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4 Comparison of Location Update Schemes in Mobile Ad Hoc Networks

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Abstract

In this paper, we present an overview of location update schemes for routing in Mobile Ad hoc Network (MANET). Many position based routing protocols have been developed for mobile ad hoc networks. These protocols assume that a location database service exists on some or all the mobile nodes in the network to provide up to date location information of a specific node in this network. We consider five location update schemes and their variants: DREAM, Home Agent, Quorum Base, Grid Location Service, and Doubling Circles location schemes. Finally we provide analysis and qualitative comparison of the above schemes based on: size of database per location server, triggering update strategies, location server availability, and scalability for large networks. We conclude that the Home agent scheme is more efficient compared to other schemes.

Keywords: Location update, DREAM, Home Agent, Quorum Base, Grid Location Service, and Doubling Circles location schemes.

ملخص

في هذا البحث، يتم عرض أنظمة تحديث الموقع للتوجيه في شبكات الحاسب السيار (MANET)لقد تم تطوير العديد من بروتوكولات التوجيه على أساس الموقع. هذه البرتوكولات تفترض وجود خدمة لقاعدة بيانات المواقع في بعض أو كل النقاط (الحواسيب) في الشبكة لتوفر أحدث المعلومات عن موقع الحاسب الهدف في الشبكة.
لقد تم اختيار الأنظمة التالية لهذا البحث:
DREAM, Home Agent, Quorum Base, Grid Location Service and Doubling Circles.
و قد تم تحليل و مقارنة هذه الأنظمة على أساس حجم قاعدة البيانات، استراتيجية التحديث للموقع، تواجد خادم االموقع، و إمكانية توسيع الشبكة. وقد وجد أن نظام Home Agent اكثر فاعلية مقارنة مع الأنظمة الأخرى في البحث.

1. INTRODUCTION

Mobile Ad Hoc networks are a set of wireless mobile nodes that do not require a pre-established infrastructure. They consist of autonomous nodes that collaborate in order[1] to transport information without specific user administration or configuration. Usually, each node in the network acts as a router and an end system at the same time, thus contributing to and maintaining connectivity of the network.

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Mobile ad hoc networks have dynamic topologies. Due to the frequent change of the topologies, routing problem becomes a challenging task in such networks, since conventional algorithms do not accommodate for topological changes. The routing algorithms proposed for MANET use either the information about the links that exist in the network to perform packet forwarding (known as topology-based routing) or use of information about the physical location (position) of the participating nodes (known as position-based routing, [Mauve et. al., 2001]).
In Position-based routing a node works as a location server for routing by keeping the location information of either all the nodes in the network or only few nodes. The nodes obtain location information of other nodes by exchanging location information based on time, distance or event [Karumanchi et. al., 1999]. This exchange of location information involves communication overheads. To reduce, the communication overheads of location information exchange, the researchers have proposed various location update schemes that are discussed in the next section. Section 3 gives the comparison among these schemes and finally conclusion is provided in the last section.

2. VARIOUS LOCATION UPDATE SCHEMES

The location based routing schemes assume that each node knows its physical location. *Global Positioning System* (GPS) [Web site http://tycho.usno.navy.mil/gpsinfo.html] is one of the services that can be used by a node to know its geographical location, if a node is equipped with small low power GPS receiver. In position based routing each node in the network maintains a database of location information of other nodes. The location databases may contain ID of a node, physical location of the node, timestamp, and additional information based on the routing algorithm used like velocity, direction,.etc.
There are two types of update schemes: proactive and reactive update schemes. In the proactive scheme, each node updates its location servers regularly and separately from destination search, like DREAM, Home Agent, Quorum Base, Grid Location Service, and Doubling Circles. Whereas in the other scheme, a node updates the location servers while it is searching for the destination like LAR scheme. In this paper, we consider the proactive update schemes only.

2.1 Distance Routing Effect Algorithm for Mobility (DREAM)

[Basagni et al., 1998], described a DREAM algorithm as an integrated location dissemination and geographic routing system. In this system, each node maintains a location database that stores position information about other nodes that are part of the network. A restricted flooding algorithm is used for location updates, so that each node floods messages to update the position information maintained by other nodes. These updates are propagated for varying distances. Moving nodes originate two kinds of update messages - short distance updates and long distances updates. Short distance updates are generated more frequently than long distance updates. In this algorithm, the precision of a location update for a destination is greatest in nodes near that destination, and less in nodes increasingly far away from the destination. If a node fails to deliver an update message using restricted flooding, it initiates a recovery procedure by using flooding i.e. transmission to cover the entire network [Basagni et. al., 1998].

2.2 Quorum based location update schemes:

In quorum systems, information updates are sent to a group (quorum) of available nodes, and information requests or queries are sent to another quorum. Therefore updated information can be found only at the nodes available at the intersection of quorums.

Given a set S of location database servers, a quorum system is a set of m subsets of S whose union is S and intersection is non empty, namely S_0, S_1, … ,S_{m-1}; such that [Karumanchi et. al., 1999]:

1. $U_{i=0}^{m-1} S_i = S$
2. $S_i \cap S_j \neq \Phi \qquad for \quad 0 \le i, j \le m-1$

[Stojmenovic and Pena, 1999] described a Quorum based location information management scheme. This scheme is based on replicating information at multiple nodes acting as location servers. A location update is triggered whenever a link is broken or created, so that the moving nodes will forward a short message containing their new location to all nodes located to the north and south (in a column) of their current location with certain thickness of reporting. The destination search then begins sending two messages. These messages are sent in the east and west (in a row) direction with certain thickness, looking for the most up to date information of destination location. When the messages reach at each end of the current row, the search is continued toward best reported destination position, with correction, along the path as better information becomes available closer to destination. One of such short messages may be sent directly from source to destination with available location information [Stojmenovic and Pena, 1999]. This scheme will be used in our comparison later.

[Haas and Liang, 1999a] proposed another variant of quorum based location database management scheme. They used a class of Uniform Quorum System (UQS). In this scheme, location databases are stored in the network nodes forming a self-organizing virtual backbone within the flat network. The databases are dynamically organized into quorums where the intersection of every pair of quorum consists of the same number of databases. A mobile node sends location update messages to the nearest backbone node, which then chooses a quorum of backbone nodes to host the location information. The querying node is guaranteed to obtain at least one response with the desired location information due to quorum intersection [Haas and Liang, 1999a]. Later, [Haas and Liang, 1999b] proposed another update scheme called Randomized Database Groups (RDG). In this scheme, in response to location update or destination search, a mobile's location information is written or read respectively, from a group of randomly chosen databases comprising a virtual backbone with a flat network [Haas and Liang, 1999a]. This scheme does not describe routing algorithms that can be used for update exchanges inside the virtual backbone since these updates are not local.

2.3 Home agent based location update scheme

The concept of Home Agent scheme is similar to the one used in cellular phone network and mobile IP.

Stojmenovic proposed a home agent based strategy for location database updates and destination searches. In this scheme, each node selects a certain circular area as its home agent, and informs other nodes about it. Therefore, when the node moves away to a new location, it sends regularly its location update messages only to the nodes located within its home agent using greedy algorithms [Mauve et. al., 2001 and Stojmenovic, 2002].

For destination search, the source node sends a query message toward its home agent, which will supply the latest available location information about the destination, and then the request is forwarded toward destination to complete the destination search [Stojmenovic, 2002]. This scheme will be considered for further comparison.
Woo and Singh proposed a geographic location database management strategy for a scalable routing protocol for MANET. In this strategy, they assigned home regions for nodes. Therefore, all nodes within a home region know the approximate location of the registered nodes. In this scheme, every node sends its location updates to a set of location servers in its home region, and destination search queries are sent also to these location servers. This algorithm is based on a combination of geographical routing and a simple static mapping procedure to maintain approximate location information for nodes [Woo and Singh, 2001].

2.4 Doubling circles scheme

Amouris, Papavassiliou, and Li proposed a position based multi-zone routing protocol for wide area mobile ad hoc networks. In this protocol, a set of routing zones (circles) is defined for each node, where the i^{th} routing zone is a geographic circle with radius $R(i)$ such that $R(1)<R(2)<R(3)<..<R(i-1)<R(i)$. Their algorithm is based on position updates within circles of increasing radii with the current radius being double the previous one. Each node updates its location to all nodes located within circle of radii P, 2P, 4P, 8P, In this scheme, each subsequent circle has double radius than previous one [Stojmenovic, 2002].
Location update takes places when a given node moves outside one of these circles of radius $2^i P$ for some i. Therefore this node broadcasts its location to all nodes available inside the circle centered at current node position, and with a radius $2^{i+1} P$. We note that the radius of larger circles will include almost all nodes of the network.

2.5 Grid-based system for location update scheme

Li, Jannotti, De Couto, Karger, and Morris described a new distributed location database service called Grid's Location Service (GLS). This scheme is similar to the doubling circles scheme, where the researchers used squares instead of circles. In this scheme, they divided the area that contains the ad hoc network into a hierarchy of squares called first order square, second-order square, and so on till nth order square. An ith order-square is made of four (i-1) squares and so on. Each node selects a small set of nodes as its location servers with ID's closest and greater than the ID of the node distributed in three squares belonging to the same order-squares excluding the square in which the node exists. Therefore, each node updates its location servers with its current location information when it moved a threshold distance using geographic forwarding algorithm. A node sends its new position to the location servers without knowing their actual identities, by using a predefined ordering on node identifiers and a predefined geographic hierarchy. A node can direct a location query to a known node with the ID nearest to the ID of the destination node [Li et. al., 2000] by using the predefined identifier ordering and the predefined geographic hierarchy.
3. COMPARISONS
In this section we compare the location update schemes described in the previous section. Mauve, Widmer, and Hartenstein compared DREAM, GLS, Quorum, and Home Agent schemes using communication overheads and time complexity [Mauve et. al., 2001]. But, it does not cover doubling circles, home agent and quorum base in

detail. In our work, we compare the update schemes using the following qualitative parameters.

- Strategy for triggering updates: A node sends an update message according to
  - Time based strategy: A node sends its location updates to its location servers after a specific period of time is passed.
  - Distance based strategy: A moving node updates its location servers when it crosses threshold distance.
  - Absolute connectivity based strategy: When a certain pre-specified number of links incident on it have been established or broken since the last update.
- Number of location servers: a scheme with high number of location servers will have high successful queries with small delay. Therefore, this scheme is more reliable.
- Database size or number of entries of the location server. This depends on the number of location servers available for each scheme.
- Computational complexity: It refers to the amount of computation to identify the location servers for updates and queries.
- Scalability to large networks: Enlarging the network size does not degrade the network performance.

We find that all the metrics except the first one are dependent on the number of location servers for each scheme, with GLS having the least location servers and doubling circles having the most location servers approximately all the nodes in the network. Based on this fact we give the following comparison for the qualitative parameters.

Dream scheme uses time based update policy for triggering location update. In Dream scheme, every node is working as a location server for all nodes in the network, and hence this scheme has a large number of entries per location server. Dream has high computations to identify its location servers. This approach is not scalable.

In quorum base scheme, a new location information for a node is updated when a certain pre-specified number of links incident on a node have been established or broken since the last update. Quorum based scheme has a low to medium number of location servers dependent on the size of a quorum, and medium database size which depends on the number of location servers. Also it is scalable.

In Home agent scheme, each node updates its new location when a certain pre-specified number of links incident on a node have been established or broken since the last update. The Home Agent scheme has a low to medium location servers based on the area of the home zone, and a medium database size since each node will work as home agent for some nodes. This scheme is more scalable to have large networks.

In GLS scheme, the location updates are based on distance traveled by the node. GLS scheme has the least number of location servers because of the criteria used here (i.e. a node acts as location server for nodes with smaller ID i.e. predecessor nodes per a square of any order square), and hence small database size. GLS involves more computations to identify location servers that are the immediate successors of nodes. Also GLS is scalable up to some extent to have large networks.

In double circles scheme, the location updates are based on distance traveled by the node where a node moving within a small circle causes unnecessary location updates. This scheme has largest location servers since the outer most circles contains almost all nodes in the network as location servers, and hence largest database size since each node will work as a server for almost all nodes covered by the outer circle. But this scheme is scalable with high consumption of energy due to its flooding for location updates.

5. CONCLUSION

For effective routing the location update schemes assume that a source already has knowledge of accurate destination location. But, enabling the source with such knowledge requires well-organized location updates. Therefore location updates for efficient routing become a challenging issue in MANET. In this paper we have examined five location services for location updates from a qualitative point of view.

We conclude that the Home agent scheme is more efficient compared to other schemes, since it has medium number of location servers, small entries per server, and small computations. Dream and GLS schemes have more computation complexity compared to others. But doubling circles performs well with high cost of updating large number of location servers that consumes more energy of the network, and large entries per server.

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