A Gateway Selections Using Signal Strength among Clusters in Ad Hoc Networks

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Abstract. Packet transmitting among the clusterheads in a cluster based wireless ad hoc networks are carried out through gateway nodes, while nodes in a cluster are communicate through the head node. Existence of multiple gateways between the clusterheads means multiple path existence. Multiple transmissions of packet though redundancy paths may not desire for efficient resource usage. Therefore, communications between clusterheads through the most stable gateway is a fascinate solution. In this paper, we propose gateway selection methods to support a stable path connection. The characteristics of proposed methods are defined.

Keywords: Stable gateway node, Beacon, Gateway routing, Clustered ad hoc networks

1 Introduction

An ad hoc network doesn't depend on any preexisting communication infrastructure, such as fixed base stations and the connecting backbone network[1-2]. Clustering is a concept of dividing the geographical region into small wireless zones[3-12]. A clustered ad hoc network consist of three kinds of nodes: clusterheads, gateways, and ordinary nodes. Clusterheads are nodes that are vested with the responsibility for routing and channel access within clusters. The communications between two adjacent clusters are conducted the gateway nodes, because each clusterhead isn't located within direct transmission range. In existence of multiple gateways between the clusterheads, multiple transmissions of packets though redundancy paths may happen[4-5]. If we choose a node which will perform as a gateway for long and safely, we can make a stable connection among clusters. In choosing the most stable gateway, the possible period is also important. Some factors like the position of the gateway, the remained battery capacity of the node, the mobility of the node, and the efficient routing possibility can be used. In this paper, we propose two kinds of the selection methods for the most stable gateway by the node positions of the candidate gateway nodes for long run.

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2 Routing in Clustered Ad hoc networks

The CGSR(Clusterhead Gateway Switch Routing)[4] is a protocol to control routing information in the clustered ad hoc networks. A packet is transmitted to the neighbor clusterhead through the clusterhead. Because each clusterhead doesn't exist in the direct transmission range the packet is transmitted through the gateways that exist inside the communication range of the two clusterheads. Therefore, the path of a packet is composed of the clusterheads and the gateways. If there are more than two candidate gateway nodes, packet flooding through all the gateway nodes may meet waste of resources. Therefore, we choose a node which will perform its role as the most stable gateway between the two clusterheads.

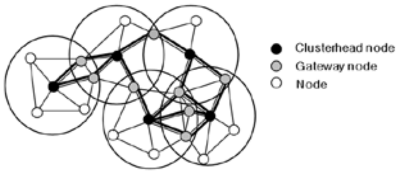
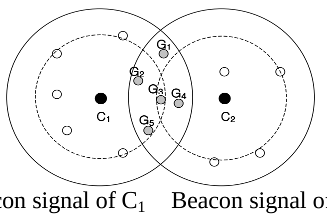


Fig. 1. Routes of clustered Ad hoc network

3 Proposed gateway selection methods

These methods use beacon signal strength from nodes for selecting the most stable positioned node. Each node broadcasts its own beacon signals periodically to let know its existence. Beacon signal strength(BSS) can be assumed in reciprocal proportion to the squared distance(d^{-2}) in the free space propagation model. Therefore, it means that a node is located in the nearest position from the both clusterheads if it receives beacon signal of strong strength from the both clusterheads. In this case, we can assume the node is placed in the stable position between the both clusterheads. In the fig. 2, G_1 has weak beacon signals from the both clusterheads. G_2 has the strong beacon signal from the clusterhead C_1 but weak beacon signal from the clusterhead C_2. G_3 has the most strong beacon signals from the clusterheads (C_1, C_2) and is located in the most stable place from the both clusterheads. The most stable node in all the candidate gateway nodes receives the strong signal from the both clusterheads. To select the most stable gateway node, we have to find out the node which has the stongest beacon signal from the both clusterheads.



Beacon signal of C_1 Beacon signal of C_2

Fig. 2. An example of selection of the most stable gateway node

3.1 Gateway selection using linearly increasing threshold

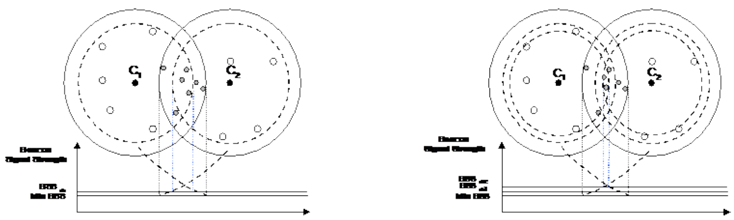
To select a stable gateway node, we assume that candidate gateway nodes receive signals from more than two cluterheads, then they broadcast their own beacon signals which include information the beacon signal strength from each clusterhead(the signal received from the clusterhead C_1 is BSS_1, the signal received from the clusterhead C2is BSS_2) to clusterheads. Then, the clusterhead C_1 checks if BSS_1 and BSS_2 of each candidate gateway node exceed a BSS threshold(BSS_{th}) and selects the proper nodes as candidate gateway nodes. BSS_{th} is presented by adding the minimum signal strength and a value of increasing rate α,

$$BSS_{th} = \text{Min BSS} + \alpha. \quad (1)$$

Where, Min BSS is the minimum signal strength which can begin communications between noes.

Clusterheads continue n-steps gateway selection process by increasing threshold linearly until selecting just one gateway. The value of threshold in n-steps gateway selections is presented by

$$BSS_{th} = \text{Min BSS} + (n \times \alpha). \quad (2)$$



(a) A threshold (b) Increasing threshold

Fig. 3. Gateway selection using threshold

Proposed gateway selection algorithm is as follows :

0. Initiate BSS_{th} value (BSS_{th} = Min BSS)
1. Check if $BSS_{i1} \geq BSS_{th}$ and $BSS_{i2} \geq BSS_{th}$ (for each candidate gateway node i = 1,2, …, m) and select nodes satisfying the conditions.
2. Check one of the following conditions.
   ① Finish the algorithm when the number of selected candidate gateway nodes is only one.
   ② Go step 3 when the number of selected candidate gateway nodes is more than two.
   ③ Go step 4 when there is no selected candidate gateway node.
3. Go step 1 after $BSS_{th} = BSS_{th} + n\alpha$ **,** where n is the number of iteration.
4. For all selected nodes in the previous step, select a node satisfying following condition and finish the algorithm.

$$MAX \left\{ \; x \mid x \in \frac{BSS_{i1} + BSS_{i2}}{2}, \quad i = 1,2,\cdots,m \; \right\}.$$

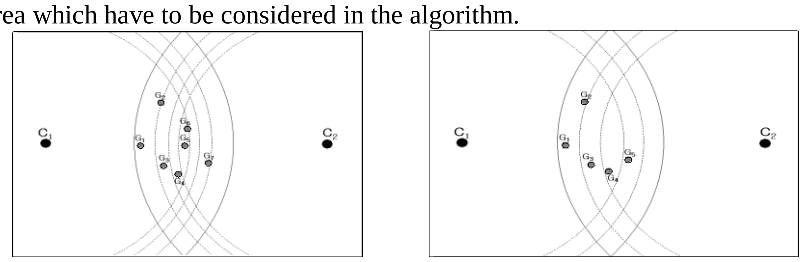
3.2 Selection by exponentially increasing threshold

A received beacon signal strength can be assumed in reciprocal of proportion(d^{-2}) to the squared distance in the free space propagation model. The received signal strength decreases exponentially as the distance between a clusterhead and a gateway node increases. Therefore, we applied a gateway selection algorithm uses BSS threshold increasing exponentially based on the signal-distance characteristics. BSS_{th} is presented by (3)

$$BSS_{th} = \text{Min BSS} + (n^2 \times \alpha). \qquad (3)$$

4 Comparison two methods

To compare the efficiency of proposed gateway selection methods in various node patterns, following experiment are practiced. As the threshold increases linearly, the size of area decreases with an exponential rate as shown in fig. 4(a). In this case, G_5 is selected. Fig. 4(b) is an example of selecting a node by exponentially increasing threshold. As the threshold increases exponentially, the size of area decreases with a constant rate. We can find out some trade-off is exist in these two thresholds. The linearly increasing threshold provide precise gateway selection possibility by continuing process. The exponentially increasing threshold predict fast contraction of the area which have to be considered in the algorithm.



(a) Linearly increasing threshold (b) Exponentially increasing threshold

Fig. 4. Examples of the proposed gateway selection

5 Conclusions

A a node placed in stable position has low probability of path breaking between clusterheads. The proposed gateway selection methods for deciding a stable gateway can reduce resource waste compared to data flooding through multiple gateways between the clusterheads. For a future work, the proposed methods could be compared their performance by selecting the most stable gateway in computer simulations.

References

1. D. J. Baker, J. Wieselthier, and A. Ephremides, "A distributed algorithm for scheduling the activation of links in a self-organizing, mobile, radio network", in Proc. IEEE Int. Conf. Communications, pp. 2F.6.1-2F.6.4, (1982)

2. J. Baker, "Distributed control of broadcast radio networks with changing topologies", in Proc. IEEE Infocom, San Diego, CA, pp. 49-55, (1983)
3. Joa-Ng and I. T. Lu, “A Peer-to-Peer Zone-based Two-level Link Status Routing for Mobile Ad hoc Networks”, IEEE Journal on Selected Areas in Communications, pp.1415-1425, (1999)
4. M. Jiang, J. Li, and Y. C. Tay, "Cluster based routing Protocol(CBRP) function specification", IETF Internet, (1998)
5. A. Bruce McDonald, Taieb F. Znati, "A Mobility-Based Framework for Adaptive Clustering in Wireless Ad hoc Networks", IEEE JOURNAL ON SELECTED AREA IN COMMUNICATIONS, VOL. 17, NO. 8, (1999)
6. Ting-Chao Hou and Tzu-Jane Tsai, "An Access-Based Clustering Protocol for Multihop Wireless Ad hoc Networks", IEEE JOURNAL ON SELECTED AREA IN COMMUNICATIONS, VOL. 19, NO. 7, (2001)
7. Ching-Chuan Chiang, Haiao-Kuang Wu, Winston Liu, Mario Gerla, "Routing in Clustered Multihop, Mobile Wireless Networks with Fading Channel", Proceedings of IEEE Singapore International Conference on Networks (SICON'97), (1997)
8. Taek Jin Kwon, Mario Gerla, "Efficient Flooding with Passive Clustering in Ad hoc Networks", Computer Communication Review ,V.32 N.1, (2002)
9. M. Gerla and J. T. Tsai, "Multicluster, mobile, multimedia redio network", Wireless Networks, Vol. 1, pp.255-265, (1995)
10. A. K.Parekh, "Selecting routers in ad-hoc wireless networks", ITS, (1994)
11. I. Leem, M. Wu and C. Kim, “An algorithm for resource allocation without inter-cluster collisions in WSN”, LNCS7425, P.1-8, (2012)
12. M. Wu, B Ahn and C Kim, “A channel reuse procedure in clustering sensor networks”, Applied Mechanics and Materials Vols284-287, pp.1981-1985, (2012)