Location Server Selection Techniques in Vehicular Ad-Hoc Network

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Abstract

In Vehicular Ad-Hoc Networks (VANETs), location service protocol is utilized to locate locations of nodes to be used by position-based routing algorithms before the start of communication between source and destination. The existing lo- cation services proposed for Mobile Ad-Hoc Networks (MANET) suffer from poor scalability in VANET environments. Due to importance of positioning in VANET environment and reliability of number of applications on locations of mobile nodes, Location- Based service protocols designed for VANET is increasing. Providing locations in challenge and rapid changing topology such as VANET need to be up-to-date, accurate retrieved with low latency and low overhead. This paper reviews critically the proposed techniques for selecting location server of location- based protocols for VANET environment.

Keywords: *location service protocol, VANET, Ad-Hoc Network, location server.*

1. Introduction

Vehicular Ad-Hoc Networks (VANETs) are a promising new technology designed to integrate and apply the capabilities of a new generation of wireless networks to transportation systems. The main function of this technology is to provide everywhere connectivity to mobile users while on the road, to connect users to the outside world through other networks, and to provide effective communications among vehicles that encourage the intelligent systems of transportation.

VANET applications are wide-ranging and promise beneficial services for users such as vehicle collision warning and the dissemination of road information. Most of VANET's applications depend on the location of both the source of a message and its destination, whereas the location of each node could be obtained through localization technologies such as global positioning systems [1]. This location can be employed to route messages to destinations using a geographically based routing protocol. The destination's location is retrieved by a location service protocol. Therefore, the location service protocol is essential in retrieving a destination's location in an ad-hoc network in order to enable geographically based routing protocols.

This research studies and analyses exiting location server selection techniques in location-based service protocols and determines the gaps among those protocols and give recommendations.

2. VANET Location-Based Service Protocols

Conventional MANET routing protocols (proactive, reactive, and hybrid) [2] [3] [4] show acceptably performance in MANET applications where each protocol tries to find the best path to destination [5], however, applying these protocols in VANET environment show different performance. Therefore, as a solution, position-based protocols adapted for VANET applications due to good performance and suitable features. A prerequisite of this type of protocols is another protocol called location-based service protocol and establishing a connection between two nodes using position based protocol requires two steps. First, the sender uses a location service to locate the position of the destination and includes this position in the packets. Secondly, forward packets to the closest neighbor to the destination. A good example of this kind of protocols is [6]. Position based routing protocols need to know the location of destination in advance before source starts communicate with a destination. Therefore, location service protocols proposed to provide locations of nodes to any queried.

The location service protocol has three main parts; location server selection, location update, and the location request. Location server selection is responsible for assigning a node to be a location server to store and manage some or all nodes' location. The location update is responsible for disseminating information about the node's location to one location server or group of location servers. Query sender invokes the location request to discover the location of the destination. The request packet traverse over the network until it reaches a location server responsible for that destination or the packet time to live expires.

Mainly, the location service protocols as shown in Figure 1are divided into two classes: Flooding-based, and Rendezvous-based. The Rendezvous-based protocols are further classified into two subcategories; hashing-based (flat and hierarchical) and quorum-based [7] [8].

2.1. Flooding-Based

Flooding-based follows the manner of that updates of nodes locations flooded in the network and each node becomes a location server. Each node requesting a location of destination needs to flood the request packet through the network, which causes overhead and packets collision.

Cache-Based Routing is location service protocol proposed for VANET environment by [9]. Once a node crosses an intersection, it sends one-hop broadcast packet includes cache contents of nodes' locations. Receivers of cache will serve as location servers called guideposts located in guideposts region. This process repeated frequently to spread locations

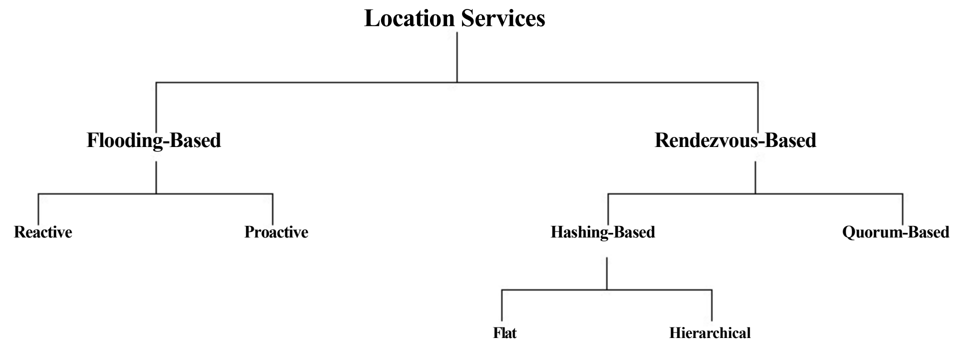

Fig. 1. Classes of Location Services Protocols

wide number of vehicles. A node needs to ask about destination's location will flood the query packet to near guideposts intersections by guidepost. Due to flooding scheme followed in this protocol in update and query, overhead expected to be high. Furthermore, query packet flooded among near intersections increases the overhead on the network due to high density of nodes at intersections with high packets rebroadcasting, all this influence the network performance.

2.2. Rendezvous-Based

This class of location service protocols is classified into Hashing-Based and Quorum-Based protocols. Hashing-based has two sub-branches: flat and hierarchical. Flat and hierarchical are deployed in MANET and in VANET. Hashing-based uses hash functions in distributing location servers and retrieving locations of those servers. Quorum-based protocols use subsets of nodes to represent location servers and disseminate these location servers over the network in a vertical path, grid layout, or even in a dynamic way. However, Rendezvous-based protocols are more scalable than Flooding-Based protocols in ad-hoc networks [7].

2.3. Hashing-Based

Hashing-based is also called home region it works by assigning a specified geographical area and designating number of nodes inside it to act as location servers that manage and provide nodes locations information. Hashing-Based is subdivided into Flat-Based and Hierarchical-Based. Flat-based protocols avoid the complication of maintaining a hierarchy of grids, which is the case in hierarchical-based. Protocols from these two sub-branches are discussed below.

Intersection Location Service (ILS) [10] is a distributed hashing-based location service algorithm. ILS utilizes the characteristics of street intersections and uses the distributed hash function Chord algorithm [11] for the location query and fault tolerant mechanism. Each intersection is given an identifier numbered from 0 to N. This number is used to select a location server for each intersection through hashing selected location server's ID to intersection's ID. In order to connect location servers on different intersection, ILS uses Chord algorithm to virtually connect the selected location servers which helps in performing the discovery of any queried nodes location within short time. Additionally, this may increase the chances of finding locations of queried destinations by forwarding packet over Chord ring. However, the limitations in ILS is that selecting nodes as location server is based on their IDs compared to intersection's ID, and this does not ensure selecting most stable location server. Stability is related to movement of this selected location server which could move in high speed, which needs re-selection of another location server and sending control packets for this selection within short time. This leads to high overhead that degrades the protocol performance. Moreover, Chord algorithm can reduce latency in retrieving locations. However, it causes ILS to keep outdated locations of nodes.

A Vehicle Location Service protocol (VLS) [12] is a location service for vehicular ad-hoc networks in urban environment. VLS selects location servers on different partitions of the network based on pre-provided map of urban area. The map is divided into squared regions and the node ID is hashed to each region. This partitioning method could reduce the delay in discovering location of destination. VLS follows the idea of clustering, where each street is clustered into small segments with sizes depending on the wireless range of nodes. The selection of cluster-head of each segment is based on its position inside the segment which could be selected as a location server. A node has to search the nearby road segments to find cluster heads. The cluster head will work as location servers for the node. Any query message to find a destination should be answered by location server which has the updated information about that destination. Otherwise, location server which has outdated location should pass the query to another location server. Selecting a location server closest to the center of region does not ensure the stability of this node because speed of this node could be high which needs re-selection of another location server frequently in short time. VLS design does not take load distribution on the selected location server into consideration.

Responsible Sections Location Service (RSLS) [13] provides locations for vehicles in urban environment. The se- lection of location servers is based on nodes moving or stopping in a responsible area, where this area could be a bus station or an intersection. The IDs of nodes are hashed to responsible area IDs using Secure Hash Algorithm (SHA-1) [14] in order to select the node that will act as a location server. The node can determine its corresponding responsible section through hashed value, therefore, if the responsible section II than or equal to node's ID, the section is considered as the responsible section. For instance, if node A wants to communicate with node B, first, A determines the location servers responsible of B position using SHA-1 algorithm. Next, A sends the query packet to the corresponding responsible section. Location servers residing inside the responsible section reply if they have the location of B. The limitation in RSLS protocol is that the selection of location servers is based on node's IDs compared to responsible sections' IDs, this does not guarantee selecting the best location server in term of stability. The node with best ID could be moving with high speed compared to others in the same area or its position does not ensure very good positioning among other nodes. The positioning of a selected location server ensures the connectivity with other surrounding nodes which increases query success ratio due to availability of surrounded nodes' information. The intersections and bus stations usually are dense areas, portraying a dense network which leads to high overhead and this metric is not measured in RSLS.

In [15] authors proposed Region-Based Location-Service-Management Protocol (RLSMP) for VANET. In RLSMP nodes are divided into virtual cells representing virtual infrastructure. The mobility space of these nodes is represented in grid shape, each grid with determined coordinates to help cells clustering through obtaining cell's ID from its location origin. Additionally, this grid is subdivided into segments which are used to construct geographical cluster. Nodes in cells send their locations update packets to a node called Cell Leader (CL). However, any node located in the central cell element and received location update can act as cell leader. CL aggregates locations of hashed nodes and sends these locations to the central Location Service Cell (LSC) of the cell geographical cluster. The mobile nodes send their location updates whenever it cross a cell based on distance moved and transmission range. A source node sends query packet to locate destination, this query packet sent to the source node's local CL that aggregates all queries comes from its responsible cell and sends these locations in a message to LSC. In case the location is found on a nearby node it will be sent to the source node. Otherwise, LSC will aggregate all queries and send them over a spiral shape path over the network in order to increase the chance of finding designation's location in global clusters. However, forwarding location query in a spiral shape path and aggregating update packets may cause an increase in the end-to-end delay.

Hierarchical Location Service with Road-adapted Grids for Vehicular Networks (HLSRG) [16] is a location service protocol proposed for large urban areas. HLSRG divides the area into grids, where each grid is 500 square meters in size and it represents level 1 in the hierarchical design of the protocol. Nodes in this level send their locations updates to the location server located in the nearest intersection to the center of the grid. This location server periodically sends the collected updates to a Road Side Unit (RSU) which represents level two of the hierarchical design in HLSRG. Furthermore, in the center of the whole area there is an RSU representing level 3 of the hierarchy. A node requesting destination's location has to send the query packet either to the location server at the center of the grid in level 1, or send it directly to nearest RSU in level 2. Using RSUs in large scale networks such as in VANET environment can make protocols to perform well due to wide coverage area; nonetheless, the problem is the cost of these infrastructure components. Another problem regarding failure of any of those RSUs is that it could lead to degradation in network performance.

Map Based Location Service (MBLS) [17] is a hierarchical location service protocol designed for VANET environment. MBLS divides the area into hierarchical levels, where level 3 covers the entire region that is divided into four sub-regions labeled as level 2. This level 2 is divided into four sub regions representing level 1. Selecting location server is based on selecting a waypoint in each sub region of level 1. Any node within the range of waypoint is eligible to be location server, but only the closest node to this waypoint is the one nominated as location server. Location updating process in MBLS is based on geographical data file; from this file MBLS retrieves waypoints. Every time a vehicle crosses a waypoint it has to send location update packet to its level 1 location server. This location server updates the level 2 server and the later updates location server located in level 3. In the query process, source node has to send the query to a location server in level 1. If the location server finds an up-to-date entry, it replies to the queried node. Otherwise, it forwards the query to level 2 and location server in this level follows the same process and forwards it to a higher level server which is level 3. Update and query process may assist in reducing control overhead on the network. Nevertheless, the limitation of MBLS selecting location server based on waypoint cannot guarantee a convenient location for the selected server, because the selected waypoint is based on random location, not reliable location. Criterion for selected location server is based on the distance to waypoint. The selected node could move in high speed during the time of selection. As a consequence, re-election of a new location server is needed within a short time, which requires exchanging extra control packets.

2.4. Quorum-Based

Vehicular Quorum Location Service protocol (VQLS) [18] designed for an urban area topology that utilized a quorum concept for constructing location servers. VQLS exploited two criteria: the distance of nodes to intersection center point and the speed of nodes in selecting the Main Location Server (MLS) by using Fuzzy Inference Engine (FIE). The chosen criteria would ensure the selection of a stable node that would stay for a longer time at the intersection. Additionally, MLS at the intersection was responsible for constructing a quorum group by nominating a number of nodes passing through the intersection from different directions. The constructed quorum of servers distributed the load of updating and answering queries on multiple servers at a dense intersection. VQLS showed a better performance in reducing control packets overhead and distributing the load on multiple servers in dense areas of the vicinity of an intersection.

2.5. Technical Features Comparison of Location Service Protocols

Figure 2 depicts the taxonomy we draw after reviewing the existing location service protocols. The taxonomy shows the

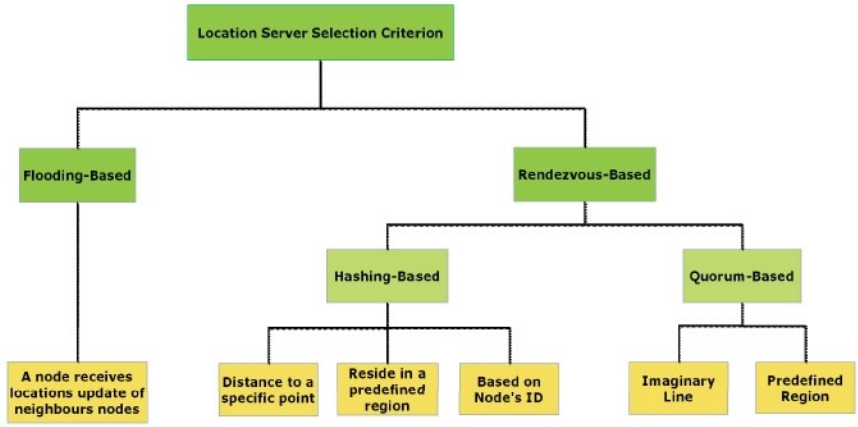

Fig 2. Taxonomy of Reviewed Location Service Protocols Based on Location Server Selection Criterion

method followed for selecting location server among reviewed protocols which is important to address the limitations in those protocols and find a new method for nominating location servers. The taxonomy shows the distribution of reviewed VANET protocols under the classification of location service protocols that shown earlier in Figure 1. Most of proposed protocols are under flooding-based and hashing-based classes except one under quorum-based protocols branch where using imaginary lines in selecting location server under quorum branch need more intention in research. Additionally, the taxonomy shows that current protocols use either a position inside a pre-specified region as a place for selecting location server or based on node's ID. The discussion about these issues is presented in this section with support of technical features details comparison in Table 1.

The home region of the selected location server is necessary due to its effects on location server functioning. The parameters used to nominated eligible node to serve as a location server are important and play a major role in selecting a reliable location server.

A number of location service protocols proposed for VANET select home regions for location servers based on random points on the map; for example, MBLS. However, this does not ensure a reliable home region in term of available nodes that guarantee high connectivity. On the other hand, other protocols, for instance, ILS and RSLS, select the intersection as a home region for location servers. However, intersection is suitable for exploitation due to the availability of nodes that increase network connectivity. Nonetheless, a high number of nodes causes limitations represented by high density that increases the load on nominated servers due to the high exchange of control packets among nodes. This load is not considered in ILS and RSLS; moreover, no tests are carried out in ILS and RSLS for control overhead, where it is expected to be high. Furthermore, a high frequency of sending packets increases network congestion, which in turn degrades network performance. Congestion could be affected by the number of transmitters, which increases with the number of nodes. Therefore, the protocol must be scalable in order to perform well in VANET by distributing load across multiple servers and reducing signaling inside dense areas.

Protocols such as MBLS, ILS, and VLS select any node in close proximity to intersection, or random way-point, or simply select the server based on its ID. These metrics do not guarantee the choice of a node that can satisfy its role as a location server for a long period. Selecting a stable node is dependent on the node's position and speed. Therefore, the stability of a selected location server can improve the efficiency of location service protocol. The longer the location server performs in managing nodes' locations, the lower the rate of control packet exchange. This exchange occurs every time a location server moves away and passes a location's table to a newly nominated location server. VQLS protocol chose intersection vicinity as a home region of location servers and distributed the load on multiple servers after selected a stable location server based on its speed and distance to intersection center point. This method reflected on performance of VQLS that showed a better performance in reducing control packets overhead and distributing the load on multiple servers in dense areas of the vicinity of an intersection.

3. CONCLUSIONS AND FUTURE WORK

Selecting best location servers in challenge environment like VANET need to consider many factors such as node moves with low mobility or high mobility the location on map dense with nodes or sparse. All these issues affect the perf

TABLE 1: TECHNICAL FEATURES OF SELECTING LOCATION SERVERS

Protocols \ Features	Location Server Selection Features			
	Region of Main Location Server	**Parameters for Selecting Location Server**	**Functions of Location Servers**	**Class of Protocol**
Cache-Based (Chang et al., 2010)	Guideposts nodes around the network	A node receives locations update of neighbours nodes	• Managing Locations • Answering queries	Flooding-Based
ILS (Chang and Wu, 2008)	Intersection	Node's ID	• Managing Locations • Answering queries	Hashing-Based
VLS (Xiang-yu and Jiang, 2009)	Specified regions	Distance to specified regions	• Managing Locations • Answering queries	Hashing-Based
RSLS (Guoqing, 2009)	Intersection and bus station	Node's ID	• Managing Locations • Answering queries	Hashing-Based
HLRSG (Chang, 2010)	Centre of the grid region	Node in nearest intersection to the centre of grid region	• Managing Locations • Answering queries	Hashing-Based
RLSMP (Saleet et al., 2009)	Every cell in grid regions	Resides inside the cell	• Managing Locations • Answering queries • Failure recovery	Hashing-Based
MBLS (Boussedjra,2009)	Waypoints in sub-regions	Closest to waypoint	• Managing Locations • Answering queries	Hashing-Based
VQLS (Zaki et al, 2013)	Intersection vicinity	Speed and distance by FIS based on realistic information	• Managing Locations • Answering queries • Load distribution • Prediction	Quorum-Based

location server due to number of nodes increases connectivity but overhead increases also. High mobility cause rapid change in nodes locations which causes outdated locations stored on location servers. Therefore, we conclude that selecting location server with low mobility in area provides good connectivity with most or all nodes on map. Additionally, selecting number of suitable location servers in dense areas to load the balance and avoid failure of location servers. For future work, we aim to extend this study to include other algorithms required in location service protocols such as query and update algorithm.

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