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Efficient Balancing of Load Using Node Usage Probability in Communication Networks

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Abstract— Node usage probability is a metric for uniformly distributing the traffic load and frequently choosing a node to relay packets in a network. However, the issues arise due to traffic congestion as it is the major cause in degrading the overall performance of the network. The concept of node usage probability comprises of effective network design strategies, routing algorithms and resource allocation schemes, which helps improve the overall traffic performance. Node usage probability is a metric used wherein the nodes in the network are used efficiently as the problems arise when the nodes are sometimes overused or not used at all inducing congestion in the network thereby hampering the network performance. The performance of the minimum node usage routing algorithm is compared with other routing algorithms, as the shortest path (SP) and minimum degree (MD) routing algorithms, that comprise attributes like network topologies and resource allocation schemes which shows routing algorithms based on minimizing the node usage (MNU) can balance the traffic load effectively also the resource allocation technique based on the node usage probability shows that the technique performs better than the uniform and degree based allocation schemes. The analysis gives an idea of the topology to be used, resource allocation scheme and the routing method, for attaining optimal network performance.

Index Terms—Shortest Path (SP), Minimum Degree (MD), Minimum Node Usage (MNU)

I. INTRODUCTION

Communication networks connect the modern world, Internet being one prominent example of the same. Traffic congestion in many communication networks has arisen on a larger scale due to the development of the society. Traffic congestion has been studied broadly in the past times in the physics and engineering communities. Communication networks and their topological properties that are characterized by small world and scale-free degree distributions, and much work on the same previously carried out have shown that network topology is much relevant to the performance of communication networks, for instance, parameters like traffic performance, the vulnerability of attacks, routing effectiveness, and so on. The communication takes place when the digital information is transmitted from a source to a destination which involved routing "packets" from source to destination along a set of intermediate nodes, called a path, which is chosen by the specific choice of routing algorithm. The routing algorithm finds the path to transmit packets from source to destination.The routing algorithm decides the construction of a network with its ultimate traffic performance. Shortest path is one of the strategies which contribute to effective routing in a network. Consider, the heterogeneous network like the Internet, widely used shortest path (SP) routing strategy here gives rise to high traffic loads at some particular hubs in the network, thereby causing congestion of the entire network. In order to improve the efficiency and avoid traffic congestion at the hubs and reliable flow of information, different routing algorithms were proposed, like the traffic awareness routing algorithm, degree based routing algorithm [1], the local routing algorithm [2], the global dynamic routing strategy [3], and more [4]. Comparing the various kinds of routing strategies, the degree based routing algorithm [1] is best known for its simplicity and efficiency. The degree based routing strategy aims at finding the path for each pair of a packet with the minimum sum of nodes degree, discussed as minimum degree (MD) routing here. Considering the static topological information, like the SP routing, the MD routing can methodically evade the presence of high degree nodes in the network and efficiently improve the overall performance of the network. For efficient and reliable data transmission [2], the traffic load has to be uniformly distributed as possible in the network, and the usual distance traveled by the data should be diminutive. The node usage probability introduced is an effective metric for describing the traffic load distribution and how repeatedly a node is chosen to transmit packets in a network. Established the concept of node usage probability, design effective strategies are developed to balance the traffic in the network nodes by eluding overuse of some particular nodes. The efficient network design includes minimization of the complete node usage for a given network topology. The Internet termed as autonomous system (AS) level topology has been broadly studied and widely used in a variety of exploration. The strategy here involves the use of network build by means ofthe Internet interconnection at AS level from an online database containing 3015 nodes and 5348 links which consider the random graph, the Barabási-Albert (BA) scale free network [8] and the onion scale free network[8]. The resource allocation established on the node usage probability performs better than the uniform and degree based, and it also allows identifying the optimal operating point.

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II. RELATED WORK

Gang Yan, et. al [9] a new routing strategy to improve the routing efficiency of complex networks. Efficient path routing algorithm was used instead of using the routing strategy for the shortest path; the generalizedrouting algorithm is used to find the so called efficient path that studies the possible congestion in the nodes along the paths. As the nodes with the largest degree are susceptible to traffic congestion, as a new technique, redistributing the traffic load in central nodes to other non central nodes proves to be an effective way to improve traffic and controls congestion. Analysis and results show that the networks capability to process traffic is improved by optimizing the efficient path.

Ming Tangand Tao Zhou [10] proposed traffic dynamics in complex networks wherein each link is assigned a limited and similar bandwidth. Even though the first-in-first-out queuing rule is broadly applied in the routing of information packets, the actual issue that arises is a drop in the overall throughput of the network which can be remarkably enhanced. Proposed are some efficient routing strategies that do not follow the FIFO rule. As compared with the shortest path strategy which is usually used, the throughput for both Barabasi-Albert (BA) networks as well as the internet can be improved. The theoretical limitation of the throughput is calculated. In Barabasi-Albert networks, the proposed strategy achieves the maximum of the theoretical optimum, but for the real Internet, it remains twelve percent indicating that there is still a huge space to improve the routing policy for the real Internet also finally possible promising ways to construct more efficient routing strategies for the Internet.

Jiajing Wu, Chi K. Tse, Francis C.M. Lau and Ivan W.H. Ho[7] proposed the performance of communication networks. Analyzing the networks of selected topologies that includes random networks and scale-free networks, and investigate the performance of these networks regarding their intended functions of delivering information as well as robustness against specific attack strategies. Considering the generic type of communication networks, wherein packets of messages are sent from one node to another under practical operational conditions, for example, the use of packet buffering in communication nodes and the implementation of specific routing algorithms. Performance parameters, including packet drop rate and time delay, are considered. The results of the best routing algorithms and the type of network topology on these performance parameters are studied. The vulnerability of the networks while subject to different attack strategies is studied. As the results reveal that the removal of a certain high degree nodes in a scale free network by shortest path routing may make the performance better regarding drop rate. The overall network performance can be improved when high degree nodes are organized to provide limited service to a specific group of privileged nodes.

Jiajing Wu, Chi K. Tse, FrancisC.M. Lau, and Ivan W.H.Ho [8] the rresearch involves the study of performance of communication networks from a network science view. In the physics research community, the earlier statistical study often assumes over-simplified communication models for the evaluating performance without incorporating realistic network operational settings and performance parameters from the communication perspective. The study here uses a model that compromises simplicity and very specific modeling by incorporating realistic network operational settings in general network topologies. The task is to establish a clear link between some structural properties of networks such as degree distribution, average distance, with communication network performance, the purpose being to improve understanding of the various factors that affect the communication performance of networks and to provide design information for optimizing performance. A generic type of communication networks, in which packets of messages are sent from one node to another under practical operational conditions and the implementation of specific routing algorithms. Studying the networks of selected topologies including regular lattice, Erdös-Rényi random network (ER random), and Barabasi- Albert scale-free networks (BA scale-free), and the real-world Internet constructed at the autonomous system (AS) level and investigate the performance of these networks regarding their intended functions of delivering information. Performance parameters, including packet drop rate, time delay, and critical generation rate, are considered.

III. PROPOSED METHODOLOGY

The Proposed system involves different algorithms to compare the network performance and to achieve the optimal performance of an algorithm under which the network performance is optimal. In the Fig 1. the system for improves the network performance in order to balance the load in the network and improve the overall network performance and avoid the packet drop and congestion in the network

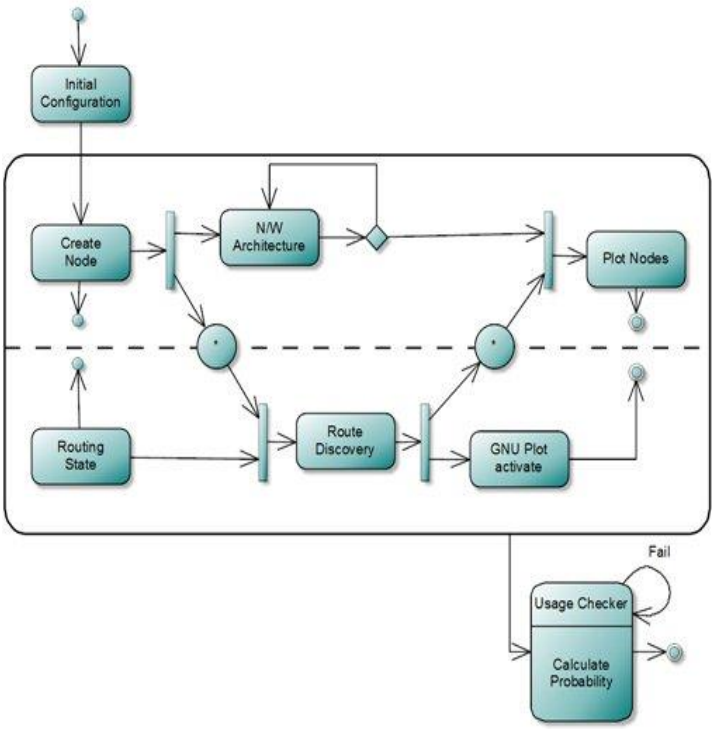

Fig 1. Overview of Node usage Probability in Complex Networks.

A. Node Path Algorithm

Let G (V, E): weighted directed graph, with set of vertices V and set of directed edges E,
W (u, v): the cost of the directed edge from node u to node v.
Consider:-
S: source node
T: destination node
K: number of shortest paths to find
Pn: Path from S to u
B: heap data structure containing paths
P: set of shortest paths from S to T
Countu: Number of shortest paths found to node u

Algorithm:

*P=empty,
*Countn=0, for all u in V
Insert path Ps={s} into B with cost 0
While B not empty and Countt< K
Let Pu be the shortest path cost B with cost C
B=B-{Pn}, Countn = Countn+1
if u = t then P = P U Pn
if Countu ≤ K then
For each vertex V adjacent to u
Consider Px be a new path and cost C + w (u,v) made by concatenating edge(u,v) to path Pu
Insert Px into B

Title	Author	Mechanism	Advantage	Limitations
1] Complex Network approach to communication Network performance analysis	Jiajing Wu, Chi K. Tse, Francis C.M. Lau and Ivan W.H. Ho	The concept lies in removal of a certain number of high degree nodes in a scale free network along with shortest path routing may help minimize the drop rate.	The overall network performance can be improved when the high-degree nodes are used exclusively as a specific group of nodes.	The random attack causes the nodes to be removed randomly from the network. The packets that begin or end at a removed nodes are dropped
2] An Adaptive Routing Algorithm for Load Balancing In Communication Networks	Jiajing Wu, Chi K. Tse, Francis C. M. Lau and Ivan W. H. Ho	An adaptive routing algorithm is proposed considering both the network structure and the dynamic trafficinformation. Also it is compared with shortest path (SP) and minimum degree (MD) routing algorithms in terms of packet drop rate and packet transmission time.	The proposed routing algorithm can effectively balance the traffic in the network and improve the overall network performance.	In SP routing, nodes with a higher degree are selected as routers with a high probability and are more vulnerable to congestion.
3] Analysis of Communication Network Performance From a Complex Network Perspective	Jiajing Wu, Chi K. Tse, Fellow, IEEE, FrancisC.M. Lau, Senior Member, IEEE, and Ivan W. H. Ho	The node usage probability an effective metric for describing the traffic load distribution is proposed and how often a node is chosen to transmit packets in a network, metric, which depends on the network topology and routing algorithm.	The degree-based node usage probability-based resource allocation can enhance the network performance. The node usage probability-based allocation gives the best performance.	Using BA scale-free network, the higher degree nodes have much higher probability to be chosen as a router, making them vulnerable to congestion and restricting the throughput of the network

4]Optimizing Performance of Communication Networks: An Application of Network Science	Jiajing Wu, Chi K. Tse, Fellow, IEEE, and Francis C. M. Lau, Senior Member, IEEE	Simulated annealing algorithm been proposed to find a near-optimal solution for minimum node usage.	SA algorithm performs better than other three algorithms in terms of critical generation rate, average transmission time.	Since the traffic load is more uniformly distributed in the network, nodes become congested after the network enters a congestion state, causing a rapid decrease in the overall throughput.
5] Effective Routing Algorithms Based on Node Usage Probability from a Complex Network Perspective	Jiajing Wu, Chi K. Tse, and Francis C. M. Lau	On the basis of node usage probability an effective routing method is proposed in order to balance traffic and avoid overuse of some nodes	Proposed routing effectively improve the overall network performance.	In a low traffic intensity, the proposed routing has the same transmission time as SP routing.

B. Proposed System

In proposed system the problem statement is decomposed into different modules such as node, node character module, routing performance, quality of service.

a). Node

Node is plot as per the position in the simulator, it will be an input for the data collection module which is nothing but our Tcl file script, x-y position value will be directly included in the text file where all the positions for the nodes with their name are allocated.

b). Node character module

Node character module is the one that defines the resource allocation strategy, packet format, message size, network design pattern along with source and destination.

c). Routing Performance

The routing performance module as defined takes into account all the three strategies to check the efficiency of protocol, the Minimum Degree, Shortest Path, Minimum Node Usage algorithms are applied and compared in a graph.

d). The Quality of Service

This is the output file value as out.tr, and it checks the network parameters like Packet drop rate, jitter, packet delivery ratio with thenode degree in the network.

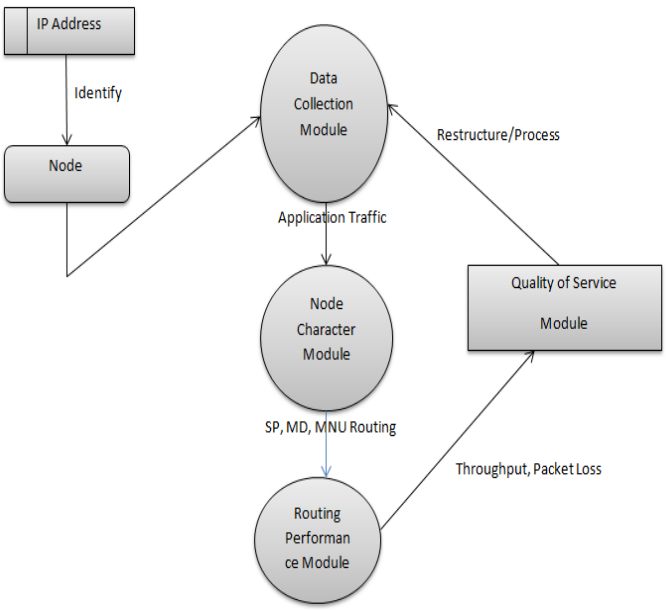

Fig. 1. System Architecture

C. Constraints

- Distributed network size is static
- Packet size, message format (packet structure) must be defined.
- Initialize source and destination.
- Register packet type, protocol with simulatorResource allocation is uniformly defined with buffer allocation and transmission capacity

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D. Mathematical Model

In some heterogeneous networks like the scale-free and Internet, which is an irregular network, nodes tend to have several degrees and. As a result, of which some nodes in the networks are selected as routers with high probability, and the traffic strength of them is high. The concept of betweenness, which is defined as the number of shortest paths between any pair of nodes which goes along a node to characterize the traffic load. By considering different routing algorithms into the node usage probability is calculated as follows:-

a). Node Usage Probability

By the concept of betweenness, Node usage probability of node i is calculated as follows:

$$U(i) = \frac{\sum_{u,w \in V} \sigma_{uw}(i)}{\sum_{j \in V} \sum_{u,w \in V} \sigma_{uw}(j)} \quad \ldots\ldots(1)$$

Where V is set of all nodes in network,

$if\ \sigma_{uw}(i)$ =1 then node I is in between u and w

Else $\sigma_{uw}(i) = 0$

So total number of paths that pass through node I is

$$C(i) = \sum_{u,w \in V} \sigma_{uw}(i)$$

Therefore

$$U(i) = \frac{C(i)}{\sum_{j \epsilon V} C(j)} \quad \ldots\ldots (2)$$

b). Average Transmission Distance

$$\widetilde{D} \approx \sum_{j \in V} C(j)/[N(N-1)] \quad \ldots\ldots (3)$$

Where N is total nodes in the network.

c). Critical Generation Rate

$$\lambda_c = \min_{i \in V} \frac{B(i)R(i)}{\widetilde{D}\, U(i)N(B(i)+R(i))} \quad \ldots\ldots.. (4)$$

B(i) = Buffer size of node i
R(i) = Transmission Capacity of node i
N = is total number of node in network
U(i) = node usage probability of node i

If Buffer and transmission capacity has same for all the nodes then node with highest usage probability can congested first so critical generation rate could be:

$$\lambda_c = \frac{BR}{\widetilde{D} U_{max} N(B+R)} \ldots\ldots (5)$$

So larger the number of paths passes through node I, implies a larger Average distance and probability and smaller critical packet generation rate.

IV. RESULTS AND DISCUSSION

In the proposed method, for minimum node usage, we use a metric called node usage probability; the methodology adopted in the paper takes into account the node usage probability metric, routing scheme along with the operational model. Packet generation, shortest path solution, node usage, and resource allocation are used in the node usage probability technique. Simulation results prove that the method effectively balances the load and minimization of overuse of node. Following graph shows a comparison of the existing and proposed system by average packet drop rate and some nodes used.

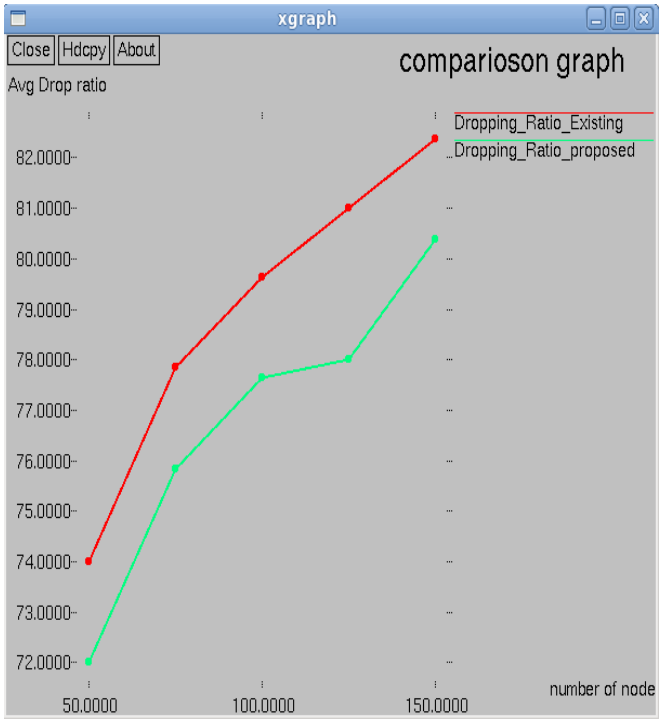

Fig. 2. Comparioson Graph.

V. CONCLUSION AND FUTURE SCOPE

For efficient data transmission, node usage probability must be the key consideration in network design. Since the node usage probability is a metric for distributing the traffic load distribution and how the node is chosen to relay packets in the network. In the network as the number of nodes increase the network packet drop ratio increases, so there is a need to minimize it by using a technique called clustering and transfer the packets to only those nodes which are active in nature to minimize packet drop in the network.

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