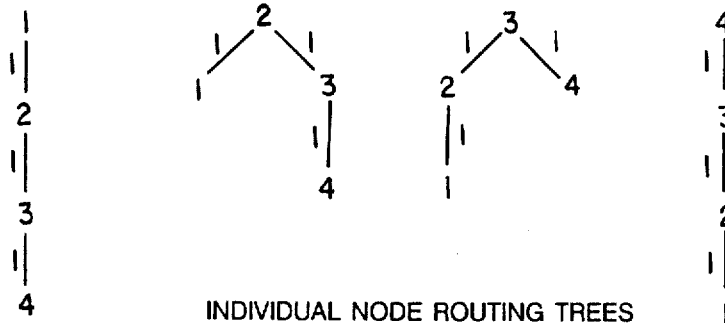
FIG.3

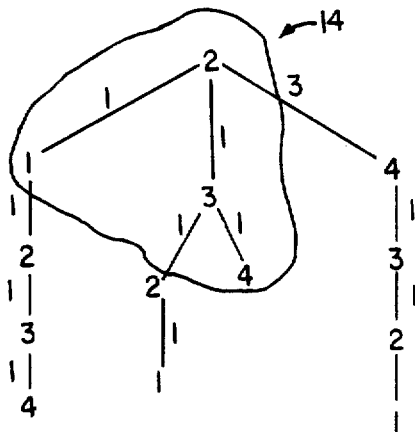**U.S. Patent**   Jan. 22, 1991   Sheet 2 of 3   **4,987,536**

BUILDING THE ROUTING TREES

NETWORK TOPOLOGY
FIG. 2a

INDIVIDUAL NODE ROUTING TREES
FIG. 2b

BUILDING THE ROUTING TREE AT NODE 2
FIG. 2c

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1

| EACH NODE FORMS A ROUTING TREE THAT REPRESENTS THE SHORTEST PATH FROM THE NODE TO OTHER NODES |

2

| EACH NODE SENDS IT'S ROUTING TREE TO ALL ADJACENT NODES |

3

| EACH NODE STORES THE ROUTING TREES AND FORMS A LARGE TREE FROM THEM |

4

| EACH NODE DOES A BREADTH FIRST SEARCH OF IT'S LARGE TREE TO FORM A NEW ROUTING TREE |

5

| BROADCAST NEW ROUTING TREE TO ALL ADJACENT NODES IF IT DIFFERS FROM PREVIOUS ROUTING TREE |

6

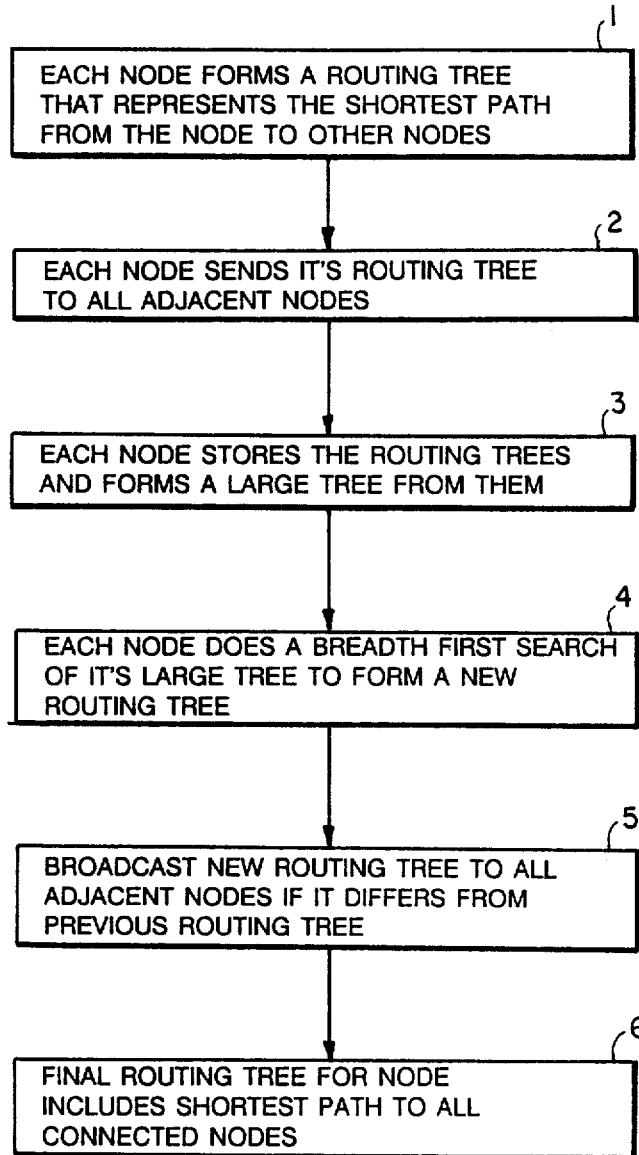| FINAL ROUTING TREE FOR NODE INCLUDES SHORTEST PATH TO ALL CONNECTED NODES |

FIG.4

DOCKET ALARM

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