IEEE ISCE 2014 1569946281

Concurrent Bluetooth Module Activation for Reducing the Latency of NFC Connection Handover

Junyong Sim
Mobile R&D, Mobile Communication
SAMSUNG ELECTRONICS
Suwon, Republic of Korea
junyong.sim@samsung.com

Youngjae Lee and Jin-Soo Kim
College of Information and Communication Engineering
Sungkyunkwan University
Suwon, Republic of Korea
yjlee@csl.skku.edu, jinsookim@skku.edu

***Abstract*—In the current NFC connection handover protocol for Bluetooth, it takes impractically long time to make a Bluetooth connection between two devices since the Bluetooth modules of the devices are activated in a serial fashion. In order to resolve this problem, we propose a novel scheme for fast NFC-to-Bluetooth connection. We devise two new handover messages called *Handover Query (HQ)* and *Handover Ack (HA)* for the concurrent activation of Bluetooth modules and revise the current handover protocol to utilize HQ/HA messages. According to the evaluation results, the elapsed time to establish a Bluetooth connection is reduced by about 30%.**

Keywords—NFC; Bluetooth; connection handover; concurrent activation

I. INTRODUCTION

The Near Field Communication (NFC) is a short-range wireless connectivity technology for simple interactions between electronic devices [1]. One of the representative uses of the NFC technology is NFC connection handover, which allows users to make Wi-Fi or Bluetooth connections easily between NFC-enabled devices [2]. Without the NFC connection handover, one should perform manually the certain procedure to make a connection. For example, a user should turn on Bluetooth modules of two devices and explicitly issue requests for the establishment of Bluetooth connections from one device to another. With the NFC connection handover, a user just needs to touch two devices.

However, the current NFC connection handover protocol for Bluetooth has a problem that it takes impractically long time when the Bluetooth modules of two devices are inactive (i.e., the power is off). The time required to make a Bluetooth connection is about six seconds. That means a user should have two devices close together for about six seconds in order to establish a Bluetooth connection between the devices.

The most time-consuming task in the connection handover is Bluetooth module activation which takes almost two seconds. To make matters worse, in the current protocol, the Bluetooth module of each device is activated in a serial fashion. The module in the device that initiates connection handover (called a *Handover Requester*) is activated first. After the activation is finished, the module of another device (called a *Handover Selector*) is turned on. The total activation time of the two Bluetooth modules is about four seconds, which is about 63% of the total connection handover time. If two Bluetooth modules are concurrently turned on, the total connection handover time can be much improved.

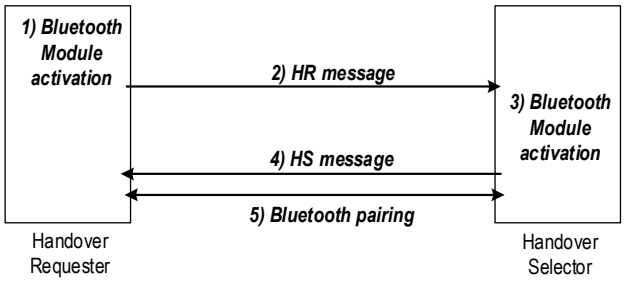

Fig. 1. The current NFC connection handover protocol for Bluetooth

In this paper, we present a novel scheme which activates each Bluetooth module of two devices concurrently. We propose two new handover messages, which are *Handover Query (HQ)* and *Handover Ack (HA)*, for the concurrent activation and revise the current NFC handover protocol to utilize HQ and HA messages.

II. CONCURRENT BLUETOOTH MODULE ACTIVATION

Fig. 1 illustrates the current protocol of the NFC connection handover for Bluetooth. In order to establish a Bluetooth connection, the Handover Requester first activates its Bluetooth module and sends a message called *Handover Request (HR)* to the Handover Selector via NFC communications. The HR message contains the physical address of the Bluetooth module and authentication values. After the Handover Selector receives the HR message, the Bluetooth module of the Handover Selector is activated and a message called *Handover Select (HS)* is sent to the Handover Requester via NFC communications. Like an HR message, an HS message has the physical address of the Bluetooth module in the Handover Selector and authentication values. Then, the Bluetooth pairing is finally performed and data is exchanged over Bluetooth communications.

Junyong Sim is also with the Sungkyunkwan University.

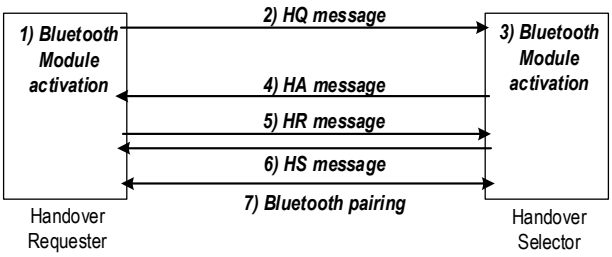

Fig. 2. The proposed scheme for NFC-to-Bluetooth connection handover

The authentication values of the HR/HS messages are defined in the Bluetooth Secure Simple Paring (SSP) protocol [3-4]. According to the SSP protocol, whenever Bluetooth pairing is performed, the authentication values of the HR and HS message are randomly generated by the Bluetooth module of the Handover Requester and the Handover Selector, respectively, due to security issues. Therefore, HR/HS messages can be transmitted only after the corresponding Bluetooth module becomes active. Consequently, in the current NFC connection handover protocol, Bluetooth modules can be activated only in a serial fashion. This is a main reason why the NFC-to-Bluetooth connection handover takes impractically long time.

To address this problem, this paper proposes a novel scheme for fast NFC-to-Bluetooth connection handover. The key idea behind the proposed scheme is to activate Bluetooth modules first before exchanging configuration data (e.g., the physical address of the Bluetooth modules and authentication values) for the establishment of a Bluetooth connection via HR/HS messages. We devise two new messages, a *Handover Query (HQ)* message and a *Handover Ack (HA)* message, and modify the NFC connection handover protocol to utilize HQ/HA messages for the concurrent activation.

Fig. 2 depicts our new NFC connection handover protocol with the proposed HQ/HA messages. In order to initiate NFC connection handover, the Handover Requester sends an HQ message to the Handover Selector via NFC communications and activates its Bluetooth module. After receiving the HQ message, the Handover Selector activates its Bluetooth module. After the activation of its Bluetooth module is completed, the Handover Selector transmits an HA message to the Handover Requester to inform that the Bluetooth module becomes active. Then, the configuration data for the Bluetooth connection establishment is exchanged through HR/HS messages and the Bluetooth pairing is accomplished. In the proposed scheme, as illustrated in Fig. 2, the Bluetooth modules are activated concurrently so that the total elapsed time to make a Bluetooth connection can be effectively reduced.

III. Evaluation

We have implemented the proposed scheme on a reference board [5] for Tizen 2.1 which is an open source platform to support the NFC-to-Bluetooth connection handover. We have measured the time to spend on establishing a Bluetooth connection between two devices by NFC connection handover when the Bluetooth modules of the devices are inactive. Fig. 3 and Fig. 4 depict the detailed operations of the current protocol and the enhanced one with our proposed HQ/HA messages,

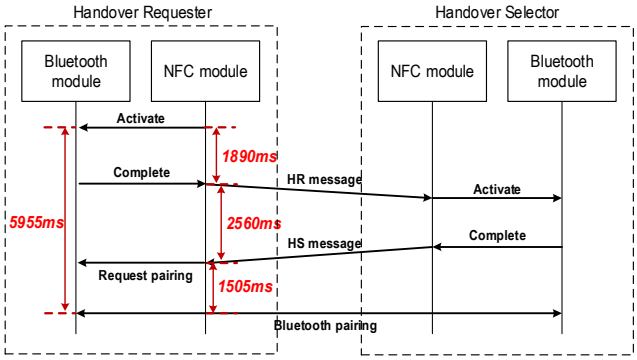

Fig. 3. The elapsed time of the current protocol

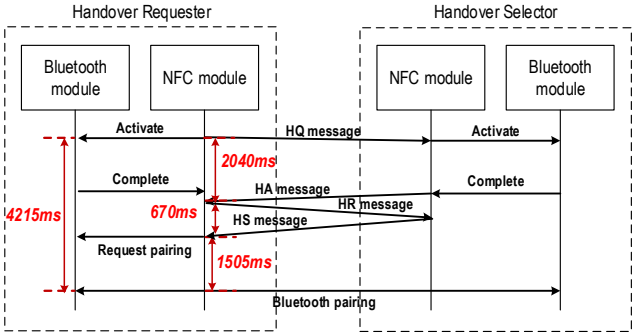

Fig. 4. The elapsed time of the proposed scheme

respectively, and also show the elapsed times. We can confirm that the proposed scheme reduces the total elapsed time by about 30% as Bluetooth modules are concurrently activated.

IV. Conclusion

In order to reduce the latency of the NFC connection handover for Bluetooth, this paper presents a novel scheme to activate Bluetooth modules concurrently. We propose two new handover messages, called HQ and HA, and revise the current NFC handover protocol to utilize HQ/HA messages. We have implemented the proposed scheme on Tizen 2.1 and observed that the time required to make a Bluetooth connection is decreased by about 30%. As future work, we plan to improve the proposed scheme to consider the various contexts of Bluetooth modules for more effective connection establishment.

V. Acknowledgments

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea Government (MSIP) (No. 2013R1A2A1A01016441). This work was also supported by the IT R&D program of MKE/KEIT (No. 10041244, SmartTV 2.0 Software Platform).

References

[1] NFC-Forum. NFC-Forum homepage. http://nfc-forum.org, 2006.

[2] NFC Forum, “NFC Connection Handover 1.2 Technical Specification”, NFC Forum , 2010.

[3] NFC Forum, “Bluetooth Secure Simple Pairing Using NFC”, 2012.

[4] Bluetooth, S. I. G. "Bluetooth specifications 1.0-2.1+ EDR. Technical specifications”, 1999–2007

[5] Reference Device-PQ – Tizen Wiki, http://wiki.tizen.org/wiki/Reference_Device -PQ