GB-KNN-WI: Group Based K-NN Queries Processing in MANETs with Wireless Integration

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Abstract— **The huge, successive and rapid advancement in technology in recent years played a major role in peoples' everyday activities. GPS-enabled devices have become ubiquitous and location-based services (LBS) are equally so. The LBS is considered among the prominent application for Mobile Ad hoc Network (MANET). In fact, observation of a node to issue K Nearest Neighbor (K-NN) queries is commonly found in the location-based services.**

Although among wireless researchers, MANET is gaining momentum because of its significant advantages. However MANET has some limitation that is the key challenging in designing system protocols such as limitations on network bandwidth, resource consuming problem and mobility. Among all these limitations, mobility has the most significant effect on routing protocol performance.

Mobility of nodes is categorized into entity based or group based. In entity mobility each node moves irrespective of each other. Group mobility has shown that nodes of the same group move in a similar moving behavior. As such, several mobile ad hoc networks applications are based on group mobility.

However existing solution for K-NNs queries is based on single node's mobility. Recently Group mobility has been utilized to improve performance and increase scalability routing. Moreover, deployment of several access points in the ad hoc network resulted in the enhancement of the connectivity.

Thus, to overcome the aforementioned limitations, this paper is proposing a novel method, namely Group Based K-NN Queries with wireless integration (GB-KNN-WI). The proposed method is to process a K-NN query in MANETs by combining group mobility based model with wireless integration to enhance the connectivity and resource consuming. In this method, MANET is divided into groups. And the groups are then treated as a single node, thus, resulting in the exchange of K-NN query between groups rather than single nodes. Thus, avoiding the problem that arises from the resource-consuming of nodes, and will speed up the packet delivery. Each group has a leader that is a central point in a group and responsible for communication with other group. Hybrid routing protocols are utilized. In order to increase the connectivity, the group leader has the ability to connect to wireless infrastructure in case that there is no connectivity with other groups.

According to the comparison and contrast of previous work related to group mobility and integration networks the proposed method is a promising solution to mobility limitations in MANET.

Keywords- Group mobility, Hybrid Wireless MANET Networks, Hybrid routing protocols, KNN query, Location Based Service (LBS)

I. INTRODUCTION

With the development of location detection technologies and the proliferation of smart phones, location based services (LBSs) have attracted considerable attention. The term location based services is literarily considered to comprise of those services that integrate mobile devices location and/or position, with other information thereby providing added value to the users. LBSs are primarily used in military and government industries, emergency services, and the commercial sector [1]. In general, LBS is viewed as a growing research field that focuses on providing technological advancement in geographic information system (GIS) and spatial information through mobile and field units, since an important trend in recent years is the availability of LBSs. With the availability of global positioning systems (GPS), it is easy to precisely figure out the location of the user [2].

In LBS, a node issues K Nearest Neighbor (K-NN) queries [3-6], that look for the information from specific point. Example application is to find the K-Nearest pizza places with a gas station on the way. One of the typical areas that K-NN query can be applied is Mobile Ad hoc Network (MANET) [7].

MANET is an independent system of mobile nodes connected by wireless links with no basic support [8]. In MANET system, every node works as routers and hosts. The significant advantages of MANET due to multi-hop, infrastructure-less transmission have made the system to have a renewed interest among researchers [9].

There are different routing protocols in support of MANETs. These protocols can be categorized based on their features into Reactive (on-demand), Proactive (table driven), and Hybrid Routing protocol [10-15].

In proactive routing protocol, single or several routing tables in every node is maintained so that information regarding another nodes in the MANET could be stored. In these protocols, the routing tables are updated either occasionally or due to change in network topology. Hence, maintaining the most updated data in the protocols is ensured.

Among the advantage of these protocols is its connection time efficiency due to the ability of the source node to identify a valid path to a destination node without route discovery procedure. Unfortunately, substantial messaging overhead is required in this protocol so that an up-to date routing table could be maintained. This incurs high usage of bandwidth and power, while decreasing the protocol's output especially in a protocol of highly active mobile nodes.

Similarly, on demand routing protocols are initiated by reactive-source. In the event of sending data packets between the source node and the destination, this kind of initiated on-demand routing protocol are normally responsible for discovering the optimal path to the destination node. Once the route is discovered, it is maintained until either it becomes no longer needed or it is difficult to reach the destination. Among the merit of such protocols is low requirement of overhead messaging. However, delay in discovering a new route is reported to be among the drawbacks of these protocols [16].

Geo-routing protocols are one of the most adaptable solutions for MANET [17]. Geo-routing [18] are reactive protocols that relied on the nodes' physical location in the network. Therefore, each node uses either GPS or some other location service to determine its location. So, the location of the destination is usually determined by the sender using a location service, while at the same time including the location in the destination address packet. Two aspects determine the routing decision in this protocol. These are: i-the position of the destination within the packet and ii-the forwarding nodes neighbor's position. The starting or updating of routes is not significant in position-based routing. This is because the storage of routing tables and overhead message transmission is not compulsory in this routing. The mentioned characteristics denoted the possible scale-up of geo-routing protocols.

However, each category has its advantages and disadvantages. In order to obtain an efficient protocol that is less prone to drawbacks, the hybrid routing protocols blended the various types of routing protocols including their adaptation into a single domain as cited by Terminodes [19]. LANMAR [20], GeoLANMAR[17] are some example of routing protocols, which attempt to balance between the reactive and the proactive protocols in an effort to enhance the performance of the system.

A number of unique features and requirements apprea, such as network bandwidth limitations since the medium of the communication is wireless, and changes in dynamic topology resulting from the node movements have made MANETs to be differentiated from conventional wired and wireless infrastructure type networks [21]. Another important constraint is energy due to the mobility of the nodes in nature [9]. Among these characteristics, perhaps the most critical attributes in MANETs is node mobility [21]. It plays a noticeable role in the development of MANETs and is used for studing the performance of ad hoc network protocols [22].

Mobility of nodes in MANET are usually grouped into two model categories: entity mobility or group mobility [23]. Entity mobility is used in simulating the movement of each individual that move independently among each other. Random Walk Mobility model [24] and the Random Waypoint Mobility model [25] are the most common entity mobility models. Group mobility models are designed to simulate the group movement that has similar moving behavior. Reference Point Group Mobility Model [26], Reference region Group mobility model [27] and Virtual Track Based Group Mobility Model [28], are among popular group mobility models.

In previous reference [21], authors have identified three obstacles from mobility: path breakage, topology control traffic overhead and long lasting disconnections. In path breakage: as nodes change position the last path fails. Many approaches have been proposed to overcome this problem. The first approach to prevent Path breakage deals with the predicting the possible time of link breakage within the path (link prediction), thus, computing a possible backup. Another approach is called Associative Based Routing. This routing approach chooses a path to connect common motion nodes, e.g., they travel. The use of geo-routing is considered as the third approach. In this approach, notion of path or that of direction to destination does not exist. There is the existence of high mobility in geo-routing approach preserved the integrity of forwarding by allowing the intermediate nodes to forward to destination in the absence of controlled stable path.

Moreover one of the common ways to combat mobility is to refresh the routing table very frequency. However, more often this leads to setbacks such as reduced performance from high overhead. In an attempt to provide solutions to the refresh problem, Fisheye State Routing (FSR) approach was developed [29-30]. In this approach, different exchange period per different entries within a routing table greatly minimized routing update problem. Additionally, there is a precise propagation of smaller scope nodes entries into the neighbors with the highest frequency.

The third challenge is the long term disconnections that happened due to low density and mobility. Several approaches are attempted to reconnect the network when MANET becomes partitioned. In [31] some extra nodes deployed to enhance the connectivity while in Message ferrying approach, special node called Message ferrying used to that relay packets between network partitions [32].

In order to process k-NN queries in MANET, all these challenges must be taken into account. Komai et al [33] proposed a novel kNN query method called filling area (FA) . This particular type of query hunts for the *K* nearest nodes, so as to minimize traffic while getting a fairly high level of correctness within MANETs results. Within the FA strategy, once a K-NN query is given by a node, it procures data items that have been reserved by nodes inside a specific area. This is a circular area with the actual node coordinates representing the circle's center point. Following this, the nodes respond with both original data as well as cached data items. This response is the query result, while circumventing replies, from the same node, by any messages that might be overhearing. In order to attain a minor search area, nodes linger at adjacent objects if they find allies next to them. Furthermore, nodes create a cache of all data items in proximity. In specific, nodes, which cache other data values, move away from the *data boundaries*, and at the same time, locates themselves farther away from the non-essential locations, and then they forward the items to nodes closest to the location associated with the node data. Authors showed results that proved their method to have minimized traffic than others. Their query result reached high accuracy. However, experiments showed that the performance of this strategy decreases due to a high number of link disconnections and high node mobility.

From the above mentioned information some researchers consider mobility as an enemy due to its responsibility of damaging and disruption in the ad hoc network; however, in the reality of this situation, mobility can also be positively exploited to improve the performance. Group mobility can be employed to obtain more scalable routing [21]. This could explain the prominent reason why many applications of mobile ad hoc networks are based on group mobility especially in those cooperative scenarios such as disaster recovery, during war situations, those visiting local fairs and even search and rescue operations [34].

Group mobility has several advantages over single mobility. Since we each group can effectively be viewed as a single node, packet exchange takes place between the individual groups rather than a single one. The problem of resource consumption could be much alleviated, while at the same time speeding up the packet delivery. Moreover, in group mobility there is an assumption that nodes moving together bear same behavior. This result in a more often connected topology within the group [35].

However occurrence of groups with small radius or coverage could result in the network disconnection [36]. In order to expand the coverage area and provide better services to sparse network and long distance communication integration between MANETs and IP micro mobility protocols can be used. Routing in a hybrid network is said to follow different strategies [37]. MANETs routing protocols are largely employed in maintaining route inside MANET. Additionally, there is no need for access points to connect with others. A detailed survey concerning addressing the protocols problems by new approach of integrating MANETs with the internet was reported [16]. Three of the main classifications of Routing in a hybrid network are mentioned in literature [38].

Fig.1 depicted the first strategy where ad hoc routing protocol is applied in the hybrid network, making the infrastructure network as a static ad hoc [39-40]

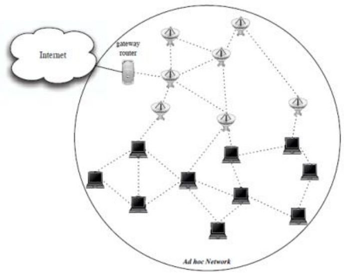

Figure 1. Unipolar hybrid architecture [38]

The second strategy (Fig. 2) involves the hybrid network splitting into two entities, namely, the infrastructure and ad hoc [41-42]. An ad hoc routing protocol is the chief protocol that takes care of the routing issue within the ad hoc network. Similarly, Cellular IP that is responsible for the routing of the ad hoc nodes within the infrastructure network, provides the micro-mobility support needed. Cooperation of the two routing protocols, Cellular IP and the ad hoc protocol, requires some modifications in their functioning.

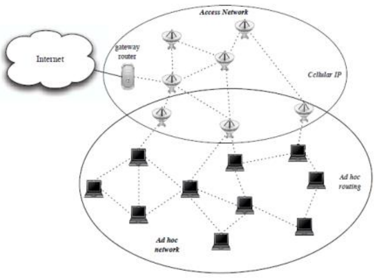

Figure 2. Bipolar hybrid architecture [38]

In the third strategy (Fig. 3), utilizing the ANA addressing architecture made it possible for the segmentation of the hybrid network in some logical sub-networks to be enabled. Thus, allowing for the application of different routing schemes. Among the existing several sub-networks, one of them links the infrastructure network, while the rest are linked to the Base Station that largely relied ad hoc nodes [43].

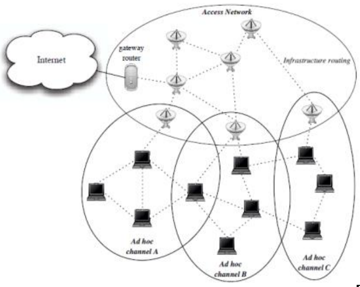

Figure 3. Multi-polar hybrid architecture [38]

From the given information our paper proposes a new method to process a K-NN query in MANETs. In particular, we would like to discuss Group Based K-NN Queries Processing with Wireless integration (GB-KNN-WI) so as to address the above concerned issues including: achieving high connectivity that will affect positively on the accuracy of the query results, improving resource consuming, reducing overhead traffic exchange and speed up the packet delivery. In the proposed method individual group is treated as a single node by assuming all the group members inside to be closer to each other. Each group will keep only one copy of data rather than each node. The problem of resource consuming in MANET can be extenuated. Each group has a leader (GL) that is a central point in a group and responsible for communication with other group. When a node inside a group issues a K-NN query, it forward it to a GL that regulates and concludes if its cached data items fulfil the K-NN, otherwise GL forward the request to other GLs within a specific region rather than to each node.

GB-KNN-WI is two layer routing schemes, including local and global group routing. Destination-sequenced distance vector (DSDV) [44] routing scheme handle the packet delivery inside the group and geo-routing [18] to exchange packets between groups. In the proposed method the geo-routing scheme provides less update that is needed for advertisements as well as trustable forwarding for global routing. In local group the routing is done using DSDV to speed up the packet delivery inside the group.

In MANET, low density and mobility may result in disconnection between groups [21]; each GL will have the privilege and ability to access the internet in case that there is no connectivity with other groups (Fig. 4). All GLs are considered to be robust, with high specification. There are two network interfaces in each GL, one to be used in ad hoc while the other for the internet.

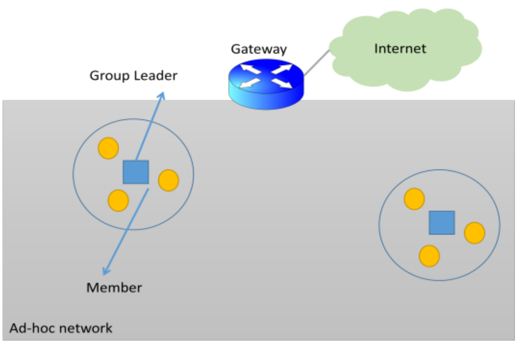

Figure 4. GB-KNN-WI Architecture concept

In general, our contributions are as follows:

- Processing K-NN query in MANET using group based model in order to reduce resource consuming, speed up the packet and improve the scalability.
- Integration between MANETs and Wireless are utilized to increase the connectivity between groups in MANET and therefore increase the accuracy of query results.
- Only GL has the facility to connect to wireless thus reducing the network traffic and time for each node to be registered.
- Using hybrid routing scheme to stabilize the tradeoff amongst both proactive and reactive routing protocols and improve the performance.

The paper also include: section 2 that includes literature review on KNN query processing, group mobility and wireless integration with MANETs. Section 3 is about the proposed method. Section 4 shows discussion, section 5 is conclusion.

II. RELATED WORK

A. Location-Dependent Data Management in LBS

In [45], for sensor networks the authors proposed data dissemination protocol based on a line. The field is divided into two parts by vertical virtual line. Sinks distribute the appropriate data to objects inside a vertical virtual line, and as such, those nodes hunt for data items in that area. Note that this method does not carry the burden of processing the kNN queries, nor does it address the duplication of location data.

In [46], the authors suggested the Skip-Copy method, which manages location-dependent objects in MANETs. This technique relies on distribution of copies of the location-dependent mobile objects sporadically, while the objects request access to a single location-dependent node.

In [47], the researchers offered a scheme which offers LBS. In this offering, the system consumes a mobile agent that resides within a definite geographical region, while staying within mobile nodes in that specific region.

B. K-NN Query Processing

In [48], the authors projected a technique for resourcefully obtaining K-NNs from mobile query points. This technique adopts the idea that the data of all static objects (such as certain building structures) has been hitherto acquired. This technique has a benefit of decreasing the search costs for disk access in databases, for when the query object is in motion and the K-NN results are in a state of alteration.

In [49], the researchers proposed Continuous All k-Nearest Neighbor (CAkNN), as being those queries that uninterruptedly classify all nodes' adjoining neighboring nodes, and projected a novel 'Proximity' technique for competently computing these types of probes in smart phone networks. This algorithm tends to labor resourcefully within areas that are being covered by a group of connectivity points in the network. Adding to that, every node is required to recurrently account for its positional data to the query processor.

In [50], the authors recommended a process to uninterruptedly observe K-NNs within a wireless sensor network. Sensors identify objects that are in motion nearby within the target area, and the sensors pool resources to constantly observe the K-NNs from the original query location. Nonetheless, as the process accepts that the sensors are statically arrayed, it does not apply to MANETs.

In [51], they suggested a K-NN approach for MANET. Using this approach, a node ends up flooding a query to all other objects in a certain circular region around the original query location, and the answer is redirected back from each object accepting the query. As such, this scheme can circumvent flooding within the full network. Unfortunately, the search object is not location-dependent data items; rather, it is k nearest node.

In [52], the authors offered a K-NN query processing technique for a pure mobile P2P environment. Within this notion, the nodes cooperate in responding to the query, and procure K-NNs with significantly lower communication cost of those required by centralized methods.

C. Group mobility

In [20] authors have proposed a routing protocol used in wireless ad hoc networks described as Landmark Ad Hoc Routing (LANMAR). This routing protocol combines the ideas of Fisheye State Routing and Landmark routing. The routing update overhead is significantly condensed by utilizing landmarks for each set of group-mobile nodes. Similar to FSR, exchange of link state occurs only between neighboring nodes. Those routes that are within fisheye range are accurate, and the corresponding landmarks summarize the routes to remote groups. A packet that is initially directed to a landmark in remote destination is switched to accurate route as it gets closer to the destination by the Fisheye.

In [17] authors employed the use of table-driven routing in local area and geo-forwarding in a hybrid combination in order to minimize the update overhead in flat link-state protocol.

The framework introduces a combination between the location data and table-driven IP addressing. Thus, leading to a proposed protocol, described as Geo Assisted

Landmark Routing (GeoLANMAR) joins geo-forwarding with IP for group management. This protocol inherits similar apparatus of LANMAR routing, in that it facilitates group management with the advantage of enhanced long distance forwarding scale-up of the geo-routing protocol.

In [35] authors proposed a routing system known as group-epidemic routing that is based on one delay-tolerant network protocol described as epidemic routing (ER). Here, two methods associated with the features of the group mobility were used to efficiently improve the routing mechansim. Firstly, each group is treated as a single node. Secondly, buffer sharing within a group that is based on the collaboration characteristic of group mobility.

Where there is significant node movement within an ad-hoc network group, another method was proposed with the focus on networks that are disconnected [53]. Distributed group membership protocol is used to identify groups, then followed by the group level routing as opposed to routing at the node level. However in this method nodes are grouped based on their physical location. Moreover this method is not K-NN query processing.

Similarly, in another study [54], a new routing protocol was developed to address disconnected ad hoc networks within which, majority of the nodes tend to travel in clusters. The method used a perfect mechanism to organize members in order to identify groups, and then followed by routing at the group level, instead of the object level. To increase the ration of delivery, a managed replication method has been used.

Additionally, in another study [55], authors proposed a clustering method for Delay Tolerant Mobile Networks. The main point here is the distribution of nodes with semi behavior into a cluster to allow sharing assets for reducing overhead and load balancing.

D. Integration

Various methods can be used for routing in hybrid network. In [39] authors proposed expansion to the Optimized Link State Routing protocol, entitled FAST-OLSR. It differs from OLSR in the functionality of Neighbor Discovery that adopted to deal with fast mobility. In FAST-OLSR, objects that move quickly are enabled to immediately identify a small percentage of neighbors, thus resulting in efficient neighbor discovery.

A new architecture described as Heterogeneous Wireless Network (HWN) was proposed [40]. The proposed architecture conglomerates ad hoc networks with cellular networks, in conjunction of a new routing protocol, Dynamic Adaptive Routing Protocol. Moving objects are effective given ubiquitous access in this method. Additionally, QoS guarantees are are provided by DARP as a further support to the hybrid network.

Alternatively, UMTS network was proposed to augment the capacity, and it is a hybrid of ad-hoc networks and traditional cellular networks [42]. Using this approach, provided that a user is within the cellular coverage area, a direct contact between the objects and the base station is preserved. In a situation where the user is out of the base station’s coverage, network reception is no longer conceivable. As such, the objects attempt to initiate an ad hoc network inside UMTS, or, in an effort to guarantee coverage, they may even join a pre-existing network.

In [43] the hybrid network is divided into one infrastructure and several ad hoc zones with various routing methods can be applied. In each ad hoc sub-network, routing is done using an ad hoc routing protocol. In the infrastructure sub-network, a cellular IP (CIP) protocol is in charge of managing down- and up-going infrastructure routes to ad hoc mobile nodes. The interface between these routing protocols is performed by each Base Station which behaves as a Gateway for ad hoc nodes and exports ad hoc node location in the infrastructure using the CIP protocol. Base Stations participate to both the ad hoc and the CIP routing.

In [56] authors presented an architecture named common gateway that uses several access points and sending data through the closest access point. These access points have common address space. In addition, they are connected to one gateway that runs AODV routing protocol. An RREQ message is send by a gateway to each access point in order to figure out the route to any node. In reply to the received RREQ, the destination refers the message to the gateway, which leads to the formation of the route from the gateway to the final target. It is worth noting that in this approach, the route with minimum hop count is selected by the gateway. When the gateway receives an RREQ message, it uses the access point to send an RREP message that transmits the RREQ message to the gateway. In case of route loss, it will be replaced using AODV protocol.

In [57] authors used a source routing protocol to propose a method for the coupling of MANET with Mobile IP. Utilizing a border router that carries two interfaces, the authors were able use DSR protocol to piggyback to the internal gateway of the internet, while, at the same time, using normal IP routing mechanisms was used to configure the interface. The internet side is configured using traditional IP routing while DSR protocol is employed within MANET. The external agents are in control of creating a connection to the Ad Hoc network with the Internet.

A source routing protocol that can integrate MANET with mobile IP was proposed [57]. In their study, the authors presented a border router bearing two interfaces. One interface is involved with routing internally on Internet gateways of the Ad Hoc networks utilizing DSR protocols, while the other interface uses normal IP routing to connect to the Internet. Using this process, home addresses are given to moving objects in an Ad Hoc network from a single network using traditional IP routing. The Ad Hoc network is connected to the Internet by using foreign agents. Others developed a novel protocol entitled Efficient DSD. [58] According to this framework, one of the nodes is used as a Mobile Internet Gateway (MIG) that serves as a bridge between the networks. The MIG is multifaceted, running both the Eff-DSDV protocol and ensuring effective transfer of packets between MANET and Internet by guarding the addressing mechanisms.

Finally, in another study [16], the authors proposed another framework that integrates cellular IP access network and MANETs. The frame work consists of: 1- several MANETS of either mixed or separated. 2-Access points with Cellular IP base stations running AODV protocol via wireless interface. These have connection to other IP nodes and gateway by wires. 3- IP nodes and gateway establish the forward data from/to the Internet and for mobile nodes. 4- Mobile nodes communicate with internet using IP home address.

The existence of numerous hops in between objects and the base station in the integrated protocol is common. Additionally, MANETs can be coincided in such a manner that an apparent boundary between the MANETs is difficult to exist, and several base stations can send a beacon signal and be received by the object. Unfortunately, the ordinary movement detection algorithm commonly employed in Cellular IP is inadequate in the current suggested method. Hence, another method for detecting movement was devised based on the total hop count between the objects and base station. An alteration to the regular Cellular, an IP handoff scheme is proposed including Modified hard handoff (MHH) and modified semi-soft handoff.

III. The Proposed Solution (GB-KNN-WI)

This section presents the proposed method for processing K-NN query using group mobility model. It includes the group structure, local and global group routing schemes and the integration mechanism between MANET and WLAN through group leaders.

A. Group Arrangement

In group mobility, nodes are grouped based on their action. [26]. Thus, earlier determination of the group is usually under taken before joining the network, with almost same members in the group. For example, when dealing with disasters, medical staff of the same team are kept together. Second, and before group formation, the group leader is determined in group mobility. In this proposed method, 3 nodes are described:

- Mobile Nodes
  Are the basic ad hoc network, running DSDV [44]. They make up the members of the groups. Each member inside the group has an internal ID.
- Group leader(GL)
  Each group has a leader with an ID that represents the group ID. Group leader has the facility to connect to the gateway. Thus each group leader has dual interfaces, the first for ad hoc and the second for the gateway. GL runs hybrid routing scheme (DSDV [44] for local group routing and Geo-routing [18] for global group routing) for the ad hoc interface and Mobile IP for the gateway interface. Only GL has the facility to connect to wireless thus reducing the network traffic and time for each node to be registered [59].
- Gateway
  All GLs share single gateway node. This gateway is connected to each GL and it has an internet interface connection, and manages the IP addresses. It is running Mobile IP. It is forwarding packets between any GLs. This gateway should have connection to both the Internet and the MANET.

Since there is only one gateway, it addresses may be preconfigured in each GL.

Fig. 5 shows the main protocol stacks for group leader, gateway, and mobile node.

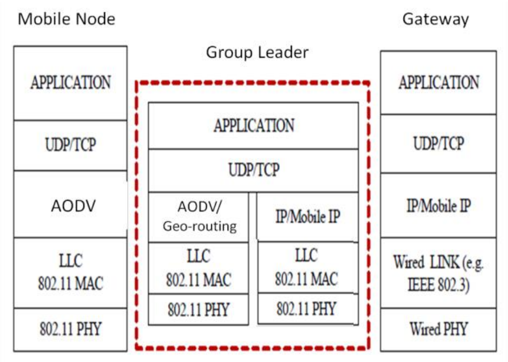

Figure 5. Protocol stack for MANET connection with internet

B. *Local Group Routing*

Here, a packet generated by any member of the group is routed to the Group leader. When a data item is generated by a node, it sends it forward to the leader that preserves this data. The local group packet is sent to the leader using the local group routing. As the relation between group members is intimate, that will lead to maximum connection; any routing protocols may be applied. However assuming the distance between groups is a mere number of hops, utilizing the table driven protocol is preferable. In this proposed method DSDV [44] is adopted for local group routing.

C. *Global Group Routing*

Here, a local group packet is sent to the closest neighbor groups. Different from the single entity model, which floods each packet to each node, the proposed method distributes a packet to every group instead off separate node. So by handling same group members as an individual node, each group may keep a replicate of each packet. Thus avoiding the problem of resource consumption.

When a group, which holds original data pieces, exit the data boundaries, d, with an away from the data location, the original item is conveyed to the groups closest the data point, which is the distance to the data point less than the threshold d. The global group packet will be exchanged between Group leaders by Geo-routing.

When a GL issues a K-NN query, the query is flooded within a specific circle region. If a GL that received the K-NN query is in close area within the K-NN circle, it sends the information on its group to the query-issuing GL using the same path through which the original query message was sent.

D. *K-NN Processing*

In the proposed method we extend and modified the K-NN processing method in [33] that deal with single entity to be suitable for group based model. Whenever a member requests a K-NN query, the query is forwarded to the GL. The GL disseminates the query to groups within the *search range*, which is simply a circular region with the coordinates of the group leader at the center. Group leaders respond to the query by returning data items expected to be in the kNN set. The details of the process are as follows:

1. The query-issuing member postulates the requested number of K-NNs, K, and then proceeds to forward it to its group leader. The GL then decides if its cached data items C is satisfying the K-NN query means K<=C. If it is doing so, the query issuing GL can then complete the search. If this does not happen, the GL, who requested the query, ultimately requests cooperation from other group leaders to obtain the kNN result.
2. The query that is issued GL, calculates the search region radius, S, by using K, C, the radius of group's area r_G and the radius r_C of the farthest C data item the GL maintain it in its C data items using the following equation:

$$S = \beta . r_G . r_c . \sqrt{\frac{K}{C}} . \quad (1)$$

Where β is a parameter that represents the density of data items.

3. The query issuing GL then continues to inundate the search region with a K-NN query request in order to use the geo-routing method. This message contains GL's ID, the remaining K (K'), S, and the location of the query issuing GL.
4. The query issuing GL calculates WT (waiting time) for replies, by :

$$WT = S/r_c . \quad (2)$$

5. Each GL that received the message sends a reply message and information on its group to the nearest GL from the query issuing GL if it is within the estimated K-NN circle
6. Each GL that receives the reply message update the K-NN result included in the reply message, by adding the information on its group.
7. When the waiting time has passed, if the quantity of collected data items is more than or equal to k, then the search has finished, otherwise the GL reestimates S by decreeing β and repeats the same process. Of course, this should not continue indefinitely; an upper limit is placed on the potential repititions.

E. *Integration*

Most of existing solution of processing K-NN query in MANET is restricted as solo networks. However one of the most critical characteristics of MANET is mobility that could cause continuous link disconnection. To overcome this problem group mobility based model is used since members of each group are considered related.

However, it has been reported that the occurrence of small group radius or coverage resulted in automatic disconnection of the group mobility network [36]. In order to expand the coverage area and provide better services to sparse network and long distance communication integration between MANETs and IP micro mobility protocols are used. Whenever a GL lose the connection with other GLs or the acquired K-NN is less than the desired number, GL can connect to the gateway. The GL send a gateway route request message. Whenever the gateway gets the request message, it transmits route reply message back to the mobile node with IP address. GL sends a massage with the needed information with estimated search area centered on the gateway location. Gateway sends ('broadcasts') the request to all GLs. The same procedure will be followed.

IV. Discussion

Recently LBSs have attracted considerable attention due to rapid advancement in GPS and wireless communications technology. In LBS, one of the popular queries is K-NN query. This query retrieves the k nearest data items that are related to this location from the coordinates of the one issuing the query. K-NN is a typical application for MANET, as it poses different attributes from sensor networks or traditional wired networks. These variations make utilization of the existing K-NN processing methods that are centered on a centralized server not pertinent in MANET. As such, the main task at hand is in designing system protocols for MANETs, which include reducing resources consuming, limitation on network bandwidth, and link disconnection due to node mobility. In literature several proposed solutions exist to overcome these limitations. One of these solutions is group mobility model that is designed to simulate the movement of the group that has similar moving behavior.

As mentioned earlier, most of the MANET applications are based on group mobility especially in those cooperative settings. Group mobility has several advantages over single mobility. For example, in group mobility packets are exchange between groups as opposed to individual nodes as every group is treated to be individual. Thus, speeding up the connection and delivery time, while reducing the resource consuming problem. Moreover, the assumption of possession of similar mobility behavior due to group movement by some nodes in group mobility resulted in the topology within a group been kept connected most often.

Several studies showed the outperformance of group mobility based protocols [17, 19, 20, 35, 53-55]. For example, the performance of group mobility studied by extensive simulations and showed that protocols based on group mobility model outperformed others in different scenarios [35]. The GeoLANMAR protocol integrated group management with hybrid routing scheme and showed scalability improvement by decreasing overhead than standard Landmark [17].

In order to expand the coverage area and provide better services to sparse network and long distance communication, integration between MANETs and IP micro mobility protocols may be used. Recently, myriads of methods for combining MANETs with wireless infrastructure are presented [16]. Two types of gateways (mobile and fixed) are used for combination procedures. Few authors have examined the solution of using multiple access point in one ad hoc network [56].

Others have tested group and single node mobility strategies when nodes change their current network [59]. They proved the effectiveness of group mobility strategy via simulation results and story lines, and mathematics. Results showed that group mobility strategy highly influence the reduction in messages overhead, network traffic and time for each node to be registered.

Our presented method is a proposal to solve the advantages faced from the aforementioned methods in the literature. The idea is to combine both group mobility model and integration MANET with wireless infrastructure. This will result in utilizing the advantages of group mobility model; namely: reducing the resource consuming problem, speed up the packet delivery, and the topology within a group will keep connected most often. Furthermore, getting advantages from the integration MANET with wireless infrastructure; namely: to expand the coverage area and provide better services to sparse network and long distance communication. Thus the presented method will expand on the advantages, while narrowing the spectrum of disadvantages. In our future work, we are planning for setting up a set of simulation with different network scenarios.

V. Conclusion

Location-based services have gained a huge attention for the recent years because of the benefits they provide. One of the popular LBS is K-NN query that can be considered as a typical application for mobile Ad hoc network. MANET has various characteristics than fixed network. It has additional challenges resulting from their inherent mobility.

This paper proposed a K-NN query method that is based on group mobility model with advantages including: 1) enhance the connectivity, 2) limit resource consuming problem, and 3) speed up packet delivery. Moreover in order to guarantee high connectivity, the proposed method has the facility to connect to the gateway. According to the comparison and contrast of previous work related to group mobility and integration networks the proposed method is a promising solution to mobility limitations in MANET. Extensive simulation with different network scenarios is to be part of our future work.

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