Location-based Asynchronous Message Delivery Scheme for Self-Organizing Services under Mobile-Stationary Co-existed WSN*

Tae-Hyon Kim, Hyeong-Gon Jo, Seol-Young Jeong, Soon-Ju Kangt College of IT,

Kyungpook National University, 1370 Sankyuk-dong, Buk-gu, Daegu, Korea

{namestrike, tsana, snowflower, sjkang}@ee.knu.ac.kr

Abstract. Self-organizing services require frequent message exchange among service subscribers because of their natural features. As increasing number of service subscribers, reliable communication is not easy work under the legacy wireless sensor networks environment due to the heavy traffic congestion. We propose three location-based asynchronous message delivery schemes that are designed for supporting self-organizing services under the IEEE 802.15.4 based wireless sensor networks environment. As the characteristics of service requirements, three strategies could be selectable by service provider and user.

Keywords: Self-Organizing Service, Asynchronous Message Delivery Scheme, Sensor Network architecture, Wireless sensor networks

1 Introduction

Recently the rapid development of wireless sensor networks (WSN) has lead to various self-organizing services, for example healthcare services [1, 2] and mobile asset management system [3, 4]. However there are some important considerations for realizing this paradigm in WSN. First, the characteristic and limitation of sensor network; low power consumption and low rate bandwidth can easily limit the network topology and the number of communication nodes in a service. The number of communication nodes can be tens of thousands, but there are no techniques to manage the nodes with stability. Second, supporting the mobility and the location awareness of communication nodes are very important but they are difficult factors in the services. In the situation of heavy traffic and/or frequent movement of nodes, the whole sensor network could easily break down during the actions. Third, for supporting legacy WSN services and minimizing installation expenses, it is necessary to reuse existing network infrastructure; mobile-stationary co-existed WSN infrastructures that were

* This work was supported by the IT R&D program of MKE/KEIT. [10041145, Self-Organized Software-platform(SOS) for welfare devices]

[1.] Corresponding author.

used to monitor environments and routing packets. With minimized modification, it should support legacy WSN services and also a newly massively-mobile service like self-organizing service.

In our previous research [5], we proposed two protocols LIDx and LAMD that guarantee the bidirectional location awareness and the efficient communication of mobile nodes in the mobile-stationary co-existed WSN environments to support location based asynchronous communication between service participants. In the proposed WSN environment, each stationary node is installed at the ceiling of a unit space (such as room, floor, kitchen and etc) and it acts not only as the legacy sensor network router, but also a location reference node with the function of the access point that communicates with numerous mobile nodes. In addition, a middleware for the proposed protocols is also implemented into the server-side. The middleware manages the current locations of mobile nodes in real-time, and routes a message from a source mobile node to destination mobile node following to the current location of the destination mobile node. The mobile nodes report its location regularly and notify the current status of the object to the server through the nearest stationary node using LIDx and LAMD.

In this paper, we propose three schemes for LAMD according to transmission methods between destination sensor node and destination mobile node. We named the methods respectively, LAMD-to-Destination, LAMD-to-Parent and LAMD-to-Destination-with-Broadcast. Each method has pros and cons. LAMD-to-Destination is less influenced by congested neighbor network but the hit-ratio of the LAMD rapidly drops down when the destination mobile node moves around so fast the area of stationary nodes. LAMD-to-Destination-with-Broadcast provides the highest hit-ratio but the network can be easily unstable when supporting numerous mobile nodes. The feature of LAMD-to-Parent is in the middle of the two methods. As the characteristics of service requirements, three strategies could be selectable by service provider and user.

2 Activity Model of LAMD

In given devices that are stationary nodes and mobile nodes under legacy WSN, we need to set up proper active and sleep period of radio for guarantee more longer operating time. Figure 1 shows a timeline between mobile node and stationary node which performs LIDx and LAMD with active mode of stationary nodes. It shows that stationary node always turn the radio on for minimizing message transmission delay, on the other hand, mobile node turn on/off periodically to minimizing power consumption. In many cases, stationary nodes could be supported with constant power and/or a large battery, but this is not an option in mobile nodes. As shown in Figure 1, each stationary node periodically sends a beacon packet including the stationary node's ID and mobile nodes collect these beacon packets and select the nearest stationary node's ID using LQI of packets. If the current location of a mobile node has changed, the mobile node sends a LIDx status report packet to the nearest stationary node, so it is updated in the location table of the server. On LAMD time, mobile node sends a

LAMD Request packet to the stationary nodes by unicast. If the stationary node has LAMD messages, it sends the messages to the mobile node. The LIDx period consists of one LIDx time, several LAMD time, and sleep time in middle of LIDx time and LAMD time. These time parameters can be modified by characteristic of provided services.

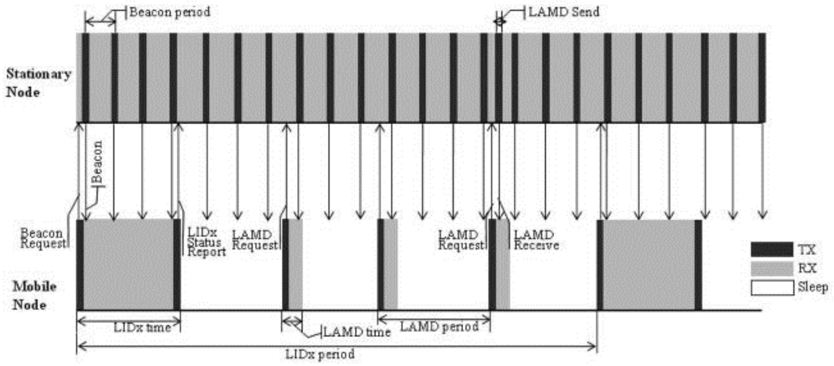

Fig. 1. A timeline of LIDx and LAMD with active mode of stationary nodes

3 Design Schemes for LAMD

We designed three schemes for LAMD according to transmission methods between destination sensor node and destination mobile node. The methods were named LAMD-to-Destination, LAMD-to-Parent and LAMD-to-Destination-with-Broadcast respectively. In LAMD-to-Destination, the destination stationary node just sends messages to the mobile node directly by unicast. It is the basic strategy for LAMD. This method has the merit that the whole network is less influenced by congested neighbor network environment. However, as figure 2 shown, when the mobile node moves from S.8 to S.9 and server needs to send an LAMD packet, the server can't know the real position of the destination mobile node before the mobile node sends new LIDx status report. So the destination mobile node lost the LAMD packet except the communication range of S.8 is reached to S.9.

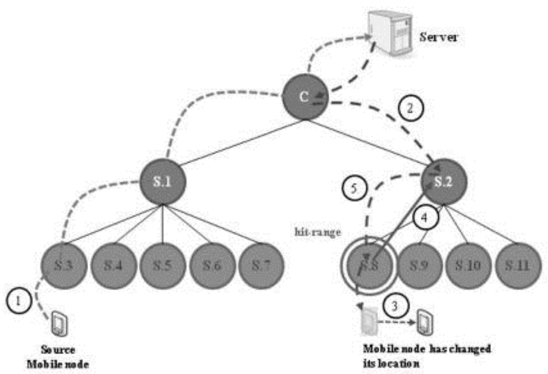

Fig. 2. LAMD-to-Destination Method

In LAMD-to-Parent, the destination mobile node receives messages from logical parent of destination stationary node. As shown in figure 3, when the destination mobile node moves, it requests a message by sending LAMD-Request packet to the destination stationary node and it fetches the message from logical parents and transfers it to destination mobile node. This method takes the advantage of probability of transmission success which is largely affected by the mobility of the destination mobile node. But if mobile node moves to a location boundary like S.11 and S.12, probability of transmission success is not different in LAMD-to-Destination's. And also the transmission delay is higher than the LAMD-to-Destination.

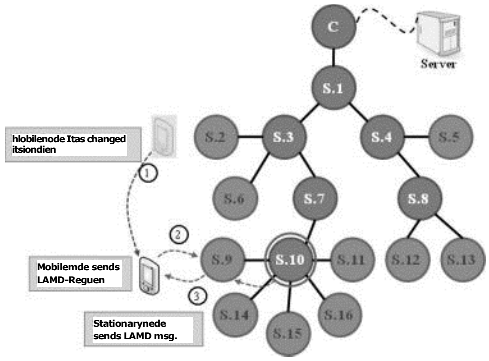

Fig. 3. LAMD-to-Parent Method

In LAMD-to-Destination-with-Broadcast, as figure 4 shows, when the mobile node moves from S.2 to S.9, mobile node broadcast LAMD request packet to neighbor stationary nodes before receiving LAMD messages from destination stationary node. So the server and neighbor stationary nodes of mobile node know the real position of mobile node. If the old location like S.2 is able to receive the broadcasted LAMD-Request packet, stationary node just sends the LAMD packet to the mobile node, otherwise server sends a new LAMD packet to a stationary node that is current location of destination mobile node. Although this method can offer the most correct location of destination mobile node, it can influence the stability of neighbor network and it is not suitable for supporting numerous mobile nodes.

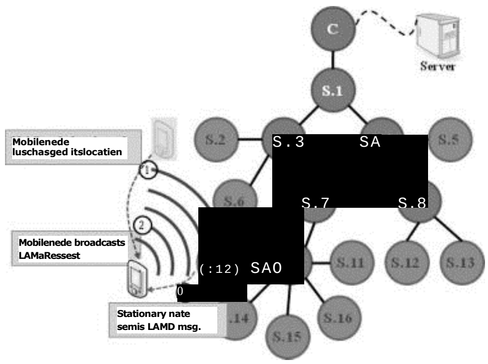

Fig. 4. LAMD-to-Destination-with-Broadcast Method

4 Experimental Evaluation

The stationary node and the mobile node commonly used TI's CC2430 that includes an 8051 MCU Core and a 2.4 GHz RF Transceiver. The LIDx and LAMD was implemented at the top of the IEEE 802.15.4 MAC standard and installed in both mobile nodes and stationary nodes. To measure the round trip time of LAMD depending on the time parameter, the server sends a message to coordination gateway N times. N is the number of mobile nodes. The message is transferred from coordination gateway to destination stationary node by ZigBee. Finally the messages that are stored in stationary nodes are transferred by LAMD to the mobile nodes. The acknowledge messages will be sent to the reverse sequence. We assume that there is no retransmit. Figure 5 shows the experimental results that are the average LAMD round trip time with variation the number of mobile nodes and LAMD period. With 70 mobile nodes, the average round trip time is near 2500 ms when LAMD period is 3s and is slightly above 500 ms when LAMD period is 0.5s. The performance is getting worse following to increasing of mobile node and LAMD period.

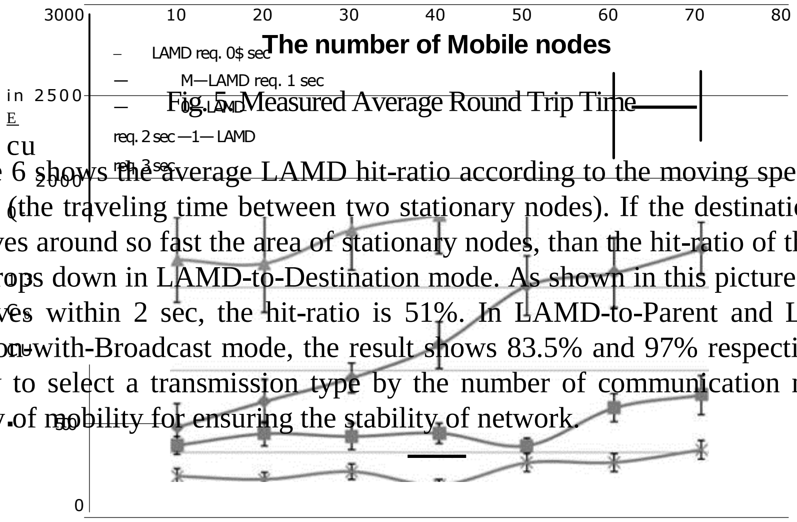

Fig. 5. Measured Average Round Trip Time

Figure 6 shows the average LAMD hit-ratio according to the moving speed of mobile node (the traveling time between two stationary nodes). If the destination mobile node moves around so fast the area of stationary nodes, than the hit-ratio of the LAMD rapidly drops down in LAMD-to-Destination mode. As shown in this picture, a mobile node moves within 2 sec, the hit-ratio is 51%. In LAMD-to-Parent and LAMD-to-Destination-with-Broadcast mode, the result shows 83.5% and 97% respectively. It is necessary to select a transmission type by the number of communication nodes and frequency of mobility for ensuring the stability of network.

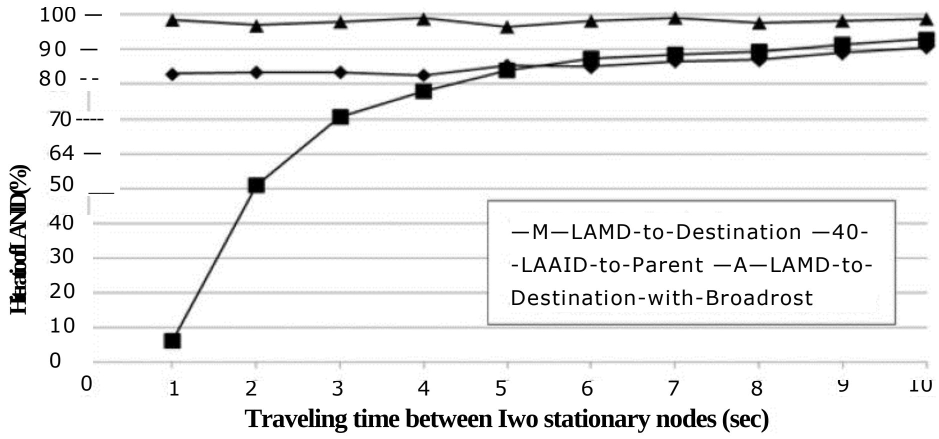

Fig. 6. Hit Ratio Comparison of LAMD Transmission Types

5 Conclusion

This paper proposed three schemes for LAMD according to transmission methods between destination stationary node and destination mobile node. The average round trip time and hit ratio of LAMD were experimentally evaluated in the test bed. LAMD-to-Parent and LAMD-to-Destination-with-Broadcast show better hit ratio than LAMD-to-Destination that is the basic strategy for LAMD. However they influence the stability of neighbor network and it is not suitable for supporting numerous mobile nodes. As the characteristics of service requirements, three strategies could be selectable by service provider and user.

Reference

1. **H.** Alemdar and C. Ersoy, "Wireless sensor networks for healthcare: A survey," Computer Networks, vol. 54, pp. 2688-2710, 2010.
2. P. Kulkarni and Y. Ozturk, "mPHASiS: Mobile patient healthcare and sensor information system," Journal of Network and Computer Applications, vol. 34, pp. 402-417, 2011.
3. Z. Wenfeng, et al., "LBS-Services of Information Integrated and Decision Supported in Logistics Industry," in Wireless Communications, Networking and Mobile Computing, 5th International Conference on, 2009, pp. 1-4.
4. M. C. Rodriguez-Sanchez, et al., "Wireless Sensor Networks for Conservation and Monitoring Cultural Assets," Sensors Journal, IEEE, vol. 11, pp. 1382-1389, 2011.
5. T. Kim, et al., "A Location-Aware Asynchronous Message Delivery for Indoor Wireless Sensor Network Applications," presented at the 2011 First ACIS/JNU International Conference on Computers, Networks, Systems, and Industrial Engineering, Jeju Island, Korea, 2011.