# Prototype implementation of RFID based health management system with low-power ARM microcomputer

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***Abstract*—This paper demonstrates a new RFID based health management system with a low-power ARM microcomputer. RFID cards are usually used as identification in many companies. The developed RFID cards can measure exercise quantity of office workers by deploying a low-power microcomputer and sensors. It is well known that a quantity of exercise has a strong relation with a health condition. Therefore, a quantity of exercise is a key indicator to prevent chronic diseases. The developed system employs a standardized RFID system to communicate with RFID reader/writers. Therefore, it is easy to install the developed system by updating software for RFID reader/writers in entrance gates, doors, etc. This paper demonstrates the prototype system for health management system built on a low-power ARM microcomputer.**

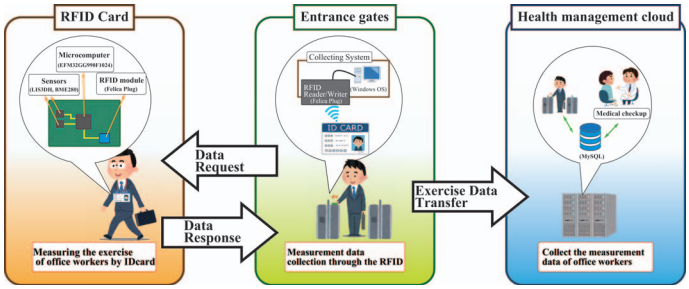


Fig. 1. Overview of System model.

## I. Introduction

The increase in patients is a major cause of swelling medical expenses. About 60 percent workers in the United States have group health insurance in a company. About 70 percent companies pay the full amount of the medicare costs for their workers. Therefore, preventive maintenance of diseases offers numerous benefits to companies by reducing medicare costs[1], [2]. Especially, due to the increase of lifestyle diseases such as cardiovascular disease, diabetes, pulmonary disease, amount of exercise in daily life has attracted attention to be effective in preventing a variety of illnesses[3].

Typically, early adapters who are mindful of their health show an interest in preventive maintenance of diseases, and buy a wearable device for fitness and activity trackers to maintain wellness. On the contrary, large majority of workers, who do not take a special interest in lifestyle diseases, are less concerned with disease prevention[4]. Therefore, almost all wearable devices are not suitable for typical workers because they tend to care nothing for wearing a special device even if they understand wearable devices are effective for disease prevention. As a result, more portable wearable devices are required to measure daily activities for typical workers[5].

This paper develops a new RFID based health management system with a low-power ARM microcomputer, and proposes a health management system for office workers in companies. The developed RFID card can measure office workers' quantity of exercise with an acceleration sensor and an air pressure sensor. RFID cards are widely used in office buildings to manage a security control and to record working hours. Therefore, our system can be installed easily by updating software for RFID reader/writers in entrance gates, doors, etc. The developed prototype consists of an RFID card, an RFID reader/writer, and a health management cloud. By employing an ARM-based microcomputer, the developed RFID card can operate with a low-power consumption.

## II. RFID based health management system

### A. System Model

The proposed system model is shown in Fig. 1. It is composed of three functions: the RFID cards, the entrance gates, and the health management cloud. The RFID card is designed for good performance in low-power consumption by employing an ARM-based microcomputer and peripheral devices such as an RFID chip supporting the FeliCa standard, acceleration and air pressure sensors, and measures a quantity of exercise continuously. The entrance gate has a base control system on Windows OS and an RFID reader/writer chip connecting by a USB cable, and transfers measured exercise data from the RFID card to the cloud. The health management cloud has a web server function and a database function to collect measured exercise data, stores them, and shows an analysis result of the data.

The advantage of the proposed system is an easy installation in any companies because updating ID cards and software is enough to collect exercise data of each workers. Additionally, the proposed system avoids the necessity of a special operation to collect the exercise data because the exercise data can be collected when workers touch their RFID card to RFID reader/writers to pass through a entrance gate.

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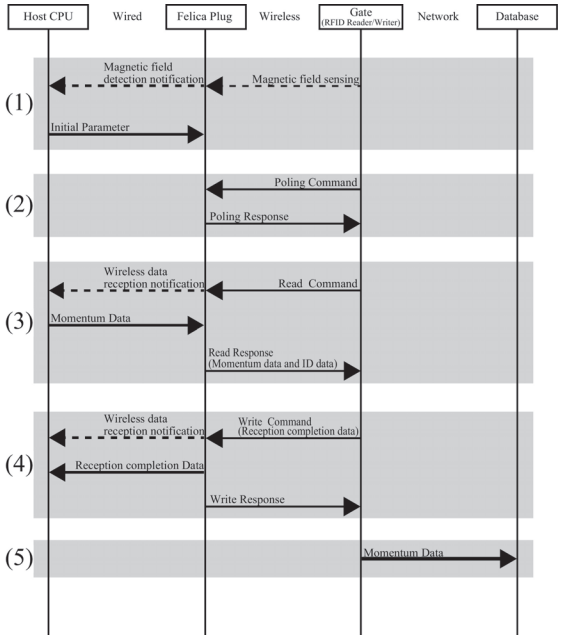


Fig. 2. Proposed data sequence.

### B. Communication Signaling

The communication signaling to collect exercise data is shown in Fig. 2. The detail procedures are as follows.

1) The ARM-based microcomputer initializes the FeliCa Plug that is the RFID chip supporting NFC Type-F, when it receives an interrupting signal from the FeliCa Plug detecting a magnetic field from an RFID reader/writer.
2) The RFID reader/writer sends the polling command to the FeliCa Plug. The microcomputer on the RFID card also replies the polling response.
3) The RFID reader/writer uses the read command and read response to transfer the measured exercise data from the microcomputer through the FeliCa Plug.
4) The RFID reader/writer uses the write command and write response to notify the completion of the data transfer.
5) The RFID reader/writer transfers the exercise data from the RFID card to the health management cloud.

## III. Implementation

We have developed a prototype system of the proposed health management system. Fig. 3 is an overview of the developed ID card. We have employed EFM32GG990F1024 ARM chip, that is designed for low-power consumption, to develop a feasible wearable device supporting long-life operation. The employed chip includes a 1024 KByte flash memory chip, a Real Time Clock (RTC), and some interfaces for sensors and the FeliCa Plug. We use a STMicroelectronics LIS3DH as the acceleration sensor for the pedometer function, and use a BOSCH BME280 as the air pressure sensor to count a flight of stairs.

## IV. Evaluation

We have evaluated three types of performance of the prototype system: a step count accuracy, a transmission period between RFID and RFID reader/writer, and an energy consumption. The step count accuracy was about 98% with 1000 steps. The transmission period was about 235 ms that is enough short to pass through an entrance gate. As the energy consumption, the operating current of the hardware was about 32mA during the step counting operation. Table. I shows the operating current of each chips. According to the specifications, we can reduce the operating current by designing a minimum configuration of hardware with a microcomputer, two sensors, and FeliCa Plug.

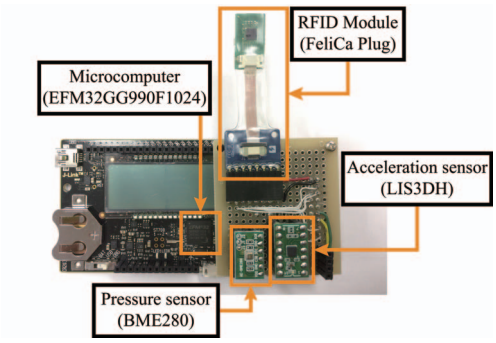


Fig. 3. Overview of developed ID card prototype.

TABLE I
Operating current of each chip

| | EFM32GG990F1024 | LIS3DH | BME280 | FeliCa Plug |
|---|---|---|---|---|
| Active | 10mA | 1mA | 3.6 $\mu$ A | 1mA |
| Sleep | 0.8 $\mu$ A | 0.5 $\mu$ A | 0.1 $\mu$ A | 0.1 $\mu$ A |

## V. Conclusion

This paper has developed the new RFID based health management system with low-power ARM microcomputer, and has proposed the health management system for office workers in companies. The developed RFID card can measure office workers' exercise with an acceleration sensor and an air pressure sensor. The proposed system avoids the necessity of a special operation to collect the exercise data by deploying both identification and fitness and activity tracker functions in an RFID card. Additionally, software updating of RFID reader/writers is enough to install the proposed system into conventional buildings. The developed prototype shows the feasibility of the ARM-based RFID card supporting a long-life operation.

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