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.
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](image)

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 strongest beacon signal from the both clusterheads.

![Fig. 2. An example of selection of the most stable gateway node](image)
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 clusterheads, 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 \( C_2 \) is \( BSS_2 \)) 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 \( \alpha \),

\[
BSS_{th} = \text{Min BSS} + \alpha.
\]  

(1)

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

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

\[
BSS_{th} = \text{Min BSS} + (n \times \alpha).
\]  

(2)

![Fig. 3. Gateway selection using threshold](image)

Proposed gateway selection algorithm is as follows:

0. Initiate \( BSS_{th} \) value (\( BSS_{th} = \text{Min BSS} \))
1. Check if \( BSS_{i1} \geq BSS_{th} \) and \( BSS_{i2} \geq BSS_{th} \) (for each candidate gateway node \( i = 1, 2, \ldots, m \)) 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.

\[
\text{MAX} \left\{ x \mid x \in \frac{BSS_{th} + BSS_{i}}{2}, \quad i = 1, 2, \ldots, m \right\}.
\]

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. $\text{BSS}_{th}$ is presented by (3)

$$\text{BSS}_{th} = \text{Min BSS} + (n^2 \times \alpha).$$  \hspace{1cm} (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.

![Linearly increasing threshold](a) ![Exponentially increasing threshold](b) Fig. 4. Examples of the proposed gateway selection

5 Conclusions

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

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