LOAD BALANCING OF ADAPTIVE ZONE ROUTING IN AD HOC NETWORKS

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ABSTRACT

A load-balancing scheme has a significant effect on the performance of the adaptive zone routing protocol, especially in an ad hoc network environment. In order to analyze the effect on the distribution of input traffic among global paths in AZRP (Adaptive Zone Routing Protocol), the routing process is evaluated in terms of two additional local history tables to be maintained in each node: One for the forward error-control (FEC) code rate and a second one for the required information rate with the neighboring nodes. Then the local routing process can then be simplified by creating an efficient load balancing rule. We then considered the load balancing as an optimization problem by using congestion parameter (CP). The solution to the optimization problem is interestingly in accordance to CP. Our simulation results show that AZRP with load balancing (B-AZRP) is so effective that the number of throughputs is increased significantly while the network resource can be utilized more efficiently than that in AZRP (Adaptive Zone Routing Protocol).

We propose a load balancing for hybrid routing protocol as its name indicates: B-AZRP as an extended from Adaptive Zone Routing Protocol (ZRP) in [1, 2, and 3].

1. INTRODUCTION

In zone routing, each node has its own zone. Intrazone routing (e.g., DSDV and DBF) maintains communication path within the zone, while Interzone routing determines routes to the destination using flooding technique. In [4, 5], techniques called "min-searching" and "traffic adaptive" have been proposed. The techniques allow individual nodes to identify changes in the network, and appropriately react to the changes in the network's configuration. The modifications are conducted by either increment or decrement the number of hops used by each node. Note that the number of hop for a particular node will be increased (or decreased) in all directions depending on the traffic between interzone and intrazone routing (see Figure 1)

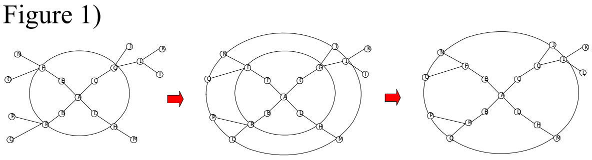

Fig 1.Changes of zone radius in all direction

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This introduces changes in routing table for intrazone routing. When that network traffic in a zone only occurs in a particular direction, changes in the zone radius for all directions can seriously increase the size of the routing table even though the traffic in other direction is not significant.

The technique for adaptively resizing the zone radius by using statistical model and concentrating the changes of network traffic in a particular direction depending on the interzone traffic by periodically monitor the interzone network traffic, the direction that generates high interzone traffic can be determined. Further, changing number of hops can also be implemented only for that particular direction. An example of this technique is demonstrated in figure 2.

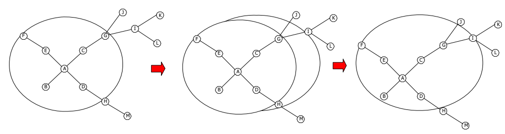

Fig 2: Changes of zone radius in a particular direction

Changing in radius only in a particular direction, which has heavily loaded traffic, can significantly reduce the size of the routing table. Therefore, maintaining small routing table for individual zones is much simpler. Moreover, the amount of control traffic particularly used to update the routing table will also be decreased since the number of nodes after changing zone radius is relatively small comparing to ZRP technique [4, 5]. However, AZRP is based on single path routing, which can not be utilized resources when congestion occurs and link breakage. Therefore, using load balancing technique by distributing traffic among a set of diverse paths, these benefits make multipath routing a good candidate for mobile bandwidth-limited ad hoc networks.

2. LOAD BALANCING TECHNIQUE

The objective of the load balancing is created the fairness in sharing the transmission channel. The result shows that it has more than one node that can be used for routing at the same time. Although it has a different routing performance, all of ad hoc nodes can be used for packet forwarding. Load balance techniques have an advantage for such condition. The advantage of the load balancing technique can be the following; Increase the routing performance because the data (normalized) will separate into a proper size and send data with it multiple routes at the same time, and also prevent the bottleneck and network time out.

In a load balancing technique, the quantities of data that needs to be sent in time interval will be compared with the available transmission capability. If the size of the transmission capability is greater than a size of the data then all the data will be sent at the same time. But the problem is when the available transmission capability is less than the size of the data; the load balancing technique will be used in this case.

In figure 3, we introduce two types of routing protocol. The first one is Global Path Routing which is a pair of source nodes and destinations nodes from AZRP. And the second is Local Path Routing for use in load balancing within a corridor which is a virtual part that is used to simulate the route selection from source to destination.

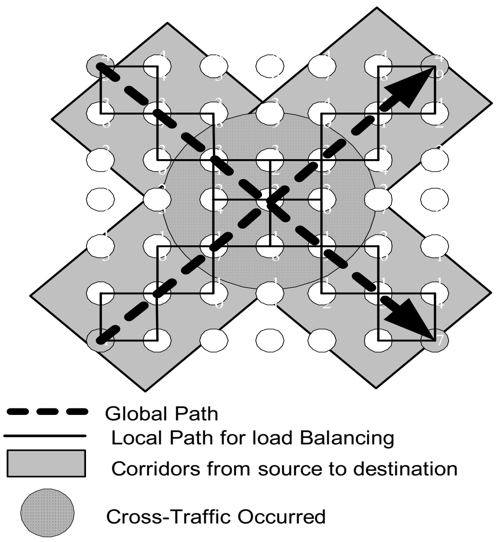

Fig 3: Load Balancing Adaptive Zone Routing Protocol

How to distribute the traffic over several paths is a key issue in multipath routing [3], and it has a significant effect on the performance of the routing. In [4], a heuristic equation was proposed to balance the traffic load based on an intuitive assumption. But their analysis did not consider cross-traffic when solving the load balancing problem. Unfortunately, bandwidth utilization is very sensitive to cross-traffic in ad hoc network. Therefore, in this paper, we have built an analytical model that would consider cross-traffic in order to explain the load balancing problem in theory

3. NORMALIZED QUANTITIES

The unit term used for simulation is defined as normalized measuring units. The term normalize is used for the interested critical factor for simulation as a network area, a buffer size and a transmission rate. The following section explains the details of each quantity.

- Normalized network area

We limit ourselves to a simple model in the geometry of two dimensions R^2 in Figure [4]. We select a rectangular area *A* as in figure 4 for possible positions of mobile nodes. Within this area *N* nodes are located. The nodes are numbered N_0 *to* *N(N-1)* .The transmission range(*Tx/Rx*) is indicated as a circle with radius *r*. With the parameters give in the figure, the areas are calculated as follows: $A = \pi r2$ and $A = xsize \cdot\cdot ysize$.

Edge effects, such as shading (by obstacles), Reflection (at big surfaces), dispersion (at small surfaces) and diffraction (at sharp edges), are neglected and only the free-space loss is taken into account. This model, as also used in [6], enforces a simple digital decision:

- If the distance d between two nodes is smaller than the transmission radius r, communication is possible.
- No transmitting can take place outside the transmission range.

We neglect mobility and uniformly distribute nodes with digital transmitting characteristics within the area A. The positions $P_a = (x_a, y_a$ and P_b of two arbitrary nodes N_a and N_b are uncorrelated and independent of each other.
The normalized area is the ratio of the total area divided by the number of nodes

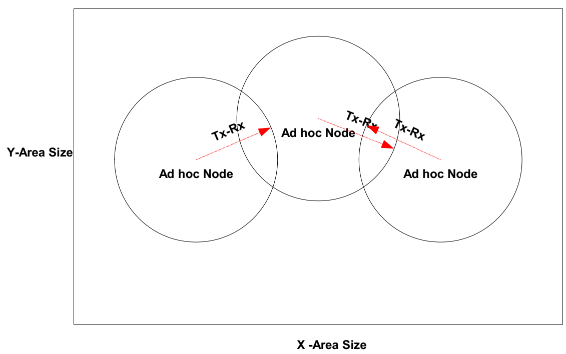

Figure 4: The normalized area

Normalized Area = Total Area / Nodes

- Normalized data (*D*)

Normalized data determines the statistical code rate in a normalized form. The normalized data is the ratio of the information rate divided by the critical transmission rate. The useful term for the normalized data for the simulation is represented by the code rate.

- Normalized buffer size

The normalized buffer size determines the size of the buffer in terms of transmission units. A transmission unit corresponds to the critical transmission rate. The buffer size used in the simulation uses several first-in-first-out shift registers according to the number of destinations stored in the node and as such is an important part for the load balancing technique.

- Normalized Transmission capabilities *(D)*

The transmission capability with the neighboring node is a numerical consideration on a normalized quantity that is used to determine the data transmission rate in the simulation.

The following is the procedure used for the load balancing technique.

Procedure for Load balancing Techniques

Select the nodes that obtain the statistical code rates and the congestion parameter *(CP)* mean values within the range of a standard deviation around the total mean values then calculate the total size of the normalized data in a buffer for each link using the formula as

$$\textit{Total data in a buffer of each node is } \sum_{j=1}^{Distination} D_{(j)}$$

Validate the size of a normalized data with the available transmission capability. If the size of the data is less than the available transmission capability then all the normalized data in a buffer has been send. But if the size of the normalized data in a buffer exceeded the available transmission capability then perform a load balance technique as shown in Figure 5. The remaining data (*D*) are kept in a buffer waiting to send in a next time interval.

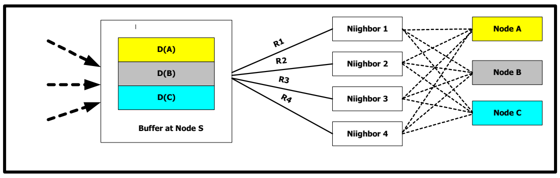

Figure 5: Buffer of Node S for load balance

Normalize data calculated by $\sum_{j=1}^{Destination} D(j)$

$D_{(A,B,C)}$ = normalize data of node *A,B,C* in buffer *S*

R_i = normalize statistical code rate

Data of Each like calculated by =

$$\sum_{i=1}^{Link} D_{(i)} = \sum_{i=1}^{Link} (D_{(i)} / \sum_{j=1}^{Distination} D_{(j)}) \times r_{(i)} \qquad (1)$$

Assume that all data can be sent in time interval.

$$\sum_{i=1}^{Neighbors} D_{(i)} \leq \sum_{j=1}^{Destinatio\,n} D_{(j)} \qquad (2)$$

In the cases that the size of the data is greater than the transmission capabilities

$$\sum_{i=1}^{Neighbors} D_{(i)} > \sum_{j=1}^{Destinatio\,n} D_{(j)} \qquad (3)$$

The remaining data in a buffer will be calculated as

$$D_{(i)} - D_{(i)} / \sum_{j=1}^{Destination} D_{(j)} \qquad (4)$$

The congestion parameter (CP) cross-traffic between all sources and all destinations is calculate as

$$CP = \frac{\frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{d_i} P_{ij}}{\frac{1}{L}\sum_{i=1}^{N}\sum_{j=1}^{U_i} R_{ij}} \qquad (5)$$

P_{ij} *= the total number of Packets.*
R_{ij} *= the total number of Link.*
Thus mean value of packet to be generated is

$$\overline{P} = \frac{1}{N}\sum_{i=1}^{dist} P_i \qquad (6)$$

And also mean value of link connectivity is

$$\overline{\Gamma} = \frac{1}{L}\sum_{i=1}^{\mu} \Gamma_i \qquad (7)$$

Therefore $CP \leq 1$ and $\overline{P} \leq \overline{\Gamma}$

4. SIMULATION MODEL

We conducted network simulator written in C++ Language that allowed us to observe and measure the protocol's performance under a variety of conditions. The model is similar to that in [7]. Node can communicate only within code rate (Foreword Error Coding) which is not based on coverage area. The experiments use different number of sources with a moderate packet rate and changing pause times.

This simulation is based on the statistical models that are used with normalized quantities. The simulation investigated a performance on one round of packets sent from source to destination. Node mobility was no issue as a priority in this simulation, due to the simulation time is only a few seconds, assuming that the node is not updating their location. The useful criteria for the simulation are the normalized network area, the normalized buffer size and the normalized transmission rate.

Scenario 1: Fixed buffer size and vary the number of node and CP

1. Setting up the simulation configuration as follow:

*Buffer size = 50, Normalized area 1000 (X size, Y size) = 56.04, Radius for a node (rd) = 1.0, Traffic Generate = Square Root of number of nod*e, Average the number of neighbors node of each node = 7.35

2. Running the software simulation with the different number of nodes such as 9, 16, 25, 36, 49, 64, 81, 100, 144, 256, 625 and 900 nodes and CP from 0 to 10. Then compare the throughput of the simulation that include and exclude load balancing models in AZRP.

Scenario 2: Fixed CP and varied the number of node and buffer size

1. Setting up the simulation configuration as follow:

Fixed *CP* = 0.5, Normalized area 1000*(Xsize, Ysize)* = 56.04, Radius for a node *(rd)* = 1.0, Traffic Generate= Square root of number of Node, Average the number of neighbors node of each node = 7.35

2. Running the software simulation with the different number of nodes from 9, 16, 25, 36, 49, 64, 81, 100, 144, 256, 625 and 900 nodes and buffer sizes from 0 to 50.

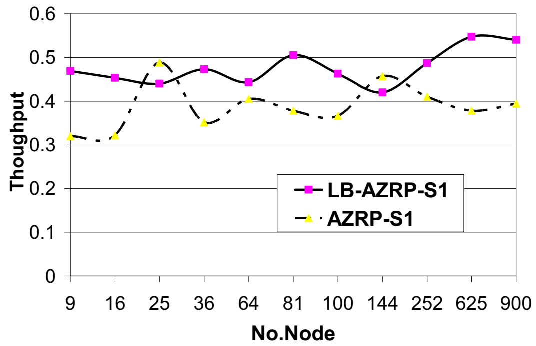

FIG 6: Throughputs of AZRP and B-AZRP (Scene 1)

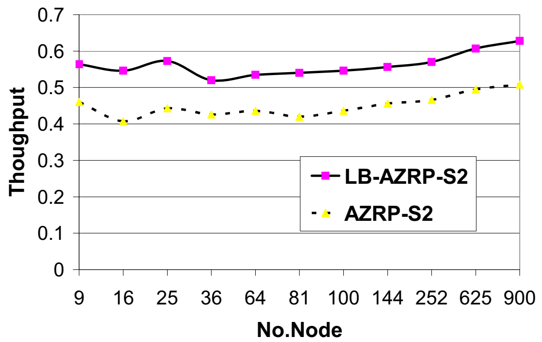

FIG 7: Throughputs of AZRP and B-AZRP (Scene 2)

As the result in fig [6,7], it shows the throughput of each protocol in packet delivery fraction. Packet delivery ratio is obtained by dividing the number of data packets correctly received by the destinations by the number of data packets originated by the sources. We can observe from the results both of scenarios outperform AZRP, especially when the number of node increases. In AZRP, only one route is used for each session and when the route is invalidated, the source is reroute again. If no such route is available, it sends a route request (RREQ) to discover a new route. In B-AZRP can provide not only the alternate path to reach to destination but also can share traffic by sent in different route to reach the intermediate node of global path which is can help AZRP to get high throughput and also share the load utilize However, This technique is base on statistical. Thus, it can not provide the best optimal path. It is depend on local history tables of each node to calculate local CP as we can see the result is not always get the highest throughput in Fig [6] but B-AZRP can improve overall throughput AZRP more than 20 percent.

5. CONCLUSION

The load balancing is afforded to create the fairness in sharing the transmission channel. The result shows that it has more than one node that can be used for routing at the same time. Although it has a different routing performance, all of them can be used for packet forwarding. Load balancing techniques have an advantage for such conditions. The advantage of the load balance technique can be the following; Increase the routing performance because the data (normalized) will separate into a proper size can be sent with multiple routes at the same time. Also it can prevent the bottleneck and network time out. This technique is afforded to create the fairness in sharing the transmission channel. The result shows that it has more than one node that can be used for routing at the same time. Although it has a different routing performance, all of them can be used for packet forwarding. The advantage of the load balance technique can be the following; Increase the routing performance because the data (normalized) will separate into a proper size and send with multiple routes at the same time. Prevent the bottleneck and network time out.

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7. REFERENCES

[1] Tawan thongpook and Thanachai Thumthawatworn "Adaptive Zone Routing Protocol for Ad hoc Networks" In Proceedings of the ITC-CSCC 2002 Conference, Thailand pp. 1839-1842, July 2002.

[2] Tawan Thongpook, "Adaptive Zone Routing Protocol for Wireless Ad hoc Network by Using Neurofuzzy", in Proceedings of the SEAL'02 Conference, Singapore, vol. 2, pp. 537-540, Nov 2002.

[3] Tawan Thongpook, "Adaptive Zone Routing Protocol for Wireless Ad hoc Network by Using Fuzzy-Rule Base", in Proceedings of the FSKD'02 Conference, Singapore, vol. 1, pp. 314-317, Nov 2002.

[4] Z.J. Haas and M.R. Pearlman, "The Performance of Query Control Schemes for the Zone Routing Protocol," ACM/IEEE Transactions on Networking, vol. 9, no. 4, pp. 427-438, August 2001.

[5] M.R. Pearlman and Z.J. Haas, ``Determining the Optimal Configuration for the Zone Routing Protocol," IEEE Journal on Selected Areas in Communications, Vol. 17, No. 8, August 1999, pages 1395-1414.

[6] Z.J. Haas and M.R. Pearlman, "The Zone Routing Protocol (ZRP) for Ad Hoc Networks," Internet Draft, draft-ietf-manet-zone-zrp-02.txt, June 1999

[7] C. E. Perkins and E. M. Royer, "Ad hoc on-demand distance vector routing," in Proc. IEEE WMCSA'99, vol. 3, New Orleans, LA, pp. 90-100.

[8] P.Gupta, "Design and Performance Analysis of Wireless Networks", PhD thesis, Coordinated Science Laboratory, University of Illinois, 2000.

[9] The CMU Monarch Project. "The CMU Monarch Projects Wireless and Mobility Extensions to ns" URL: http://www.monarch. cs.cmu.edu/. (1998-11-29)