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Node Skiping Routing

Koj Sambyo[1], Anish Kumar Saha[2] and C.T. Bhunia[3]

Department of Computer Science and Engineering, National Institute of Technology, Arunachal Pradesh-791112, India
[1]sambyo.koj@gmail.com, [2]anishkumarsaha@gmail.com, [3]ctbhunia@vsnl.com

Abstract

Path is establish prior to transmission of information from source to destination. Along the established path, packets encounter queuing delay and processing delay in all the nodes through which the packet travels to reach destination. Moreover nodes implement variety of other function like firewall and classification of the packet. Thus every node adds nodal delay in end to end delay. In this paper we proposed to skip node from established path using the broadcast nature of wireless that will reduce nodal delay. Proposed scheme uses skip graph for the skipping of the nodes in the established path. The study shows there is significant reduction in end to end delay in the proposed scheme compared to traditional method. Paths from source to destination are also more stable, particularly when large number of nodes are present in established path.

Keywords: *Node, Skip graph, Skip list, Queuing Delay, Processing Delay, Little's theorem, Latency, Delay*

1. Introduction

Routing algorithm uses flooding method to find path from source to destination in the wireless network [1, 2, and 3]. The path is established prior to transmit of the packets by computing various accepted network method such as network traffic, load balancing, least numbers of nodes *etc*. Once the path has been established then packets are sent from source to destination. It is well known that path can be modified on account of traffic load or movement of the sender or destination or of the nodes but still in this case the path discovery has to be made through flooding process and from that established path the packets are to be transmitted. Even with the change of the network the packets are transmitted through dedicated establish path that was established prior to transmission of the packet.

Proposed scheme use traditional method for establishing the path from source to destination in the initial stage and maintain skip graph while transferring packet from source to destination and when the network traffic changes it will try to skip some of the nodes from the established path by using the broad cast property of the network so that the nodal delay is reduced. It also avoids unnecessary flooding of the packets for establishing the new path when the nodes are already present in the skip graph.

End to end delay depends on number of nodes in the established path [4]. By skipping a few nodes in the path, nodal delay of the skipped nodes are reduced thus reducing the end to end delay of transmission. In Section 2 we provide motivational and background of the proposed scheme. Section 3 gives the algorithm, Section 4 shows simulation and result we have concluded in Section 5.

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2. Motivation and Background

2.1 Skip Graph

Skip graph [5, 6, 7, 8, 9], introduced by Aspnes and Shah is structured overlay distributed data structure that is based on skip list[10], which support the functionality of randomized balanced tree and organized as a tower of increasingly refined link list in various level. Each node in Skip Graph consists of key and membership vector. Let m(x) represent membership vector of node x. Let Σ denotes a finite alphabet and *w* denotes the word from Σ. Let |*w* | be the length of word *w*. Membership vector is denoted by the words. Eg. 01, 10, 11 … are words that represent membership vector and every link list in skip graph is given some word 'w'.

Skip Graph consist of multiple levels, nodes are grouped into increasingly smaller sorted doubly link lists within each successively higher level. At level 0, all peers belong to one list. At level 1, nodes are separated into n sorted double link lists. Similarly, all nodes of level i are separated into 'm' list. The word 'w' that represent membership vector determines which lists the nodes belongs to at each level. Depending on the number of prefix match in *w*, nodes are list i.e. in level 0 number of prefix match could be zero, in level 1 number of prefix match is 1 and in level 2 number of prefix match is 2 and so on. Nodes are ordered in a circular doubly linked list so that node i is connected to $i - 1 \bmod n$ and $i + 1 \bmod n$.

Two node *l* and *m* belong to the same list at level i if and only if words of m(p) and m(q) have the identical prefix of length i.

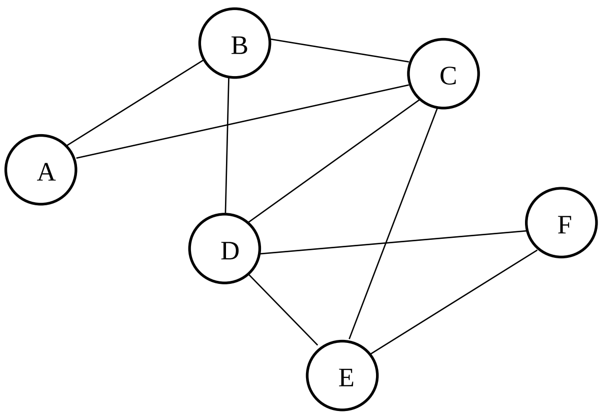

Figure 1. Nodes to be Travers from Node A to Node F

The skip graph of the Figure 1 is given by:

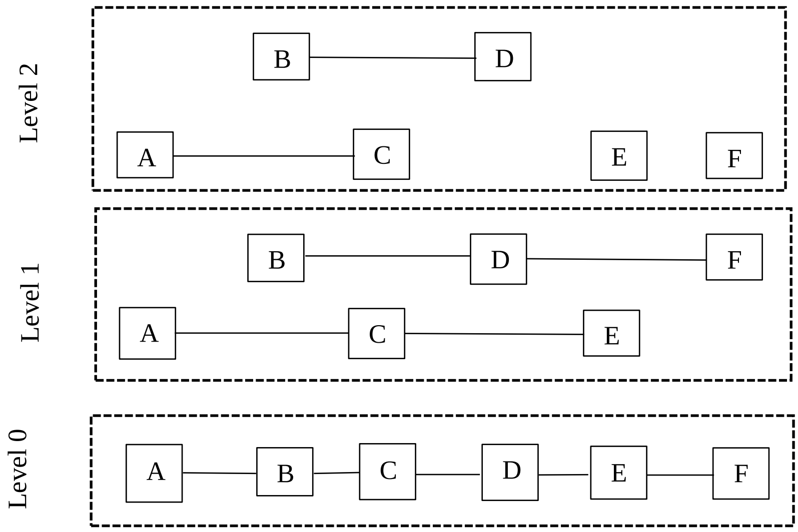

Figure 2. Skip Graph of Figure 1

Number of levels in skip graph is log(n).

2.2 Queueing Delay

If arrival rate of packet exceed transmission rate of the link for a period of time then packet will wait in queue for its turn for the processing and transmission to other link. The delay that encounter in queue is queuing delay. The time in the queue depends on the number of packets ahead and the rate they are removed from the queue.

Little's theorem provides relation between the average numbers of packets in the system, the arrival rate and average delay given by:

$$N = \lambda T$$

Where λ is the average packet arrival

$$\lambda = \text{total packet arrived / total time}$$

Let C denotes the transmission capacity, μ be the service rate and L denotes the header length in bits then

$$\mu = C/L$$

The system utilization which arrival rate over service rate is given by

$$\rho = \lambda/\mu$$

We consider The M/M/1 queuing system where rate of arrival of packets is λ and it arrives in Poisson process and the service time is exponential with 1/μ (service rate μ) [11, 12]. Let p_i denote the probability that there are *i* numbers of packets in the queue. We have

$$p_i\lambda = p_{i+1}\mu \quad \text{for } i = 0,1, 2,..$$

$$p_{i-1}\lambda = p_i\mu$$

$$\text{but } \rho = \lambda/\mu,$$

$$p_i = \rho p_{i-1} = \rho^i p_0$$

since $\sum_{i=0}^{\infty} p_i = 1$, therefore

$$1 = \sum_{i=0}^{\infty} p_i = \sum_{i=0}^{\infty} \rho^i p^0 = \frac{p^0}{1-\rho}$$

The average number N of packets in the system is

$$N = \sum_{i=0}^{\infty} ip_i = \sum_{i=0}^{\infty} i\rho^i(1-\rho)\frac{\rho}{1-\rho} = \frac{\lambda}{\mu-\lambda}$$

The average delay T of a packet in the system is from Little's theorem

$$T = \frac{N}{\lambda} = \frac{\rho}{\lambda(1-\rho)} = \frac{1}{(\mu-\lambda)}$$

Packets have to wait in the queue:

$$T - \frac{1}{\mu} = \frac{1}{(\mu-\lambda)} - \frac{1}{\mu} = \frac{\rho}{(\mu-\lambda)}$$

Where processing time of the packets = $\frac{1}{\mu}$.

2.3 Processing Delay

Packet header has to be processed in the node to route the packet from source to destination. During processing, node may check for bit-level errors in the packet that might have occurred during transmission and determine the packet's next destination. This is done through reading the content of the header. Time taken to read the header depends on the hardware composition of the node. Let α be the time to read the header.

$$PD = \alpha * sizeof\_header$$

3. Proposed Scheme

In conventional method, path is selected by some method either through reactive or proactive process and packets are to be transfer from established path. Proposed scheme construct a skip graph from any preferred algorithm to find the route from source to destination and try to skip the route so that the nodal delay of the node is eliminated and end to end delay is reduced.

Algorithm:

1. Use any preferred algorithm to find path from source to destination. Most algorithms consider the traffic flow and congestion of the path. Let us consider that the algorithm has selected nodes A, B, C, D, E and F of Figure 1.
2. Make the skip graph of the path as shown in the Figure 2 by checking the connectivity of the nodes in the path. It becomes the lowest level. (Broadcasting to nearby nodes).
3. Skip the nodes when new shorter path are available and has connectivity (by using broad cast property of wireless network). As in example if connectivity between node A and C is establish then skip node B. similarly skip node D when connectivity between node C and node E is establish thus going up in next higher level. Thus in level 1 the path for the packets can be node A, C, E and F. (if nodes are not found in that level go to lower level and then move right.)
4. If skipped node transmit the duplicate copy, then discard the packet and inform the node that it has been skipped. In node A, B and C if packets comes from node A and C then discard the packets from B and inform node B that it is skipped.
5. To search the nodes from source to destination, start from highest level, if connectivity is not available down to lower level and move right until the destination is reached.

4. Simulation and Result

Probability of at least one error on a given path of length r is given by

$$= 1 - (1 - p)^r . \quad \text{I}$$

Similarly for the skip node, probability of at least one error on a given path of length is given by:

$$= 1 - (1 - p)^{2 \log n} \quad \text{II}$$

The number of node visited in skip node is 2log n.

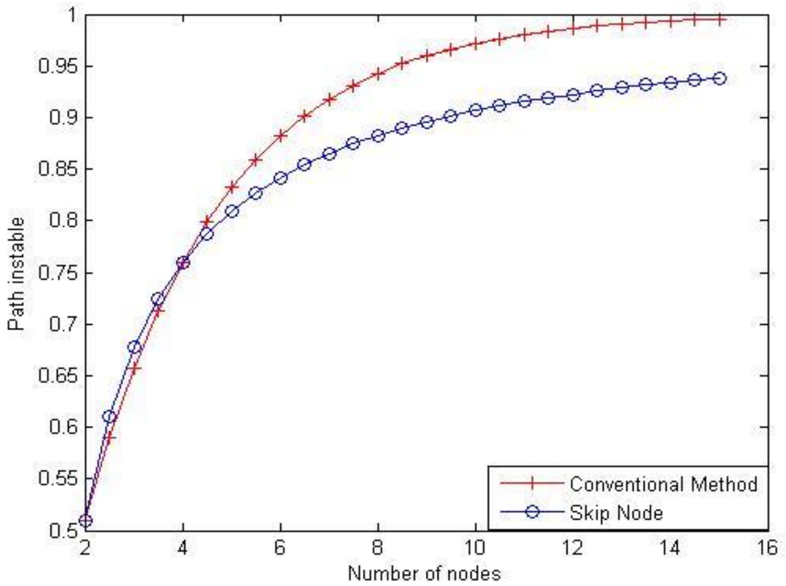

Figure 3. Path Instability of Skip Node and Traditional Method

Run of equation I and II is shown in Figure 4. It shows the facts that when the number of nodes are less the probability of path being instable is more in skip node but as the number of nodes increases the instability increases for conventional method because the probability of node being disconnected increases as the number of nodes increases.

Skip node uses skip graph for skipping the nodes and it uses number of levels for skipping the nodes as the number of level increases number of nodes will decreases. Let us consider skip graph consist of two links, L2 contains the entire node in established path (n) and L1 contains some nodes (some nodes are skipped).

Then cost for search as per search algorithm of the skip graph will be

$$|L1| + \frac{|L0|}{|L1|} = |L1| + \frac{n}{|L1|}$$

Minimized when

$$|L1| = \frac{n}{|L1|}$$

$$|L1|^2 = n$$

$$|L1| = \sqrt{n}$$

That is search cost for two links = $2\sqrt{n}$

Generalizing,

3 levels will cost = $3\sqrt[3]{n}$

k levels will cost = $k\sqrt[k]{n}$

since number of level in skip graph is log n

Number of nodes visited from source to destination is given by

$$= \log n \sqrt[\log n]{n}$$

$$= \log n * n^{1/\log n}$$

$$= \log n * 2^{\log n / \log n}$$

$$= 2 \log n$$

Let us consider the nodal delay in each node is nd. In a traditional method the end to end delay because of nodal delay is given by

$$= No\_of\_nodes * nd \qquad \text{III}$$

We are ignoring transmission delay and propagation delay in the network.

Similarly end to end delay in skip nodes is given by

$$= 2 * \log(n) * nd \qquad \text{IV}$$

Run of equation III & IV is given in Figure 4. It shows that when the number of nodes are less the end to end delay is same as that of traditional method as it is understood that in less number of nodes the nodes to skip is negligible but as the number of nodes increases there is higher probability of skipping the nodes in the established path and as the number of skip nodes increases the nodal delay of the skipped nodes are eliminated thus the end to end delay is reduced.

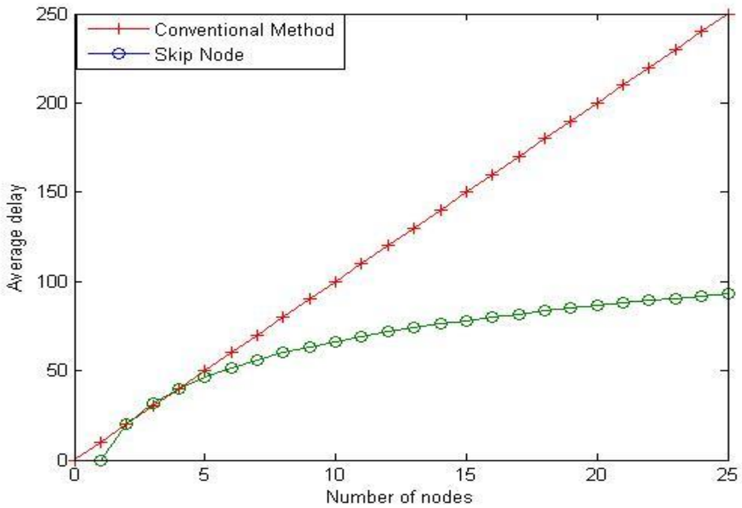

Figure 4. End to End Delay of Skip Node and Traditional Method

5. Conclusion

This paper proposed skip node routing in which node skipping is done using skip graph for reduction of end to end delay. For node skipping, broadcast nature of the wireless has been used and selected path (consisting of selected node) goes to higher level. Study shows that skip nodes path are more stable and also there is significant decrease in end to end delay.

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Authors

Koj Sambyo received his M.Tech in Computer Science & Engineering in 2011 from Rajiv Gandhi University, Arunachal Pradesh, India. He is working as Assistant Professor in the department of Computer Science & Engineering in National Institute of Technology, Arunachal Pradesh. His research interests are Cloud Computing, Software Defined Networking.

Anish Kumar Saha received his M.Tech in Computer Science & Engineering in 2011 from Tripura University, India. He is working as Assistant Professor in the department of Computer Science & Engineering in National Institute of Technology, Arunachal Pradesh. His research interests are Green Computing, Software Defined Networking, and Computer Algorithms.

Chandan Tilak Bhunia did his B. Tech. in Radiophysics and Electronics in 1983 from Calcutta University. He received his M. Tech. in Radiophysics and Electronics in 1985 and then joined North Bengal University as a lecturer of Computer Science & Applications in 1988. He became Assistant Professor of ECE at NERIST, Govt. of India in 1990. He got P.hD. in Computer Science & Engineering from Jadavpur University. He became a full Professor in 1997 at NERIST. Currently, he is working as a Director of National Institute of Technology, Arunachal Pradesh. He has published around 150 research papers in various national and international journals of repute. Under his supervision, five Ph.D. scholars got awarded and nine scholars are currently working in various fields.