Development of ZigBee Mobile Router for Supporting Network Mobility in Healthcare System

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***Abstract*—In this paper, we propose a Network Mobility (NEMO) based ZigBee Mobile Router architecture and operations for supporting the network mobility of ZigBee network. Also, we present a design and implementation of the ZigBee Mobile Router for healthcare system. The architecture is particularly useful to manage patient's mobility where each patient is equipped with ZigBee sensor nodes.**

I. INTRODUCTION

ZigBee [1] is a low rate wireless communication technology using small, low-cost and low-power sensors based on IEEE 802.15.4 [2] standard. In this paper, we focus on the scheme which supports mobility to ZigBee nodes. In order to provide mobility to ZigBee nodes, we adopt the NEMO (Network Mobility) protocol [3]. If the NEMO is applied in the ZigBee sensor network, even though each ZigBee node does not equipped with mobility protocol, it can maintain connectivity with the Internet through the ZigBee Mobile Router as a network unit. Therefore, the network mobility of ZigBee sensor nodes can be supported by interoperable architecture between ZigBee and NEMO. In this paper, we propose interworking mechanism between ZigBee and NEMO for providing the network mobility of the ZigBee network. Also, we implement the ZigBee Mobile Router for healthcare system.

II. PROPOSED ZIGBEE MOBILE ROUTER

In this section, we describe the architecture of the ZigBee Mobile Router and the interworking mechanism between ZigBee and NEMO. Figure 1 shows a scenario that a ZigBee Mobile Network moves to another network away from home network. In this scenario, some of ZigBee sensor nodes are deployed on a patent's body for medical surveillance. Also, the patient has one ZigBee Mobile Router for supporting the network mobility to such ZigBee sensor nodes. These nodes monitor vital signs such as heart beats or blood pressure rate and temperature information. The patient has the freedom of moving in his room or within the hospital. The sensing data is sent to the Health Management Server periodically.

If the ZigBee Mobile Router moves to another IPv6 network and detects the movement, it creates a CoA (Care-of address) i.e. IPv6 address of the ZigBee Mobile Router at its current Internet attachment point. After that, the ZigBee Mobile Router sends a BU (Binding Update) message to its HA (Home Agent) in order to notify the movement. The BU message includes a proposed ZigBee PAN Coordinator option to inform the ZigBee PAN information. In this case, a ZigBee flag (Z) should be set to notify the ZigBee Mobile Router. At the same time, the ZigBee Mobile Router stores the mobility information in Binding Update List table and establishes a bi-directional tunnel between ZigBee Mobile Router and HA. Upon receipt of the BU, the HA updates the ZigBee Mobile Router's information with ZigBee network, CoA and home address for Binding Cache Entry, and replies by sending a BA (Binding Acknowledgement) message.

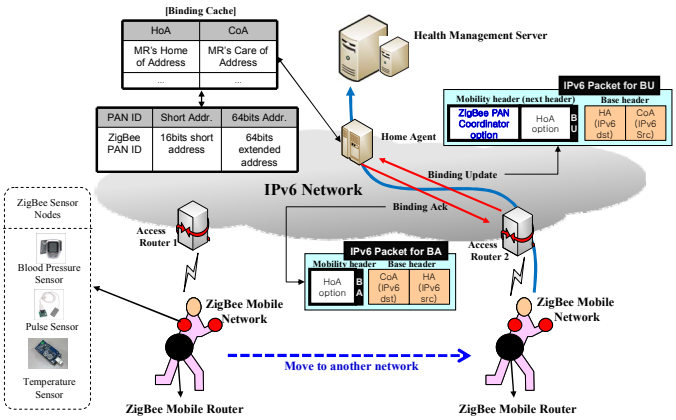

Figure 1. The scenario of interworking between ZigBee and NEMO

Figure 2 shows the architecture of the ZigBee Mobile Router. As shown in figure 2, the translation process from ZigBee frame into IPv6 packet is as follows: If ZigBee nodes send the sensing data packets to the Health Management Server, the ZigBee Mobile Router looks up the IP address mapping table to discover the destination IP-ID of ZigBee frames. The source of the IPv6 packet is the ZigBee Mobile Router, and the destination is the Health Management Server. The Attribute, Sensing Data and Message Type are stored in IPv6 payload. The source address of the ZigBee node is added in the Source ZigBee Address field of IPv6 payload.

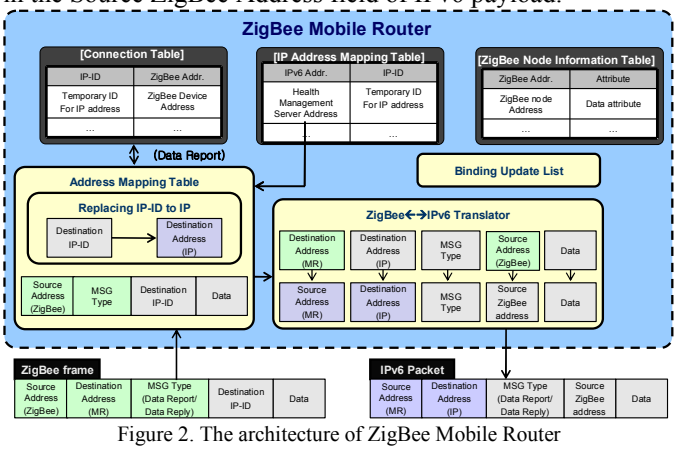

Figure 2. The architecture of ZigBee Mobile Router

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III. IMPLEMENTATION AND TEST

We have implemented IPv6 network and wireless testbed for supporting NEMO protocol. ZIGBEE-NEMO Daemon has been developed for the ZigBee Mobile Router which is implemented in Linux using modified NEPL [4]. The ZIGBEE-NEMO has two major functions: IPv6 packet ←→ ZigBee frame translation module and proposed NEMO protocol for supporting the ZigBee network mobility. We also have implemented a TinyOS [5] based ZigBee communication protocol including the mesh routing module for both ZigBee Mobile Router and ZigBee sensor nodes as shown in figure 3.

Figure 4 shows the testbed for our proposed interworking mechanism between ZigBee and NEMO to apply it in the healthcare system.

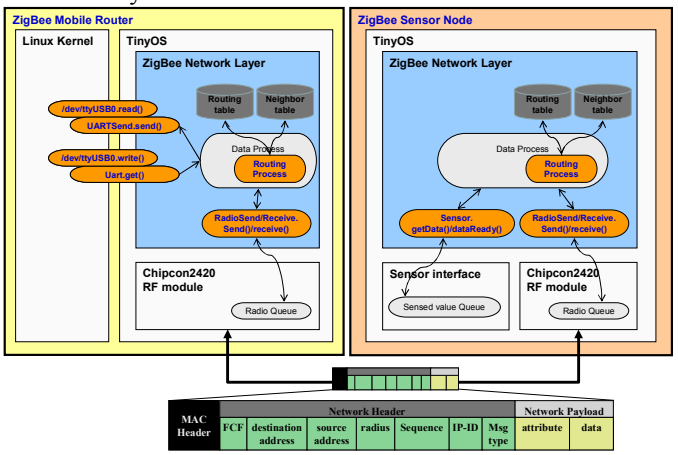

Figure 3. The structure of TinyOS based ZigBee communication module

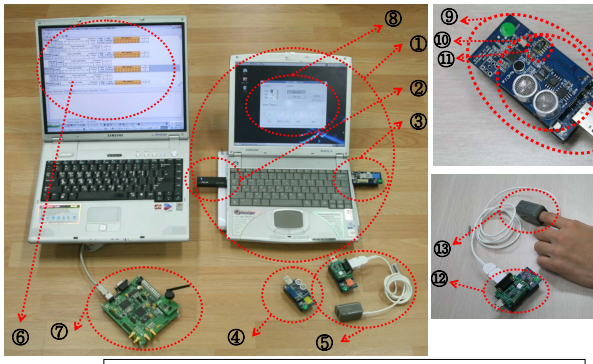

Figure 4. Testbed for ZigBee network mobility

Figure 5 shows the handoff procedure of the ZIGBEE-NEMO Daemon when the ZigBee Mobile Router moves to another link away from home link. With the exchange of binding messages between the ZigBee Mobile Router and its Home Agent, the NEMO based ZigBee Mobile Router completes home registration procedure successfully.

Figure 6 describes the results of the IPv6-ZigBee translation module in the ZigBee Mobile Router. When the Health Management Server requests the data to ZigBee sensor nodes, the ZigBee Mobile Router performs the packet translation operation. IPv6-ZigBee translation module converts the IPv6 request packet into the ZigBee frame and forwards it to ZigBee sensor nodes. After that, ZigBee sensor nodes reply the sensing data to the Health Management Server.

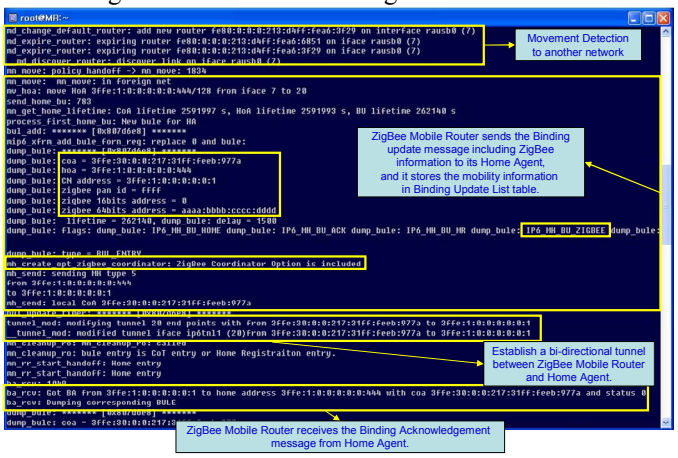

Figure 5. ZIGBEE-NEMO Daemon

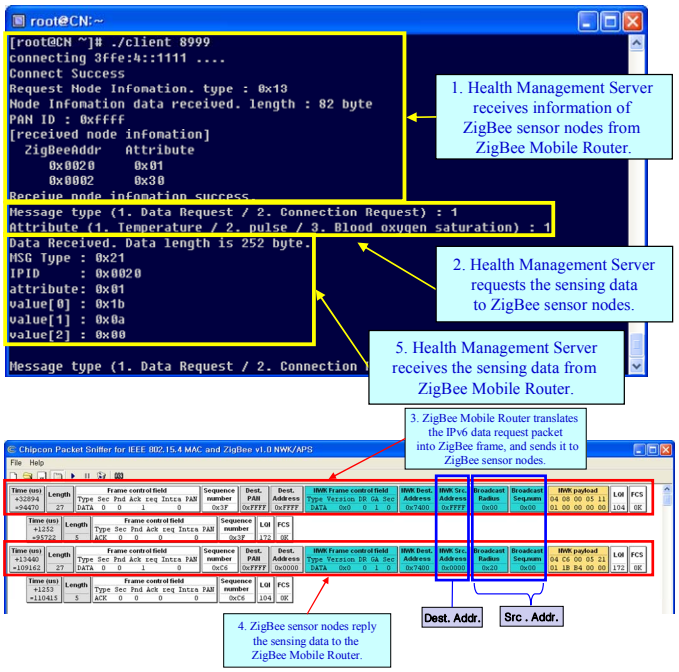

Figure 6. IPv6-ZigBee translation procedure

IV. CONCLUSION

In this paper, we have proposed the interworking mechanism between ZigBee and NEMO for supporting the ZigBee network mobility. Also, we have implemented NEMO based ZigBee Mobile Router for the healthcare system. In our future works, we will evaluate the performance of our proposed mechanism under various mobility models.

REFERENCES

[1] ZigBee Document 053474r13, "ZigBee Specification," Dec. 2006, http://www.zigbee.org/.

[2] IEEE Computer Society, "IEEE Std. 802.15.4-2003," Oct. 2003.

[3] V. Devarapalli, R. Wakikawa, A. Petrescu, and P. Thubert, "Network Mobility (NEMO) Basic Support Protocol," IETF RFC 3963, Jan. 2005.

[4] "NEMO Platform for Linux (NEPL)," http://www.nautilus6.org/nemo/.

[5] TinyOS Community Forum, http://www.tinyos.net/.