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Floor Sensor Pads as an Ad-Hoc Network

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ABSTRACT: Our laboratory has designed data acquisition systems to detect personnel activity using floor-based sensors. We implemented the wireless communication between data acquisition boards creating an Ad Hoc network using the Spark Core board, a wireless Wi-Fi transceiver board. The Spark Core sends sensor data from the data acquisition board to the Internet then to the cloud. We tested our system pads by walking on carpet pads each with a PCB board, and placed four of them in four different locations. We displayed the sensor data on the cloud using the provided Dashboard. In addition, an HTML page displayed the sensor data from the four PCB boards. A notification system announces new sensor data by sending an Email or SMS message. Finally, we saved the sensor data on a local PC.

KEYWORDS: Ad Hoc Network, Wireless Communication, Spark Core, Four PCB boards, Cloud Dash board.

I. INTRODUCTION

Previously, our laboratory designed, built and tested a data acquisition system with a smart carpet, which consists of 32 sensors, to detect personnel activity [1,2,3,4,5,6,7,8,9]. In our system, we built four carpet pads with four sensors each. When someone steps on the pad sensor, the sensor produces an analog signal acquired by the data acquisition board, which identifies the activated sensor. The sensor data will be transmitted to the Spark Core Wi-Fi board, which will send the data to the cloud. The data acquisition system was described in a previous paper [10]. The paper here deals with the wireless transmitted data, which uses the Spark Core Wi-Fi board [11].

We built data acquisition boards with Wi-Fi chips on them. The Wi-Fi chip receives the data from a data acquisition board and sends it wirelessly to the cloud for display. The cloud provides the connectivity for our boards.

The small size of the carpet pad enabled us to place it anywhere; such portability can be enhanced by a battery.We tested our system by installing four carpet pads in four different locations.This paper is structured as follows. Section 2 presents the related work. Section 3 describes some of the features for the Spark Core Wi-Fi board. Section 4 discusses the methodology, which is the proposed work. Section 5 shows the results, and Section 6 includes the conclusion and the future work.

II. RELATED WORK

In industrialized and developed countries, the advancement in medicine leads to increase the average age for people and decrease the number of disease related deaths. Consequently, the increase in elderly in society requires us to understand how to provide them with better life needs [12]. According to the United Nations Population Division, the number of people whose age is 60 years or above was about 901M in 2015, which is about 12.3 % of the total world population, and this number grows to 1400M in 2030, which is about 16.5 % of the total world population [13].

Researchers working in geriatrics aim to preserve the health of the elderly. One important tool is assessment of their daily activity. Different methods are used to monitor people’s activity such as the floor based sensors and the spot check system.

An important area for us is monitoring the patient when leaving the bed by using a step sensor mat. This mat can be placed under the bed and connected with the alarm phone system. When the patient steps on the sensor, it sends a signal to the phone system. Each mat has an identification number ID so we can install many of them in the house or in the hospital. The alert system will call a caregiver and warn that the patient is getting out of bed. In addition, a light placed around the mat that can be switched on for the patient [14].

In another area of importance to us, a home security system to detect an unauthorized entry consists of sensors, a microcontroller, a communication module, and a buzzer. The sensor used is infrared sensor IR, transmitter and receiver that is installed on the windows to detect the intruders. Whenever the IR sensor detects that the window is opened, it

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will send a signal to the ADC, located inside the microcontroller, to convert the signal to digital then turn the buzzer on to warn the house owner for an unauthorized entry through the window. There are other sensors in the system to check the gas leakage and the temperature increasing. The communication is through the European Global System for Mobile Communication GSM, that module will send an SMS message for gas leakage or temperature increase with the location to the owner thus alerting about a fire possibility [15].

III. THE SPARK CORE

The Wi-Fi board that we used is called the Spark Core development board. In this board, Spark Labs Inc. has provided many features that made the Spark Core a better choice to use. The Spark Core has a very small size with a dimension of (1.5" x 0.8" x 0.2"). The wireless chip in the Spark Core, CC3000 from Texas Instrument Inc., has an on chip antenna with a transmit power of +18 dBm at 11 Mbps and a receive sensitivity of – 88 dBm at 11 Mbps [16]. Moreover, Spark Labs Inc. has provided the Spark Core with a notification capability that can be easily used to send an email, SMS message, and a voice call to the Spark Core's user [17]. In addition, the Spark Core has a cloud display, called the Dashboard, which can display the received data from the Spark Core with the timestamp. It also has some others features such as:

1- Peer-to-Peer communication ability,
2- Easy to setup and program,
3- Low cost and low power consumption,
4- Notification system,
5- Save the output data in different formats (Text, XML).

IV. METHODOLOGY

In this section, we explain how we installed four carpet pads, each with four sensors. Each carpet pad required a PCB board, so that four PCB boards on different locations can monitor a person's activity. The PCB board includes the data acquisition board with the Spark Core board, which we embedded in the PCB. The data acquisition board is the electronic device that scans the carpet pad for any active sensor, processes the sensor data, and sends the data to the Spark Core Wi-Fi board. The Spark Core sends the data wirelessly to the Dashboard cloud. We used the PCB artist software to build four PCB boards which are labeled as PCB A, PCB B, PCB C, and PCB D [6,11]. We also need a PC or tablet with Wi-Fi connectivity (or any Wi-Fi enabled system) to monitor the sensor data. The system sends a notification to the care giver's cellphone or email. The goal of this experiment is to test the system that we designed displaying the four carpet pads sensor data, working with the notification system, and tracking the person's location. See figure 1 for the connection diagram for one PCB board.

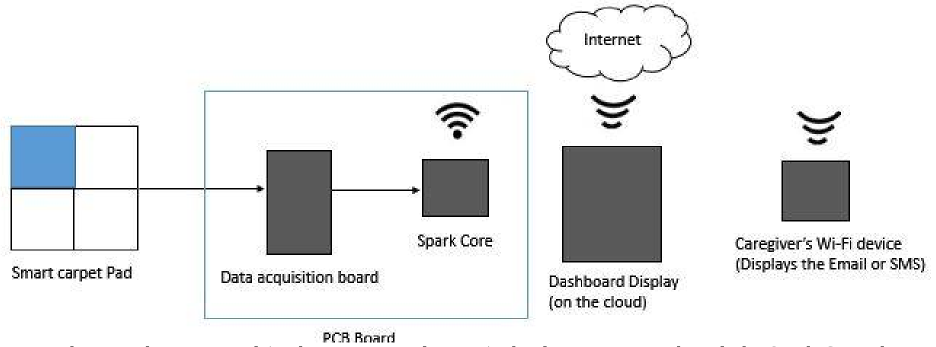

Fig 1. The connection diagram showing the carpet pad (with one activated sensor), the data acquisition board, the Spark Core, the Dashboard, and the caregiver Wi-Fi device

Although we have the Dashboard cloud website that can display the data from each board in separate line, it is useful to display the four PCB data as a single stream for monitoring the data easily. We modified this webpage with the help of [18] to display the sensor data from four Spark Core as a single stream.

One of the useful features in the Spark Core is having a notification system (Alerts). The Spark Labs Inc. website, Particle [19], has a channel with a notification website called IFTTT. The website's name (IFTTT) means that IF we

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have This condition happen, then it will cause That action (full syntax name for the website). For instance, we can setup a connection to create an alert that sends an email by using the Email channel when we get a new data from the Spark Core device by using the Particle channel. There are many other channel for the alert systems including Office 365 mail, Gmail, SMS, Phone Call, Google Spreadsheet, Facebook, etc. In the website language, a recipe is an algorithm- usually to setup a connection.

We can display the data on the cloud using the Dashboard display, but there is value in saving this also on a PC. We used the Node JS library to run JavaScript script to save the sensor data on the local PC. This allows us to save the four PCB sensor data as a single stream. We modified the script to read the sensor data from PCB A, PCB B, PCB C, and PCB D respectively. In addition, we modified the code to read the sensor data from one PCB board in case of the other PCB boards do not have a new data [20]. For example, if sensor 1 on PCB C is activated while the other boards (PCB A, PCB B, and PCB D) are waiting for the new data, the script will only save the data for PCB C and give the others 0, so the saved data will be 0 for PCB A, 0 for PCB B, SC1E for PCB C, and 0 for PCB D (00SC1E0).

V. Results

Here we describe the activation of the four carpet pads with their PCB boards at four different locations. We had a person step on these pads placed at the lab entrance (Carpet1), a window (Carpet2), a restroom entrance (Carpet3), and exiting the building (Carpet4).From each of these four locations, we transmitted the sensor data wirelessly to the cloud and displayed it on the Dashboard using the PC (figure 2 a,b,c,d). So first we discuss the frame structure for the sensor data which starts with the letter S, followed by the Pad letter (A, B, C, or D), then the sensor location in Hexadecimal (1,2,4,8), and finally the frame ends with letter E. The sensor's location values1,2,4,8 correspond to sensor1, sensor2, sensor3, and sensor4.When more than one sensor becomes activated, their location's values will be logically ORed to form the hexadecimal digitor the sensor's location value.

Figure 2(a) shows the Dashboard displaying sensor data(SA2E) at the lab entrance, an event name labeled Carpet1, a timestamp, and Spark Core device name.

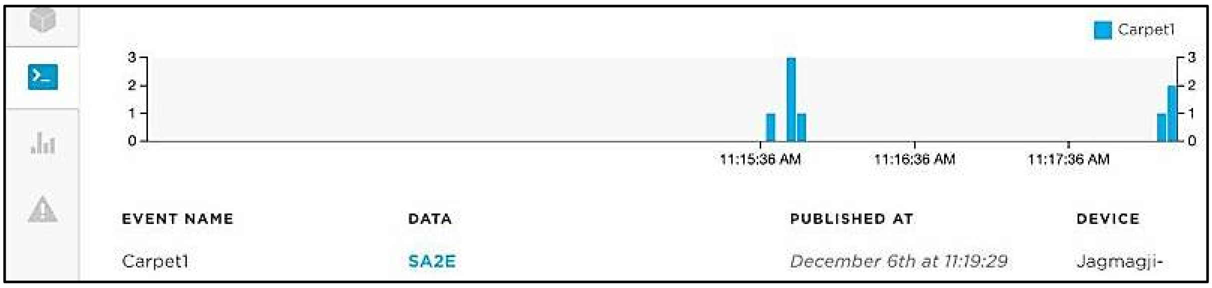

Fig 2(a). The cloud Dashboard displaying the event name Carpet1, sensor data for the lab entrance (sensor 2 was activated), a timestamp, and the device name.

Figure 2(b) shows the Dashboard displaying sensor data (SB4E) at a window, an event name labeled Carpet2, a timestamp, and Spark Core device name.

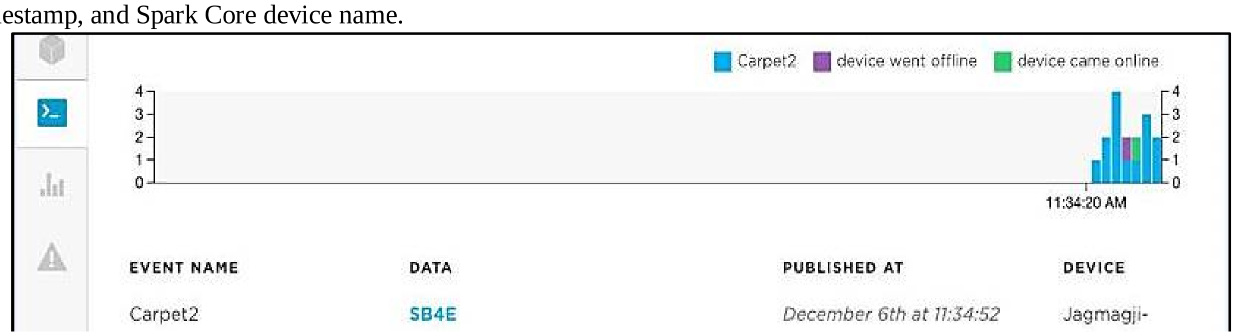

Fig 2(b). The cloud Dashboard displaying the event name Carpet2, sensor data for the lab entrance (sensor 3 was activated), a timestamp, and the device name.

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Figure 2(c) shows the Dashboard displaying sensor data (SC8E) at a restroom entrance, an event name labeled Carpet3, a timestamp, and Spark Core device name.

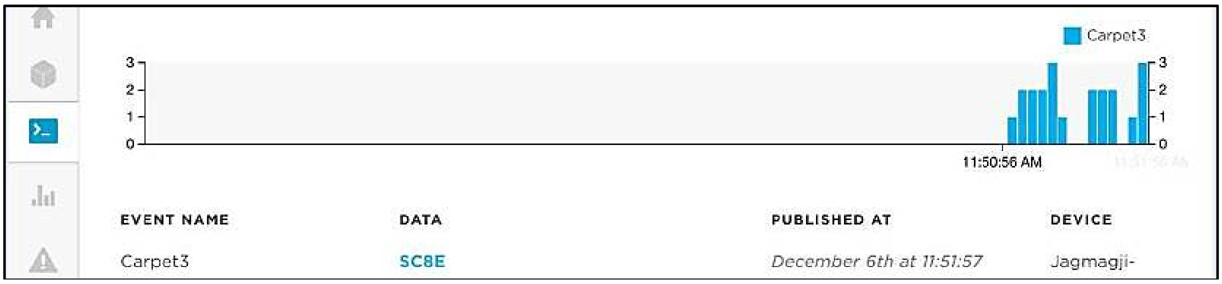


Fig 2(c). The cloud Dashboard displaying the event name Carpet3, sensor data for the lab entrance (sensor 4 was activated), a timestamp, and the device name.

Finally, figure 2(d) shows the Dashboard displaying sensor data (SD1E) at exiting the building, an event name labeled Carpet4, a timestamp, and Spark Core device name.

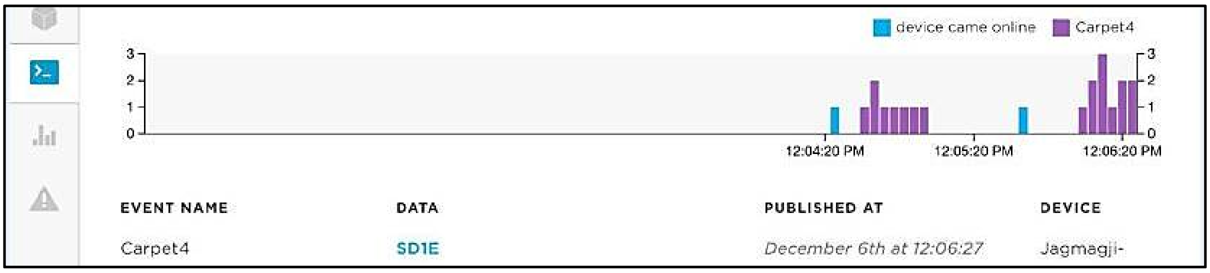
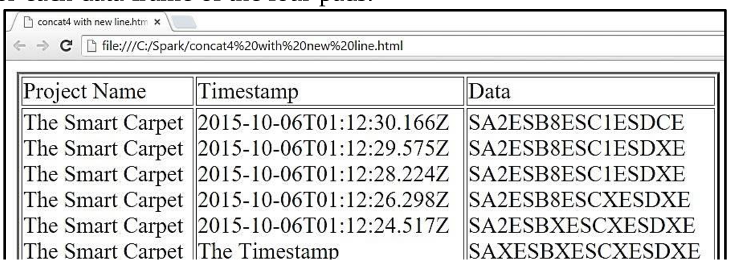


Fig 2(d).The cloud Dashboard displaying the event name Carpet4, sensor data for the lab entrance (sensor 1 was activated), a timestamp, and the device name.

We required a display of all four pads, hence modifying it from the Particle community website [21] to match our project. So, we read and display the sensor data from the four Spark Core boards as a single-stream as shown in figure 3. Figure 3 shows the desired given project name, followed by the four integrated pad data arriving as a single-stream, and finally the timestamp for each data frame of the four pads.



Project Name	Timestamp	Data
The Smart Carpet	2015-10-06T01:12:30.166Z	SA2ESB8ESC1ESDCE
The Smart Carpet	2015-10-06T01:12:29.575Z	SA2ESB8ESC1ESDXE
The Smart Carpet	2015-10-06T01:12:28.224Z	SA2ESB8ESC1ESDXE
The Smart Carpet	2015-10-06T01:12:26.298Z	SA2ESB8ESCXESDXE
The Smart Carpet	2015-10-06T01:12:24.517Z	SA2ESBXESCXESDXE
The Smart Carpet	The Timestamp	SAXESBXESCXESDXE

Fig 3. A screen display of webpage showing the concatenated data from four pads with the timestamp [21]

We notice in figure 3 that we have SAXE, SBXE, SCXE, and SDXE for the pads A, B, C, and D. The ASCII data with X represents the non-initialized status for the four Spark Core devices prior to anyone walking on the carpet pads. Initially, the pads were not activated then we successively activated pads A, B, C, D, and terminated the sequence with all four pads activated. In figure 3, lower is earlier.

Spark Core provides a notification system through the IFTTT website. It can send alerts as an email or SMS regarding sensor data or its power status. For examples for receiving the sensor data from the Spark Core (Pad A) to the

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Gmail. Figure 4 shows the received sensor data (SA1E) on the Gmail service after we got a sensor one activated on Pad 1 (Carpet A) with the timestamp of activation.

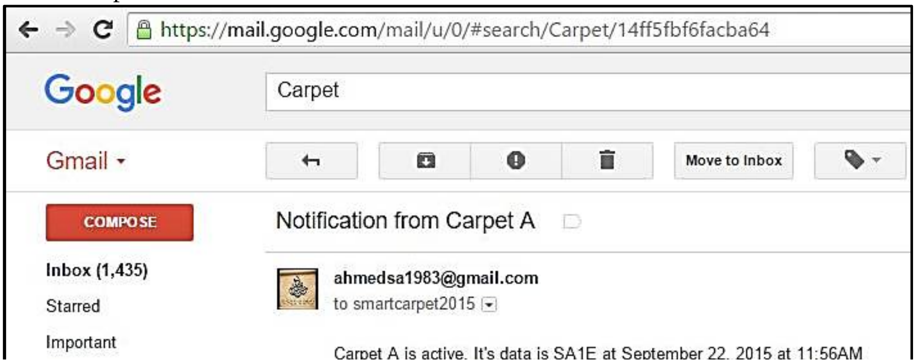
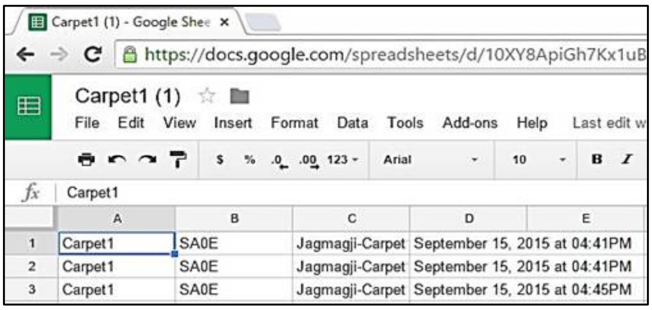


Fig 4. The received sensor's data on the Gmail from the Spark Core (pad A)

Moreover, figure 5(a) shows the saved sensor data on the Google Spreadsheet for Pad 1 (Carpet A) with the timestamp. In addition, figure 5(b) shows Smartphone notification SMS message from the Spark Core Wi-Fi board showing it's power status (Offline) that gave an alert to the caregiver to check for power outage.



(a)

(b)

Fig 5(a). The received sensor's data on the Google Spreadsheet from the Spark Core (pad A). Fig 5(b) the received sensor's data in SMS message from the Spark Core (pad A)

We can also save the four carpet pads sensor data locally. Saving the sensor data for all the four Spark Core devices (Pad A, Pad B, Pad C, and Pad D) with pad B and D become activated before pad A and C, the resulting data frame in the text file will skip A's S and E to form (0SB1E0SD2E) with 0 for the text string of pad A and C.

Figure 6 shows the saved sensor data for four carpet pads as a form of text file, followed by the timestamp, and the project name (The Smart Carpet).

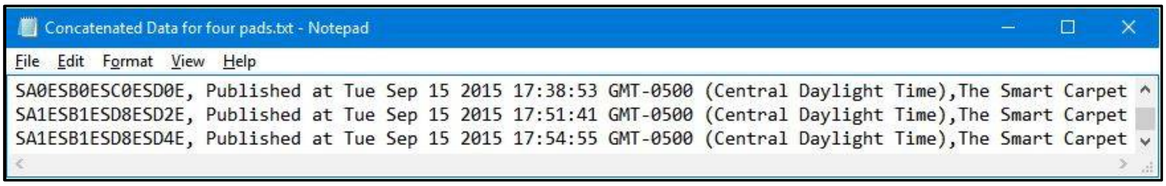


Fig 6. The final form of the four pads sensor data, concatenated data, saved on a text file with the timestamp and project name

VI. Conclusion and Future Work

We have implemented an Ad Hoc network using the Spark Core Wi-Fi board. We used four PCB boards to implement a Pad activation by walking experiment that includes placing each PCB board in different location and

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activating it by walking. In addition, we modified a webpage to display the sensors' data from four Spark Core boards as a single stream on the local PC. Then, we set up a notification alerts to send the sensors' data to the caregiver through SMS message or Email. Finally, we used a Node JS script to save the four carpet pads data on the local PC as a single stream.

As a future work, we can use newer versions of the board, which has a better specification including faster processor, cheaper (half price of the Spark Core), faster Wi-Fi network, less power consumption, and more GPIO interfaces. A database feature to save the sensor data on the Internet will also be helpful. We are also interested in designing a smartphone application that we can use to control the system remotely.

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BIOGRAPHY

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