Network Platform for Location-Based Network Applications in MANETs

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Abstract—Until now, network applications are developed based on the TCP/IP network model which is intrinsically based on stationary wired networks. Here, the socket interface is the most widely used API (application program interface). However, due to widely available mobile wireless computers, location-based network services are required to be developed, e.g. location-based advertisement and query for sensor data. In order to support development such applications, novel API and network platform are required. This paper proposes an API for location-based network applications by which the destination of transmission is specified by its location and a network platform supporting such applications on ad-hoc networks adopting a location-based routing protocol.

I. INTRODUCTION

Due to widely available wireless communications and mobile computing technologies, wireless multihop networking becomes to be expected. MANETs (Mobile Ad-Hoc Networks) provides higher availability supported by location-transparent connectivity based on wireless multihop communication with ad-hoc routing in spite of higher mobility of wireless nodes. In addition, node identification is also important to realize communication among nodes. As various mobile wireless nodes gets popular, various network services are developed. Especially, according to location acquisition technologies, location-based network applications and services becomes attractive. Here, data messages are required to be transmitted to wireless nodes specified by their locations. However, currently available network platforms do not well support such location-based applications since they are designed for conventional wired networks with stationary nodes. This paper proposes a novel network platform dedicated to location-based applications in MANETs. By combination of location-based ad-hoc routing and application program interface (API) for location-based network applications by which destinations of data messages are specified by their locations, not only performance of application development but also execution performance of location-based applications in MANETs are expected to be improved.

II. RELATED WORKS

In the conventional TCP/IP Internet technology based on wired networks, nodes, i.e. computers connected to the Internet such as servers and clients (terminals), are identified by their IP addresses intrinsically independent of their geographical locations. For data message transmissions, their destinations are specified by the IP addresses and their routing protocols such as OSPF, RIP and BGP are designed to best fit to treat the IP addresses. The most widely used application program interface to TCP/IP Internet communication is the socket interface [3]. In order to describe data message transmission between nodes in an application program, a socket is created by an primitive socket() which returns a socket identifier. Sending of a data message is described by a send() primitive whose parameters are the socket identifier, an IP address of a destination node and a transmitted message; i.e., send(socket_id, destination_address, message). On the other hand, receipt of a data message is described by a receive() primitive whose parameters are socket identifier, an IP address of a source node and a received message; i.e., receive(socket_id, source_address, message).

In wireless multihop networks such as MANETs, wireless sensor networks and mesh networks, data messages are transmitted by using wireless multihop transmissions. Data messages are transmitted from a source wireless node to a destination one along a wireless multihop transmission route consisting of a sequence of intermediate wireless nodes which forward the data messages. For wireless multihop transmissions, various ad-hoc routing protocols such as AODV, DSR, TORA and OLSR have been designed [10]. In these protocols, each wireless node is specified and identified by its identifier. Hence, source and destination nodes are required to be specified by their identifier, e.g. their IP addresses, and the socket interface can be used in description of application programs.

Not only fundamental but also the most important property of mobile wireless nodes in MANETs is their locations which are changed by their mobility. Recently, location-based network services are widely discussed and are expected to provide their customers novel value. For example, location-based advertisement of shops and stores are expected to achieve higher effectiveness against its cost since explicit and implicit (potential) uses and customers are tend to be geographically maldistributed. Hence, data messages containing their sales information are required to be destined to some specific locations (areas or ranges). In sensor networks, gathering sensing data achieved within a specific area are often required. Hence, a query message is transmitted from a user terminal to wireless sensor nodes in the specified area. As shown in these examples, messages are required to be transmitted to destination wireless nodes specified not by their identifier but by their geographical locations. That is, GEOCAST [8] is...
required to be available in MANETs supporting location-based services.

Different from the above mentioned ad-hoc routing protocols which are based on flooding of route request control messages or continuous exchange of control messages to maintain routing tables based on up-to-date network topology, location-based ad-hoc routing protocols have been developed and improved. GEDIR [6] and Compass [5] are greedy location-based ad-hoc routing which may achieve shortest wireless multihop transmission route though they might cause dead-ends. Face [1] and GPSR [4] are guaranteed delivery ad-hoc routing which are dead-end-free but may suffer longer transmission delay due to detour wireless multihop transmission route. In these location-based ad-hoc routing protocols, it is required for each intermediate wireless node to achieve the location of the destination wireless node for determination of its next-hop wireless node. In other words, these protocols can be applied to transmit data messages to wireless nodes in a specified geographical area.

### III. PROPOSAL

It is difficult for combination of conventional ad-hoc routing protocols based on flooding of route request control messages and the socket application program interface designed for stable networks, e.g. wired networks, composed of stationary nodes to support location-based services in mobile wireless networks. Although a set of destination wireless nodes are required to be specified by an area where they are included, the socket application interface requires to specify the destination nodes by their IP addresses. Hence, a translator (or a resolver) to achieve an IP address from location of an area is required. For mobile ad-hoc networks, various location services such as HRLI [7], DREAM [2] and ABLA [9] have been proposed. Most of these location services are mainly designed to achieve location information of mobile wireless nodes by their identifiers such as IP addresses and the reverse translation is not explicitly supported. Since HRLI and some others are fully or partially centralized services, i.e. one or multiple location servers provide the translation service, it may be possible to provide the reverse translation. However, since DREAM and ABLA provides the translation in fully distributed manner, it is difficult to provide the reverse translation with reasonable communication overhead. After achieving a set of IP addresses of the destination mobile wireless nodes in the specified area, data messages are required to be transmitted through the send primitive invoked multiple times, i.e. transmitted to the destination nodes one by one in unicast. It requires redundant transmission of copies of the data messages since most of the intermediate mobile wireless nodes are shared by all the destination nodes located in the specified area. Moreover, in order to route a copy of data message to each destination node, a route detection procedure based on flooding is required in case of no cash entry in a source and/or intermediate nodes.

For avoidance of the communication overhead for flooding, introduction of the location-based ad-hoc routing protocols is effective. However, in an application program, location information of each destination mobile wireless node is required to be treated explicitly. That is, both location to identifier translation for invocation of the send primitive and identifier to location translation for routing are required, which is obviously redundant.

In order to solve this problem, this paper proposes a network platform for location-based network applications in MANETs. Here, data messages are routed by location-based ad-hoc routing protocols and a set of destination mobile wireless nodes are specified by an area; i.e. a location information.

#### A. Platform Architecture

In order to avoid the redundant translation between location information and identifier of destination mobile wireless nodes for addressing and routing to support location-based services, this paper proposes a wireless network platform in which location information is used in both addressing and routing and no translators (resolvers) are introduced. In an application program of a source wireless node of data messages, the destination is specified by an area determined its location information; i.e. longitude and latitude. The specified location information is directly transferred to the location-based routing for data messages without any translation or resolution. Data messages are routed by using the specified location.

As discussed in the next subsection, the destination is specified not by a point of location but by an area (or a region). Thus, there may be one mobile wireless node or
multiple wireless mobile nodes, or even no wireless mobile nodes in the area. Anyway, the data messages are required to be transmitted to the area; however, most of the location-based ad-hoc routing protocols require to be provided the location information of the destination location which is a point strictly though the destination is specified by an area in an application program. This problem is easily solved by introduction of the representative point of the area; e.g. the center of gravity of the area as shown in Figure 4. Now, without modification, the data messages are expected to reach one of the mobile wireless nodes in the destination area if it exists by using the location-based ad-hoc routing protocols.

![Fig. 4. Data Message Transmission to Representative Point in Area.](image)

**B. Application Program Interface**

Since the proposed platform architecture requires no address resolution for data message transmissions in location-based services, required! application program interface consists of only send() and receive() primitives. However, as discussed in the previous subsection, since the destination is specified not by identifiers of destination mobile wireless nodes but by location information of an area including the destination nodes, the area may contain multiple mobile wireless nodes. Hence, a location-based application program is required to specify that the data message is transmitted to ALL the mobile wireless nodes in the area or ANY one of them. That is, request for broadcast (ALL) or anycast (ANY) should be described in an application program.

![Fig. 5. Broadcast and Anycast.](image)

There are various location-based services and they are classified into the following categories: oneway services and query-reply (client-server) services. In the former, only oneway transmissions of data messages are required as shown in Figure 6(a). Advertisement of some location-based information to nodes in the specified area is the representative service. On the other hand in the latter in Figure 6(b), a query message (or copies of the query messages) are transmitted to mobile wireless nodes in the specified area same as in the oneway transmissions. However, for transmissions of a reply message (or multiple reply messages), its destination should be specified by the identifier of the source node of the query message. Thus, an application program in the receiver mobile wireless node requires to achieve the identifier of the source node and to specify the destination of its reply message by the identifier. According to the considerations, we design the following application program interface; i.e. send() and receive() primitives.

**[Send Primitive]**

Send (destination_area, destination_ID, Delivery_Type, message) where destination_area is location information of destination, destination_ID is destination ID for reply message to which NULL is assigned in a oneway data message and a query message and Delivery_Type for multicast (ALL) or anycast (ANY).

- destination_area: location information of destination.
- destination_ID: destination ID of reply message.
- Delivery_Type: multicast (ALL) or anycast (ANY).

**[Receive Primitive]**

Receive (source_location, source_ID, message) where source_location is location information of source node and source_ID is source ID for reply message.

- source_location: location information of source.
- source_ID: source ID for reply message.

In order to available these primitives to application programs, the platform (library functions) embeds the current location information and identifier of the source node into the header in a data message.

**C. Implementation**

Data message transmissions specified by our proposed application program interface is implemented in the network platform based on the location-based ad-hoc routing.

For oneway data message transmission, the destination_area is specified but the destination_ID is NULL. If Delivery_Type is ANY, data message is transmitted to one of the mobile wireless nodes in the destination area. As discussed in subsection 3.1, data messages are routed as if the representative point in the destination area is the destination point though there may be no mobile wireless nodes at that point. When the data message is routed to one of the wireless nodes in the area, transmission procedure terminates. On the other hand, if Delivery_Type is ALL, copy of data message are propagated in the destination area by restricted flooding.
For query-reply data message transmission, a query message is transmitted same as oneway data message transmission. However, a reply message is required to be transmitted differently from the query message. Since the destination of the reply message is specified not by its location but by its identifier, destination ID in the send() primitive should be specified by the source node ID of the query message achieved through the receive() primitive. However, the underlying wireless multihop network is based on location-based routing protocol, destination area is also required to be specified. Here, to reach the reply message to the destination node, the destination area should include the current location of the destination node. In addition, independently of Delivery_Type, if destination_ID is specified, the data message is transmitted to all mobile wireless nodes in the specified area same as in the case that Delivery_Type is ALL. In mobile wireless nodes receiving this reply message, according to the result of comparison between its own identifier and the identifier specified in the message header, it only receives the message only in the case that these identifiers are the same.

In order to evaluate the effect of the introduction of the proposed location-based network application platform, the authors develop two simple application programs. One is for location-based advertisement applications and the other is for location-based query-reply applications. In the former, a data message is distributed to all the mobile wireless nodes in the dedicated area which is different from the widely available multicast services where destination nodes are determined by a multicast address. In the latter, a query message is transmitted to a server node which is in the dedicated area, i.e., the server node is specified not by its address but by its location, and a reply message is transmitted to a sender client node. In both programs in the conventional method, translation from location information to an IP address is required and should be explicitly described in programs as a function call get_address(location_information). The function returns a list of IP addresses of mobile wireless nodes which is in the specified area. In the advertisement application programs, a data message is required to be transmitted to all the nodes by repetition of a message sending function call which implement unicast transmission of a data message. In the query-reply application programs, a query message is also required to be transmitted to all the nodes in the area since it is impossible to detect an IP address of a server node. On the other hand, in our proposed location-based wireless network platform, only one message sending primitive is required to be called since a data message is transmitted to all the wireless nodes in the specified area due to the underlying location-based platform including the proposed API and the location-based ad-hoc routing protocols.

Table I shows the results of the evaluation. In both advertisement and query-reply application programs, our proposed API and platform reduces the numbers of lines in the programs, i.e., it is expected that shorter development period and higher quality are provided by our proposed method than the conventional one.

<table>
<thead>
<tr>
<th></th>
<th>Proposed</th>
<th>Conventional</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advertisement</td>
<td>57</td>
<td>115</td>
<td>50.4%</td>
</tr>
<tr>
<td>Query-Reply</td>
<td>73</td>
<td>231</td>
<td>78.4%</td>
</tr>
</tbody>
</table>

V. CONCLUSION

This paper has proposed a wireless multihop network platform and an application program interface for location-based services based on location-based ad-hoc routing protocol. Here, destination of data messages are directly specified by the destination location information in application programs. The application program interface and the network platform supports both oneway transmissions as for advertisement and query-reply transmissions as for sensor data retrieval. Since both of them are location-based, no address resolution mechanism is needed and avoidance of loss of performance is expected.

REFERENCES


