The Provisional of Bluetooth Low Energy Based Real Time Patient Tracking System

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Abstract: Nowadays, the increment of patients represent one of the critical relevant challenges, the use of patient tracking system may reduce the management faults and improve the treatment quality. The coming on internet structure has permit scenarios in which objects can communicate and identified data over wide networks. Therefore, in this study, we design a real-time patient tracking system based on using Bluetooth Low Energy (BLE) technology. The BLE using is preferable according to low modules price, low power consumption, and scalability.

Keywords: Bluetooth Low Energy, Wireless Monitoring, Distance Measurements, RSSI.

1. Introduction

The location positioning schemes overgrow and spread used in various life activity such as monitoring, navigation and tracking systems [1]. The hospitals are regularly large establishments, and it can be difficult to localize or estimate the equipment location and individuals when needed. Moreover, as such, “patients were sometimes in transit or were moved to a different room after a diagnostic study or procedure, and the new location was not immediately noted. Unaware of the changes, staff would direct friends and family members to the wrong room, inconveniencing visitors” [2]. Moreover, the emergency rooms in hospitals around the world are overcrowding due to popularity growing. The resource limitations forced the patient to spend more time for waiting their turn to get a medical treatment. During waiting time, the patient’s locations are not fixed as they move around, this may reduce the emergency room efficiency and add more unnecessary burden to the hospital staff [3].

The patients continuous tracking is a vital activity not only in the emergency room but in all hospital places, where it contains many forbid and hazardous sites that may threaten patient’s life. The Real-Time location methods and systems (RTLSs) that used to locate and identify of patients as well as staff can be assessed to trace them in real or near real time events [1, 4].

The GPS is an efficient and well-known technique to acquire the position of objects. Unfortunately, it is implemented only for outdoor usage, and many recent works proposed to use in indoor tracking system technology [5]. The wearable wireless sensors transmit the signal from varying patient’s location to the tracking monitor system, and it can be identified by the authorized staff that have the authority to access to this kind of data [6].

Various types of RTLSs hardware are incorporated with software interfaces, which require more attention to select the proper choice of RTLS [7]. The radiofrequency identification (RFID), the ZigBee, Bluetooth, wireless local area networks (WLANs), and others wireless techniques can be employed to serve as a sensing device for RTLSs [8, 9]. The RFIDs are well known and used in logistic location systems. The RFID system contains some RFID readers and many RFID tags which characterized as either passive or active. The passive tags can sense the RF signals and reflect it in a range of 1-2 meters while the active tags can go through up to 20 meters [10]. The WLANs usage in public internet hotspots, as well as localization systems, are increased during the last decade during to pre-existing infrastructure that based on [11]. The WLANs systems are more accurate than RFIDs where it depends upon the use of received signal strength indicator (RSSI) to estimate the range and then the object position [9].

The Bluetooth is standard wireless technology that used for data exchanging in short range distance. The low cost and easy to develop are lead to use this technology for indoor tracking system [12]. Moreover, Bluetooth technique provides a compromising solution between RFIDs and WLANs regarding accuracy and power consumption efficiency [21]. Bluetooth tags are small gizmo transceivers that used in the hospital to send, in real time, biomedical data (e.g., heart rate, blood pressure, temperature, electrocardiogram, oxygen saturation, location information, etc.) [13]. The data generated in these devices are transmitted to personal computers or other such devices via Bluetooth. As any Bluetooth device, each tag has a unique ID [14]. A new generation of Bluetooth are drawn up to enhance the efficiency as well as reduced power consumption, it is called Bluetooth Low Energy (BLE) which is used in this study. The BLE acts as continuous signals Bluetooth broadcasting; each
signal contains such information like Universal Unique Identifier (UUID) or MAC address, scan record, Received Signal Strength Indicator (RSSI), and so forth. In this study, the state of the art of Bluetooth Low Energy (BLE) we used to construct the real-time patient tracking system. The accuracy of proposed system uses the RSSI as a sensing indication that can give a feedback information about new moving body location.

2. Literature review

The attention in patient tracking system increased in recent years for automating the care process in hospitals and health cares. Jong-Hoon, Youn et al. [15] proposed a real-time tracking system within a hospital which tracked the number of mobiles small Wi-Fi tags, and this system utilizes the radio signals that received from many distributed access points to estimate the tag position. Campo, E. et al. [16] present a monitoring system independent grey-haired people living in a retirement house. This system can automatically monitor and detect the living activities of these people to sense the risk situation and accident that could face. Monitoring is carried out locally through many sensors system and remotely via GPS. Lee, C. K. M. proposed a project for effective asset management in hospitals by employing neural network forecasting method with the aid of RFID technology in hospitals management [17]. In commercial side, Zonith “a group of Nokia engineers” develop software for indoor tracking used in case of emergency and urgent alarm, this application can be work in the home, hospital and another workplace [18].

3. Methodology

3.1. System architecture

The proposed system architecture based on using BLE module nRF51822 as a central mode signal transmitter and using Beacon module in slave mode. The central mode modules fixed in different hospital locations such as emergency room, outpatient room, patients lobby, etc., while Beacon module equipped with the patient at admission process. All these devices can be managed via system server.

3.2. The central BLE

The nRF51822 module used in this design contains a powerful 32-bit microcontroller with 256 Kbyte programmable flash ram with embedded 2.4 GHz transceiver. The BLE device capabilities are bound packets data transmission in 20 bytes data length; it is necessary to reduce the power cost during transmission. The BLE architecture has three main layers which are a controller, application, and host. The controller layer is the RF transceiver module. The application layer contains UUID which is module specification read by a machine, also the characteristic, service and profile are included in this layer, the connection services, and advertising discovery signals are described in the profile. The host contains procedures and protocols [19].

The BLE modules are set to place inside the hospital. Figure 1 shows the proposed distribution in single hospital floor, the modules marked as red dots. Each module can auto-pairing with many patients (around 15 at the same time). The BLE modules in each floor connected to the microcontroller board via I2C protocol, this protocol accept 127 devices per one port, this connection is essential to send the module acknowledgment that contains the patient’s name and location to main system server as shown in figure 2.

The firmware flowchart of nRF51822 shown in figure 3, each module start with Bluetooth signal scanning and advertising for searching a new pairing signal from patient’s Beacon. This process repeated each 30 seconds, after finding a signal within module range; the UUID checking is started, this process ensures the system security and distinguish the Bluetooth tracking signal from others that used in different devices such as headphones, smartphones, ... etc. Once the connection is made, the module starts to read advertising patient’s name and send it with RSSI value and module number to connected microcontroller board then arranged it in the database server.
3.3. The deployment of Beacon

In this study, we used the Beacon BLE module due to its excellent characteristics such as low power consumption, light weight, low price and easy to developing compared with other wireless techniques.

The Beacon profile configuration in this work is set to transmit one packet every one second to save power drawn in transmitting process, this will lead to saving the battery life and use small batteries for reducing patient’s wearable device. The Beacon range is around 20 meters, and it depends on fixing a place that it put on [20].

Figure 2. Proposed System

Figure 3. BLE Flowchart

Figure 4. Beacon Flochart

Process is started to discover if there is another signal or not. The next step is chosen the highest RSSI signal to ensure localization quality. After selecting highest RSSI, the pairing connection is complete, and patient name transmits to the server through BLE connection for determining position. The selecting of higher RSSI is important to ensure the tracking quality where the BLE signal is weak because of power saving the profile and may effect by interior objects.
3.4. The system server

The main program which deals with module mapping and patients data application running on the system server. It controls the role between patients Beacon and BLE module as well as estimates nearest module for mapping calculations of the correspondent areas. The lookup table of BLE location store in this server for accurate mapping locations, the location services update its status each minute for more accuracy. With web-based application facility, the system monitoring, controlling and maintaining becomes easier and more efficient, its enable staff to log-in even by their smartphone which makes the patients under control for 24 hours.

4. Results

Figure 5 describes the distance influence on the RSSI values, where the increase in distance lead to reduce in RSSI (from -42 dB at 0.5m to -90 dB at 30m). This variance depends on the advertising signal type. The using of Bluetooth Low energy is contributing to enhancing the power consumption which is a crucial issue in wearable devices. The system accuracy is restricted by the tag readers distribution in the required location where the accuracy is considered in positioning systems. In this study, the locating of the individual at a room accuracy with normal setting is varying around 0.8 to 1 m. The distance among fixed BLE modules in each room are within 6 to 8 meters which leads to improving the overall accuracy.

![Figure 5. Measured RSSI](image)

5. Conclusion

In this study, we design an indoor patient tracking system to assist hospital staff finding their patients quickly and efficiently. The system based on Bluetooth low energy techniques which give the ability and facility with more functional efforts, also using this technique leads to reduce the operation cost by reducing total power consumption. However, the real working area environment contains many factors that might affect the overall efficiency and performance in determining the location, this needs more discussion in the future work implementation.

6. References