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"SURVEY ON IMPLEMENTATION OF GRAPH THEORY IN ROUTING PROTOCOLS OF WIRED COMPUTER NETWORK"

Deepak Kumar Malviya[1], Neeraj Malviya[2]

[1]M.Tech. Student Department of IT, UIT BU Bhopal MP
[2]Associate Professor, Department of Mathamatics, NRI IST Bhopal MP

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ABSTRACT - In wired Computer Networking Routing Protocols are used to select the best route between any two reachable nodes .Different types of Routing Protocol are defined for specific network environment as which routing protocol seems to be efficient to find the best route especially when the number of nodes varies. When numbers of nodes are limited Routing Information Protocol (RIP) is used and in large enterprise network Open Shortest Path First (OSPF) and Enhanced Interior Gateway Routing Protocol are used. This paper analyze the Algorithms which are used by Routing Protocol to select the best routes , these algorithm is defined in Graph Theory.

Keywords- Routing Protocol, Graph, Vertices, Edges, Weight, Shortest Path Algorithm and Bandwidth (BW).

1. INTRODUCTION

Networks are group of node which are connected each other by wired/ wireless communication media through different paths and each node is able to communicate any of other nodes of networks. In scope of Mathematics, we can describe these networks with the help of Graph Theory. A Graph is representation of set objects called vertices in which some of vertices are connected by links also known as edges. Normally undirected graph, directed graph and weighted graph are used to represent network. An undirected graph shown in Fig 1, a graph which has no orientations. A more practical example of an undirected graph would be two people sharing hands. Person A is sharing hands with person B and at the same time Person B is sharing hands with Person B. Fig 2 shows a directed graph or digraph. A graph has edges that have direction. Arrow on the edges are used to show the flow from one node to another. For example in Fig 2 vertices A can move to vertices B, vertices B can move to vertices A and vertices C but vertices cannot move to vertices B. Here Vertices movement shows the direction of communication between network nodes. And weighted graph shown in Fig 3 , a graph in which each edge is given weight in terms of numbers . In network it is used to analyze better path on the basis of weight on the edges of graph. Weight denotes the cost it takes to get from one vertices to the next vertices. For example in Fig 3

for moving from vertices A to vertices we have two routes one is from directly vertices A to vertices C which has weight/cost 5 and second is from vertices A to vertices B weight/cost is 2 and vertices B to vertices C weight is 1 and in second route total weight is 3 which is lesser weight than first routes i.e. 5 it means second routes is better.

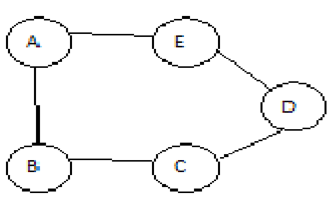

Fig 1

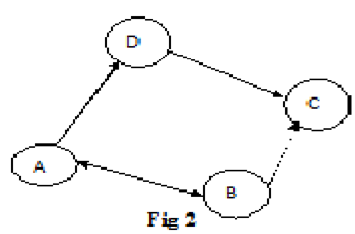

Fig 2

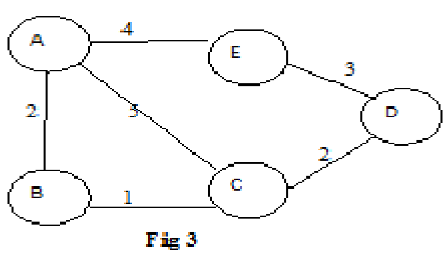

Fig 3

There are many topics being researched related to graph theory. However the context of this paper will be focused on shortest path algorithms (SPAs). We will discuss how shortest path algorithms (SPAs) are used to find the best or least cost path from given node to another node and also we discuss two of most common shortest path algorithms (SPAs) Bellman-Ford algorithm and Dijkstra'salgorithm.Without SPAs, network traffic would have no direction and not know where to go. It is also very important that network traffic does not loop.

There are two types of protocols are used in wired computer network Exterior Gateway Protocol (EGP) and Interior Gateway Protocol (IGP) .EGP is used to share routing information between the Autonomous System (AS). An AS is a heterogeneous network (group of network nodes) typically governed by large enterprise. An Enterprise which wants to be a part of world wide web or internet has to allocate the Autonomous System Number (ASN) from Internet Assigned Number Authority (IANA).The routing protocol which is used to communicate between two different AS is called IGP e.g Border Gateway Protocol (BGP).IGP is used to share routing information within an AS (between the nodes of an enterprise).

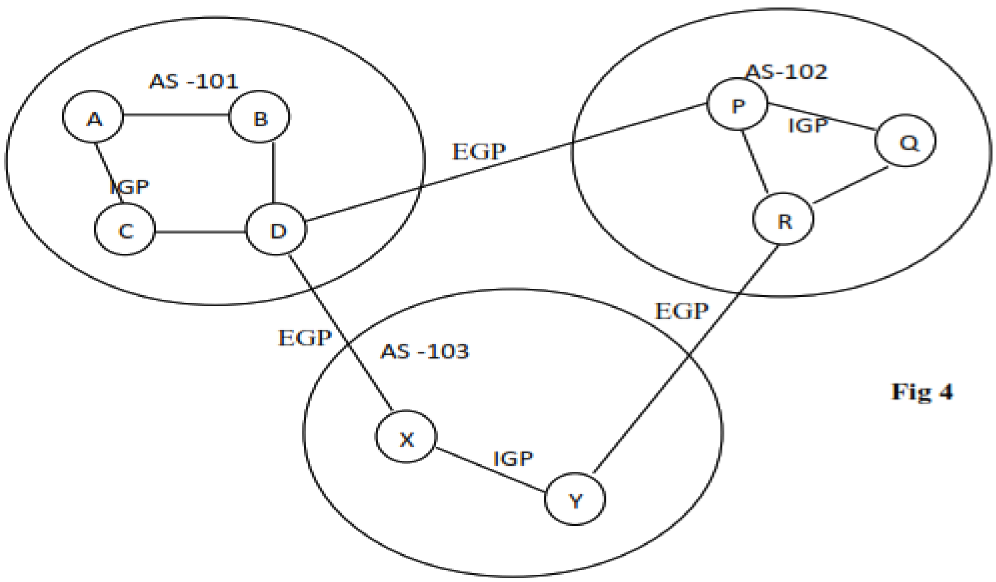

Fig 4

Fig 4 show the communication between AS (ASN 101,102 &104) through Exterior Gateway Protocol (EGP) and In each AS every node (ABCD in AS 101 or PQR in AS 102 or XY in AS 103) communicate by IGP with each other in same AS only. There are two types of Interior Gateway Protocols (IGP) , Distance Vector Routing Protocol and Link State Routing Protocol .Distance Vector Routing Protocols i.e. Routing Information Protocol (RIP), Interior Gateway Routing Protocol (IGRP) and Enhanced Interior Gateway Routing Protocol (EIGRP) uses Bellman-Ford algorithm and Link State Routing Protocol i.e. Open Shortest Path First (OSPF) uses Dijkstra's algorithm for finding the best path. Each of these algorithms uses a unique method to find shortest paths between network routes. Also, one of the most unique distinctions between each routing protocol is how each chooses their edge weights. RIP considers the cost from vertex to vertex to all be equal. Therefore, the shortest path is determined solely on the shortest number of nodes used to get to the destination. EIGRP uses a more complex formula in calculating weight called metric or cost but still does not require much overhead. The cost metric can be found by using the following formula (the K variables are predefined and a default value is most often used).

EIGRP Cost = [{K1×BW+(k2×BW)/(256-Load)+k3×Delay}×k5/(k4+Reliability)] ×256 where BW=Bandwidth

OSPF uses a very simple calculation to find its edge weight called metric or cost. Its cost is found by taking one hundred divided by the bandwidth in units of Megabits per second. The cost metric can be found by using the following formula

OSPF Cost =Reference Bandwidth / Interface Bandwidth, where reference bandwidth is 100 Mega bit per second.

From the information provided above, it is clear that each algorithm is unique. I studied each of these routing protocols in depth, and analyzed the efficiencies of each and worked to find which one is best. It is well known that each of these routing protocols were built around a previously discovered graph theory algorithm. For example, OSPF was created knowing that Dijkstra's algorithm would be used in finding the shortest path. There have been several revisions of this protocol since its release, but those changes were made to accommodate for new technology. Overall, the method used to find the shortest path has remained the same for years. There are many times where multiple routing protocols find a shortest path to be the same path as another protocol. Therefore, I define efficiency to be equal to the time it takes for an algorithm to actually calculate the shortest path. Given the size of today's networks, the process of calculating routing paths can be exhausting. Any time a path is modified or changed, the algorithm must be ran again on the network to determine if a new shortest path is available. For example, a cable between two routers being cut would represent an edge being removed from a graph because there is no longer a connection between routers, or vertices. Similarly, when a router is taken out of a network, this represents a vertex being removed from the graph. From past experience in computer networking, the arguments posed on choosing a particular routing protocol are only related to which protocol is best for the type of equipment or connections that are being used. It should also be known that this paper will focus on undirected graphs. In the area of computer networking, it is not practical to say that network traffic can flow in one direction across a given path, but not the other direction. Therefore, directed graphs will be excluded from most of the research topics. I will show my analysis of the shortest path algorithms. Then, I will move in to the experimental portion and explain, in detail, how I used computer software to find the results.

2. RELATED WORK

Now a days many applications are using shortest path algorithms. Consider using computer navigation software to obtain directions to a place you have never driven to before. In most cases, there are many paths one could take in order to arrive at that location. This software creates a graph with the vertices representing a physical location and the edges which represent the road that connects two locations. If there is not a road between locations, then there is not an edge in the graph. Next, a weight is associated with each edge. In this example, the primary metric used for weight is distance. However, other factors in this example are considered when assigning a weight, or cost, to an edge, such as traffic and average speed of vehicles on a given road.

Path finding algorithms date back to the late 1800s. "Path finding, in particular searching for a maze, belongs to the classical graph problems, and the classical references are Wiener [1873], Lucas [1882], and Tarry [1895]. They form the basis for depth-first search techniques". However, it wasn't until the 1950s that shortest path algorithm.

Development began to rise. This time period marked a new era of complex network applications. For example, telephone networks were growing significantly larger, creating a demand for a more efficient process to find the shortest path to the end caller. Before this period, call routing had to be completed manually by telephone operators. Therefore, if a particular call path was broken, it was not automatically intuitive as to which backup path should be taken. While several mathematicians and computer scientists contributed to this research, two major contributions were Edsger Dijkstra and Dijkstra's algorithm in 1956 and also the Bellman-Ford algorithm, developed by Lester Ford, Jr. and Richard Bellman in 1956 and 1958 respectively. The Bellman-Ford algorithm was also published in 1957 by Edward F. Moore and is sometimes referred to as the Bellman-Ford-Moore algorithm. Computer networks began to evolve throughout the late 1950s and 1960s. The majority of these networks were initially used in military operations for top secret data transfer and also for radar system Semi-Automatic Ground Environment (SAGE) [1] . This created a great opportunity for computer networking in the corporate world as well.

American Airlines was the first American company to fully utilize a complex network to connect mainframe systems for the use of Semi-automated Business Research Environment (SABRE).

As corporate networks began to grow, it became very difficult to manually manage every connection between sites. Configuring routers to direct traffic to a fixed location at all times was completely inefficient. Routers needed the ability to dynamically calculate the best and shortest path quickly. This process is referred to as dynamic routing. The first major dynamic routing protocol, Routing Information Protocol (RIP), was implemented in 1988. "This algorithm has been used for routing computations in computer networks since the early days for the ARPANET" (RFC 1058). RIP runs as a software component on routers based on the Bellman-Ford algorithm. Each routing protocol uses a different method in calculating the cost between routers. RIP determines that the hop count is the routing metric. RIP is still commonly used in networks today. The second major dynamic routing protocol is called Open Shortest Path First (OSPF). This protocol is current on version 2, which is defined by RFC 2328 and published by the Internet Engineering Task Force (IETF) in 1998. Similarly, OSPF exercises a previously defined shortest path algorithm, Dijkstra's Algorithm. OSPF calculates determines the bandwidth between two routers and then assigns that bandwidth amount in megabits per second to the edge cost. This protocol is also implemented frequently in corporate networks around the world today.

3. SHORTEST PATH ALGORITHMS

3.1 The Dijkstra algorithm

Finite element models of hot-rolled RHS/SHS stub columns were developed by using the non-linear finite element program ABAQUS, in which two steps including linear perturbation and non-linear analyses were performed in order to obtain the ultimate carrying capacity and failure modes of RHS/SHS stub columns. Material properties and cross-section dimensions measured from Joanna's test were included in the finite element model. The typical nomenclature is defined in Figure 5.

The Dijkstra algorithm is used to find a single node as the source node and calculate the shortest paths from the source to all other nodes in the graph, increasing node by node to get a shortest path tree. Here is the algorithm:

Step1: Initializing D[i]. D[i]represents the distance from the starting point V to the point Vi. If there is an arc between the two vertices, then D[i] is the weight of the arc; Otherwise, D[i]=∞.

Step2: Finding a node Vj, which is abutting to node V and has the shortest distance from V.

Step3: Then finding a node Vk, which is abutting to node Vj and has the shortest distance from Vj. Making D[j]=Min{D[j], D[i] + the weight from Vj to Vk}.

Step4: Repeating the step3 until reaching the destination node.

Here is a simple example to show detailed steps of the algorithm.[9]

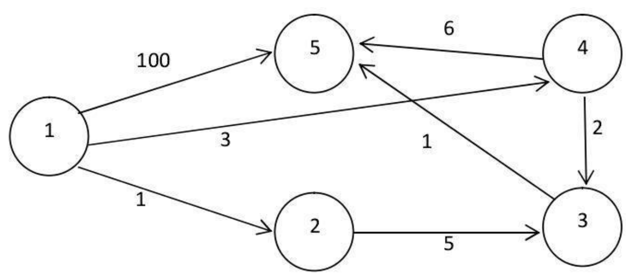

Figure 5. A example of the Dijkstra algorithm

Table 1. A example of the Dijkstra algorithm

Circulation	V	Node2	Node3	Node4	Node5
Initial node	1	1	Max	3	10
1	1,2	1	6	3	10
2	1,2,4	1	5	3	9
3	1,2,4,3	1	5	3	6
4	1,2,4,3,5	1	5	3	6

3.2. The Bellman–Ford algorithm

The Bellman–Ford algorithm is an algorithm that computes the shortest path from a single source vertex to all of the other vertices. It is capable of solving graphs in which some of the edge weights are negative numbers. Here is the algorithm:

Step1: Initializing D[i]. D[i] represents the distance from the starting point V to the object point Vi.

Step2: w (m,n) is the weight of the edge e (m,n), and e is the shortest path between (m,n). For each edge e (m,n). If D[m] + w(m, n) < D[n],

D[n] = D[m] + w(u, v).

Step3: The loop performs up to i - 1 times, and i is the number of the vertices. If the operation above does not update the D[i], the shortest path has been searched, or some of the points cannot be reached. Otherwise, executing to the next cycle.

Step4: Testing the diagram to find whether it has a negative loop (the sum of weight is less than 0). If D [u] + w (u, v) < Distant [v], there is a negative loop, which means the shortest path cannot be founded in the graph. Otherwise D[i] records the shortest path. For example, if there is a negative loop, the values of each point will decrease, after one traversal. It is shown in Figure 6.

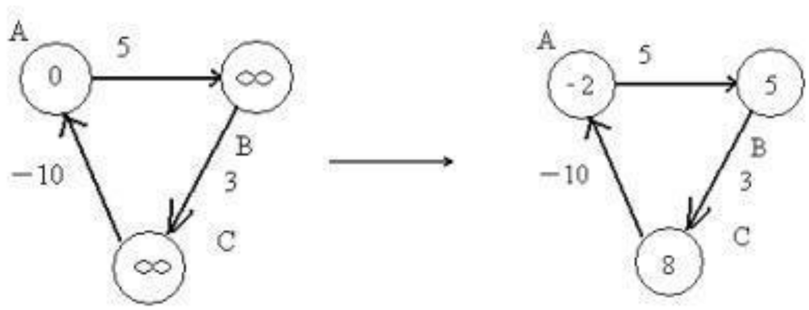

Figure 6. A negative loop

4. CONCLUSIONS

This Paper introduces the Routing Protocol which are used to find the best path between the nodes in computer networking on the basis of their shortest path algorithms of graph .When studying routing protocol, there is a widely used the shortest path algorithm. The main idea is to create a figure. Each node in the diagram represents a router and each edge/arc is a communication line. In order to select the routing among a pair of routers, the algorithm should find the shortest path in the diagram.

Modern computer networks usually use dynamic routing protocol, namely distance vector routing protocol and link state routing protocol.

The distance vector routing algorithm is that each router maintains a table. The table has the best path and route for each destination through exchanging the information with neighboring routers to update the table information. RIP protocol is a dynamic routing protocol and uses the Bellman-Ford algorithm. The process of routing announcement is the process of the Bellman-Ford algorithm's implementation. The routers collect all different paths to the destination and save the number of sites about information of each destination path. Any other information will be discarded, except the best route to the destination.

Link state routing protocol collects all kinds of information of the whole network, which constitute a topological database of routers. Open Shortest Path First (OSPF) is a typical protocol which is an internal gateway protocol which used to make routing decision within a single autonomous system. Besides, it is a specific implementation of Dijkstra algorithm. It mainly uses the algorithm to generates a tree without loops. Then starting from a router and passing the information to all the routers in the tree. Thus, all the routers is shared by all the state of the link. Each router is calculated in the local routing and avoids updating the routing table blindly.

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