A Smart Healthcare System using IoT

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ABSTRACT

IoT is a fast growing technology which enables all type of devices to communicate with each other and share information among each other. Most of the IoT inventions make life sophisticated and real world comes into virtual world. Health care systems have the drawback of monitoring the patient in persons which suffers from increasing population growth and shortage of nursing staffs. This paper describes an implementation of IoT based Smart health care system to enable continuous monitoring of the environmental condition of a hospital and also tracking the patient’s health condition through a single application. Radio Frequency Identification (RFID), Wireless Sensor Network (WSN) and smart mobiles provides a great platform to improve the healthcare systems. The combined implementation of RFID and WSN makes the Healthcare Systems to behave smart by automatic monitoring of environmental conditions and tracking of patient’s health condition. Sensors are used to sense the environmental condition such as temperature, humidity, ambient light, etc inside the hospital premises and patient’s ward and also patient’s health by means of monitoring patient’s body temperature and heart rate. The data recorded by the Wireless Sensor Network are uploaded automatically to the configured server at the prescribed time interval. The authenticated staffs in the hospital can monitor and track the environmental conditions of the hospital premises as well as patient’s health conditions data. This system enables the doctor and Nurse to track the patient’s health even from remote places either through web application or through the mobile application. This system generates dynamic graphical chart based on the received data which helps much easier for the doctors and nurses to diagnose any irregularity. This system also enables the doctors to prescribe the medicines to the patients even from remote places based on which the local staff nurses can take care of the patient. Also this system can be used to send the notifications about patient’s health conditions automatically to the respective nurses and doctors based on the predefined conditions through which emergencies can be handled immediately.

INTRODUCTION

The most difficult objective of current society is to enhance the efficiency of healthcare systems. Indeed, it is generally perceived that the consolidated impacts of increase in population and nursing staff shortage might in the long run lead current healthcare system frameworks to crumple. As per A. Redondi, M. Chirico, L. Borsani, M. Cesana and M. Tagliasacchi, (2013), patient monitoring, administration, environment monitoring is done by nursing staff. In real time this may cause manual errors and efficiency bottleneck.

The advances of Internet of Things (IoT) could be a path changer for the healthcare industry. It transforms healthcare industry by observing and control of the considerable number of operations occurring in healthcare systems. Enable asset and operations optimization, Analyze protein and provide precision of their structure Support, functionalities needed by doctors, also front office and billing staff, Monitor hand hygiene compliance...
and ongoing checking of patients' physiological parameters for right on time recognition of clinical crumbling are some examples. Smart healthcare systems are implemented efficiently by adopting the new technologies such as Ultra-High-Frequency (UHF) Radio Frequency Identification (RFID), Wireless Sensor Network (WSN) and Smart mobiles.

Radio frequency identification (RFID) uses electromagnetic fields to transfer data. For automatic identification and tracking of objects it is used. Information is stored electronically inside the tags. It is low cost and consumes low power. It consists of readers and named tags. Within the electromagnetic field readers and tags are communicate with each other. It's categorized as Active and Passive tags. Active RFID tags have battery and transmitter. Passive RFID tags do not have battery; they consume power from the electromagnetic waves of reader and induce current in tag’s antenna. Life time of passive tags is decades, since this is used for several applications (A.A.N. Shirehjini, A. Yassine, S. Shirmohammadi, 2012). UHF RFID frequency range from 300 MHz to 3 GHz. Capabilities of the UHF RFID is increased; this represents added advantage (S. Tennina, M. Di Renzo, E. Kartsakli, F. Graziosi, A. S. Lalos, A. Antonopoulos, P. V. Mekikis, and L. Alonso, 2014). However the pitfall of RFID tags is that they can operate under the coverage region of the reader (up to 15m to 25m). Thus the region it can operate limits the UHF RFID technology.

On the other hand, WSNs are self-configuring adhoc networks. This network consists of sensor nodes (called motes), capable of processing, gathering sensor information and communicate with other nodes in the network. It’s able to communicate in a multi-hop design to provide monitoring and control functionalities. Presently, most WSN motes are battery powered and an IEEE 802.15.4 radio empowering up to 100m in a single hop. Prof. T.P. Jayakumar and Dr. N. Gunasekaran (2015), to preserve energy of nodes, higher communication power can increase strength as added to multipath routing. Compared to UHF RFID tags, WSN consume more power. Since the life time of the network is limited. In such a context, the integration of UHF RFID and WSN may give extended functionalities and can be used in variety of applications (N. Renuka, N. C. Nan, and W. Ismail, Sept. 2013). S. Kannan (2015), to achieve energy efficiency and load balancing an extension of Reselection-based Energy Efficient Routing Algorithm (REERA) and minheap algorithm for WSN is proposed. In healthcare applications only few attempts are made to leverage the consolidated use of UHF RFID and WSN.

Proposed system is to implement an IoT Smart HealthCare System. Smart Healthcare Systems for automatic monitoring environmental conditions of a hospital and monitoring health condition of patients. Sensors are used to sense the environmental condition i.e. is (temperature, humidity, ambientlight, etc.). The local staffs in the hospital are responsible for tracking the ward environmental conditions. Radio Frequency Identification (RFID) is used to identify the sensors. By using a RFID reader sensor identity can be verified to ensure authenticity and integrity.

The Nurse is responsible for tracking or monitoring the patient health condition. Based on the patient description the patient id will be updated to the nurse. The monitoring data of the patients are temperature and a heart rate. The nurse starts monitoring the patient details i.e. (temperature and heart rate) are updated in the nurse page and based on the temperature and a heart rate value will be displayed in a dynamic graphical chart. After that monitored details will be sent to the doctor. Based on the patient details doctor will generate a graphical chart and give the prescription. The graphical chart and the prescription will be created as a PDF File and send to that patient.

Related Work:

Several technological trends have developed the opportunities for the implementation of innovative services. In particular, sensors are used widely in IoT to improve the life style and healthcare. Different types of sensors are used to collect the data (heartbeat, movement, body temperature, blood pressure), this shapes the healthcare systems. Several research activities are taken in this field, especially the use of UHF RFID technology are focused on tracking patients and biomedical devices in the hospitals.

Use of passive RFID technology:

In C. Occhiuzzi, C. Vallese, S. Amendola, S. Manzari, and G. Marrocco, (2014), author proposed a NIGHT Care which controls and monitors the night environment in the hospital. A fully passive RFID technology is developed by combining ambient and wearable tags. Using the sleep parameters an ambient intelligent platform is capable of detecting the patient’s status presence, absence, and fall and generates automatic alarms in case of emergency. UHF –RFID reader is placed close to the bed scans the entire environment and receives signals from both the tags. In P. Fuhrer and D. Guinard, (2006), RFID Locator an eHealth application combined with mobile device is used to optimize business process and improve patient safety. It is developed at the Software Engineering Group of the University of Fribourg (CH) and Sun Microsystems. In A.A.N. Shirehjini, A. Yassine, S. Shirmohammadi, (2012), a passive RFID technology and several peripherals of sensors are utilized for position and orientation determination of equipments in the hospital.
Use of WSN technology:

According to the author A. Redondi, M. Chirico, L. Borsani, M. Cesana, and M. Tagliasacchi, (2013), WSN is used for patient monitoring, localization and tracking. The localization is determined by the received signal strength indicator (RSSI). Tracking is done through the particle filter and monitoring is based on bi-axial accelerometers which identifies the patient movements. Claudia Grace Rajakumari V. and Nesasudha M. (2016) use Kalman algorithm for target tracking in WSN. Target position is given as an input to the kalman filter and recursively it finds the next position of the object. M. Usha, Dr. N. Sankarram, and P. Prittopaul, (2016), propose a data-gathering algorithm where multiple M-collectors traverse through several shorter sub-tours concurrently to satisfy the distance/time constraints. Deepak v biradar and Dr. Nataraj K.R. (2015), Sink relocation is an efficient network lifetime extension method, which avoids consuming too much battery energy for a specific group of sensor nodes. As per M. D’Souza, T. Wark, and M. Ros, (2008), wireless localization network was implemented using Fleck Nano wireless sensor. This ability to track the location of the patients in an indoor environment and monitor the patient’s physical statuses like walking, running etc. In A.K. Chandra-Sekaran, P. Dheenathayalan, P. Weisser, C. Kunze, and W. Stork, (2009), to track the patients at disaster site the author proposed a ranging using environment and mobility adaptive RSSI (REMA) filter to estimate the distance. WSN4QoL enables the monitoring of aged people. Specifically, it provides network coding (NC) for data communication protocol and distributed localization algorithm, for energy-efficiency, context-awareness and security. S. Tennina, M. Di Renzo, E. Kartsakli, F. Graziosi, A. S. Lalos, A. Antonopoulos, P. V. Mekikis, and L. Alonso (2014). In S.-J. Jung, R. Myllyla, and W.-Y. Chung (2013), mobile and IPv6 techniques in WSN are combined to provide healthcare services. Doctors and patients are able to see the recorded biomedical signal graphs on their own android mobiles. J. Rejina Parvin and C. Vasanthanayaki (2015) Instead of cluster heads mobile sink nodes are used to gather sensed data, aggregating it and routing operations. To achieve better throughput and life time Gravitational Search Algorithm is used. UHF RFID provides accurate detections, WSN provides adequate RSSI observations. The WSN is combined with UHF RFID could bring notable benefits.

Combined use of UHF RFID and WSN technology:

As per C. Chen (2010), combining RFID and WSN technologies to build a child tracking system within a theme park. The design can be used in object tracking and surveillance. Z. Xiong, F. Sottile, M. Spirito, and R. Garello (2011), hybrid use of WSN and RFID is used for indoor positioning system. Z. Xiaoguang and L. Wei (2008), proposes a warehouse management system by combining WSN nodes and UHF-RFID readers. In N. Renuka, N. C. Nan, and W. Ismail (2013), RFID system, Zigbee and GSM are combined to provide a tracking system for hospitals enhances the user interface system. As discussed in S. M. Rajesh (2013), UHF RFID and parameter monitoring sensors are used to monitor the real time parameters of patient. GSM module is an added feature that will notify the emergency situation. In L. Catarinucci, D. De Donno, L. Mainetti, L. Palano, L. Patrono, M. L. Stefanizzi, and L. Tarricone (2014), integration of UHF RFID and IEEE 802.15.4 WSN nodes transmit data to a central server for patient localization, tracking and monitoring. RESTful Java and database push notification technologies to manage alert events through an iOS mobile application. In H. A. Khattak, M. Ruta, and E. Di Sciascio (2014), implementation of Constrained Application Protocol (CoAP), application layer protocol supports resource constrained devices and easy integration with TCP/IP standards. The author discusses the technologies and techniques for using CoAP based Wireless sensor network for monitoring medical sensors. Karthik J. and Dr. A. Rajesh (2015), propose sleep awake concept for an energy efficient management in Wireless Body Area Sensor Network.

System Design:

This outlines and implements smart healthcare systems (SHS) having, the capability to combine distinctive, yet correlative, technologies enabling the functionalities. Fundamentally, the framework is ought to have the capacity to gather, in real time both the environmental conditions and patients physiological parameters and convey them to a control center. A propelled monitoring application ought to examine the received data and send alert message in emergency situations. The architecture illustrated in Fig. 1 depicts the conceived smart healthcare system.

As shown, it is made out of three parts: (1) User Interface (2) Integration of RFID and Wireless Sensor Networks (Hybrid Sensing Network, HSN) (3) Data storage. Fig. 1 depicts three-tier architecture. (1) Presentation tier (2) Business logic tier (3) Data store tier. In the HSN, sensors are attached for monitoring the environmental conditions and patients health condition. Environmental conditions that can be monitored are temperature, humidity, ambient light and pressure. The sensors used to collect data from the environment, LM35 temperature sensor, humidity sensor, LDR (light depending resistor) sensor. The patients tag has two sensors, optical heart rate sensor and LM35 to monitor body temperature.
The proposed system assumes that several sensors are planted in each ward to collect environmental details. The main function of the sensor nodes are sensing capabilities, in addition to that it will track the patients, nursing staffs and doctors embedded with RFID tags. In particular, we predict patients wearing a HT tag which is capable to detect imperative psychological parameters, for example heartbeat and movement. Detected information is periodically logged on and delivers them to monitoring application. The monitoring application analyzes the received data and store in the database. The REST Web-based paradigm has been adopted to easily access the collected data by both local and remote users. In particular, a web based graphical interface permits local users to manage environmental parameters. The doctors and nursing staff will use the same interface with specific privilege to access patient’s data. Mobile application can also access the same information remotely. Doctors can access patient data via this application. The patients can also access their data and the doctor’s prescription using the same mobile application. Doctors will send the details in a pdf format and patients can download it through mobile app.

Fig. 1: System Architecture

Fig. 2: Cardiologist ward environmental parameter monitoring, sensor ID and patient ID

Fig. 3: Patient details and visualization of their physiological parameter graph
Fig. 4: Abnormality notification of environmental parameters

In emergency situations a push notification will be sent to the monitoring application (MA) and mobile. In case any abnormality absorbed in the environment data or in the patients physiological data it will be notified to the nursing staff via MA. Then the doctors can check the patients data through their mobile or monitoring application, thus the critical situation will be timely managed.

Now a day’s security is a main concern. Since we are collecting patient’s sensitive data, it must be secured. So the storage and access of the data is to be secured. The level of access is different for the patient, nurse, local user and doctor. Registered users can only access the information.

Board:

Fig. 6: Prototype multisensory board

A prototype multisensory board is constructed in lab. It consists of four sensors such as LM35 temperature sensor, humidity sensor, LDR (light depending resistor) sensor and optical heart rate sensor. A 40 pin 16F877A peripheral interface communication (PIC) microcontroller is used. The communication between the PC and the kit is done through MAX232 IC. Optical heart rate sensor uses infra red (IR) light photo receiver, which passes
Monitoring Application:
Using JAVA, a web based monitoring application is developed. Through this application local user enable to monitor the environment status, nurse and doctor is responsible for monitoring patient’s data. It stores the received data in the MySQL database, at any time the current data and the historical data are retrieved from the DB. Only data collection is done in DB. Data manipulation is done by MA. Dynamic graphical chart is displayed for the environmental details and the patient data. It is developed using JSON. Threshold based technique is used to notify the abnormal status, when the parameter fits outside a specified range. In case of emergency situations the patient details are sent to the doctor’s mobile by the nursing staff. Nurse will send the patient id to the mobile app. It interacts with the database and collects the patient data. A pdf can also be generated with the patient details, graphical display and the doctor’s prescription. The same can be downloaded from the mobile application by the patient.

Security Management:
Data protection and privacy is more important, we can achieve this through security management. Balamurugan, B., Venkata Krishna, P., Rajya Lakshmi, G.V., Anusha, K. (2015) proposes a Tiny Encryption Algorithm (TEA) for security. This allows the sensor devices to use less energy for cryptographic techniques. As per Lilly Roseline Mary J and Buvana M (2016), calculation of the direct and indirect trust using trust management scheme and the removal of the malicious node using the intrusion detection system. F. Vincylloyd, Dr. B. Anand, Mr.J. Jijin Godwin (2015), Selective jamming attacks are addressed by optimizing the link state routing protocol to maintain a stable route between source and destination. Error Tolerant Model (ETM) is used to check whether jammer is present or not. Monitoring application and mobile application allows only authorized users to access the information. Doctors, nurse, local users are requested to register first. User name and password are stored in MYSQL database. User interface allows authorized users and coordinate their communications, accessible through web browsers and mobile.

Conclusion:
Proposed system is to implement an IoT Smart Health Care System. Smart Healthcare Systems for automatic monitoring environmental conditions of a hospital and monitoring health condition of patients. UHF RFID is combined with WSN has been implemented. Sensors are used to sense the environmental condition i.e. is (temperature, humidity, ambientlight, etc...). The local staffs in the hospital are responsible for tracking the ward environmental conditions. Radio Frequency Identification (RFID) is used to identify the sensors. By using a RFID reader sensor identity can be verified to ensure authenticity and integrity.

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Future Work:
Sensed data needs to be protected. Enhance the security of data to avoid the malicious attack. In the patients tag we can add humidity sensor to monitor incontinence. Electromagnetic field should be in a acceptable range. It should not exceed the specified range. Monitoring of Electromagnetic level should be done. Interference is one of the new challenges while integrating RFID and WSN. We have to carefully design the collision free schedule for RFID and WSN.

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REFERENCES


