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ROUTING ALGORITHM SIMULATORS

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Summary. In computer networks**,** it is impossible to see the working of routing algorithms by the routers. However, with computer simulations it can be observed easly. In this study, simulators that are designed to understand shortest path, distance vector and link state routing algorithms are explained.

Keywords : *routing algorithms, simulators, routers, computer networks.*

INTRODUCTION

One of the important aim of network layer is to define the path of packets from sender to destination. Algorithms, which calculate the path and define way of the incoming packets are called routing algorithms. In most computer networks, packets have to visit routers more than one. When source and destination are not in the same network, routing becomes more important. There are some conditions for routing algorithms; a routing algorithm should be compatible, correct, simple, robust and stable. Routing algorithm in computer networks must make routing accurate. With the compatibility feature, algorithm should select the most proper path. In addition, a routing algorithm should be simple. As an algorithm becomes functional an effective it should require less software and fewer physical resources. On the other hand, a routing algorithm has to be robust and stable. In abnormal conditions, routing algorithm should run correctly, because routers are junction for computer networks and when they make an error, serious problems could occur [1].

Routing algorithms can be classified as adaptive and nonadaptive. Nonadaptive algorithms decide routing without the effect of current network traffic and topology. In this type of routing algorithm, decision about the routing from one router to another is made when network opens. This type of routing is also called static routing. In adaptive routing algorithm routing changes according to topology and traffic. Adaptive algorithms differ by where they get information, when they make routing modification and what they use as a metric. This type of routing algorithm is also called dynamic routing [2].

Routing algorithms use various metrics to find the most appropriate path. Complex routing algorithm can use more than one metric and they can combine them for best decision. In computer networks, distance, safety, time, bandwidth and communication cost can be used as various metrics.

In this study,

1. Shortest path
2. Distance vector
3. Link state routing algorithms simulations,

which are designed for understanding their working principle, are explained.

SIMULATION DESIGN

In the simulations, the network model, which has six nodes, is used and it can be seen in Figure. 1. Simulators can be used to work with N node network. In this way, they can be developed. In Figure. 1, distances between nodes are defined by random numbers.

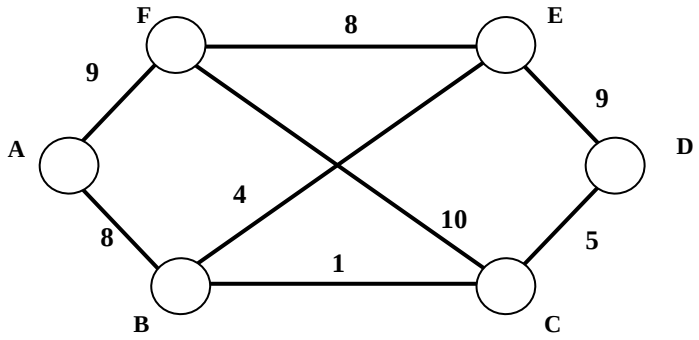

Figure 1. Network Model Used in the Simulators.

Simulator Design for Shortest Path Routing Algorithm

Shortest path routing algorithm is mainly used in computer networks and understanding it is easy. To find the shortest path between two nodes different routing algorithms are used. One of them is "Dijkstra's algorithm" and it is used in this study. In this algorithm each node has a label according to the distance to source node. At the beginning, because no path is known, each node to source node is marked as infinity. As the algorithm works, paths are defined and marked nodes' values are changed when shorter distances are found. When the algorithm starts, each node is temporary. As algorithm works, shortest paths are found and these nodes are marked as permanent and they can not be changed.

Shortest path routing algorithm works in forward direction and it works as follows:

- Algorithm finds the shortest path distance of all nodes to the source node.
- ***P*** represents the routers set and ***s*** represents the source node. At the *b*eginning ***P={s}.***
- As algorithm continues nodes are included into P, one node at a time.

Network model, which can be seen in Figure. 1 is used in simulators. Shortest path routing algorithm simulation is consist of mainly three procedures, they are:

1. Define_value procedure,
2. Mark procedure,
3. Find procedure.

In the simulation program, firstly, distances between nodes are defined by Define_value procedure. Distance values can be changed randomly by using this procedure in the range of 1 and 10. To define the shortest path, there are two procedures are used which are mark and find procedures. With mark procedure, nodes are marked as temporary and their distances are written on them. In the simulation, Find procedure, finds the shortest path in the nodes, which are marked temporarily.

In Figure.2 designed simulator is shown. With "Random Value" button randomly assigned distances between nodes can be defined in range of 1 to 10. After defining distance values, any node from A to F can be selected as working (source) node from combo box.

In the simulation program, the shortest distance value from source node to every node is found. When the working node is defined, with clicking "Step" button, simulation is worked step by step. Source node is represented with shading that circle. Then, the user can observe the simulation by pressing the "Step" button. With pressing "Step" button, nodes which can be reached from source node are defined and their distances to source node are written in the circles. Then, the node, which has the minimum distance, is selected from reachable node set.

This continues until all nodes' distances to source node is found. When all distances are found the step button is disabled. Simulation results can be seen at the "Results" area. As simulation continues with pressing Step button shortest path order is written to the result area.

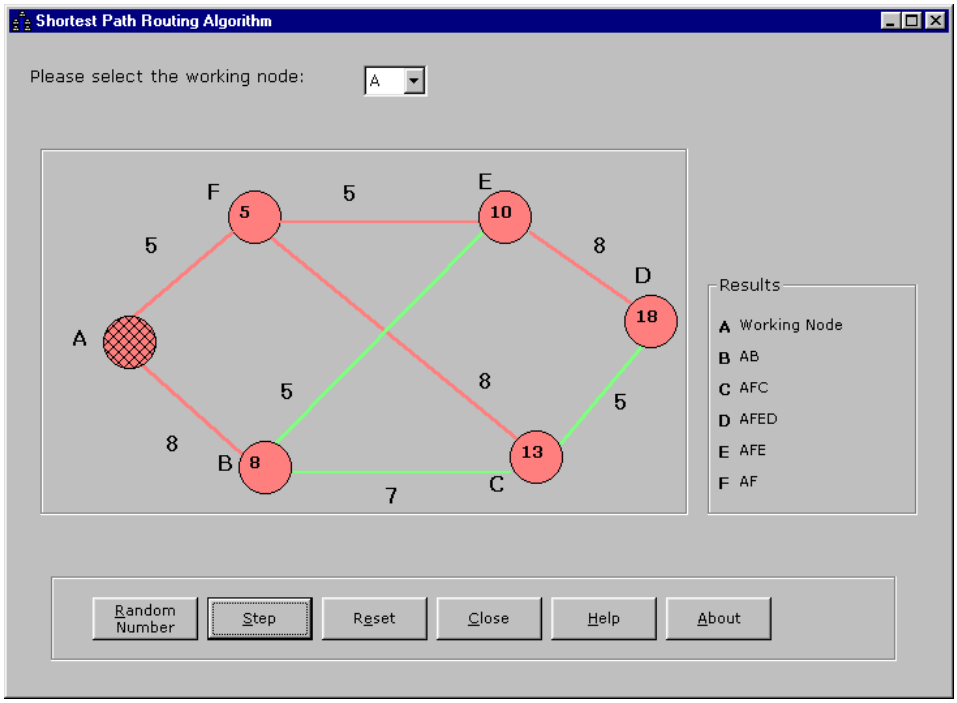

Figure 2. Shortest Path Routing Algorithm Simulator.

For example, shortest path for node D from node A can be reached when AFED node order is followed and the shortest path from node A to

node D is 18. For all other nodes results can be observed in this way. Reachable nodes are painted in different color and distances to source node is written in the circles. Then, the node which has the shortest distance to source node is selected and painted in red.

Simulation can run again by pressing “Reset” button. When the “Reset” button is pressed, all results are cleared, and defining the distances between the nodes simulation can be repeated with new values. With the “Help” button the main principle of shortest path routing algorithm and simulation usage information can be received. After observing simulation, program is terminated by clicking “Close” button.

Simulator Design for Distance Vector Routing Algorithm

Modern computer networks use dynamic routing algorithms instead of static routing algorithms. Distance vector and link state algorithms are mainly used dynamic algorithms. With distance vector algorithm each router has shortest path information to all other routers in the network and its route order. This information is kept in a table. Table is constructed with sending and receiving information to the neighbours.

In distance vector routing algorithm each router keeps the routing table about all routers in the network. This table consists of two parts. In routing table, path order, which is necessary to reach the destination and distance or time information, are kept. Before algorithm starts, metric must be defined. Router’s number which is used to reach destination, time, distance can be used as metric. Routers are supposed to know the distance information to their neighbours. When router number is used as metric, distance to directly connected neighbour will be one.

When i and j are nodes in a network, if it is possible to reach directly from i to j, d(i,j) will be different from infinity. d(i,j) information should be defined for all routers in the network. For routers, which are not directly connected, shortest path is calculated using this algorithm. In this condition, the router distances, which are used to reach, destination is added to calculate the shortest distance. Shortest path from i to j is called D(i,j). Therefore, for shortest path equations 1 and 2 are used.

$$D(i,i)=0 \quad \textbf{(1)}$$

For all i *values*

$$D(i,j)= \min[d(i,k)+D(k,j)] \quad \textbf{(2)}$$

From starting node i and continuing with node, k minimum value of shortest path will be equal to d(i,k)+D(k,j). When node i wants to reach to j, firstly it receives distance information from directly connected neighbours. When k is i's directly connected neighbour, i receives information from k about its distance to j node. i node then calculates the distance to j with adding its distance to k which is represented by d(i,k) and k's distance to j which is denoted by D(k,j). The result will be d(i,k)+D(k,j). node i will receive the same type information from all other neighbour nodes and calculates the distance. Then it selects the path, which has minimum value [3].

In distance vector routing algorithm simulation program, the network model that is seen in Figure.3 is used. In the simulation, there are three main procedures used, they are:

1. Define_Value procedure,
2. Calculate procedure,
3. Run procedure.

With Define_Value procedure, distances between nodes are defined in the range of 1 and 15 randomly. In addition, these values are kept into an array. In the simulation using "Random Value" button distance values can be changed. Router pairs have not the same distance values. For example, distance value from A to B is not equal to the distance value from B to A. After defining values, a router pair is selected from combo boxes. After that using "Run" button, to calculate the shortest distance from source to distance, routing tables constructed with using "Calculate" procedure.

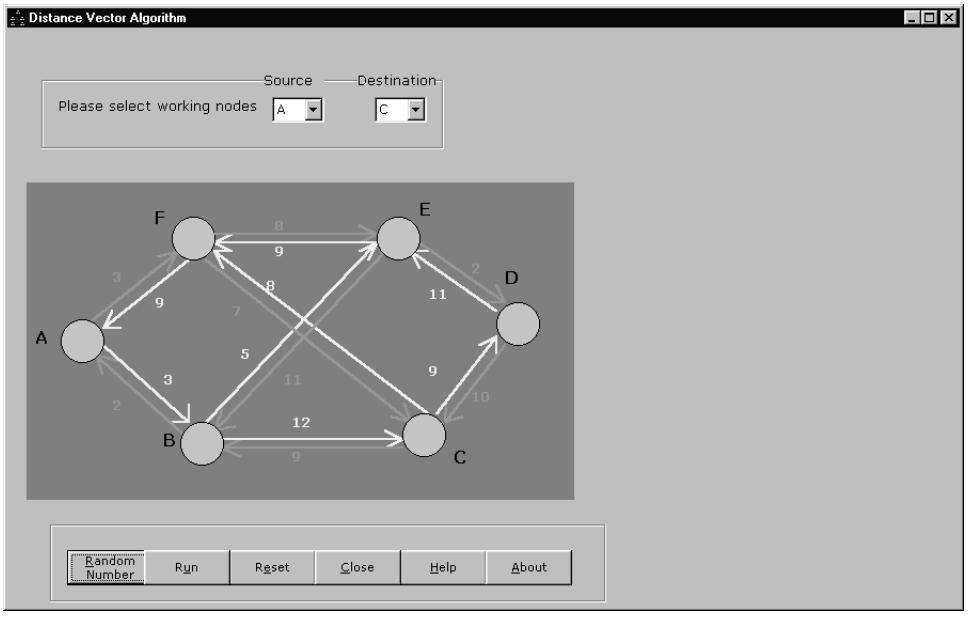

Figure 3. Distance Vector Routing Algorithm simulation Program.

With "Run" procedure, routing tables, which come from neighbour nodes, are evaluated and routing path for shortest path is decided. Firstly, distance value to neighbour node is received, this is represented by d(e,j) and d denotes destination and i denotes neighbour node. Coming routing tables from neighbour nodes is controlled and from this table the distance from j node to destination [D(j,i)] is found. These operation is made for all node and the smallest value from d(e,i)+D(j,i) values is selected.

Neighbour routers have different distance according to each other. For example, d (A, B) distance value (distance from A router to B) is not equal to d (B, A) value.

Source and destination router is selected from combo box in the simulation. Then, with clicking "Run" button shortest distance from source to destination is calculated. Shortest path is shown in different colour in the simulation. Selected source and destination routers are also stated with blackening

In distance vector routing algorithm, routing tables, which come from neighbour routers, is used. In the simulation selected source node's neighbour

nodes' routing tables are constructed. In this tables shortest path distance of node from all other nodes in network is reserved. Source router uses the distance to neighbour node and distance from neighbour node to destination to calculate the shortest distance. This calculation is made for all neighbouring nodes and the node, which provides shortest distance, is selected.

In Figure 4 the simulation screen is shown. In this screen at the routing table area node A's neighbour nodes' distance table can be seen. Node A has two neighbour nodes for obtaining shortest path. Distance from A to B is 3 and B's distance to D is 8. Therefore, the distance to node D over node B is 3+8=11. Distance value between A and F is 9 and from F to D the distance is 12. When A node goes over F to D, the distance would be 9+12=19. With these results, shortest value is 19 and A will go over B to D for shortest distance.

In the simulation, shortest distance from source to distance and routing tables can be observed. To restart the simulation "Reset" button should be used. With this button, all results are cleaned and simulation can be run again.

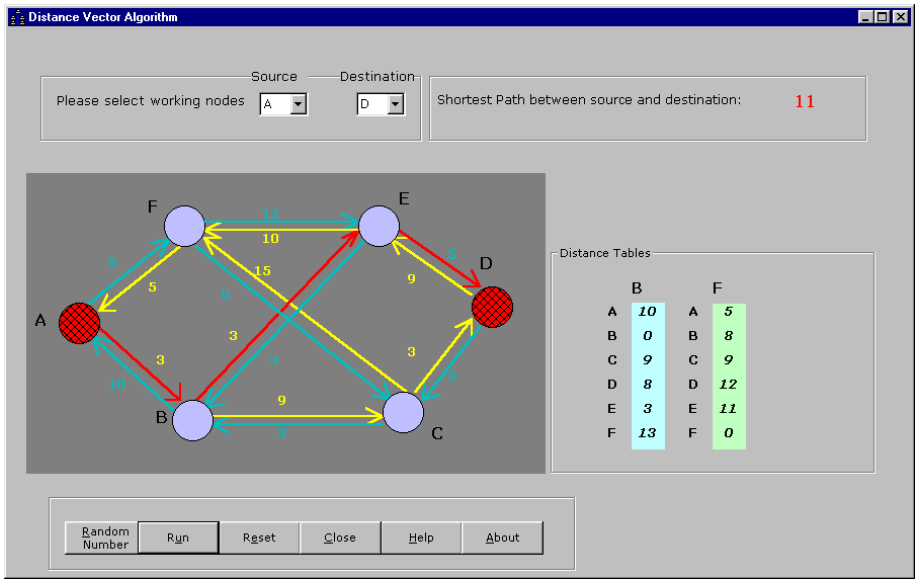

Figure 4. Simulation Screen of Distance Vector Routing Algorithm Simulation Program.

Simulator Design For Link State Routing Algorithm

Link state routing algorithm is widely used in computer network. For example, OSPF (Open Shortest Path First) and DECnet IS-IS (Intermediate System-Intermediate System) protocols use this algorithm.

Link state routing algorithm has some basic component. Each node has database about network topology and distance values. This database is distributed to all nodes except the node, which produces it. With using this database the shortest distance for all node is calculated and shortest path routing algorithm is used.

Network traffic can change. Each router in the network controls the distance to neighbour node and they sent an update packet to update the database when changing occurs. These packets are generally small (approximately 176 bit) and they are delivered to all routers. When changing in packets is occurred, the changing part of information is sent [4].

In link state routing algorithm, routers must know the distance to their neighbours. This information is sent to all routers as a database. In these packets, sender information, sequence number and age information are included.

Each packet contains sequence number. Sequence number is increased for each new packet. Routers keep number of sender and packet's sequence number. When new packet comes, sequence number is controlled by router to understand if it is a new packet or not. If it is a new packet, router takes it, if not packet is discarded.

Age area determines how long time a packet can stay in the network. Age area is decreased at each minute. In addition, while delivering packets, the router, which receives the packet, decreases the age value. When age value becomes zero, the packet is discarded.

According to the information in the packets, the shortest path is found with "shortest path routing" algorithm. In the algorithm definitions at the below are used.

- C(i,j) = the distance value between i and j. (c(i,j) is equal to zero, if there is no connection between i and j.
- D(v) = Shortest distance from source to v.
- p(v) = In the shortest path from source to v , previous router from v.
- N = The router set, whose shortest distance from source are known.

Shortest path routing algorithm works step by step in a loop. The loop continues until all routers are included to N [5].

Algorithm works as follows:

1. When A router is selected as a starting point. Firstly, A router is added to N set, N={A}. The first distance value will be D(v) = c(A,v). If A and v are not connected directly, D(v) = ∞.
2. In each step, the router, which is not in the N set and has the smallest D(w) value is found. Then, this router added to N set. For updating the distance of routers, which are not in the N set Formula 3 is used.

$$D(v) = \text{Min}[D(v), D(w)+c(w,v)] \quad \textbf{(3)}$$

These steps continue until each router is added to N set.
Link state routing algorithm firstly delivers link state packets by flooding to all router in the network. A router sends this packet to all routers except itself. In the simulation firstly packets are produced and distributed. These procedures are used in the simulation:

1. Packet procedure.
2. Define_value procedure.
3. Mark procedure.
4. Find procedure.

Packet procedure produces the link state packets in the simulation. In these packets, sequence number, age value and distances to neighbour nodes are included and they are distributed to all routers. In Figure. 5 a link state packet, which is used in the simulation, are shown. This packet belongs to A router. Its sequence number and age value are one and two respectively. B and F letters represent the neighbours of A router. Distance values are shown by the side of these letters.

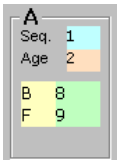

Figure 5. Link State Packet

With Define_value procedure distance the range from 1 to 10 defines values between routers. These values are determined randomly and kept into an array. Mark and find procedures are used to find shortest path. With mark procedure, nodes are marked as temporary and their distances are written on them. Find procedure, finds the shortest path in the nodes, which are marked temporarily, and this node becomes a new working point.

In the simulation, firstly packet operation is made. In the simulation screen, using "Deliver Packet" button each router produces the link state packet and delivers it to all routers except itself. Each router keeps these packets as shown in the Figure. 6.

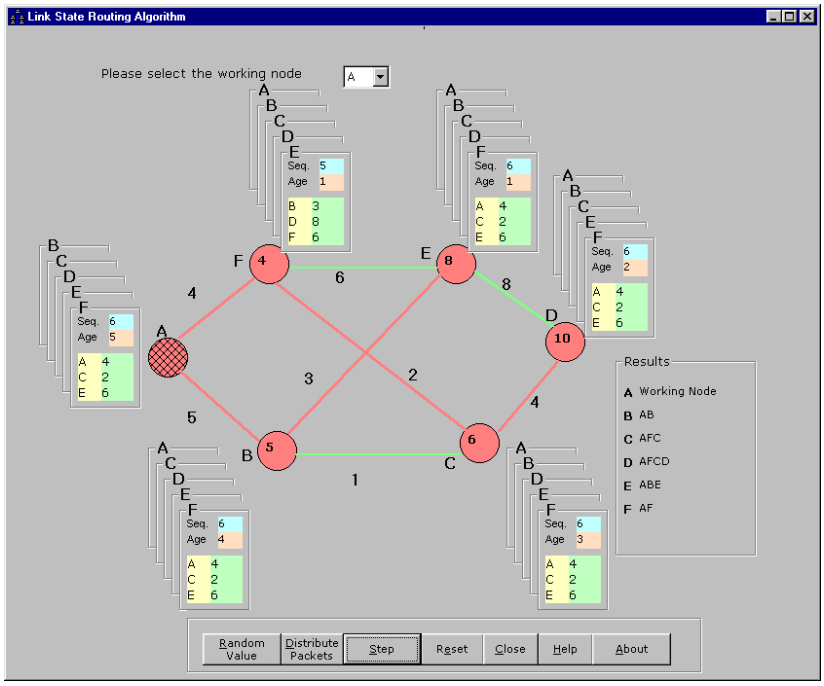

Figure 6. Link State Routing Algorithm Simulation Program.

Packets are sent one after the other and packet of F is sent at last. The sequence number of F's link state packet is 6. This value is different for each router. Routers control this value for understanding that the packet is new or not. Router, which receives packet, decreases the age value. Packets also contain the distances of directly connected routers and their distances. For example, A,C

and E are neighbours of F and their distances to F are 4,2,6 respectively. This information can be seen in the simulation screen. F's link state packet is found for all routers except F.

After delivering packets, source node is selected from the combo boxes which is shown in Figure.6. from these boxes, router from A to F can be selected. To watch the simulation step by step "Step" button is used. With pressing "Step" button, nodes which can be reached from source node is defined and their distances to source node is written in the circles. Then, the node, which has the minimum distance, is selected from reachable node set. Until all routers' shortest path is found, this process continues. Nodes, which are added to N set, can be seen at the result area. At the end of simulation all nodes' shortest path from working node are found. Shortest path values can be seen in the circles.

RESULTS

Simulators work with the principle of algorithms in the network model. Distance values can be changed dynamically. For example, in distance vector routing algorithm, shortest path is calculated according to the information, which comes from neighbour nodes. Distance tables of nodes are calculated for understanding the algorithm. Other simulations are also work with the simulation of related algorithm.

In the shortest path, distance vector and link state routing algorithm simulations same network model is used. The purpose is , to realise the differences of algorithms in the same network.

For comprehension of this subject it will be useful to benefit from simulations, because there is no possibility to exercise this subject in the laboratory.

In the simulations network model can not be changed. User can define different distance values for the simulation. Next step will be, network model configuration can be done by user.

It is expected that simulations will be beneficial for Computer Network courses as a learning tool.

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