Geocast Routing - Performance of LBM and GeoGRID

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Abstract: Geocast is a special kind of Multicast in which a member of the Multicast group is defined by its position in a so-called Geocast-Region. In this paper we will figure out, how to select parameters for two selected Geocast routing protocols. In the end, we will evaluate the performance of the two protocols and compare the results.

1 Introduction

Especially scenarios like public safety or battle field require reliable Multicast (voice) communication. There are different ways to choose and maintain the groups of receivers. One alternative for certain use cases, especially for areas of danger, is Geocast. Using Geocast, a receiver is defined by its geographic position. Especially for mobile ad hoc networks (MANETs) there are several Geocast routing protocols that solve the problem of finding a path to the Geocast region. In the Geocast region the messages are flooded. Generally, a Geocast protocol assumes that each node knows its own geographic position. In reality this implies the existence of a system such as the Global Positioning System (GPS), EGNOS, or GALILEO. Using one of these systems, a node can determine its position up to 5m accuracy. In [YKC04] several Geocast routing protocols are classified and their performance is evaluated. In addition to this, it is important to know how to set the parameters of the different protocols. Thus, in this paper we will at first describe two different Geocast routing protocols (section 2). Next, we will describe the evaluation environment (section 3). After this, we will show in detail, how the parameters can be set (section 4). Finally, we will show briefly some performance evaluation results (section 5) and conclude our paper (section 6).

2 Protocols

In this section we describe the two Geocast routing protocols we chose. We chose LBM for its simplicity and GeoGRID for promising to minimize the broadcast storm problems of flooding based approaches.

Location Based Multicast: The Location Based Multicast (LBM) protocol [KV99][KV02] determines the way to the Geocast region by using a special optimized flooding. Only nodes that are in the so called *forwarding zone* forward the packets. There are different possibilities for choosing the zone. On the one hand, it can be chosen as a box. A node forwards the packet only if its position is inside a box containing itself and the whole Geocast region. On the other hand, it can be calculated using the Euclidean distance to the center of the Geocast region. The potential forwarder forwards the packet only if it is closer to the Geocast region than its precursor. As an optimization for loosely coupled networks a δ-parameter can be used. In this case, a node also forwards the packet if its distance is smaller than that of its precursor plus δ. In this paper, we use the second approach with the δ-parameter.

GeoGRID: The GeoGRID protocol [LTLS00] is a Geocast extension of the GRID protocol [LTS01]. GRID separates the area in squares of size $d * d$, the so called grids. In [LTS01] it is shown that a good choice for d is: $d = \frac{\sqrt{2} * r}{3}$, where r is the transmission range. For each grid one node is elected as gateway, which is the only node that is allowed to forward packets. The challenge in GRID and GeoGRID is the maintenance of the gateway election, because a gateway may move out of his grid. In GeoGRID the structure of the grid is used to forward the packets to the Geocast region. GeoGRID contains two approaches: the Flooding-Based approach, in which all grids in a box (similar to the first approach of LBM) are used for flooding; the Ticket-Based approach, which tries to divide the forwarding load more equally. In this paper we use the first approach, due to the problems of the ticket based approach described in [YKC04]. The parameters that influence the behavior of GRID are different timers:

- *Refresh timer*: Time after which a node refreshes its geographic information. If the node is a gateway and observes that it has left its GRID it sends a Retire message.
- *GATE send timer*: As long as there is a gateway in a grid, it broadcasts its existence by sending a GATE message when the GATE timer expires.
- *GATE receive timer*: Each time a GATE message is received, the timer is restarted. If it expires, the gateway has left without retiring, thus anybody can apply for becoming the new gateway by sending a BID message.
- *BID timer*: If a node wants to become the new gateway, it has to send a BID message and to start the BID timer. If there is no GATE message of the old gateway and no BID message of another applicant closer to the center till the timer expires, the node will be the new gateway of this grid.
- *Neighbor timer*: For each neighbor grid a node has a neighbor timer. It will be reset if it receives a GATE message of the neighbor grid. Note: a node can receive messages of the neighbor grids due to the choice of the grid size d. If the timer expires, the node remembers this information. Thus, when it enters the neighbor grid it can try to become gateway without waiting for GATE receive timer expiration.

3 Evaluation Environment

For the parameter optimization as well as for the performance analysis, we used the network simulator ns-2. We simulated 50 and 100 nodes for 300s and 900s in an area of 1000m x 1000m with one Geocast Region of 100m x 100m square. Each node has a transmission range of 200m. Thus, the size of the GeoGRID grids was set to 94.2m x 94.2m (see section 2). A Wireless LAN (IEEE 802.11b) model was used over the Two-Ray-Ground propagation model. We decided to use the Random Waypoint (RWP) [BW02] for the parameter optimization to achieve general results on how to set the parameters. The RWP movement files for different maximum speeds were generated using Bonnmotion. As traffic we simulated disaster area voice traffic (modelled as constant bit rate (CBR)) according to the distributions described in [AFM05].

The metrics that were used to analyze the results are:

- packet delivery fraction (PDF): $\frac{\text{data packets received}}{\text{data packets sent}}$
- the count of forwarders per packet (FPP): $\frac{\text{count of forwarders}}{\text{packets received}}$

The nodes move (enter and leave the Geocast zone), thus the group of receivers varies. To calculate the metrics accurately, we decided to use one fixed node in the center of the Geocast region.

4 Parameter Optimization

LBM: We performed simulations for different RWP maximum speeds up to 8 m/s (approx. 30 km/h) and different counts of nodes. The results concerning the PDF over different speeds were as expected. Generally, when the speed rises the PDF should lower. However, in our scenario the average PDF at 8 m/s was still about 0.98. A reason for this is (even for 50 nodes) the dense network in the scenario. Thus, the choice of the δ-parameter has no significant influence on the PDF. However, the FPP increases with a larger δ-parameter (cf. figure 1). A large count of forwarders in dense networks may show broadcast storm effects [TNCS02]. Thus, in dense networks the δ-parameter should be chosen nearby zero.

GeoGRID: There are five timers for GeoGRID to be set. The Refresh Timer was set to: *Refresh Timer (s)* $= \frac{\text{Accuracy geo. information}(m)}{max.Speed(m/s)}$. If the geographic information is refreshed more often, there is no difference due to accuracy of the geo-positioning systems. The calculated value can be seen as a minimum. If choosing a larger value, there may be positive impacts concerning power consumption, but there can be negative impacts on the PDF. Thus, for our simulations we set it according to the equation above. The GATE receive timer was set to: *GATE receive timer* $= 2.5 *$ *GATE send timer*. This means that a node has to miss at least two GATE messages before it starts applying for gateway.

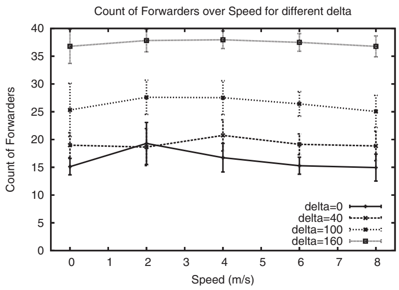

Figure 1: LBM δ-parameter - FPP over speed - 50 nodes

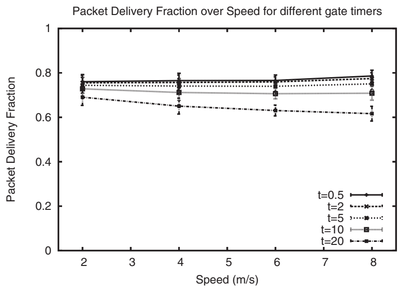

Figure 2: GeoGRID GATE send timer - PDF over speed - 50 nodes

The *BID timer* was set to 0.5s. In our opinion, this seems to be quite a large and thus secure choice. A more accurate choice could be achieved by performing some analytical calculations concerning size of the grid, signal propagation delay, and processing time in a node. The neighbor timer was set to: *Neighbor timer* $= 2 *$ *GATE receive timer*. Finally the *GATE send timer* is evaluated for different values. A larger value leads to less load, but there may be a negative impact if the speed rises. Figure 2 shows the average PDF over the speed. At higher speeds the PDF lowers. This can be explained by packets losses due to old Gateway elections. However, the GATE send timer has only significant impact on the packet delivery fraction for large GATE send timers. The reason for this is the optimal choice of the Refresh Timer. As soon as a node realizes that it has left its Grid it sends a retire packet. Thus, in a dense network, as long as the Refresh timer is low enough, a lower GATE send timer has no significant impact on the PDF. Due to our simulations, a GATE send timer of 2s seems to be good choice.

5 Performance Evaluations

In this chapter we compare LBM (δ = 0) with GeoGRID (GATE send timer = 2s) for different maximum speeds and node densities/counts. Figures 3 and 4 show PDF and FPP average values and 0.95 confidence intervals. In general, LBM achieves a higher PDF compared to GeoGRID. However, the FPP for LBM is larger than using GeoGRID. Both can be explained through the protocols. LBM floods the packets. Thus, as long as there is no overload (which was not the case in our scenarios) the PDF is ideal. GeoGRID minimizes the FPP by electing gateways, but some packets are lost due to gateway updates, which has bad impact on the PDF especially in not so dense scenarios. Thus, the denser a scenario the better it is to use GeoGRID.

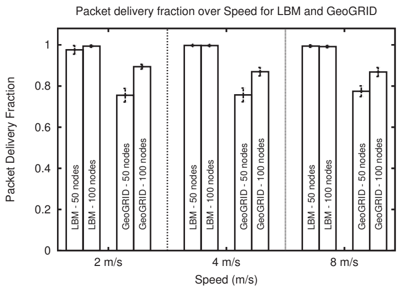

Figure 3: PDF of LBM and GeoGRID

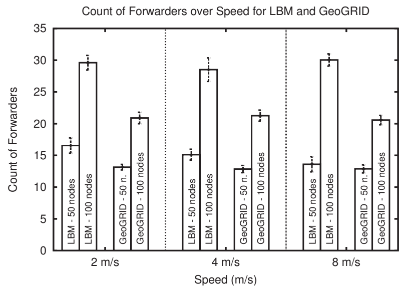

Figure 4: FPP of LBM and GeoGRID

6 Conclusion and Future Work

In this paper we showed in general how to choose parameters for LBM and GeoGRID in dense scenarios. The results of the performance evaluation show that LBM has higher PDF than GeoGRID. However, LBM has a higher count of FPP, which may cause overload in other scenarios. In the future the performance analysis should be extended to other scenarios and different load, e.g. video transmission.

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