Design of a Node Status Visualizing Software Utilizing the AR Technology for Multihop Wireless Networks

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***Abstract*—Along with the growth of the Internet of Things (IoT), the number of wireless devices and mobile nodes significantly increases and they are connected among them over wireless links. Many application software and network system software for these wireless devices/mobile nodes are being developing. However, we cannot confirm a wireless connection between the two adjacent devices, the network topology which consists of these devices, and the node status of a wireless device which is not equipped with the display for a software developer while the software is running. In this paper, we propose the design of a visualizing software to visualize the network topology and the node status by utilizing the Augmented Reality (AR) technology, and then present the demonstration of the prototype development.**

***Keywords*—Network visualization; Visualizing Software; M2M communication; Wireless networks**

I. Introduction

Recently, smart phones which are capable of establishing concurrently cellular connections (4G/LTE) and short range connections (WiFi/Bluetooth) have become popular as mobile nodes. In addition, along with the growth of the Internet of Things (IoT) demands, the demands of a machine-to-machine (M2M) communication among wireless devices considerably increases [1][2]. Mobile application software and network system software have been developing by utilizing these mobile nodes and wireless devices. We also have developed the assessment information acquisition and dissemination system based on mobile nodes and conducted field experiments at the Hiroshima national confectionery exposition [3]. This system mainly utilizes Bluetooth to communicate among mobile nodes (Android terminals) in addition to the cellular connection. However, it is not easy to confirm whether there is a wireless connection between two adjacent mobile nodes in real-time or not when we run the application software on mobile nodes. Therefore, we have developed the system to visualize the network topology and message flow for field experiments using mobile nodes [4]. This system collects the log message such as receipt and transmission of data messages from each node to a log management server, and then the network topology and data message flow are visualized on a display terminal which obtains the collected log messages from the server. In addition, at present, the AR (Augmented Reality) technologies have become popular rapidly and many application software have been developed for various purposes. The visualization for the network application and system which is utilized by the AR technology also have studied [5]. In this paper, we present the design of a node status visualizing software to visualize the status of each node using the AR (Augmented Reality) technology. The application software and network system software can be easily developed and tested thanks to the visualizing software, and it becomes easier to confirm a status of each node such as the wireless connection among the wireless devices in the vicinity of each device and the routing table while running application software and network system software.

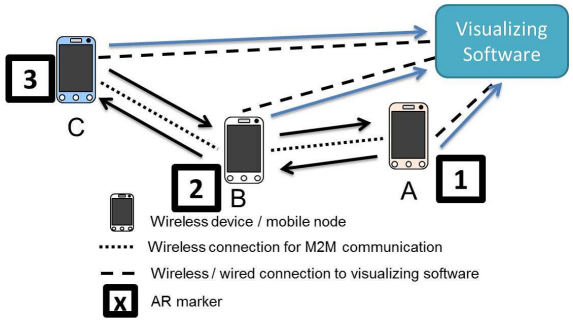

Fig. 1. System overview.

II. Design of a Node Status Visualizing Software

Figure 1 shows the system overview to visualize the node status by the visualizing software. There are three wireless devices with the corresponding AR marker. The visualizing software uses an AR marker to identify each wireless device. The developer can see the visualization of each node status and the network topology through the camera of the hardware such as a tablet which the visualizing software is running on.

Wireless devices are communicated with each other through wireless connection (WiFi/Bluetooth). In Figure 1, nodes A and B, and nodes B and C are within the transmission rage with each other. Each wireless device sends a log message to the visualizing software by using wired connection, WiFi connection (which is different from the above WiFi con-

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nection) or 4G/LTE connection whenever it sends/receives any message to/from another device. The visualizing software displays the node status and the network topology by using AR technology based on the transmitted log messages when the camera focuses on an AR marker. The log message formats designed for the prototype development are as follows.

- "type=SHMSG&&nodeID=192.168.114.xxx&& time=hh:mm:ss.sss"
  It is generated and sent to the visualizing software when node 192.168.114.xxx sends a Hello message at time hh:mm:ss.sss, where h, m, and s are hour, minute, and second, respectively.
- "type=NNL&&nodeID=192.168.114.xxx&& 192.168.114.yyy=hh:mm:ss.sss&& 192.168.114.zzz=hh:mm:ss.sss"
  It is generated and sent to the visualizing software by Node 192.168.114.xxx periodically as the neighboring list. Whenever node 192.168.114.xxx receives a Hello message, it records the node ID (e.g. yyy, and zzz) and the reception time (hh:mm:ss.sss) as a neighboring node and then adds it to the neighboring list.
- "type=RMSG&&nodeID=192.168.114.xxx&& previousID=192.168.114.yyy"
  It is generated and sent to the visualizing software when node 192.168.114.xxx receives a message except for Hello message from node 192.168.114.yyy.
- "type=SMSG&&nodeID=192.168.114.xxx&& nextID=192.168.114.yyy"
  It is generated and sent to the visualizing software when node 192.168.114.xxx sends a message except for Hello message to node 192.168.114.yyy.

III. Prototype Development

We developed the network system software on Raspberry Pi 3 Model B as a wireless device. The device can communicate with each other by using WiFi connection which is run by ad hoc mode, and send the log message to the visualizing software by wired LAN. Each node periodically sends a Hello message to confirm the neighboring nodes, and then makes the list of neighboring nodes. In addition, it can send a data message to the neighboring node. Figure 2 shows the prototype of the node status visualizing software and visualizes the snapshot of a node status at a moment of time. There are three wireless devices as nodes in this figure. This visualizing software is developed by Processing [6], [7]. An AR marker is used to identify a wireless device. The network topology and the list of neighboring nodes of a node are visualized by the log message which the visualizing software collected by wired LANs. The red line denotes the wireless connection. The left node and the center node, and the center node and the right node are connected with each other. The white circle denotes the transmission of a message and gradually becomes larger by animation. The blue arrow denotes a message flow. It means that the data message is forwarded from the left node to the center node. In addition, the center node shows the list of neighboring nodes. In case that the right node moves away, the red line between the center and right nodes disappears as well as the left node is removed from the list of the neighboring nodes of the center node because the wireless connection is disconnected. As a result, we confirmed the effect of the visualizing software by our prototype development.

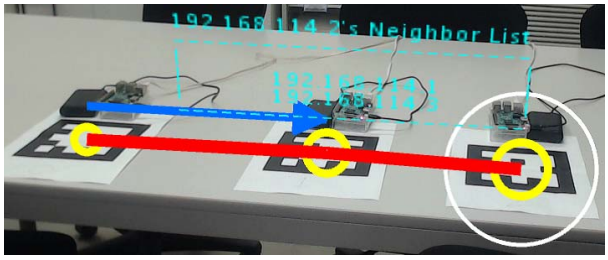

Fig. 2. Prototype of the node status visualizing software.

IV. Conclusion

We have presented the design of the node status visualizing software and the prototype development. As the AR technology can be utilized for the software development of IoT application and system which consists of wireless devices, we expect that many types of software will be developed for the network application and system from now. In the future work, we are planning to develop the visualizing software attempting to visualize the node status in real time and consider how to recognize a wireless device and a mobile node.

ACKNOWLEDGMENT

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