On Design of Mobile Agent Based Location Service for Geographic Routing

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Abstract

On the impact of the node mobility, location service approaches based on the node location management incur high protocol overhead and low validity of location information. Therefore, a mobile location agent (MLA) algorithm is introduced to optimize location service. For each node, a location agent will be used to perform the location update and query by location service to decrease the protocol overhead. The location agent will assist the packet routing to the destination, which will upgrade the validity of location information caching in the network and improve the performance of geographic routing. When analyzing routing according to the location agent, we show a new method traversing all local closest nodes around a void location agent region to obtain the location information of the destination node. We select representative location service protocols and perform MLA algorithm. Simulation experimental results show that MLA algorithm can significantly reduce the protocol overhead of location service and improve the packet delivery ratio of geographic routing effectively.

1. Introduction

A multihop mobile ad hoc network (MANET) is characterized by the dynamic change of the network topology, not depending on any fixed infrastructure, so it is rather to be used in the environments such as the battlefield, emergency rescue and so on. A fundamental challenge in MANETs is the design of scalable and robust routing protocols. Geographic routing can be implemented as a stateless manner achieving very low cost of route maintenance, so it gains great advantages over the traditional topology-based routing in large scale ad hoc networks. However, to propagate packets via geographic routing, the source node needs to retrieve the location of the destination node. The flooding-based methods[1, 2] can be used to retrieve the location of the destination node, but they consume a great deal of network resources and are very inefficient in large scale ad hoc networks[3]. So the design of location service that can track the locations of mobile nodes and reply to location queries for them is a central challenge in geographic routing recently. Numerous protocols for location service have been proposed, including flat location service protocols based on the quorum[4-6] and the home region[7-9], and hierarchical location service protocols based on multi-level hashing[10-13]. Once the location of a destination node is retrieved by a source node, data packets can be delivered under geographic routing[14-16].

Numerous researches on geographic routing address how to construct the location server (*LS*) and how to update and query the locations of nodes with lower routing overhead and high successful ratio. However, the existing location service protocols mainly perform the location management based on the node, and the location change of the node will greatly impact the performances of the protocols. In the mobile ad hoc network, the accuracy of node location information caching in the source nodes and the *LS* will drop sharply with the mobility of the node. Although the frequency of the location update and query can be adjusted to increase the accuracy of node location information, large amounts of protocol overhead will be incurred and interfere with the delivery of data packets. Moreover, in the large scale network, due to the limitation of the node bandwidth, a large delay will occur during the procedure of the location update and query, which decreases the validity of the node location information further and degrades the performance of location service protocols significantly. Although the hierarchical *LS* can be performed to improve the performance of location service in a local region of the network, it is hardly to gain more advantages while the communication nodes are distributed in the whole network[17]. Boon-Chong[18] proposed a multi-home region location service protocol to create and maintain beyond a single location server for each node on-demand, which can decrease the location query overhead but incur more location update overhead. Siva and George [19] employed a clustering

978-0-7695-3457-2/08 $25.00 © 2008 IEEE
DOI 10.1109/MSN.2008.40

scheme in order to minimize control traffic, but maintaining cluster headers in a distributed manner is more complex. Moreover, almost all existing schemes are designed to maintain the locations of nodes, and under the limitation of the frequent location changes of nodes, they can hardly make more improvements on the performance of geographic routing.

In this paper, we propose a location service optimizing algorithm based on mobile location agent. We name it mobile location agent (MLA) algorithm. MLA algorithm employs the location agent (LA) for each node and maintains the node location information in the *LA*. Instead of the node location, the *LA* location will be updated and maintained in the node's *LS*. Unlike other existing location service protocols, in MLA, besides using the node location information, the source node can also deliver data packets according to the *LA* location of the destination node, and this will improve the validity of the location information caching in the network significantly. Meanwhile, the *LA* will move with the node in a jumping manner and change its location less frequently than the node, which will decrease the cost of the location update and query, hence conserving bandwidth and transmission power. When discussing routing according to the *LA* location, we show a new method traversing all local nearest nodes around a void *LA* region to retrieve the location of the destination node. Finally, simulations are used to evaluate the performance of our algorithm.

The rest of the paper is organized as follows. In Section 2, we describe the detail of the MLA algorithm. Section 3 presents how to implement MLA algorithm in the existing location service protocols. Section 4 evaluates the performance of MLA algorithm through simulations and Section 5 summarizes the paper's contributions.

2. MLA Algorithm

In geographic routing, location service can be described as follows: In the network N composed of some nodes, each node i is mapped to one or several regions or nodes that are its *LS* according to a well-known mapping function *map*: $i \rightarrow \{LS | LS \in N\}$, and updates its location to the *LS*. The source node s can query the *LS* which can be achieved according to the *map* function to retrieve the location of the destination node d, and deliver packets to d via geographic routing. The processes of performing MLA algorithm to optimize location service are as follows.

1) *Selecting location agents and performing location updates*

Shown as Figure 1, each node in the network selects a region as its *LA*. At intervals of time $T_{udpate\_to\_LA}$ or distance $D_{udpate\_to\_LA}$, the node sends a location update (LUPD) packet to its *LA* for the location update. And at intervals of time $T_{udpate\_to\_LS}$, each node selects a new *LA* and sends the LUPD packet to its *LS* for the *LA* location update. Assuming $T_{update\text{-}to\text{-}LS}=p\times T_{update\text{-}to\text{-}LA}$, p is the MLA optimizing parameter. Since the change frequency of the *LA* location is normally much lower, the *LA* location can be updated to *LS* with a very low frequency. For a shorter location update, a node always selects its *LA* in a close range around itself. The size of the *LA* region is determined by the radio range of the node, the node density, and so on. A reasonable size of the *LA* region can reduce the cost of the location update and caching.

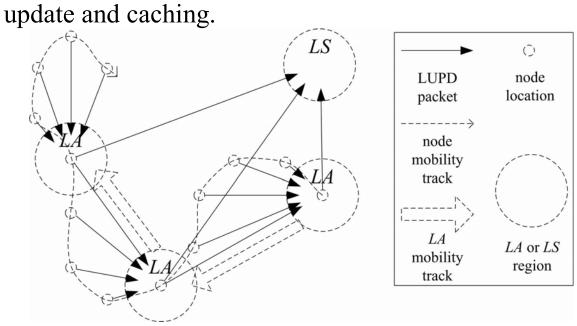


Figure 1 The schematic diagram of the LA selection and location updates

2) *Performing location queries*

When a source node needs to deliver the data packet but does not find the location or the *LA* location of the destination node in its local cache, it will perform a location query. In this process, a location request (LREQ) packet will be sent by the source node to the *LS* of the destination node to obtain the *LA* location, then to the *LA* to achieve the location of the destination node, and finally to the destination node. Once receiving the LREQ packet, the destination node will return a location reply (LREP) packet containing the location information of itself and its *LA* to the source node. The source node will cache the location information with different timeout $T_{Lnode\text{-}timeout}$ and $T_{LLA\text{-}timeout}$ once receiving the LREP packet. Generally, the value of $T_{LLA\text{-}timeout}$ is much larger than $T_{Lnode\text{-}timeout}$, and either of the location information can be used to deliver the data packet, but the node location will be used firstly. The *LA* location can be used longer than the node location, which will enhance the validity of the location information caching in the source node. We set $T_{LLA\text{-}timeout}=T_{update\text{-}to\text{-}LS}+\delta$, where δ is a short period of time. When the *LA* location information is time-out, a new location query will be performed by the source node to retrieve the new location.

3) *Delivering data packets*

The source node can deliver data packets according to the node location or the *LA* location of the destination node. When using the *LA* location information to deliver data packets, the packets will traverse the *LA* region and be redirected to the destination node.

In MLA, packets are forwarded using the GPSR protocol[14, 20]. GPSR performs two forwarding modes: *greedy* and *perimeter*. In *greedy*, the closest neighbor node to the destination will be selected to forward packets. In *perimeter*, the right-hand rule is used to traverse a void region. In MLA, both forwarding modes are used to forward a packet to the *LA* region. Once the packet enters the *LA* region, two cases will be considered: For the LUPD packet, a *LA* region broadcast will be performed and all nodes in the *LA* will cache the updated node location information; For the LREQ packet and the data packet, they will be forwarded to the central location of the *LA* region, and once the destination node location is retrieved, the packet will change to the *greedy* forwarding mode and be delivered to the destination node directly. In addition, the following conditions should be considered specially.

1) *The case that a node moves out of the LA region*

In the mobile network, a node caching node location information may move out of the *LA* region. In this case, a *handover* method[11] must be performed by the node to send the location information back to the *LA* through a LUPD packet.

2) *The case that the LA is a void region*

When the *LA* is a void region, which means there is no node in the *LA* region, according to the packet forwarding method mentioned above, the destination node can not update its location to the *LA* successfully, and the source node can not deliver data packets through the *LA* of the destination node. In the static network, the *greedy* and *perimeter* forwarding modes can be used by MLA to ensure successful packet delivery. For example, in Figure 2(a)-(b), a LUPD packet is delivered by the destination node *d* to its *LA* under the *greedy* forwarding mode for the location update, and in node *i,* the LUPD packet changes to the *perimeter* forwarding mode and traverses around the void *LA* region. When the LUPD packet reaches the node *i* again but does not find another node closer to the *LA* region, it will finish forwarding and the node *i* will cache the updated location information. When the source node *s* delivers a packet to the destination node *d* according to its *LA* location, the packet changes the forwarding mode to *perimeter* in the node *a*, achieves the location of the node *d* in the node *i*, and finally is forwarded to the node *d* successfully. We can see that, in the static network, the location of the destination node will be updated through the LUPD packet and cached in the closest node to the void *LA*, which is traversed by the LREQ and data packets to achieve the node location information and forwards the packet to the destination node. In the mobile network, the locations of the nodes around the void *LA* region will change dynamically. In Figure 2(c)-(d), when the node *i* caching the location of the destination node *d* moves away from *d*'s *LA* region, the location information will be forwarded back to the current closest node *j* by a LUPD packet.

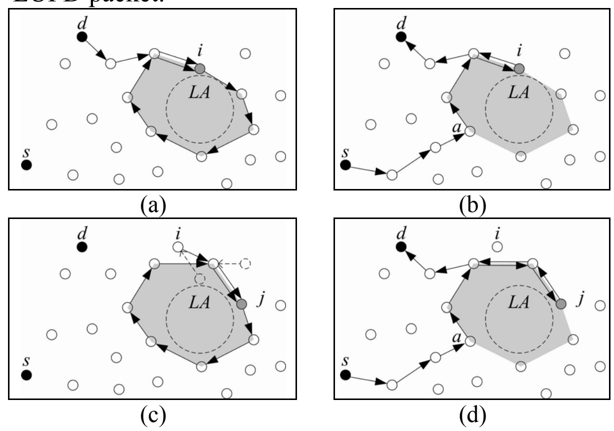
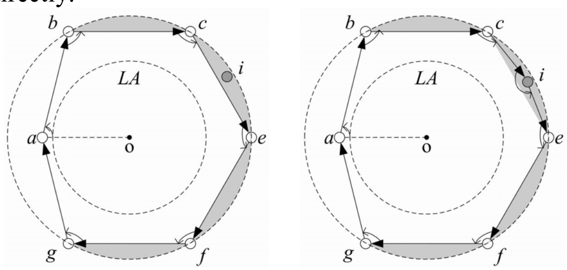


Figure 2 The schematic diagram of the location update and the packet delivery when the *LA* is void. (a)Location update in the static network. (b)Packet delivery in the static network. (c)Location update in the mobile network. (d)Packet delivery in the mobile network.

In the mobile network, the node caching the node location information will ensure whether it is still the closest node to the void *LA*, and propagate the location information to the new closest node when it is not. However, according to location relations between a node and its neighbors, the node can only judge the state of the local closest node but not the global closest node to the *LA*. For example, in the case shown in Figure 3(a), the node *a* moves to the void *LA* and becomes the new global closest node to the *LA*. But due to the unknowing location change, the node *i* will not propagate the cached location information to the node *a*. The packet delivered by the source node *s* reaches the node *a*, and changes to the *perimeter* forwarding mode. The packet is forwarded along the node *b*,*c*,*e*,*f*,*g* and finally returns to the node *a*. Since the packet does not traverse the node *i* which caches the location information of the destination *d*, it is failed to be delivered. In fact, any node caching the location information of the destination node in the grey regions will cause the packet delivery failure, i.e. the *perimeter* mode can not ensure that the packet traverses all local closest nodes around the void *LA* region.

In MLA algorithm, we use a new forwarding mode called *peri-min* to ensure to traverse all local closest nodes around a void *LA* region to obtain the location information of the destination node. For each node forwarding the packet to the *LA* via the *perimeter* mode, a cache lookup procedure will be performed to check whether a local closest node to the *LA* is existed, and the *peri-min* forwarding mode will be initiated once it exists. In the *peri-min* mode, the packet will first be forwarded to the local closest node, then be forwarded to the node which is the next hop node before the packet entering the *peri-min* mode, and finally be changed back to the *perimeter* forwarding mode. For example, in Figure 3(b), when the node *c* decides to propagate the packet to the next hop node *e* via the *perimeter* mode, it looks up its cache and finds the local closest node *i*. So it initiates the *peri-min* mode and propagates the packet to the node *i*. Then the node *i* forwards the packet to the node *e* which changes the packet's forwarding mode to *perimeter*. In addition, once the packet's destination location information is updated from the *LA* location to the destination node location, the packet will change to the *greedy* mode and be forwarded to the destination node directly.



(a) (b)

Figure 3 The schematic diagram of traversing all local closest nodes around the void *LA* region. (a) Node *i* is a local closest node. (b) Traversing the local closest node *i* via the *peri-min* forwarding mode.

As the limitation of space, we will not present the detailed process of the *peri-min* forwarding mode. Note that each node forwarding the packet through the *perimeter* mode needs to look up its local cache to check whether a local closest node is existed among its neighbor nodes. However, this process can be combined with the procedure in GPSR that the forwarding node looks up its local cache for the closest neighbor node to the destination location. So we can draw the conclusion that the *peri-min* forwarding mode will not increase the time complexity of each node's forwarding process.

3. Examples

MLA algorithm is almost suitable to optimize all kinds of location service protocols. In this section, we choose the representative protocols of flat location service (FLS) and hierarchical location service (HLS), and introduce how to optimize them using MLA algorithm.

In FLS protocols, flat *LS*s for all nodes are constructed. We choose the conception of the home region based location service protocol[7] as an example of FLS and perform optimizing using MLA algorithm. Here, the whole network region is divided into several square sub-regions called *cells*, and nodes in each *cell* serve as the *LS* of some other nodes. The well-known mapping function to calculate the *LS* of a node is as follows:

$$LS(node\_id)=node\_id\ \mathbf{mod}\ num\_of\_cells \quad (1)$$

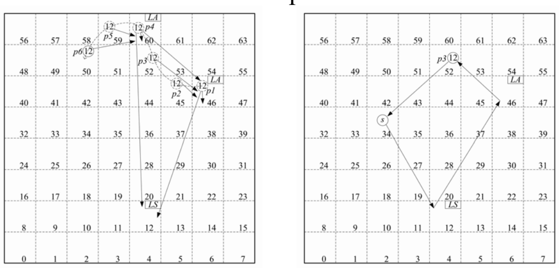
Where, *node_id* represents the node identifier and *num_of_cells* is the number of *cells* in the network. According to Formula (1), a node can achieve the *LS* of itself or another node and perform the location update and query. When optimizing by MLA algorithm, named as FLS-MLA protocol, each node chooses the *cell* where it is located as its *LA*, and updates its location to the *LA*. While the node moves far away from its *LA*, it will select a closer *cell* as its new *LA*. Figure 4(a) shows the procedure of the location update. The *LS* of node12 is *cell12*, and node12 moves from *p1* to *p6*. At *p1*, node12 chooses *cell46* as its *LA*, and updates the location of *cell46* as its *LA* location to *cell12*, node12's *LS*. When node12 moves to *p4*, it selects *cell60* as its new *LA*, and updates the location of *cell60* to its *LS*. When node12 moves to *p2*, *p3*, *p5* and *p6* respectively, it only needs to update its location to the *LA*. We can see that the transmission distance of the node location update to the *LA* is shorter and the frequency of the *LA* location update to the *LS* is lower. Figure 4(b) presents the procedure of the location query. When the node *s* needs to retrieve the location of node12, the following steps will be performed. Firstly, node12 figures out that its *LS* is *cell12* and sends the LREQ packet to *cell12* for the *LA* location query. Secondly, in *cell12*, the LREQ packet is redirected to *cell46* which is the *LA* of node12. Thirdly, in *cell46*, *p3* is known as the location of node12, and the LREQ packet is forwarded to node12. Finally, node12 receives the LREQ packet and returns the LREP packet containing the node location and the *LA* location of node12 to the source node *s*.

In HLS protocols, each node in the network has multiple *LS*s which are organized as a hierarchical structure. We perform the hierarchical location service protocol[11] as an example of HLS and optimize it through MLA algorithm. In the HLS protocol, the network region is divided into several square *cells* which are combined to several levels of hierarchical regions. For each node, the mapping function to calculate the *LS* in a *level-i* region is as follows:

$$LS_i(node\_id)=(node\_id+i)\ \mathbf{mod}\ num\_of\_cells_i \quad (2)$$

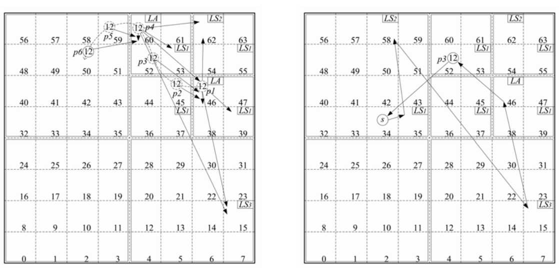
Where, *i* is the level number, *node_id* represents the node identifier, and $num\_of\_cells_i$ represents the number of *cells* in each *level-i* region. Using Fomula

(2), a node can figure out the *LS cell* of itself or another node in every level of the network, and then performs the location update and query. In Figure 5, we present HLS-MLA, an MLA algorithm optimized version of HLS. Here, node12 updates its location to its *LA cell* and updates its *LA* location to every *LS* of each level region where its *LA* is located once selecting a new *LA*. On the other hand, when the node *s* performs a location query to node12, the LREQ packet will traverse every *LS* of node12 from the low to high level of its located network regions, here are *cell35*(*LS1*), *cell58*(*LS2*) and *cell15*(*LS3*) in order, and in *cell15*, obtain the *LA cell* location of node12, in this case, is *cell46* which knows that *p3* is the current location of node12. Finally, the LREQ packet will be forwarded to node12, in which a LREP packet containing the node location and the *LA* location of node12 will be replied to the source node *s*.



(a) (b)

Figure 4 The schematic diagram of the location update and querie via FLS-MLA. (a)Location update. (b)Location query.



(a) (b)

Figure 5 The schematic diagram of the location update and querie via HLS-MLA. (a)Location update. (b)Location query.

4. Simulations

In this section, we evaluate the performance of FLS, HLS and their MLA optimizing protocols in the NS2 platform to verify the MLA algorithm further through simulations. The experiment environments are as follows: The distributed coordination function (DCF) of IEEE 802.11 for wireless LANs is used as the MAC layer. The radio model is based on the Lucent Technologies WaveLAN product, which is a shared-media radio with a transmission rate of 2Mbps, and a radio range of 250m. Nodes are distributed randomly and move following the random Waypoint model with a randomly chosen speed distributed between 0 and 30m/s in square networks with node density ρ. The proportion q of the source nodes will select the constant destination nodes and generate the traffic using CBR connections having a payload size of 128 bytes and the packet delivery rate of 1 packet per second. All CBR connections are randomly generated at the first 50s of simulations and last until the end of the simulation. The simulation is 300s long, and results are averaged over 5 runs. For FLS and HLS, set $T_{update\text{-}to\text{-}LS}$=15s, $D_{update\text{-}to\text{-}LS}$= 225m, $T_{Lnode\text{-}timeout}$=17s. For FLS-MLA and HLS-MLA, set $T_{update\text{-}to\text{-}LA}$= 15s, $D_{update\text{-}to\text{-}LA}$=225m, $T_{update\text{-}to\text{-}LS}$= $p \times T_{update\text{-}to\text{-}LA}$, $T_{Lnode\text{-}timeout}$=17s, $T_{LLA\text{-}timeout}$= $T_{update\text{-}to\text{-}LS}$ +2s. We use GPSR to implement the geographic routing, and set the beacon period of 2s.

The following metrics are evaluated for the locatin services and geographic routing: (1) LS protocol overhead – The number of the location service protocol packets forwarded, including the LUPD, LREQ, LREP and the *handover* packets. Note that the LS protocol overhead excludes the overhead due to beaconing. (2) Data packet delivery ratio (PDR) – The ratio of the data packets delivered to the destinations to those generated by the CBR sources. (3) Data packet delivery end-to-end delay (PDD) – The time from the data packets generated by the CBR sources to those received by the destinations.

We measure the impacts of the node density, the traffic, the MLA algorithm optimizing parameter *p* and the network size on the performance of geographic routing and location service protocols

1) *Impact of the node density*

The node density will impact the performance of the location service protocol and geographic routing, since the location information is cached in the nodes within *LS* and *LA* regions. So in our experiments, we set p=5 and q=10%, and select 100 to 400 nodes randomly distributed in a square area of 2km×2km, i.e. we measure the positions for the node density ρ from 25node/km^2 to 100node/km^2. Figure 6 depicts the experimental results. It shows that there are large impacts of the node density on the performance of location services and grograhpic routing. Firstly, when the number of nodes equals 100, for all protocols, the PDRs are low and the PDDs are high. MLA algorithm can decrease the LS protocol overhead by 22.99% and 49.09% and the PDDs by 65.87% and 67.62% respectively compared with FLS and HLS. However, it may slightly degrade the PDRs at the same time. The reason is that, in the low node density environment, the network may be partitionable and be divided into several groups, and under this environment, the scheme that the source node propagates the data packet first to the *LA* and then to the destination node will increase the possibility of the packet delivery failure and degrade the PDRs of MLA optimizing protocols. Another observation is that HLS has the highest PDR among all protocols, which is because HLS maintains more *LS*s for each node, so it has more opporunities to retrieve the destination node location and perform the data packet delivery, i.e. it is more robust in low node density enviroment. Secondly, with the increase of the node density, the PDRs increase and the PDDs decrease for all protocols. When the number of nodes is up to 300, FLS and HLS achieve their best performances on the aspects of the PDR and the PDD. However, at this time, MLA can still upgrade the PDRs slightly and decrease the PDDs by 35.81% and 52.68% respectively. Thirdly, when nodes in the network become much more, the performances of HLS and FLS descend, but those of HLS-MLA and FLS-MLA ascend further. When the number of nodes is up to 400, MLA can increase the PDRs by 1.98% and 4.87% and decrease the PDDs by 38.66% and 68.64% respectively compared with FLS and HLS. The reason is that MLA can decrease the LS protocol overhead and alleviate the packet congestion significantly, which benefits the successful packet delivery. Summarily, MLA can improve the performance on the LS protocol overhead and the PDD, and step up the PDR when increasing the node density.

2) *Impact of the traffic*

Under the limitation of the node bandwidth, the LS protocol overhead will significantly affect the performance of geographic routing. Because MLA can degrade the frequency of location update and query and decrease the LS protocol overhead, it is expected that it will make a great impact on the performance of geographic routing under various traffic environments. Consequently, the following experiments are performed: Given that 400 nodes are distributed in the 2km×2km network and the MLA optimizing parameter p=5, we set the proportion q of the source nodes from 10% (40 source nodes) to 30% (120 source nodes) to establish CBR connections and deliver data packets. Figure 7 plots the results. It shows that, for all protocols, the PDRs drop and the PDDs rise when increasing the traffic. However, for FLS-MLA and HLS-MLA, the changes of the curves are much slower, which suggests MLA can achieve more improvement on the performance of geographic routing when increasing the traffic. Compared with FLS and HLS, when q=10%, the improvements of PDRs are 1.98% and 4.87% respectively, and when q=30%, those are 24.28% and 39.50% respectively. This is due to the fact that the LS protocol overhead of MLA optimized location services increases more slightly than original location services. Moreover, MLA can also obtain lower PDDs under various traffic environments.

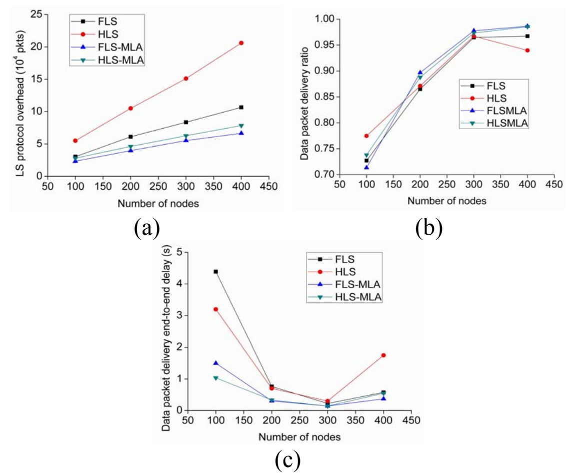


Figure 6 The performance of geographic routing on the impact of the node density. (a)LS protocol overhead. (b)Data packet delivery ratio(PDR). (c)Data packet delivery end-to-end delay(PDD).

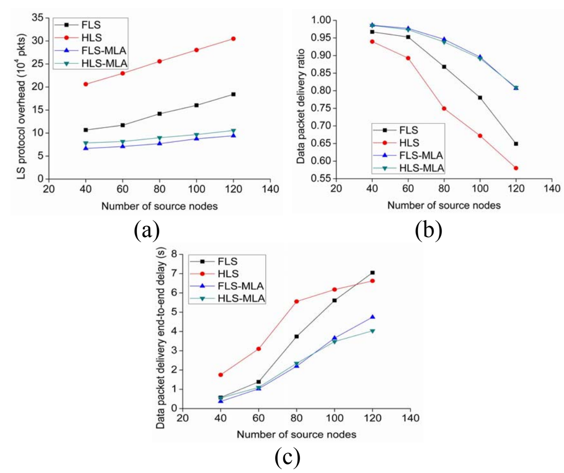


Figure 7 The performance of geographic routing on the impact of the traffic. (a)LS protocol overhead. (b)Data packet delivery ratio(PDR). (c)Data packet delivery end-to-end delay(PDD).

3) *Impact of the MLA optimizing parameter p*

Given that 400 nodes are distributed in the 2km×2km network area and 40 CBR connnections are established between source and destination nodes, we evaluate the impacts of the optimizing parameter p on the performance of MLA and Figure 8 plots the results. It shows that the optimal values of p are 5 to 7 and the acceptable values of p are about 4 to 8. Moreover, when p is larger than 10, the PDRs for the MLA optimizing protocols decrease significantly, suggesting that the value of p greatly impacts on the protocol performances.

4) *Impact of the network size*

Figure 9 depicts the performance of FLS, HLS and their MLA optimizing against the network size changed from 200 nodes (1.41km×1.41km) to 1000 nodes (3.16km×3.16km) with the node density ρ=100node/km^2 , q=10% and optimal values of p are selected on different scales of networks, so that FLS-MLA and HLS-MLA produce the least LS protocol overhead. For the network size smaller than 400 nodes, all protocols have good performances, the LS protocol overhead is low, the PDRs exceed 90%, and the PDDs are less than 2s. But when the network size is larger than 400 nodes, the performance of FLS and HLS decrease sharply. Especially in the 1000 nodes network, the PDDs reach 8.96s and 7.49s respectively which nearly approach the valid time of the node location information caching in *LS*s, *LA*s and source nodes. It will degrade the validity of the location information significantly, and therefore, induce that the PDRs of FLS and HLS are only 46.00% and 30.35% respectively. However, for FLS-MLA and HLS-MLA, although the performances of them decrease, the degree of the performance improvements increase compared with FLS and HLS when enlarging the size of networks, because *LA* locations can be used to propagate data packets and less location updates and queries need to be performed. Compared with FLS and HLS, the decreases of the LS protocol overhead are upgraded from 24.80% and 48.30% in the 200 nodes network to 67.13% and 78.74% in the 1000 nodes network, the increases of the PDRs are sharply upgraded from 1.18% and 1.48% in the 200 nodes network to 64.22% and 144.50%, and the decreases of the PDDs are holden on more than 30%.

5. Conclusions

In this paper, we propose a location service optimizing algorithm based on mobile location agent. The location agent is introduced to reduce the location service protocol overhead and improve the validity of location information. We show a new packet forwarding approach through traversing all local nearest nodes around a void location agent to achieve the location of the destination node and avoid the packet delivery failure. We also propose a calculation model which can be used to discuss the optimization of MLA algorithm and the location service protocol overhead. We evaluate the performance of MLA algorithm through simulations, the results show that MLA algorithm can be well suitable for the moderate and denser networks. It can optimize the location service protocol and significantly improve the performance of geographic routing, especially in high traffic or large scale networks. MLA algorithm can reduce the protocol overhead and packet delivery delay, and upgrade the packet delivery ratio effectively.

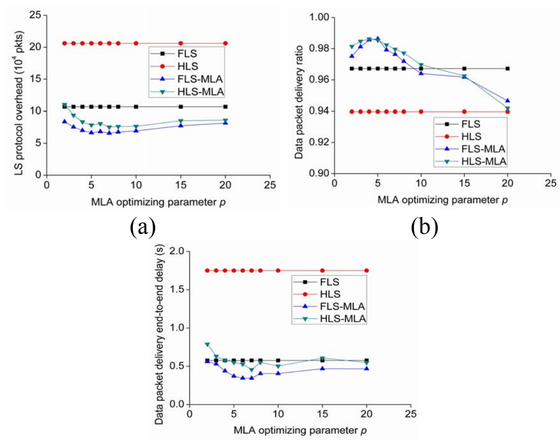


Figure 8 The performance of geographic routing on the impact of the MLA algorithm optimizing parameter p. (a)LS protocol overhead. (b)Data packet delivery ratio(PDR). (c)Data packet delivery end-to-end delay(PDD).

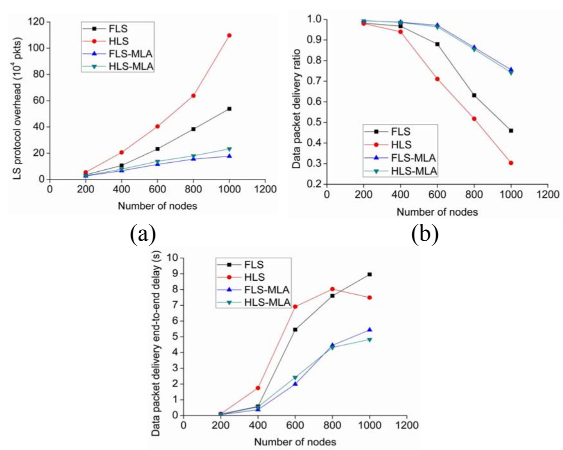


Figure 9 The performance of geographic routing on the impact of the network scale. (a)LS protocol overhead. (b)Data packet delivery ratio(PDR). (c)Data packet delivery end-to-end delay(PDD).

6. Acknowledgements

We would like to thank the anonymous referees for their comments. This work is partly supported by the China's Natural Science Foundation under Grant No.60803120, the Key Subject Foundation of Beijing under Grant No.XK100060423 and the Graduate Innovation and Practice Foundation of Beihang University under Grant No.2007.20.

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