

# A Feasibility Study on the Safety Confirmation System Using NFC and UHF Band RFID Tags

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**SUMMARY** This letter presents the safety confirmation system based on Near Field Communication (NFC) and Ultra High Frequency (UHF) band Radio Frequency IDentification (RFID) tags. Because these RFID tags can operate without the need for internal batteries, the proposed safety confirmation system is effective during large-scale disasters that cause loss of electricity and communication infrastructures. Sharing safety confirmation data between the NFC and UHF band RFID tags was studied to confirm the feasibility of the data sharing. The prototype of the proposed system was fabricated, confirming the feasibility of the proposed safety confirmation system.

**key words:** safety confirmation system, disaster, NFC, UHF band RFID tag

## 1. Introduction

We have experienced several large-scale earthquakes in Japan, which brings attention to the need for preparing diverse safety confirmation methods. During large-scale earthquakes, we are likely to lose electricity and communication infrastructures. Therefore, collecting information about residents and providing disaster information without depending on infrastructure are desired [1]. We have proposed the electronic signboard based on Ultra High Frequency (UHF) band Radio Frequency IDentification (RFID) tags [2], where the UHF band RFID tags work without internal batteries. However, smartphones currently have no UHF band RFID reader/writer functions to write safety confirmation data to the electronic signboard. Therefore, this letter reports further improvements to the safety confirmation function by considering the use of Near Field Communication (NFC) systems, which are expected to be widely employed in smartphones; the NFC tags also operate without the need for internal batteries.

The dual frequency RFID tag, having both NFC and UHF radio frequency (RF) interfaces, was developed in [3]; this RFID tag is appropriate for the above-mentioned safety confirmation system because it has shared memory between the NFC and UHF RF interfaces. However, the memory capacity of this RFID tag, 2080 bits, is insufficient for our system; about 256 bits of data, which is discussed later, is needed for each registrant. Alternatively, the NFC integrated circuit (IC) and UHF band RFID IC [4] have very

large memory capacities, 9 Kbytes and 8 Kbytes, respectively. These RFID ICs were developed in [4] and have digital interfaces, Serial Peripheral Interface (SPI). These two RFID tags allow us to accommodate a suitable number of registrants, with a storage capacity of about 250 safety confirmations using both RFID tags. This number of registrants is enough to implement the proposed system in small regional communities. If the memory capacities remain too limited, further RFID tags can be loaded in parallel to the digital interface, increasing the capacities.

This letter presents a feasibility study of the safety confirmation system using the NFC and UHF band RFID tags with digital interfaces (Inter Integrated Circuit (I<sup>2</sup>C)) [5], [6], which were available in the market. In the proposed system, residents write safety confirmation data to the NFC tag's memory using smartphones within several centimeters of the NFC tag. The stored data in the NFC tag is then transferred to the UHF band RFID tag by a microcomputer through the I<sup>2</sup>C bus. Because the UHF band RFID system has a longer read distance, rescue personnel can effectively collect the residents' data far from the safety confirmation system, even without getting out of their vehicles. Thus, the system's feasibility was validated.

## 2. Safety Confirmation System Using NFC and UHF Band RFID Tags

Figure 1 shows the basic concept of the safety confirmation system. In contrast to the previous work in [2], the NFC tag is now employed and its memory is shared with that of the UHF band RFID tag through a connection to a microcomputer's I<sup>2</sup>C bus, with one I<sup>2</sup>C bus capable of controlling multiple I<sup>2</sup>C devices based on individual I<sup>2</sup>C addresses. Using the I<sup>2</sup>C bus in a microcomputer, data in the NFC tag's memory is transferred to the UHF band RFID tag's memory. We assume that electric power is provided by a solar panel and a rechargeable battery, and this power is consumed only when the data are transferred to another RFID tag. The proposed method uses electronic paper (e-paper) to display stored safety confirmation data and instructions for registrants. The e-paper consumes electric power only when it is updated with new information or instructions.

## 3. Demonstration of the Safety Confirmation System

Figure 2 shows the prototype of the RFID based safety confirmation system, where an Impinj Monza X-8K Dura [5]

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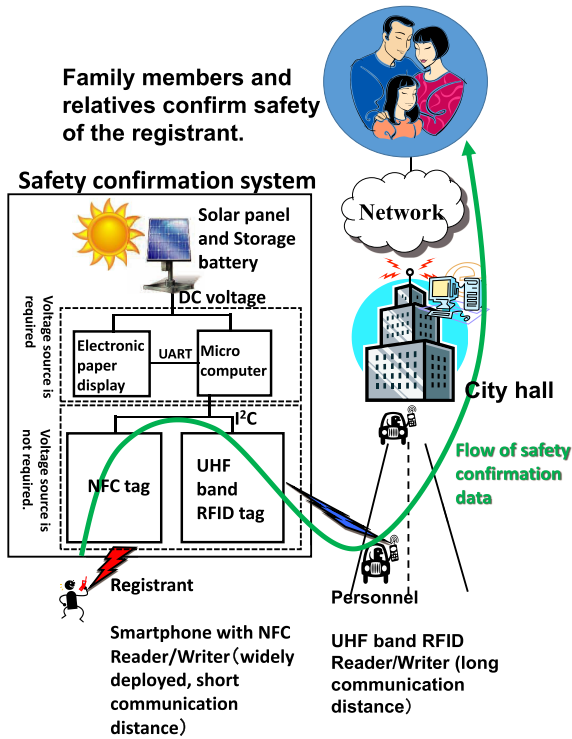


Fig. 1 Safety confirmation system based on NFC and UHF band RFID tags.

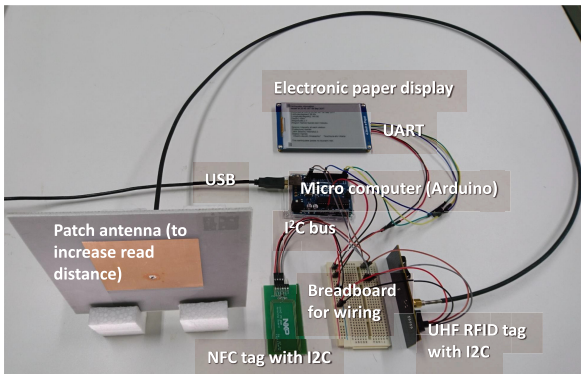


Fig. 2 Evaluation setup of the safety confirmation system.

as a UHF band RFID tag, an NXP NTAG I<sup>2</sup>C (NFC Forum Type 2 Tag) [6] as an NFC tag, and Waveshare 4.3-inch e-Paper [7] are employed. In this prototype, voltage is supplied by the Universal Serial Bus (USB). A patch antenna is employed to enhance read distances, providing a read distance of 3.5m. When applications require much longer read distances to help the rescue personnels in their vehicles running read the UHF band RFID tag, the use of a Battery Assisted Passive (BAP) mode [5] is supposed to be effective to further enhance the read distances. In this case, the required voltage is assumed to be supplied by the solar panel.

Figure 3 shows the safety confirmation data write procedure. The first resident's smartphone (smartphone A in Fig. 3) reads the specified addresses, which stores the write

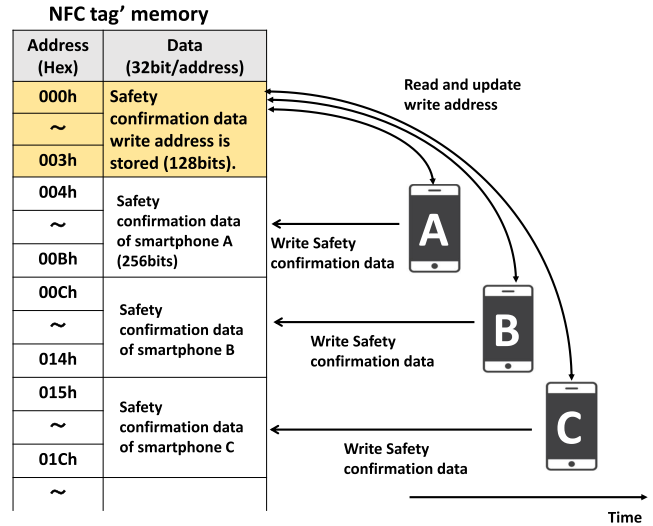


Fig. 3 Safety confirmation data write procedure.

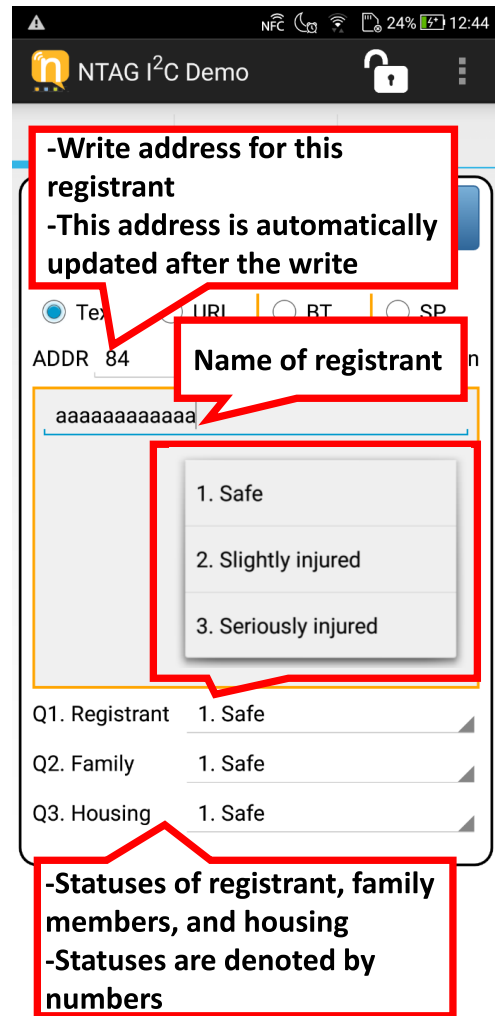


Fig. 4 NFC write application for this demonstration ("111aaaaaaaaaaaa" was written.).

address for this user. The addresses are from 000h to 003h in Fig. 3. Then, the safety confirmation data, including the name of the registrant, the status of registrant: (1. Safe, 2.

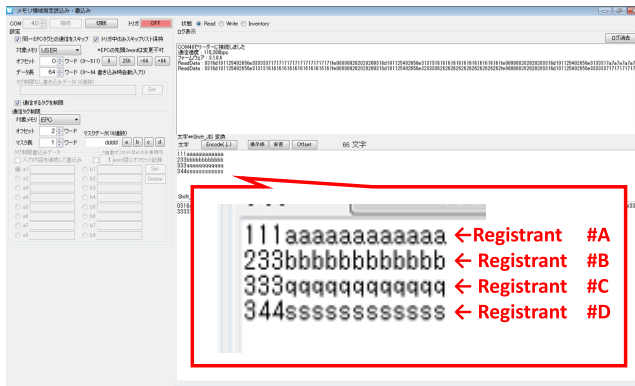


Fig. 5 UHF band RFID reader application for this demonstration.

Slightly injured, 3. Severely injured), the statuses of family members and housing, are determined as shown in Fig. 4. These data are written to the memory allocated by the previously read write address. We used the software that we developed based on the software development kit (SDK) provided by NXP [6]. After the safety confirmation data were written by the first registrant, the write address is then updated by the first registrant (smartphone A in Fig. 3) for the next registrant (smartphone B in Fig. 3). The safety confirmation data length, including header and termination codes, is 256 bits. These additional codes are automatically added by the software,

The safety confirmation data stored in the NFC tag are transferred to the UHF band RFID tag by a microcomputer, where an Arduino Uno R3 was used. The time required for this transfer was several seconds. The transferred data were read by a UHF band RFID reader. Figure 5 shows the UHF band RFID reader software that we developed based on the SDK [8]. The data for the first four registrants were read by the UHF band RFID reader; this result confirmed that the status numbers and names were transferred from the NFC tag to the UHF band RFID tag.

#### 4. Conclusion

This letter has presented an NFC and UHF band RFID based safety confirmation system. NFC equipped smartphones, which will be widely used in the near future, can write the safety confirmation data of residents in small regional communities. The RFID tags can retain safety confirmation data without the need for internal batteries. The safety confirma-

tion data were shared between the NFC and UHF band RFID tags using a microcomputer and a digital interface bus. The obtained results confirmed that the stored safety confirmation data were transferred to the UHF band RFID tag and extracted by the UHF band RFID reader.

To ensure secure read and write operations, introductions of password authentications, encryption techniques and further advanced techniques are desired. The UHF band RFID tag used in this letter has password authentication and QT functions [5], where the QT function can hide specified memory addresses. The NFC tag used in this letter has password protection functions to prevent unauthorized memory operations [9], which include a password acknowledge response function to prevent unauthorized data reception and a function to limit negative password authentication attempts. These features are effective to ensure secure data exchanges. The implementations of these security functions to our developed applications are further studies.

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