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A NOVEL OPTIMAL ROUTING PROTOCOL WITH IMPLEMENTATION OF M/M/1 QUEUING MODEL

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ABSTRACT

*Routing data packets in an effective way from source node to destination node is an important phase in the management of network. The efficiency of the routing depends on many factors such as service time, transmission time, waiting time, shortest and feasible path etc. An Optimal Routing Protocol along with M/M/1 queue is proposed in this paper, which combines the feature of shortest path and the waiting time of the packets, to choose the best path for the transmission. In Phase I, multiple possible paths from source to the destination are found out by implementing Breadth First Search Algorithm (BFS). Using BFS algorithm, all paths from source to destination are identified and cost for traversing each path is calculated. In Phase II, each link can be considered as M/M/1 queuing model and the total waiting time is calculated for every path. Total cost of the path is then, the Cost of the chosen path * Total waiting time of the path. Path corresponding to the least total cost is considered for routing. In case of the link failure or congestion in the chosen path, next path with least total cost becomes the best path and considered for routing.*

Key words: Shortest Path, M/M/1 Queuing Model, Smart Protocol, Least Cost Path, Breadth First Search, Optimal Path, Waiting Time

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1. INTRODUCTION

In present networking scenario, which is of heterogeneous nature, emphasis is on the performance of the network which mainly depends on the implementation of an optimal routing algorithm. Routing algorithm plays an important role in maintaining the QoS of the network by choosing the optimal (shortest) path which reduces the delay and cost. Finding the shortest path between the source and destination in a network is always linked with a cost of each link. Despite there are numerous routing algorithms, complexity in data communication is increasing day by day as the number of people getting connected to network are increasing rapidly. This complexity leads to unpleasant behaviour of the network such as delay in transmission and dropping of packets. An extensive study has been done in the past literature on various routing algorithms and their implementation issues. Different routing algorithm of different strategy is modelled for different goals. The goals can be achieving fairness, maximize throughput, minimize cost, choosing shortest path, minimize waiting time and avoid packet dropping. A routing algorithm should allow temporary bursty traffic, and penalize flows that persistently overuse bandwidth. Also, the algorithm should prevent high delay by restricting the queue length, avoid underutilization by allowing temporary queuing, and allocate resource fairly among different types of traffic. In practice, most of the routers being deployed use simple Drop Tail algorithm, which is simple to implement with minimal computation overhead, but provides unsatisfactory performance. The optimality of the routing algorithm is a relative attribute which usually implies an efficient use of the network resources so as to optimize selected performance measure, such as network throughput or mean packet delay [1].

This paper focuses on a routing algorithm which finds the optimal path, which minimizes the overhead of network. The proposed model is an improved version of Dijkstra’s shortest path algorithm with the implementation of single server queuing model.

2. REVIEW OF LITERATURE

Breadth first searching algorithm is an effective and commonly used algorithm applied to many different applications. BFS processes tree-like structures and starts off at the root of the tree (the source) and explores the neighbouring nodes first [2]. After all the neighbours are processed, then the next levels of nodes are processed until all of the levels have been visited. Eric Klukovich et al. have presented a sequential implementation of BFS using a FIFO queue structure. Single and multiple GPU BFS algorithms are implemented to perform analysis on different topology graphs.

A new shortest path algorithm has been proposed in [3] which is a modified Floyd-Warshall’s algorithm. This algorithm is an improvement over the existing Dijkstra’s Shortest Path Algorithm. In Dijkstra’s Algorithm, the shortest path between two particular nodes is found at a time. But, simultaneously the shortest path between every two nodes is not found out in that algorithm. To get that, every time the two particular nodes would have to be specified. The new algorithm has the flexibility that it can be used to find the shortest path between every pair of nodes of a wireless sensor network at a time. In this work, the presence of acknowledgement paths between every two nodes for modification has been considered.

Wang Shu-Xi [16] has addressed three issues in Dijkstra’s algorithm viz. I. Its exiting mechanism is effective to undigraph but ineffective to digraph, or even gets into an infinite loop; II. It hasn't addressed the problem of adjacent vertices in shortest path; III. It hasn't considered the possibility that many vertices may obtain the "p-label" simultaneously. By addressing these issues, an improved algorithm has been presented in this work. By experimental results it has been proved that the improved algorithm is better than the original algorithm since: a. the improved algorithm’s exit mechanism is improved so that the algorithm will avoid falling into an infinite loop. b. The improved algorithm can get adjacent vertices (specific to the previous vertices) in the shortest path. c. The improved algorithm solved the problem of more than one vertices obtain “p-label” at the same time.

An Improved Genetic Algorithm Based on the Shortest Path Problem has been presented in [4]. In this paper, the dynamic stochastic shortest path problem and its mathematical model are introduced. The paper investigates the shortest path problem based on the genetic algorithm principle. An improved self-adaptive genetic algorithm is proposed by encoding the chromosomal mode. Genetic algorithm is improved by adjusting the encoding parameters. Experimental results has been compared with A* and Dijkstra's algorithm and results indicate that the improved genetic algorithm DRSP-GA could obtain the better solutions which adapt to new transportation rapidly in global optimization than A* algorithm and Dijkstra algorithm in the shortest path problem.

Shortest path problem using advanced Boolean satisfiability (SAT) techniques has been introduced in [5]. Despite the advancements in Dijkstra's shortest path algorithm, it is difficult to incorporate user specific conditions on the solution. Such conditions can include forcing the path to go through a specific node, forcing the path to avoid a specific node, using any combination of inclusion/exclusion of nodes in the path, etc. A new approach has been proposed in this work [5] to solve the shortest path problem using advanced Boolean satisfiability (SAT) techniques. This paper has shown how to formulate the shortest path problem as a SAT problem. The algorithm is implemented on various network topologies and results indicate that using the proposed approach has improvement over previous techniques.

3. PROPOSED MODEL – M/M/1 QUEUE APPROACH FOR OPTIMAL PATH

In routing data packets, waiting time of packets play a significant role, since as the waiting time increases, probability of packet drop will also be increasing. Taking this point into consideration our model deals with shortest path as well as waiting time to find the optimal path.

Initially, all possible paths between the source and destination are found out through Breadth First Search Algorithm. Then the cost of traversing $i^{th}\,path$ with $'m'$ nodes is calculated as

$$: CP_i = \sum_{j=1}^{m} C_j \qquad (1)$$

where, C_j is the traversing cost of j^{th} node to the next node in the path.

In our model, each link is considered as M/M/1 queuing model. The average waiting time in each node of i^{th} path is calculated as [6],

$$: W_{si} = \frac{1}{(\mu-\lambda)} \qquad (2)$$

μ = service rate of packets

λ= arrival rate of packets

It has to be noted that, in the steady state, the traffic intensity

$$\rho = \frac{\lambda}{\mu} < 1.$$

The cumulative average waiting time of i^{th} path with $'m'$ nodes is evaluated as,

$$: P_i WS = \sum_{i=2}^{m-1} W_{si} \qquad (3)$$

Total Cost of the path $'i'$ is then estimated as

$$:TC_i = CP_i * P_iWS \tag{4}$$

The optimal path the path with least TC_i.

4. CASE STUDY & SIMULATION

The simulation is being carried out in C++.

The network we have considered has been depicted in Fig. 1 and values of μ and λ for all the nodes are represented in Table 1. We have considered the source node as node 1 and destination node as node 4.

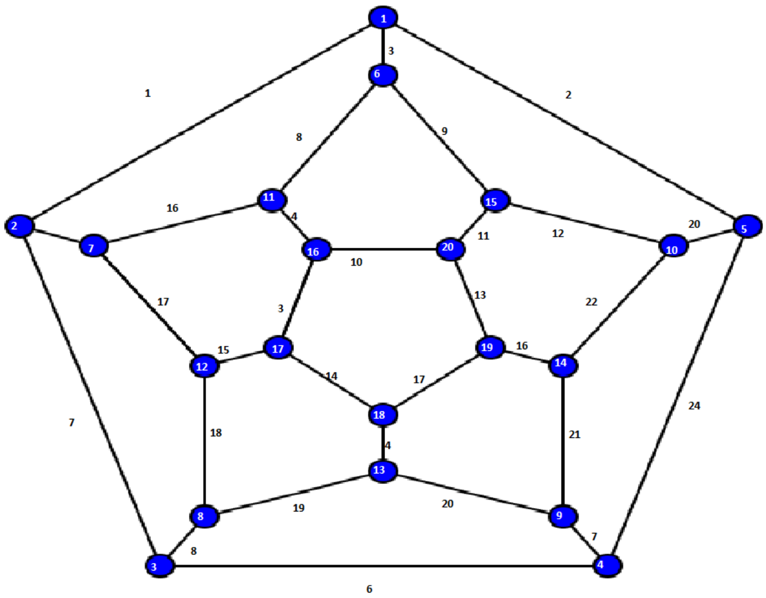

Figure 1 Network Topology

Table 1 Arrival and Service rates

Node	μ (sec)	λ (sec)
1	0.008	0.006
2	0.006	0.004
3	0.005	0.001
4	0.009	0.008
5	0.004	0.001
6	0.004	0.002
7	0.007	0.001
8	0.009	0.003
9	0.006	0.005
10	0.007	0.005
11	0.002	0.001
12	0.007	0.001
13	0.006	0.004
14	0.009	0.005
15	0.003	0.001
16	0.005	0.003
17	0.006	0.003
18	0.007	0.006
19	0.003	0.001
20	0.004	0.002

Pseudo Code

```
for i in range(0,20):
 ws[i]=(1/(myu[i]-lam[i]))
shordist=[];
for item in abc:
 sd=0;swt=0;
for i in range(0,len(item)-1):
 sd=sd+dist[int(item[i])-1][int(item[i+1])-1];
 swt=swt+ws[int(item[i])-1];
swt=swt-ws[int(item[0])-1];
shordist.append(sd*swt)
min=shordist[0];
for i in range (1,len(shordist)):
if shordist[i]<min:
 min=shordist[i];
```

5. RESULT ANALYSIS

On implementing simple Breadth First search on the topology shown in Fig.1, the shortest path is found to be 1-2-3-4 whose total cost is 14. Implementing our Optimal path algorithm, the shortest path is found to be 1-5-4 whose total cost is 8.66667, which is significantly lesser. Thus our routing algorithm which combines the feature of shortest path and waiting time yields better result by giving the optimal path with less cost.

6. CONCLUDING REMARKS

In this paper we have presented a routing protocol for finding the optimal path which combines the feature of shortest path and waiting time at each node. Since waiting time plays a major role in communication network, we have considered the waiting time for calculating the total cost. The promising aspect of our protocol is that it gives the optimal path which includes the cost aspect rather than giving the shortest path alone. The simulated result shows that our model is better than Breadth First Search Algorithm in giving the optimal path.

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