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An RFID based COVID Patient Health Care Monitoring System for Government Hospitals

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A B S T R A C T

The RFID technology is a cheap and effective medium ranged wireless communication service. Compared to Bar codes RFID is more robust and highly durable in communication with mobile devices within a range suitable for room level network. RFID supports several data encryptions and provide high scale security to data. In this paper a real time implementation model proposed and conducted a case study over AP COVID Isolation center. The traditional manual model is currently followed in GGH Kakinada in COVID center. Daily requirement of human resources such as Nurses, Medical Attendee, Drug suppliers and Para medical staff increasing in current service model. The proposed model minimizes rate of human resources utilization as well as increased monitoring effectiveness with well data organization, communication and security are some major advantages in our model. Mobile device assistance increases the flexibility and data collection efficiency for duty doctors on the fly. The model is a compact but efficient over digital communication environment forged within short ranged Wi-Fi zones like Isolation wards.

Keywords: RFID, ICT, Tagging, Servers, Digital Signatures, IoT.

1. Introduction

In recent years increased utilization of wireless communication devices improved the flexibility of the digital system communications [1]. The LAN/WAN/SWAN technologies introduced a hierarchical based global internet communication turning entire earth as a 'Global village' [2]. The IOT enabled services already available in medical services in many countries to assist medical staff in treating patients effectively [4][6]. The cost factor is becoming a primal barrier among medical service effectiveness as many medical centers are utilizing high human resources for organizing their medical camps [3]. The RFID tagging is a smart product information management service originally developed to Industrial applications [7]. But its utilization not limited to Industrial zones, currently RFID gaining more popularity due to its simple architecture and cheaper communication entities implanted in that network [9]. RFID comes in forms of tags which are identifiers of objects in a distributed network zone [15]. In fisheries, poultry and agronomy based industries RFID applied to support services in product management [10]. The antenna propagation delays are very low due to closed network enhances the bandwidth utilization. Many algorithms like FDM, TDM are available to boost the transmission capacity [13]. Business sectors adopted this technology to Human Resource management activities. Sensitive zones like Server Farms, scientific research labs and atomic plants are some domains where RFID tagging widely used to secured data processing and sharing with data privacy among hierarchical departments [14]. The cryptographic mechanism integrated with RFID technology enables greater security and confidentiality to patient's as well as hospital databases [5]. In this paper an attempt made to propose an RFID model for COVID center medical assistance. The features of proposed model over traditional manual medical service assistance are contrasted in technical perspective.

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2. RFID Technology

The RFID technology is used in recent era over many domains. It's special application of RFID in the health care system becoming an interest. The RFID strip or band attached to patient wrist like a tag. This band behaves like an electronic data carrier between the Client (patient) and Server (hospital server). RFID is limited wireless network environment with powerful data transmission rates. It is cheaper infrastructure but communication is "Line of Sight" oriented.

- The major Objectives of using RFID in Hospital Patient Caring Systems:
- Tracking of patient information timely with flexible data record management
- Interfacing medical equipment to direct data communications
- Patient Medicine and Drug prescription maintenance
- Hospital staff privacy and Log-In and Log-out process
- Mobile device interfacing with flexible App managers
- Third party software tools adoptable data generation for high end analysis & decision support systems
- Easy disposal of tags and data isolation techniques
- Very effective and advanced than QR-Code/ Bar-Code technologies must
- Characteristics of RFID Bands

There are different types of RFID bands based on their application environment available by many manufacturers today. Basically these bands are categorized on their Radio Frequency receiving/transmission capacity as Low, High and Ultra-High types. Also based on chips installed in RFID tags they are classified as PASSIVE and ACTIVE bands. The IC technology is very sophisticated in these bands with limited components hence they are cheaper to create.

The materials used to create these bands are also one classifier for RFID bands, selection of RFID band manufacturing material depends on the environment where they used as shown in given below table-1.

Table 1 - RFID Materials and Benefits.

Material	Name	Environment	Benefits
Silicon	NFC-Silicon	Companies, Hospitals, Educational Institutes and organizations	Plastic-Rubber material high folding flexibility water resistance and thin with smooth textures advanced graphic printings can be done
Plastic fiber	CDSE-Fiber	Companies, Factories	High scale resistance to heat & water. Very thin but strong strips. Elastic in nature useful in robust dust environments with high scratch resistance nature. Cost is more than others
Polymer LF/HF/UHF	A bandwidth based polymer material based	All environments except factories	Flexible to choose band width impacts cost UHF is high band with greater transmission capacities most affordable RFID bands.
Fused Bands	Polymer/Silicon/ Fiber	Materials used Organizations, Companies	Cost is high due to mixed technology assistance. Where smart cards are fused in IC of RFID to manage business/economic transactions of customers.
Soft PVC	PVC material	Temples, Conferences, Corporate Meetings	Stylish and Layer Graphics enriched bands. Must be disposed after a period.

The RFID bands or tags are the only communication devices interact with Wi-Fi environments and mobile devices. They are part of RFID infrastructure as shown in figure 1.

Fig. 1 – RFID Wrist Bands.

Recent technology paying attention of battery powers supporting the wrist band devices. Solar rechargeable batteries are applied over traditional Li-Ion batteries to save rare metal resources. These solar Strips must be charged 3 Hrs in bright sunlight for a backup of 2 days. Highly environment friendly in future these are going to become the future solution for RFID bands.

3. RFID Patient Care System

The proposed model is shown in figure 2 below.

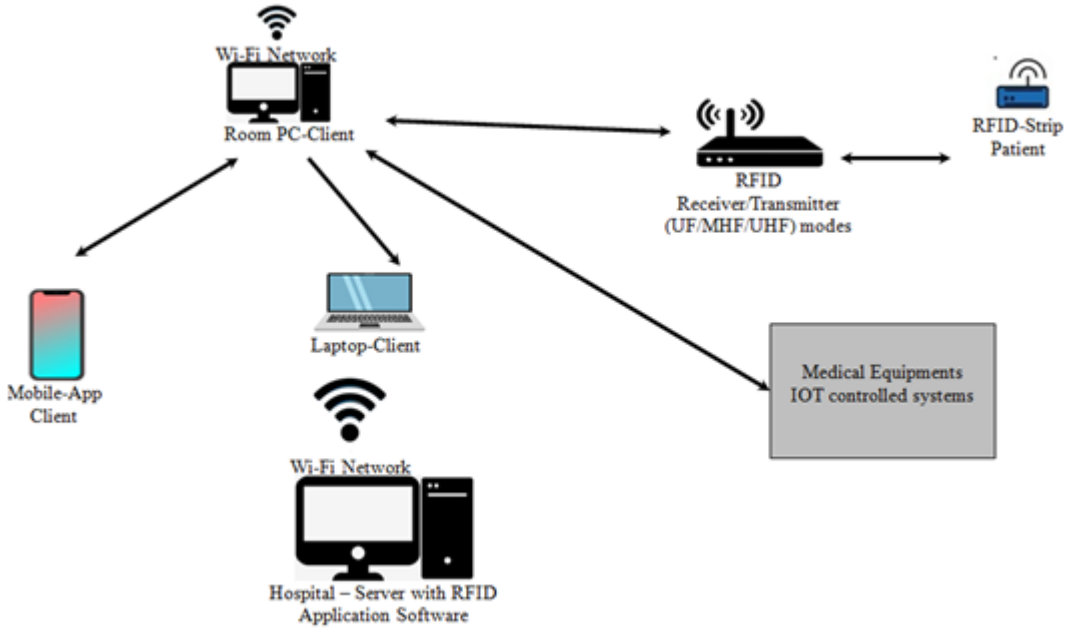

Fig. 2 – RFID Patient Care System.

3.1. Hospital Central Server

The central Server is a highly configured Linux/Window Server with high-speed broadband internet supported. This server is assisted with cloud service to communicate with other hospital networks across the globe. A secured intranet arrangement is there for hospital staff interaction with internet oriented services. The server supported with RFID application suitable for patient monitoring system. A huge set of repositories of heterogeneous data related to multi-dimensions stored in server. The hospital organization also assisted with third party Data Warehouse and Knowledge engineering service provider.

3.2. RFID Transmitter/Receiver Box

The RFID system responsible for data I/O transmissions and regulation between RFID wrist bands with Room-PC established with this device. The central server RFID application regulated and co-ordinates all the services exist in Room-PC to interact with RFID Box. The whole system security, privacy, data rates, band widths and functionalities can be tuned from central server easily. The RFID transmission box has an antenna, frequency modulator, data switcher and noise reducer. It is responsible for receiving transmission from wrist bands and pre-processes it before forwarding it to Room-PC.

3.3. RFID Wrist Strips

The major data collector in system which is attached to the patient behaves like real-time health care monitoring system. Limited buttons provided such as SCAN/SEND/ RECEIVE three buttons. SCAN button used to instant scanning of patient current health characteristic metrics. SEND button used to submit data to all the connected authenticated data devices in the room, Room-PC is default data extractor. RFID strip doesn't support data storage due to its thin and smart nature. But it can store up to 5 previous scan patient data with auto erase of old data snapshots when new data snapshots are coming.

3.4. IOT controlled Medical Equipments

The IOT enabled services improve the efficiency of data communication among mobile devices with internet services. The IoT system is boosted with IC regulation to support smart services. All the hospital medical equipment is connected and regulated with IoT system. Automatic patient monitoring and report distribution to hospital secured authenticated doctor data (mobile/laptop) device. Provide online assistance to tune equipment with voice control facility. Activating health monitoring systems with patient aligned health care programming snippets. Various sensors support for wide range of data collection scope.

3.5. Laptop Client

Doctors use laptops loaded with RFID client application assisted with Hospital Server RFID Server application. The Room-PC instantly connects with this Lap-Top by providing patient data with several options and timestamps. Doctor can simply use checkboxes to accept or reject a specific time stamp patient data. Doctor's prescriptions are instantly loaded into patient's wrist bands and Room-PC for nursing staff assistance during rounds. The laptop connectivity with RFID is strictly authenticated with digital signatures.

3.6. Mobile App-Client

Doctors may also use mobiles for communications and services of RFID similar to Lap-tops. The mobile must be equipped with Hospital RFID Server supportive mobile android app. Al the services and data I/O operations are similar to Lap-Top application. The mobile App comes under Server side program and Client side program. Server side program used to tune up and control Hospital RFID server program in central server. Administrative tools, system utility tools and Data administration tools are vital services of this program. In Client side program all the hospital RFID patient monitoring systems operations, diagnosis systems and Room PC systems are managed and controlled by this APP.

4. RFID Patient Monitoring System Framework

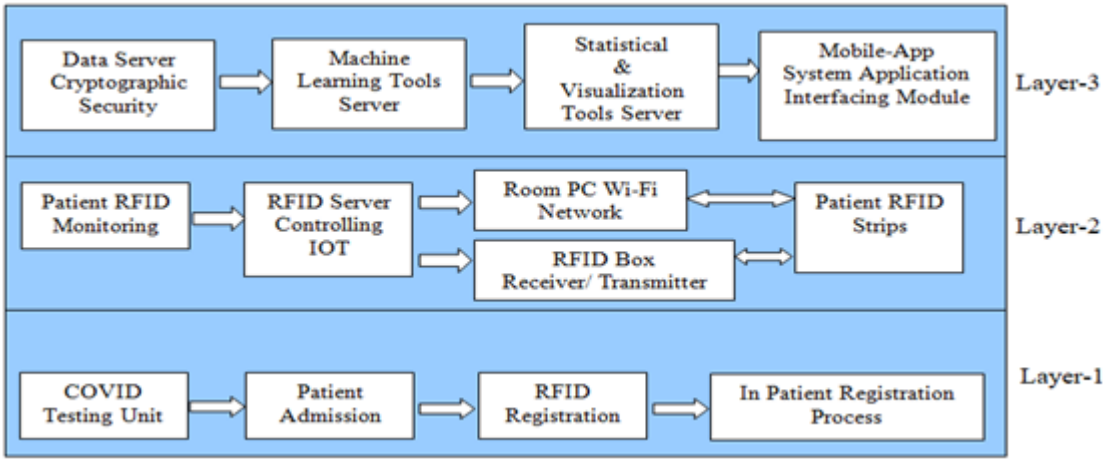

Fig. 3 – Framework model for Hospital RFID Network for patient health care system.

The RFID patient monitoring system supports various functionalities and methods to support automated health care and medical data analysis. Proposed system implanted in AP government COVID CARING UNIT at Kakinada. Major role of this camp is to admit COVID positive patients and provide treatment until they get recovered from the COVID infection. The frame work is as shown below figure 3, Described as follows.

LAYER-1 Services:

COVID Testing Unit :	The primary data station where Patients registration process begins. Performs COVID test for patients. If positive then an ID generated for admission into camp for treatment.
Patient Admission :	Patient details from Adhar card registered into AP-Government Chief Minister Medical Relief Fund database server. Diagnosis report data loaded into Patient diagnosis database.
RFID Registration :	RFID strip generation, Diagnostic data loaded into database. RFID strip linked to Room PC where patient is admitted. Once all setup done RFID strip to central data server data channel established. Patient record updated in Mobile App & System Application.
In Patient Registration	The patient admitted as Government Hospital In-Patient for treatment depending on the admission CRITICAL/ICU/GENERAL ward. This registration is mandatory for hospital treatment for sensitive and critical cases. Once patient admitted as In-Patient until hospital issues discharge patient not allowed leaving the hospital.

***LAYER – 2 Services*:**

Patient RFID Monitoring :	The Inpatient RFID registration takes place. RFID strip generated and attached to patient hand. Central server and Room-Pc activates the RFID patient record in Mobile & System Apps. RFID strip ID added to RFID Box. The communication network link established between RFID strips to Hospital Central Data Server. Patient RFID strip receives MAC

	Addresses and Wi-Fi credentials to join with Hospital Wi-Fi network anytime.
RFID Server Controlling IOT :	The hospital medical diagnosis equipments and patient monitoring sensors are controlled by IOT system module. IOT provides flexibility in data transmission among sensor oriented electronic devices. This module makes hospital wards/rooms as automatic patient health tracking zones.
Room PC Wi-Fi Network :	Each Room equipped with Wi-Fi enabled PC behaves like local server to mobile and RFID clients. Supports I/O transmission among mobile devices and RFID Boxes.
RFID Box Receiver/ Transmitter :	The RFID transmitter and controller of patient RFID strips within a room. Capable to tune the radio frequencies and data exchange formats.
RFID Patient Strips:	The patient real-time body characteristics monitoring and tracking metrics of various organs in patient. This strip supports Wi-Fi, Bluetooth data exchange capabilities with cryptographic data security to provide patient data confidentiality.

***LAYER – 3 Services*:**

Data Server(Cryptographic)	The central server for data management with high confidentiality and security for patient data. The Cryptographic support enhances the data privacy in these server
Machine Learning Tool Server	Supports knowledge engineering tools to analyze the data in server to support Decision making and data mining techniques.
Statistical & Visualization tools Server	Various statistical analysis techniques available as tools flexible to support tuning inputs. Bundle of Visualization Tools to project standard to high scale visualizations for data analysis results.
Mobile-App & System Application Interfacing Module	For assisting mobile device communication and Cloud computing facilities a Mobile App created and System App developed to manage entire application from Room PC clients. Nurses and Visiting doctors use mobile App and connect to Hospital server/ Room PC securely to support medical assistance to Patients.

5. Case Study Government Hospital Kakinada

In this work we approached AP-Government COVID Caring Camp, Kakinada East Government Hospital, Andhra-Pradesh. The traditional treatment followed here needs high human resource (Nurses, Doctors, Medical Attenders, Medical Officers, Ward Boys, Visiting Doctors and In-Patient Doctors. We introduced practically proposed RFID based IOT enabled Patient Monitoring System Model. Identified following merits over Traditional treatment approach. Where in traditional approach doctors and nurses are employed to diagnosis the ward patients by manually reading the metrics. Table-2 represents the time sequences recorded during diagnosis of patients per day. Table-3 represents the time sequences recorded from proposed RFID based IOT services enabled system. Figure 4 & 5 represents the visualization of both diagnosis timelines. In traditional diagnosis time line each recording by nurses taken in a span of average time gap of 33.33 Minutes. The human resource employed per room is approximately 9 members. Hence 81 nurses are required for monitoring patients in COVID ward rooms. In proposed system average time gap of 0.43 minutes which is very minute represents 24 hours monitoring. The human resource also 1 or 2 nurses per ward room which is less than 26 nurses for entire COVID relief camp of 9 rooms. These results justified that 67.23% reduced.

Table 2 - Critical Patient Data Analysis Traditional

Traditional Approach	Human Resource	Fluid low Level recording time(Min.)	Oxygen Level recording time(Min.)	Pulse & BP Monitoring record tracking time(Min.)
Room01	08	30	28	30
Room02	10	30	29	29
Room03	07	35	30	26
Room04	11	36	24	29
Room05	08	38	26	28
Room06	09	32	27	28
Room07	12	38	28	30
Room08	06	31	30	30
Room09	14	30	30	30

Table 3 - Critical Patient Data Analysis proposed system

Traditional Approach	Human Resource	Fluid low Level recording time(Min.)	Oxygen Level recording time(Min.)	Pulse & BP Monitoring record tracking time(Min.)
Room01	1	0.42	0.43	0.45
Room02	1	0.33	0.34	0.35
Room03	2	0.35	0.36	0.37
Room04	1	0.32	0.33	0.34
Room05	1	0.36	0.27	0.38
Room06	1	0.21	0.22	0.23
Room07	2	0.43	0.43	0.44
Room08	1	0.41	0.42	0.43
Room09	2	0.38	0.39	0.40

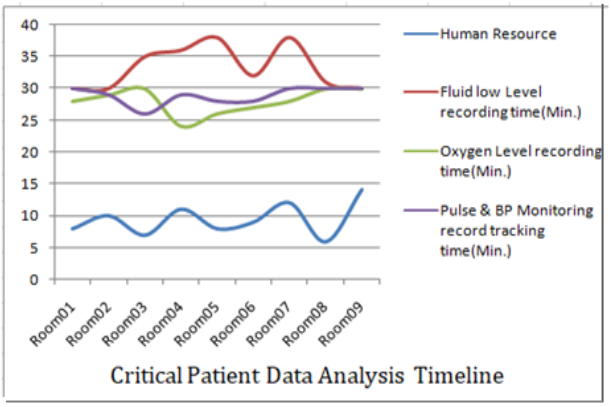

Fig. 4 – Critical Ward Patient Health Care tracking timeline traditional.

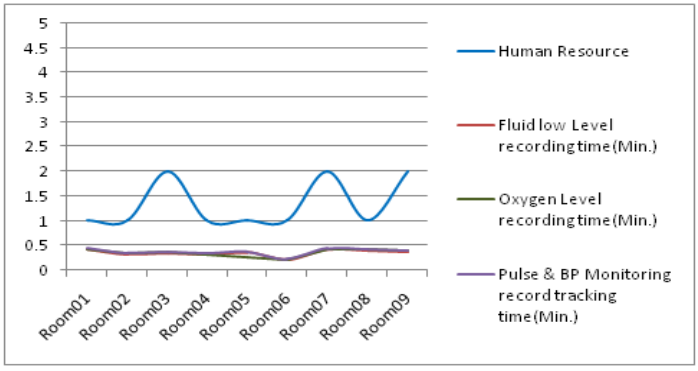

Fig. 5 – Critical Ward Patient Health Care tracking timeline RFID Smart IOT.

RFID data communication between mobile devices and patient medical equipment is cryptographic encryption supported. Data is highly confidential. The remainder alarm for patient medicine supply is highly reliable compared to nurse's timely visits which are varied in time.

6.Conclusion

The proposed model is fully digitalized supporting secured communication between among hospital staff mobile equipment. The RFID network maintains limited coverage (room) but provides good bandwidth for handling high volumes of data. In traditional caring system nurses and doctors need to diagnose patient in timed slots (3 times daily), whereas in our model continuous monitoring and diagnosis patient frequently to update the patient health metrics is an advantage. The proposed model also supports sharing of patient data across the hospitals in Andhra-Pradesh instantly so that patient treatment can be transparent and can get suggestions from other expert doctors in critical situations.

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