Loop-Based Source Routing Protocol for Mobile Ad hoc Networks *

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1 Introduction

For supporting temporary computer networks for disaster rescue, communication in conventions and conferences, a system consisting of a set of autonomous mobile robots controlled by micro computers, cost and overhead required for construction and maintenance of a wired network infrastructure and base stations are high. In addition, less flexibility is achieved due to a fixed infrastructure. In a mobile ad hoc network (MANET), there is no base station and only mobile computers are connected to the network. Due to a bounded transmission range of a mobile computer m, m does not always exchange a message directly with another mobile computer m'. Thus, all or most of mobile computers are engaged in routing of a message and multi-hop transmission is required to exchange a message between m and m'. Here, a routing protocol for supporting mobility of computers is required. That is, a mobile computer is required to serve a role of router.

Until now, many kinds of ad hoc routing protocols have been proposed such as AODV [4] and TORA [3]. In these protocols, it is assumed that a message transmission range of mobile computers are the same and stable. That is, most of communication links are bi-directional and uni-directional links are omitted in these routing protocols. However, due to limited battery capacity, transmission power of mobile computers is not the same and changes. Thus, if only bi-directional links are used in an ad hoc routing protocol, network connectivity gets lower. Hence, it is required for multi-hop transmission to detect a route including uni-directional links for achieving higher network connectivity. Though DSR (Dynamic Source Routing) [1] and CBRP [2] have this property, communication overhead is high because of using two floodings and membership management, respectively.

The authors have proposed another ad hoc routing protocol LBSR (Loop-Based Source Routing) in which looped routes including a source mobile computer are detected. One of the detected looped routes contains a destination mobile computer. LBSR requires a single flooding and multiple unicast message transmissions and is designed for supporting an environment with many uni-directional communication links. Here, higher connectivity, higher probability of successful route detection and higher cache efficiency are achieved. However, unexpectedly many unicast message transmissions are required. In this paper, 3 additional methods to reduce control message transmission are proposed and the evaluation result is presented.

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2 DSR protocol

In most of on-demand routing protocols, *flooding* is used to detect a transmission route from a source mobile computer S to a destination mobile computer D. Most of wireless communication media on which wireless LAN protocols depend is broadcast-based. A message broadcasted by a mobile computer M is received by all mobile computers within a transmission range of M. Suppose that a mobile computer S broadcasts a message *mes* to all mobile computers in a transmission range of S. If each mobile computer M_i which receives *mes* broadcasts *mes* to all mobile computers in a transmission range of M_i, all mobile computers with which S communicates by multi-hop message transmission receive *mes*. In DSR, in order to find a route from S to D, *Rreq* message is transmitted by flooding. In addition, in order to inform the detected route of S, *Rrep* message is also transmitted by flooding in an environment with uni-directional links.

3 LBSR protocol

In an ad hoc routing protocol using only bi-directional communication links, by detection of $R_{S\to D}$, $R_{D\to S}$ is achieved as a reverse route of $R_{S\to D}$. However, for achieving higher probability of successful transmission route detection between S and D, uni-directional communication links are also used to transmit messages. In DSR as discussed in the previous section, $R_{S\to D}$ and $R_{D\to S}$ are detected independently. In order to solve this problem, in LBSR, by combining detection of $R_{S\to D}$ and of $R_{D\to S}$, S detects a looped route $R_{S\to D} + R_{D\to S}$ containing both S and D. This is realized by flooding of a control message *Lreq* and detecting a copy of the *Lreq* which is initiated by S, forwarded by D and received by S. While searching the looped route, S finds other looped routes which contain not D but S. These routes are used to reduce communication overhead caused by broadcast transmissions. If a mobile computer on an already detected looped route receives an *Lreq* message, it does neither broadcast nor discard but unicast the *Lreq* message to a next mobile computer on the looped route. By using this method, the copy of *Lreq* message is surely transmitted to a source mobile computer along the looped route without broadcast transmission. In order to achieve this unicast transmission, if a source mobile computer receives an *Lreq* message, i.e. a new looped route is detected, a confirmation message *Lconf* is transmitted along the looped route. Since the *Lconf* carries a sequence of addresses of mobile computers on the looped route, the *Lconf* is source routed and each mobile computer on the route gets an address of a next hop mobile computer to transmit future receiving *Lreq* messages to the source mobile computer.

In [5], the number of broadcast messages is reduced and higher successful route detection probability is achieved. However, unexpected number of unicast messages are required. In this paper, 3 additional methods are introduced to conventional LBSR in order to solve this problem.

[Piggybacking *Lreq* messages]

In conventional LBSR, when a mobile computer which blocks some *Lreq* messages receives an *Lconf* message, the mobile computer forwards the *Lconf* message and the *Lreq* messages, respectively. For reducing unicast messages, the *Lreq* messages are piggied back to the *Lconf* message in a novel protocol.

[Omitting redundant *Lconf* transmission]

A source mobile computer detects multiple looped routes until it finds a looped route containing a destination mobile computer. In the process of the looped route detection, a source mobile computer finds a looped route which is part of the others. In this case, there is no need to transmit an *Lconf* message along the looped route. Hence, in our protocol, a source mobile computer does not transmit an *Lconf* message if it receives an *Lreq* message that contain a sequence of addresses of mobile computers each of which is included in an already detected looped route.

[Initiating *Lconf* by intermediate mobile computer]

An *Lconf* message is transmitted along a newly detected looped route to inform a next hop mobile computer of each mobile computer on the looped route for a future *Lreq* unicast transmission. In the conventional LBSR, an *Lconf* transmission is always initiated by a source mobile computers S. Hence, if an intermediate mobile computer M_i on an already detected looped route receives an *Lreq* message, the *Lreq* message is forwarded to S and S initiates an *Lconf* transmission. However, M_i achieves a sequence of addresses of mobile computers on the newly detected looped route by combining sequences of addresses carried by an already forwarded *Lconf* message and by the received *Lreq* message. Hence, an *Lconf* transmission along the newly detected looped route is initiated and terminated by M_i not S. Here, transmission of an *Lreq* message from M_i to S is omitted.

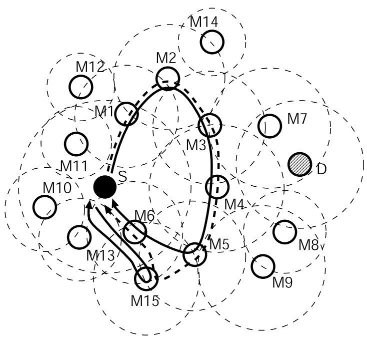

Figure 1: Omitting redundant Lconf transmission.

4 Evaluation

This section discusses performance evaluation of the extended LBSR comparing with DSR and LBSR.

Figures 3 shows a simulation result for evaluation of number of control messages. Here, a simulation area is 500m × 500m and a distribution of diameters of a wireless transmission range is uniform between 20m and 200m. Here, the number of total messages in the extended LBSR is only about 40% in the conventional LBSR and only about 60% in DSR. Hence, the proposed 3 methods works well to reduce the number of control messages.

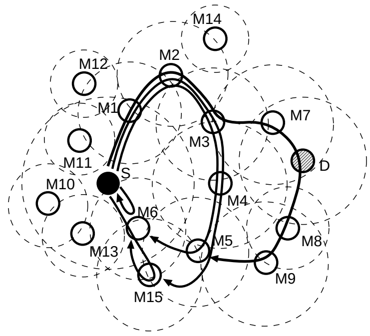

Figure 2: Initiating Lconf by intermediate mobile computer.

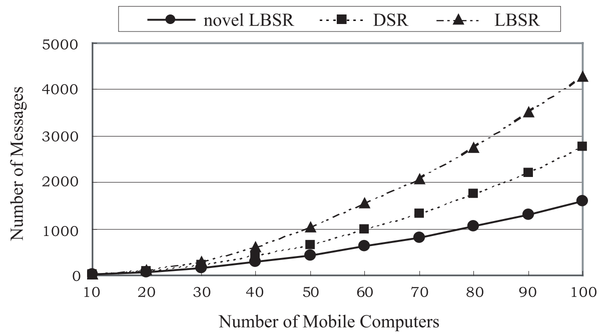

Figure 3: Total Number of Messages.

5 Concluding Remarks

This paper proposed an extended LBSR to reduce unicast control message transmission in the conventional LBSR. In future work, we evaluate our protocol in different metric, e.g. required time to detect a message transmission route.

References

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