# Application of RFID Technology in Patient Management System

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# Application of RFID in Patient Management System


## ABSTRACT

Hospitals and other medical service facilities are trying to minimize the time it takes to serve a patient in an efficient manner. Typically, the service time involves identifying the patient, type of service required, history of treatment and accessing personal information. The current methodology consumes excessive time to perform these tasks. In addition, human error can make the procedure even longer. Radio Frequency Identification (RFID) technology can play a key role to retrieve patient data and track patients within the medical facility. A basic RFID system consists of a tag, antenna and a reader. RFID tag is a low power communication device which is capable of storing information that can be attached to the patient ID card. Using this RFID methodology it is possible to access patient information and movement within the medical facility once registered. This paper details how a pilot model was developed to retrieve patient information quickly and locate the individual from registration onwards. A database was designed to facilitate data gathering and organizing them to be retrieved quickly. An output patient profile will be presented.

## INTRODUCTION

Patient safety is one of the factors in the state of quality of health services and is considered a priority in health care. Assuring this safety is a task that is more and more complicated and which entails potential risks with no one method being capable of guaranteeing a total absence of errors. The Institute of Medicine estimates that “tens of thousands of deaths and injuries are caused by medical mistakes every year [1]. The FDA estimates that number to be nearly 500,000 [1]. Nowadays, one of the main worries in maintaining a high level of safety in health care environments is to closely follow the patient throughout their stay in a healthcare facility, i.e., from their arrival until they are discharged, registering both waiting and care times in each of the areas subject to control. However, Mentioned patient waiting time is a detriment to the on improving effectiveness (quality and timeliness) of patient service. Effective treatment with minimal appointment duration will not only increase revenue, but also increase patient satisfaction. Radio Frequency Identification (RFID) is a fast developing technology that uses radio waves for data collection and transfer; it can capture data efficiently and automatically without human intervention. RFID is believed to be the next generation innovation for automatic data collection and asset tracking. In this paper a RFID based Real-Time Hospital Patient Management system is simulated. The patients could be tracked through their movement and their location could be seen by the rest of the hospital staff. This system would help increase visibility and give the facility real-time data to help determine how long each process takes during a patient visit.

## OVERVIEW OF RFID TECHNOLOGY

The route of a patient through the schedule appointment in a healthcare service facility begins with registration. This will include gathering of personal details and entering them into a database. Registration department will now issue a passive RFID tag with the related information of the patient that will irrefutably identify the patient throughout their hospital stay. Data is collected from the time a patient enters into a processing area(Admission, Waiting, Nurse Exam, Waiting, Doctor Exam ,Billing) until they leave with minimal interference from external human intervention factors. The purpose of the patient management system is to integrate RFID technology into a segment of the healthcare as a tracking system to identify, analyze and reduce the patient throughput time. Function of RFID tracking system is as follows in Figure 1:

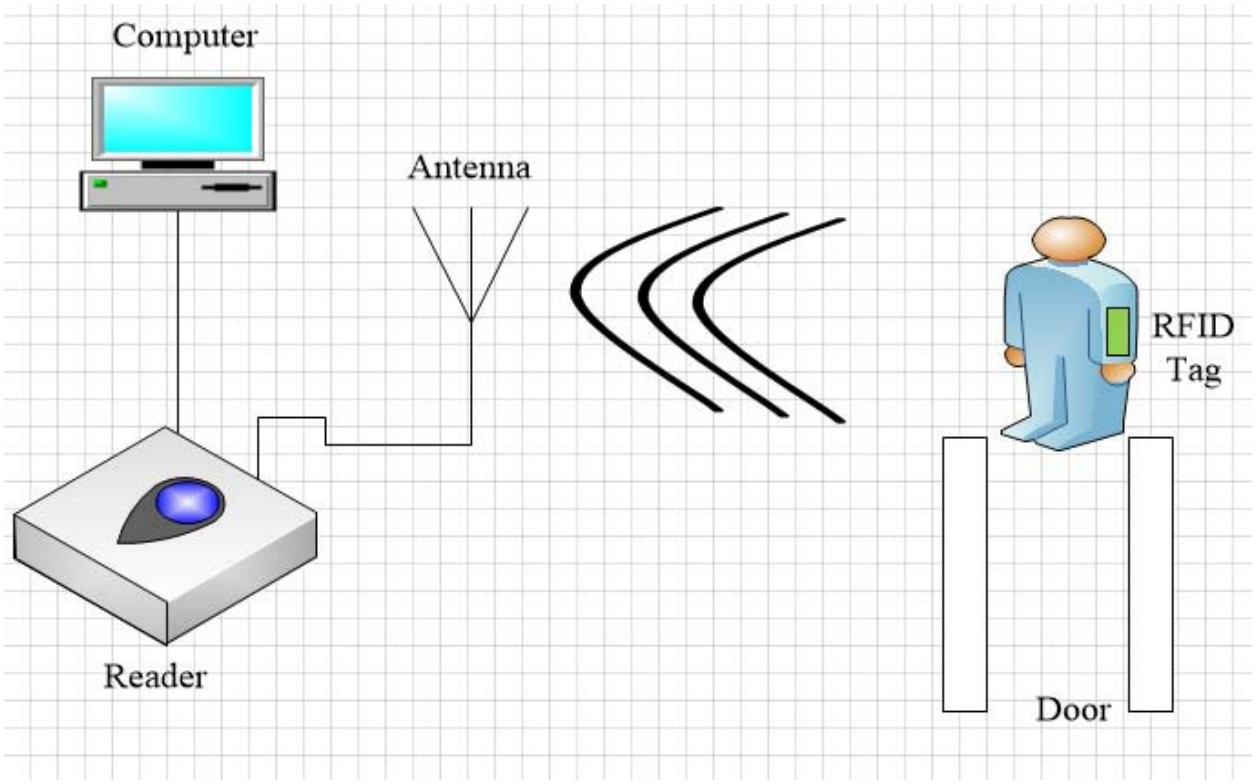



Figure 1: RFID Patient Tracking System

## METHODOLOGY

The inputs to the system are data stored in the RFID tags that was entered at the admission desk. The RFID tags used in this experiment are attached to traditional hospital wrist bands. Each patient is given a unique individualized RFID tag during their stay at the hospital and each tag's identification number (ID#) is assigned to the patient database system. The ID# on each patient's tag is also synchronized with a patient's health records and identification information. Once the person receives the wristband, the interaction between their tag and the tag readers begins to be processed by the proposed system. Figure 2 depicts the patient journey in a healthcare through a typical appointment:

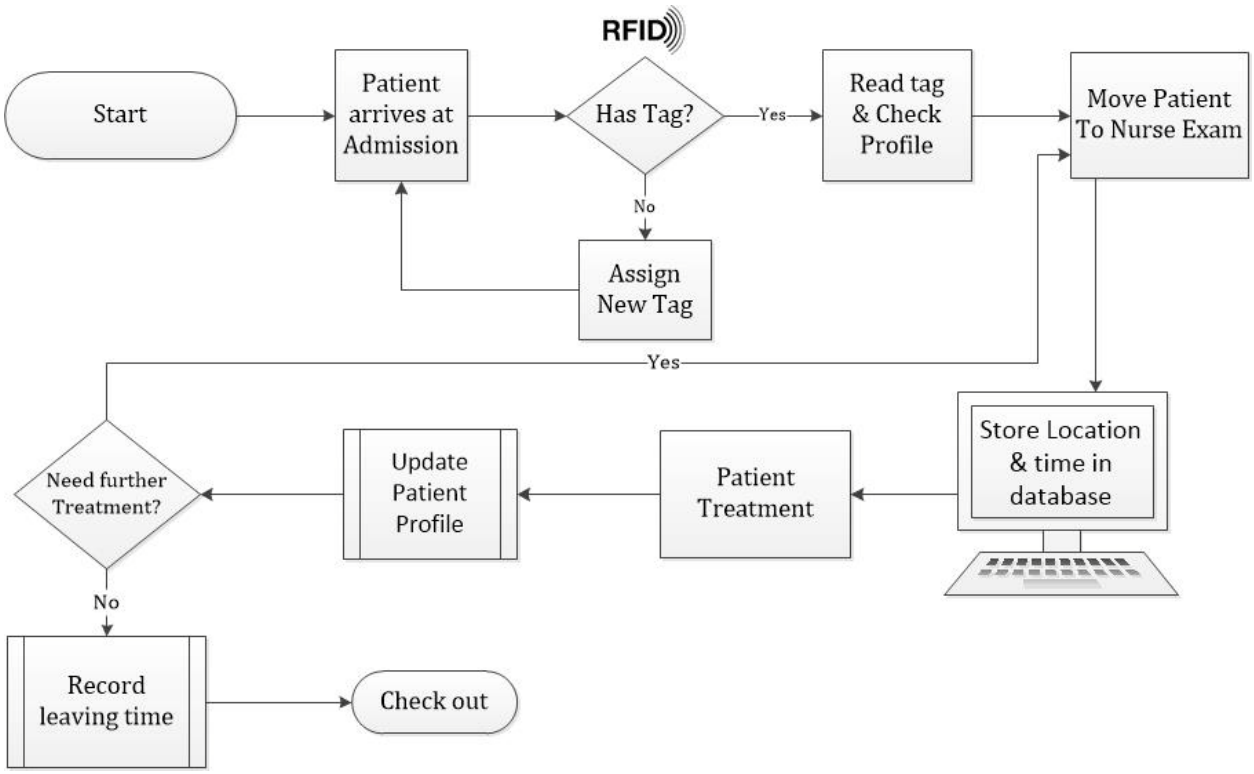



Figure 2: Flow Chart of RFID Patient Tracking System

## EQUIPMENT

The equipment consists of a reader, antenna and Passive Tags. The reader was manufactured by Motorola and the reader configuration is Electronic Product Code (EPC) class I Gen2 Motorola MC9090-G RFID reader. The objective of the EPC is to provide unique identification of physical objects. This is used to address and access information from individual objects from the computer network, much as the internet protocol (IP) address allows the computers to identify, organize and communicate with one another. The antenna used for data collection was Alien Technology Corporation circularly polarized 915MHz ALR-9610-BC Model [2]. The reader communicates to the tag through the antenna ports on the reader. Two tag types was used for the experiments, one Alien Squiggle inlay tag ALN-9640 and one Alien Squiggle inlay tag ALN-9740, both being subset of EPC Class 1 Gen 2 RFID Tag. Gen2 tags are the second generation of tags used for worldwide operation in the RFID UHF bands (860-960MHz). Figure 3 include some of the RFID components:

MC9090-G RFID reader [3]

Alien ALR9800 RFID Reader [2]

ALN-9640/9740 Tag [2]

External Circular Polarized Antenna [2]

Figure 3 : RFID Components

A simulated hospital environment has been created. Six stations were created as follows:

1. Admission
2. Waiting
3. Nurse Exam
4. Waiting for doctor
5. Doctor Exam
6. Billing

We assigned six RFID readers for each location, hence an Admission reader reads a tag and it means that the patient possessing the tag has entered that location. Figure 4 showed the necessary arrangements:

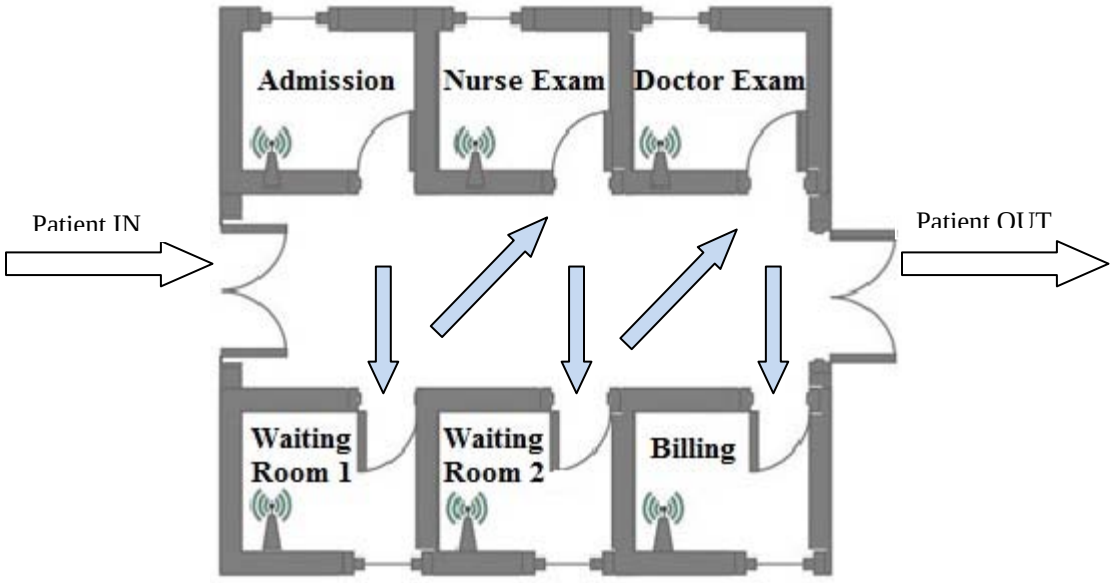



Figure 4: Schematic of the hospital

At minimum 30 samples are needed for statistical analysis. Thirty patients were selected randomly, each patient is given a unique RFID tag. RFID Readers send notification and presence of the patient within their range to the main server which is responsible to process that data and

keep track of it. The data collected are, entry and exit times at each location, personal identification of the patient (figure 5).

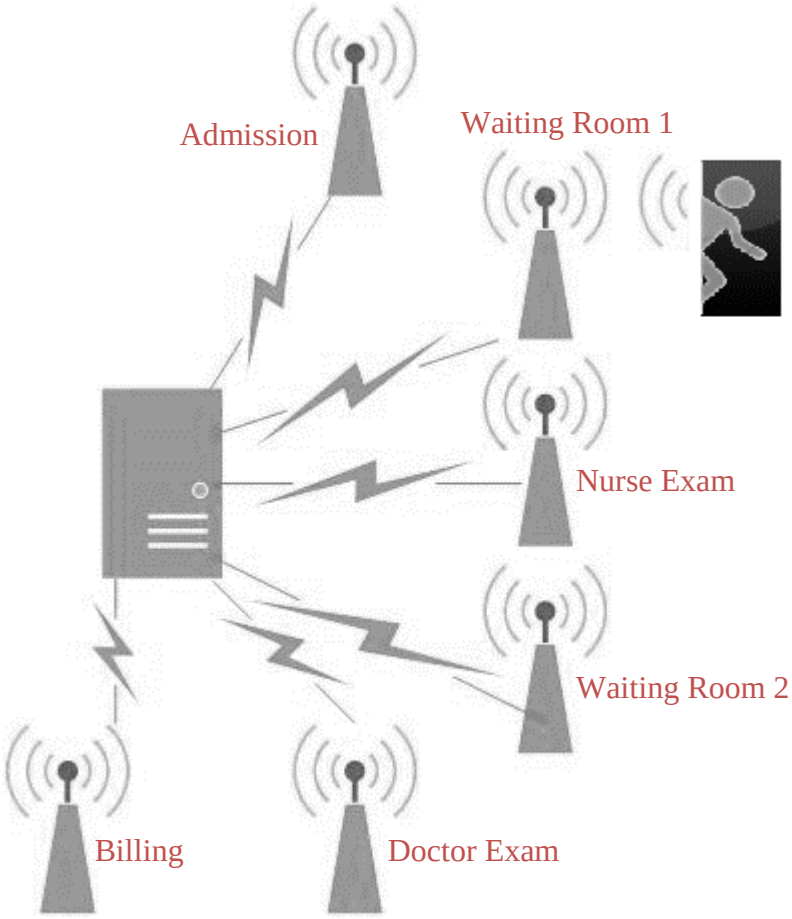



Figure 5: RFID Reader set up

**DEVELOPEMENT OF RFID TRACKING SYSTEM**

RFID reader receives signals sent by the tag. This information is the raw data which needs to be processed and analyzed. For this purpose the information can be forwarded through the medium such as Ethernet cable, wireless or even serial ports. The received information is stored in the server side database that has been created. The Microsoft Access technology [4] used in this case

since its lightweight and easy to manage. Inside the database four tables have been created as shown in tables 1-4:

**Patient table:**

This table records the patient information such as patient ID, name, doctor name phone number, emergency number and also picture. Table 1 shows a data sample from that table.

Table 1: Patient Information Table

| pid | first_name | last_name | doc_name | phone_num | emergency_ | patient_image |
|---|---|---|---|---|---|---|
| 1001 | mahdi | hosseini | mapa | 1234567 | 7654321 | Package |
| 1002 | kerman | soodeh | mapa | 1234569 | 7654320 | Package |
| 1003 | rajab | ali | mapa | 1234571 | 7654319 | Package |
| 1004 | razieh | feyz | alireza | 1234573 | 7654318 | Package |
| 1005 | saeed | ahmad | alireza | 1234575 | 7654317 | Package |
| 1006 | hossein | keshmiri | alireza | 1234577 | 7654316 | Package |
| 1007 | amir | naser | zahraee | 1234579 | 7654315 | Package |

**Reader table:**

This table maps each reader to its location by assigning reader name, for example reader #1 is installed in Admission room.

Table 2: Reader table

| reader_id | section |
|---|---|
| 1 | Admission |
| 2 | Waiting |
| 3 | Nurse Exam |
| 4 | Waiting |
| 5 | Doctor Exam |
| 6 | Billing |

**Tag table:**

Since each patient has a unique tag, this table records tag ID and patient ID. This table has only two columns: tag ID and patient ID (Table 3). Tag ID is in the hexadecimal form.

Table 3: Tag Table

| tid | pid |
|---|---|
| HE2009009761100560470E25B | 1020 |
| HE2009009761100570470E257 | 1018 |
| HE2009009761100580470E253 | 1005 |
| HE2009009761100600460E24A | 1001 |
| HE2009009761100620460E242 | 1004 |
| HE2009009761100630460E23E | 1003 |
| HE2009009761100690370E7E5 | 1029 |

**History table:**

This table keeps the log of the events. Each time a tag is being read by the reader, the information regarding the time period that tag was in the proximity of the reader with the tag id along with the time slot and the reader ID which read the tag is being stored into database.

Table 4-History Table

| ID | tid | start_time | end_time | reader_id | waiting_tim |
|---|---|---|---|---|---|
| 1 | HE2009009761 | 3/14/2014 8:00:00 AM | 3/14/2014 8:01:50 AM | 1 | 110 |
| 2 | HE2009009761 | 3/14/2014 8:02:50 AM | 3/14/2014 8:08:11 AM | 2 | 321 |
| 3 | HE2009009761 | 3/14/2014 8:09:11 AM | 3/14/2014 8:19:04 AM | 3 | 593 |
| 4 | HE2009009761 | 3/14/2014 8:20:04 AM | 3/14/2014 8:26:05 AM | 4 | 361 |
| 5 | HE2009009761 | 3/14/2014 8:27:05 AM | 3/14/2014 8:40:46 AM | 5 | 821 |
| 6 | HE2009009761 | 3/14/2014 8:41:46 AM | 3/14/2014 8:43:11 AM | 6 | 85 |
| 7 | HE2009009761 | 3/15/2014 8:00:00 AM | 3/15/2014 8:01:13 AM | 1 | 74 |

Above tables are related to each other as shown in figure 6. For example both Tag table(Table 3) and History table(Table 4) have tag ID, having shared key in the tables help us to find related information in separate table (figure 6) shows a general relationship between tables.

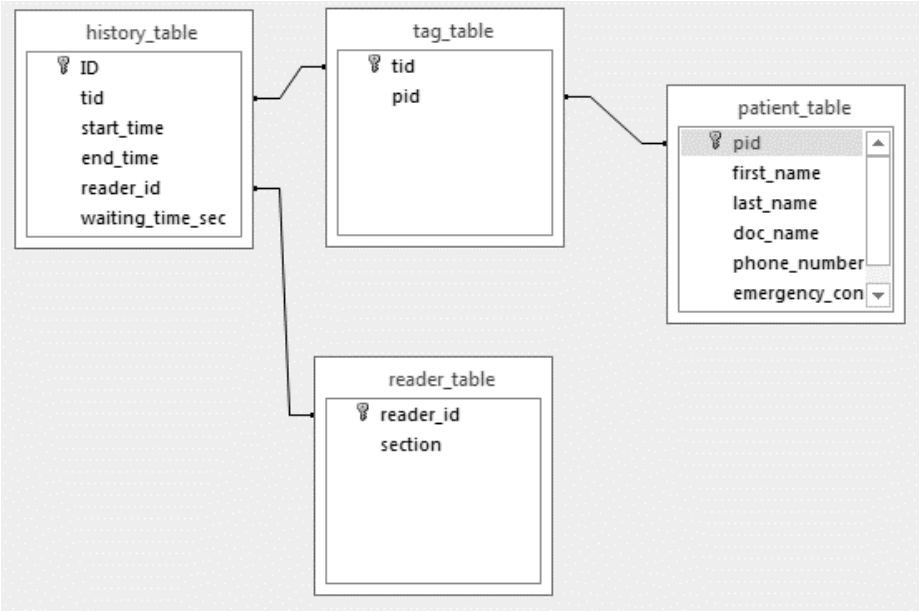



Figure 6: Address of different tables

Storing information in the database is an efficient way to store and access data. However, retrieving data from the database can be a tedious job, for this purpose a pilot application has been developed that helps to retrieve information from the data base and update patient information as well. This application has been developed in C# programming language and can reside anywhere and is capable of accessing to the database remotely. A sample display from this application is shown in figure 7:

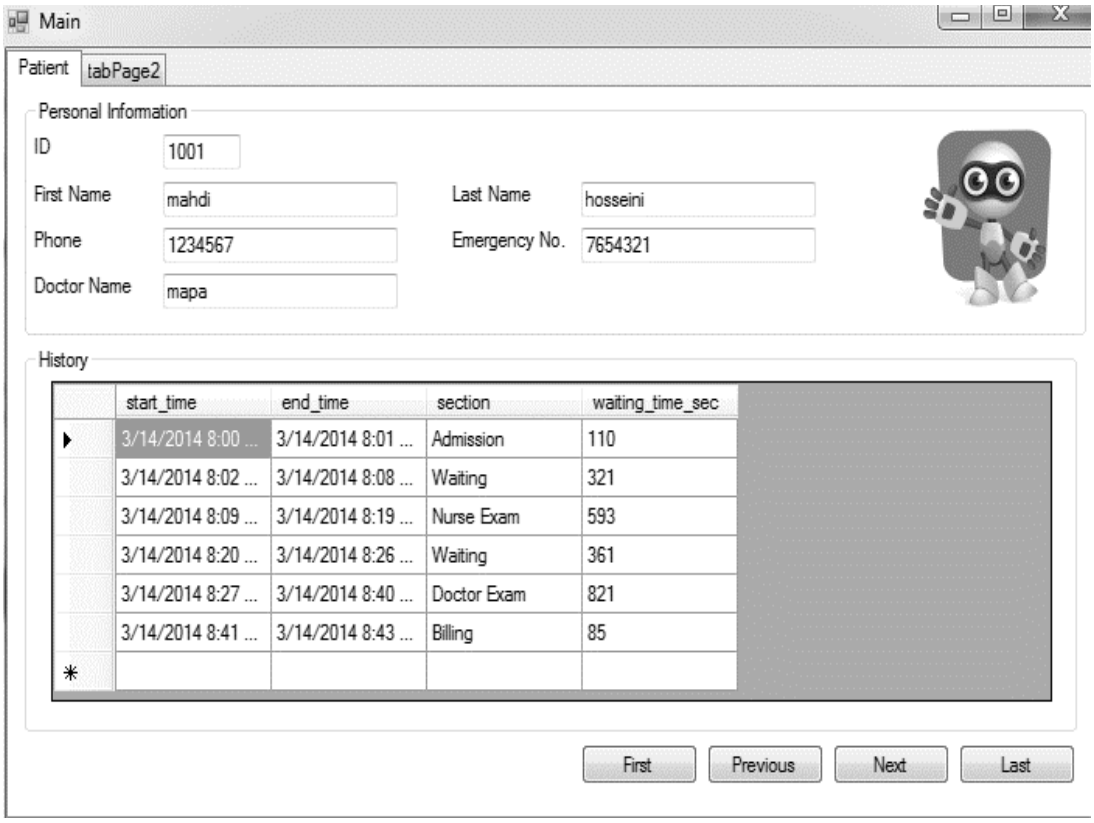



Figure 7: Time tracking display

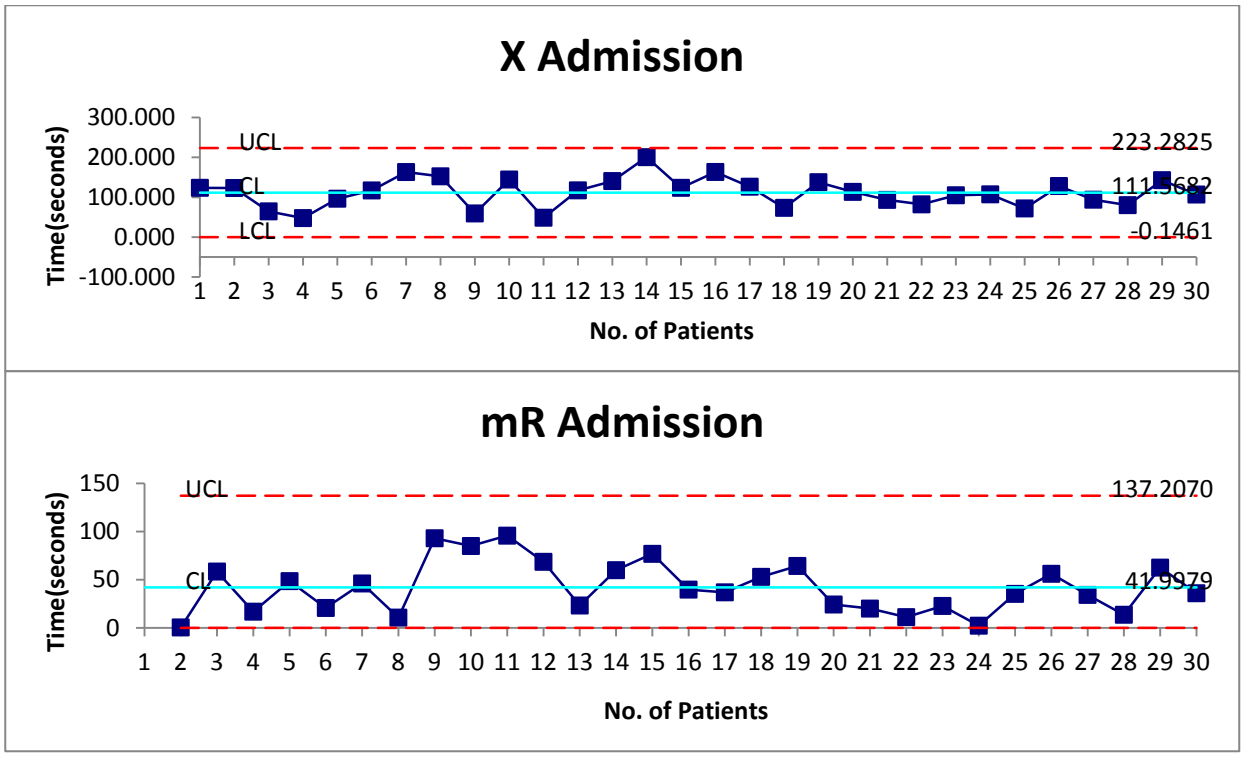
## DATA COLLECTION AND ANALYSIS

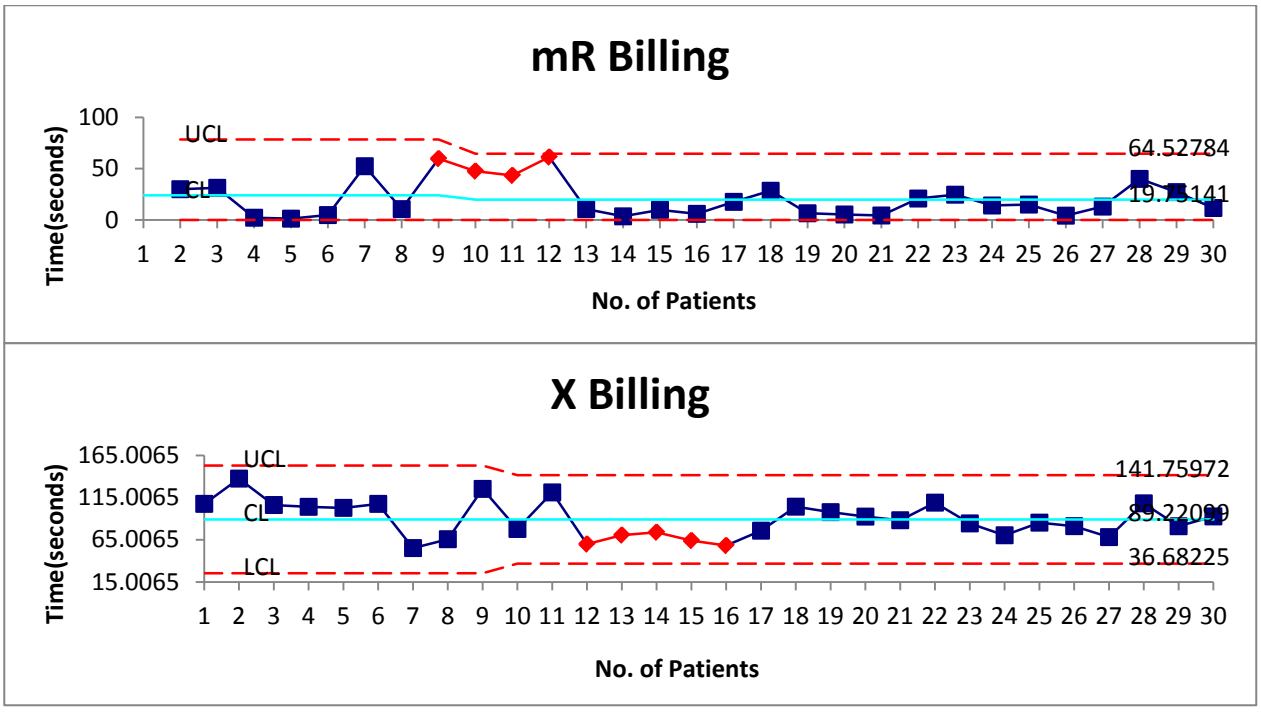
Typical Length of Stay (LOS) data at each processing center was obtained from published values [5]. First attempt to simulate a patient movement was created by taking the range of processing time and picking 30 random data points. The output from six processing centers are shown in table 5:

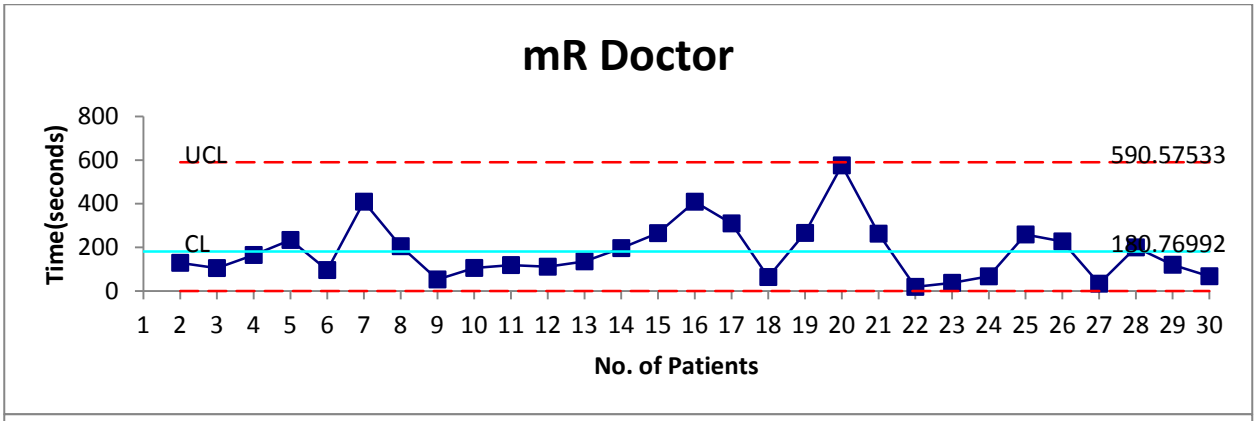
Table 5 : Processing Center Data

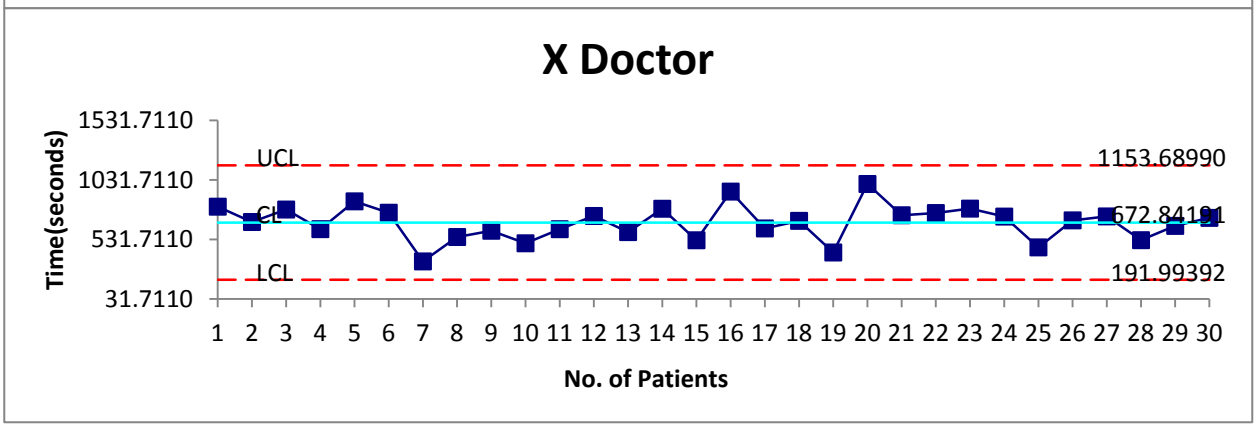
| Patient No. | Admission | Waiting | Nurse Exam | Waiting | Doctor Exam | Billing |
|---|---|---|---|---|---|---|
| 1 | 110 | 321 | 593 | 361 | 821 | 85 |
| 2 | 74 | 233 | 427 | 247 | 487 | 123 |
| 3 | 137 | 523 | 659 | 216 | 506 | 77 |
| 4 | 175 | 163 | 458 | 330 | 591 | 64 |
| 5 | 173 | 470 | 715 | 1137 | 1003 | 71 |
| 6 | 183 | 298 | 692 | 702 | 657 | 57 |
| 7 | 63 | 296 | 607 | 1369 | 612 | 110 |
| 8 | 113 | 117 | 593 | 1344 | 692 | 64 |
| 9 | 171 | 224 | 490 | 179 | 853 | 103 |
| 10 | 79 | 248 | 482 | 1004 | 496 | 117 |
| 11 | 92 | 362 | 579 | 1305 | 432 | 74 |
| 12 | 67 | 163 | 544 | 96 | 742 | 80 |
| 13 | 65 | 301 | 622 | 779 | 828 | 114 |
| 14 | 82 | 203 | 412 | 339 | 729 | 113 |
| 15 | 89 | 204 | 430 | 1080 | 596 | 83 |
| 16 | 63 | 252 | 690 | 1073 | 695 | 85 |
| 17 | 97 | 372 | 392 | 680 | 500 | 80 |
| 18 | 105 | 512 | 649 | 436 | 523 | 119 |
| 19 | 131 | 468 | 563 | 186 | 858 | 102 |
| 20 | 106 | 508 | 740 | 822 | 434 | 96 |
| 21 | 108 | 79 | 554 | 773 | 737 | 104 |
| 22 | 106 | 129 | 492 | 1254 | 697 | 112 |
| 23 | 177 | 288 | 576 | 1298 | 512 | 94 |
| 24 | 120 | 124 | 499 | 1081 | 641 | 66 |
| 25 | 115 | 341 | 379 | 706 | 590 | 106 |
| 26 | 100 | 126 | 543 | 1090 | 532 | 87 |
| 27 | 185 | 386 | 287 | 374 | 1000 | 54 |
| 28 | 163 | 527 | 680 | 309 | 605 | 55 |
| 29 | 187 | 121 | 324 | 793 | 992 | 118 |
| 30 | 94 | 92 | 535 | 90 | 507 | 81 |

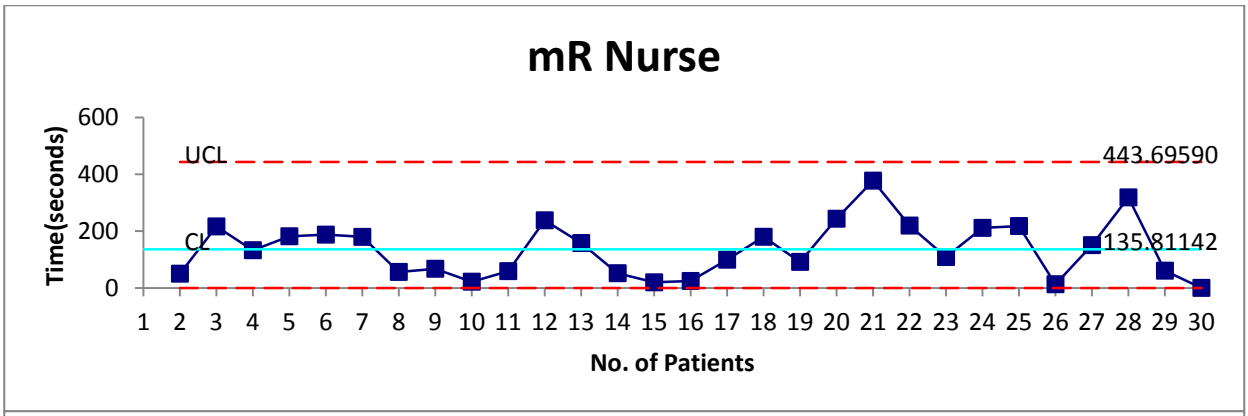
The second attempt to simulate patient movement was by generating processing times using normal distribution from the published values. The control chart is a graph used to study how a process changes over time [6]. The control charts for the processing times are shown in figure 8 created from QI Macros software [7]:

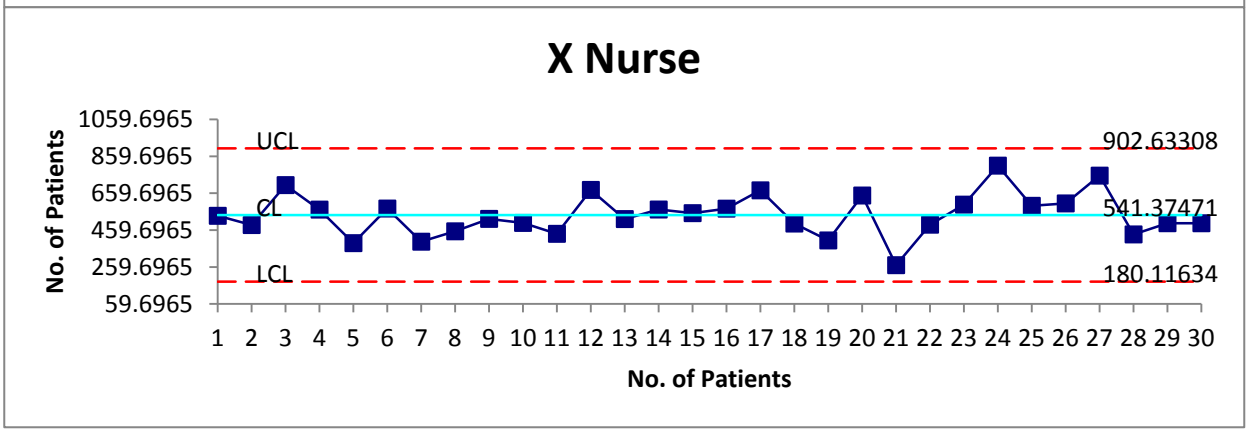


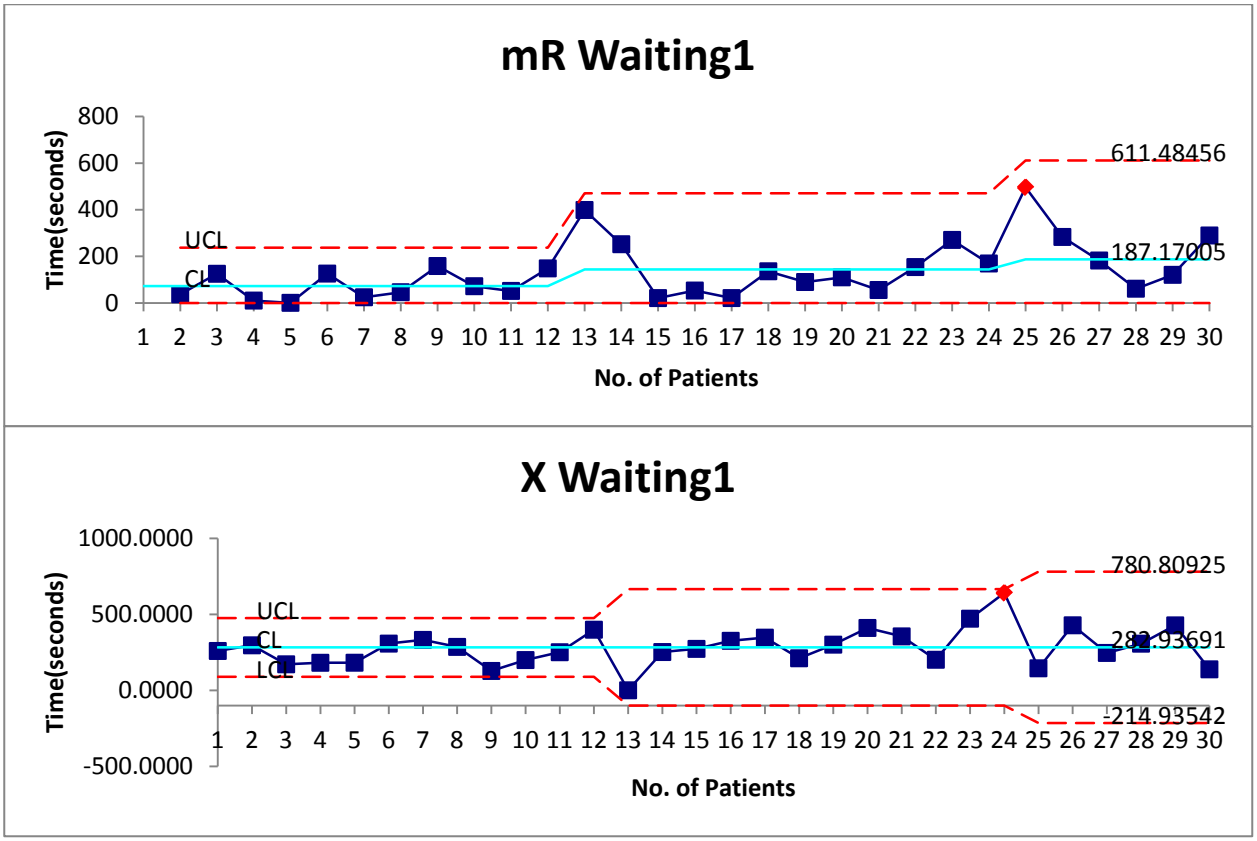




mR Doctor
Time(seconds)
800
600
400
200
0
UCL
CL
590.57533
180.76992
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
No. of Patients


X Doctor
Time(seconds)
1531.7110
1031.7110
531.7110
31.7110
UCL
CL
LCL
1153.68990
672.84191
191.99392
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
No. of Patients


mR Nurse
Time(seconds)
600
400
200
0
UCL
CL
443.69590
135.81142
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
No. of Patients


X Nurse
No. of Patients
1059.6965
859.6965
659.6965
459.6965
259.6965
59.6965
UCL
CL
LCL
902.63308
541.37471
180.11634
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
No. of Patients



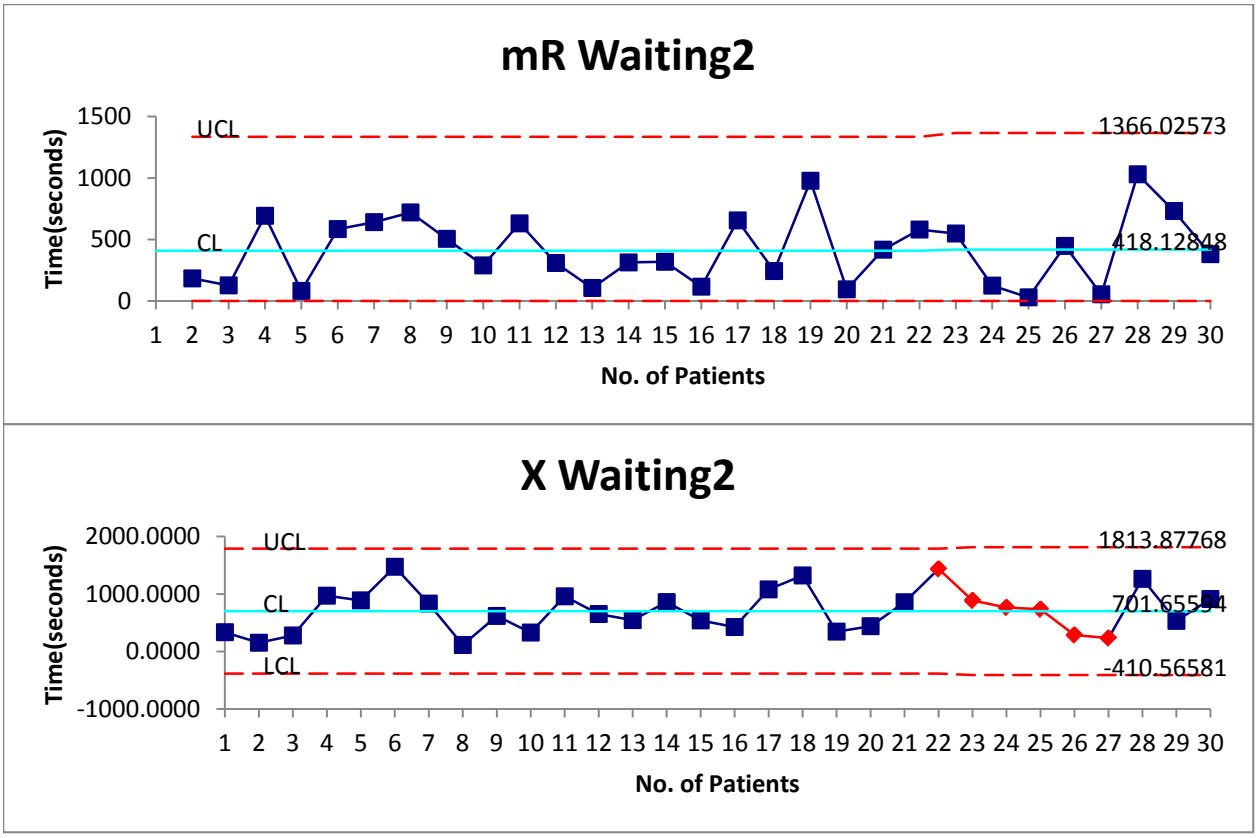




Figure 8: Control Chart of six healthcare departments

## CONCLUSION

From the above plotted control chart of six departments the following can be concluded:

- Billing department time variation has continued to fall and rise on the same side of the centerline and more than one sigma unit away from the centerline which indicates that the process is drifting out of control.
- In waiting department1 control chart has a single point outside the 3 sigma control limits which indicates lack of control in the process.
- Waiting department2 control chart has seven consecutive points, all decreasing in value which indicates a trend in the process.

## REFERENCES


[1] McGee M. 2004. Health-care I.T. has a new face. Information Week 988: 16

[2] Alien Technology Reader Interface guide; September 2008

[3] Motorola MC9090-G RFID; Handheld RFID Reader for Global Deployments

[4] Introduction to Microsoft Access 2007; Office of Information Technology Montclair State University

[5] Joseph C. Chen & Thomas J. Collins; Creation of a RFID Based Real Time Tracking (R-RTT) System for Small Healthcare Clinics. Journal of Medical Systems- December 2012, Volume 36, Issue 6, pp 3851-3860

[6] Control Chart from American Society for Quality- a Global Leader in Quality Improvement & Standards

[7] QI Macros for Excel from http://www.qimacros.com/