Medical Laboratory Specimen Tracking System Using RFID Technology
(e-Specimen)

by

Mohd. Harris bin Zahari
(7758)

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the requirements for the
Bachelor of Technology (Hons)
(Business Information System)

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Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MOHD. HARRIS BIN ZAHARI

CERTIFICATION OF APPROVAL

Content- Based Image Retrieval System

By

Mohd. Harris bin Zahari

A Project Dissertation submitted to the
Computer Information Science Programme
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(Mohd Hilmi bin Hasan)

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ABSTRACT

The objective of this project is to tracking the medical samples in the hospital using radio frequency identification (RFID). Medical Laboratory Specimen Tracking System (e-Specimen) includes a range of specimen bottle tagged with an RFID tag and a system that can read and write the details about specimen. RFID is a system that transmits the identity of any object (in the form of a unique serial number) wirelessly using radio waves. The specimen bottle labeled using RFID tag and the details about it and patients will be computerized in database, so doctor and lab assistant easily can access to the database to view the information. The possibility also exists for a wide range of more advanced applications ranging for using RFID technology for asset and patient tracking in the health care industry.

ACKNOWLEDGEMENTS

The author wishes to take the opportunity to express his utmost gratitude to the individuals who have taken the time and effort to assist the author in completing the project. Without the cooperation of these individuals, the author would undoubtedly have faced complications throughout the course.

First and foremost the author's utmost gratitude to his advisor, Mr. Mohd Hilmi bin Hasan, for his invaluable support, encouragement, supervision and useful suggestions throughout this research work. His moral support and continuous guidance enabled me to complete my work successfully. To the Final Year Research Project Coordinator, Ms. Savita A/P K. Sugathan for providing him with all the initial information required to begin the project. The author also highly thankful to Mr. Adam Amir for the valuable suggestions throughout this study.

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Mohd, Harris bin Zahari

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Medical laboratory specimen is patient's tissues, fluid or other materials derived from the patient used for laboratory analysis to assist differential diagnosis or staging of a disease process. There are some common type of specimen taken from patients included throat swabs, sputum, urine, blood, surgical drain fluids and tissue biopsies.

Nowadays, the specimen bottle using only paper labels affixed to the bottles. In addition to having human-readable printed text, the labels also typically contained handwritten patient information and lab instructions. But such manual procedures were prone to errors. The RFID system has allowed the practice to step away from an old habit of adding handwriting to the printed labels

So as my Final Year Project (FYP), I will develop a Medical Laboratory Specimen Tracking System using Radio Frequency Identification (RFID) technology. I will focus on the development of embedded chip at the specimen bottle as a transmitter and program for admin; doctor and lab assistant to receive information from the transmitter and store it in the database together with the description and result of the lab test.

1.2 Problem Statement

> *Aug. 11— After 67-year-old Hurshell Ralls went into surgery for bladder cancer, he came out of surgery missing more than he ever expected. His penis and testicles were gone caused by misdiagnosed in United Hospital* – ABCNews January 2003, 'Total Disbelief'

The specimen nowadays in handled using the hand writing label and that such manual procedure were prone to errors. Hence, the manual label needs to be replaced by a system that can work effectively and systematically. The economical designs are a challenge to the design community. They are required to be properly designed in order to keep it economical and effectively to users.

1.3 Objective and Scope of Study

The objective of this study is to develop Medical Laboratory Specimen Tracking System to tracking the specimen and to keep specimen's information into database and can be access by authorize persons. In order to achieve this objective, a few tasks and research need to be carried out by collecting all technical details regarding RFID technology. For the scope of study for this project will cover the development of database and design the interface of system and configure the system to connect it with RFID hardware.

CHAPTER 2
LITERATURE REVIEW

2.1 RFID Definition

Radio-frequency identification (RFID) is the use of an object (typically referred to as an RFID tag) applied to or incorporated into a product, animal, or person for the purpose of identification and tracking using radio waves. Some tags can be read from several meters away and beyond the line of sight of the reader.

Most RFID tags contain at least two parts. One is an integrated circuit for storing and processing information, modulating and demodulating a radio-frequency (RF) signal, and other specialized functions. The second is an antenna for receiving and transmitting the signal.

There are generally two types of RFID tags: active RFID tags, which contain a battery and can transmit signals autonomously and passive RFID tags, which have no battery and require an external source to provoke signal.

ISO/IEC 14443; This standard is a popular HF (13.56 MHz) standard for HighFIDs which is being used as the basis of RFID-enabled passports under ICAO 9303 allow RFID communicates via magnetic field induction, where two loop antennas are located within each other's near field, effectively forming an air-core transformer. It operates within the globally available and unlicensed radio frequency ISM band of Low-frequency (LF: 125–134.2 kHz and 140–148.5 kHz) (LowFID) and high-frequency (HF: 13.56 MHz). As mentioned earlier, RFID can be differentiating into two type's modes of it;

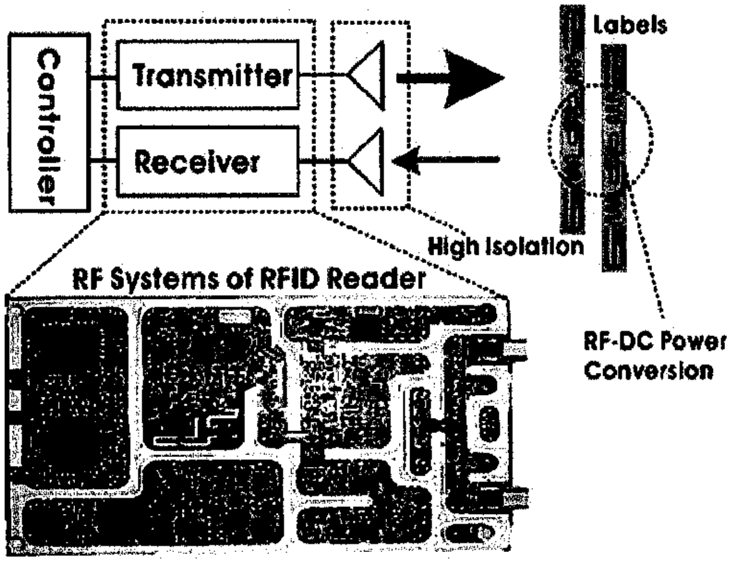

Figure 1.1 : The Passive RFID

- **Passive Communication Mode**: The Initiator device provides a carrier field and the target device answers by modulating existing field. In this mode, the Target device may draw its operating power from the Initiator-provided electromagnetic field, thus making the Target device a transponder.

- **Active Communication Mode**: Both Initiator and Target device communicate by alternately generating their own field. A device deactivates its RF field while it is waiting for data. In this mode, both devices typically need to have a power supply.

2.2 History of RFID

It's generally said that the roots of radio frequency identification technology can be traced back to World War II. The Germans, Japanese, Americans and British were all using radar—which had been discovered in 1935 by Scottish physicist Sir Robert Alexander Watson-Watt—to warn of approaching planes while they were still miles away. The problem was there was no way to identify which planes belonged to the enemy and which were a country's own pilots returning from a mission.

The Germans discovered that if pilots rolled their planes as they returned to base, it would change the radio signal reflected back. This crude method alerted the radar crew on the ground that these were German planes and not Allied aircraft (this is, essentially, the first passive RFID system).

Under Watson-Watt, who headed a secret project, the British developed the first active identify friend or foe (IFF) system. They put a transmitter on each British plane. When it received signals from radar stations on the ground, it began broadcasting a signal back that identified the aircraft as friendly. RFID works on this same basic concept. A signal is sent to a transponder, which wakes up and either reflects back a signal (passive system) or broadcasts a signal (active system).

Advances in radar and RF communications systems continued through the 1950s and 1960s. Scientists and academics in the United States, Europe and Japan did research and presented papers explaining how RF energy could be used to identify objects remotely. Companies began commercializing anti-theft systems that used radio waves to determine whether an item had been paid for or not. Electronic article surveillance tags, which are still used in packaging today, have a 1-bit tag. The bit is either on or off. If someone pays for the item, the bit is turned off, and a person can leave the store. But if the person doesn't pay and tries to walk out of the store, readers at the door detect the tag and sound an alarm.

2.3 RFID Technology versus Barcode Technology

The question that is most frequently asked is "when is RFID better than Barcodes." RFID is not necessarily better than Barcodes. The two are different technologies and have different applications, which sometimes overlap. In many circumstances, RFID offers advantages over traditional bar codes. The big difference between the two is bar codes are line-of-sight technology. That is, a scanner has to "see" the bar code to read it, which means people usually have to orient the bar code toward a scanner for it to be read.

One advantage of RFID is that the technology doesn't require line of sight. RFID tags can be read as long as they are within range of a reader. Bar codes have other shortcomings as well. If a label is ripped or soiled or has fallen off, there is no way to scan the item, and standard bar codes identify only the manufacturer and product, not the unique item. For example, the bar code on one milk carton is the same as every other, making it impossible to identify which one might pass its expiration date first.

	RFID	Barcode
Read Rate	High throughput. Multiple (>100) tags can be read simultaneously.	Very low throughput. Tags can only be read manually, one at a time.
Line of Sight	Not required. Items can be oriented in any direction, as long as it is in the read range, and direct line of sight is never required.	Definitely required. Scanner must physically see each item directly to scan, and items must be oriented in a very specific manner.
Human Capital	Virtually none. Once up and running, the system is completely automated.	Large requirements. Laborers must scan each tag.
Read/Write Capability	More than just reading. Ability to read, write, modify, and update.	Read only. Ability to read items and nothing else.
Durability	High. Much better protected, and can even be internally attached, so it can be read through very harsh environments.	Low. Easily damaged or removed; cannot be read if dirty or greasy.
Security	High. Difficult to replicate. Data can be encrypted, password protected, or include a	Low. Much easier to reproduce or counterfeit.

	"kill" feature to remove data permanently, so information stored is much more secure.	
Event Triggering	Capable. Can be used to trigger certain events (like door openings, alarms, etc.).	Not capable. Cannot be used to trigger events.

Table 2.1 The RFID versus barcode.

What jumps out from this comparison is RFID's capability to greatly amplify the benefits received from traditional bar coding. By eliminating the manual task of reading a bar code, RFID automates data entry. This permits new ways of processing items, events or transactions.

2.4 RFID in Healthcare Industry

The RFID tags in healthcare may be applied to people (patients and staff) and to objects, allowing the readers on door frames, wards and treatment areas to detect and record interactions. The figure below shows the potential of RFID applications in healthcare settings:

Figure 2.1 How RFID technologies working healthcare industry.

Identification and Verification	Tracking	Sensing	Interventions	Alerts and Triggers
Patient and Staff ID Access and Security Pharmaceuticals	Vulnerable Patients Assets and Equipment Patient Flow Supplies and Stock	Temperature Pressure Failure or Fatigue	Automated Care Pathways Prodecures Audit Management	Blood Transfusions Drug Administrator Tubes Syringes

Table 2.2 The potential of RFID application in healthcare industry.

RFID tags can be active or passive. Active tags have a battery life of several years, with a range of tens of meters and a larger data capacity compared to passive tags. The passive tags use reader emissions to power a response that is usually an identification number. Passive tags have short range and are small enough to implant under the skin. The basic advantage of RFID tags over barcodes is that you can write on them, automatically read them even if you cannot see them and read many of them simultaneously. How quickly does RFID achieves its potential is all a matter of time, but for adopters, many good reasons encourage the use of RFID technology in healthcare systems. These are some current system that implementin RFID in healthcare industry.

2.4.1 Identification of patients and hospital staff

In July 2004, the US Food and Drug Administration issued a ruling that essentially begins a final review process that will determine whether hospitals can use RFID systems to identify patients and/or permit relevant hospital staff to access medical records. Since then, a number of U.S. hospitals have begun implanting patients with RFID tags and using RFID systems, usually for workflow and inventory management. There is some evidence, as well, that nurses and other hospital staff may be subjected to increased surveillance of their activities or to labor intensification as a result of the implementation of RFID systems in hospitals. The use of RFID to prevent mixups between sperm and ova in IVF clinics is also being considered.

In October 2004, the FDA approved USA's first RFID chips that can be implanted in humans. The 134 kHz RFID chips, from VeriChip Corp. can incorporate personal medical information and could save lives and limit injuries from errors in medical treatments, according to the company. The FDA approval was disclosed during a conference call with investors. Shortly after the approval, authors and anti-RFID activists Katherine Albrecht and Liz McIntyre discovered a warning letter from the FDA that spelled out serious health risks associated with the VeriChip. According to the FDA, these include "adverse tissue reaction", "migration of the implanted transponder", "failure of implanted transponder", "electrical hazards" and "magnetic resonance imaging [MRI] incompatibility."

St. Clair Hospital in Pittsburgh has deployed an RFID and barcode based bedside medication verification system that improves patient safety by reducing medication errors. Nurses use a PDA equipped with a portable RFID reader and barcode scanner to check patient ID and medications before administering any drugs, including drugs delivered through IV pumps.

To combat home health fraud, the Centers for Medicare & Medicaid Services recently announced heightened scrutiny of the home health care industry. In March, 2009, Elite Medical Supply, a durable medical equipment supplier in New York were one of the first to sign on to combat Medical fraud. They selected CYBRA's EdgeMagic RFID and Bar Code Software to rollout the process.

2.4.2 Equipment Tracking Applications

Even before the recent RFID mandates were introduced, the problems of managing and tracking equipment and assets have plagued hospitals and healthcare facilities worldwide. Ranging from bed facilities, IV pumps, surgical equipment, to wheel chairs, there are assets and equipment that create challenges for the healthcare facility.

2.5 RFID Price Issues

RFID is becoming increasingly prevalent as the price of the technology decreases. In January 2003 Gillette announced that it ordered 500 million tags from Alien Technology. Gillette VP Dick Cantwell, now an employee of Cisco says the company paid "well under ten cents" for each tag. The Japanese HIBIKI initiative aims to reduce the price to 5 Yen (4 eurocents). And in January 2009 Envego announced a 5.9 cent tag.

2.6 Current Implementation

2.6.1 IT Asset Tracking

In 2008 more than a dozen new passive UHF RFID tags emerged to be specifically mounted on metal. At the same time new integrated circuits (ICs) were introduced by Impinj and NXP (formerly Philips) which proved much better performance and the IT Asset Tracking application exploded. The largest adopter to date appear to be Bank of America and Wells Fargo - each with more than 100,000 assets across more than a dozen data centers

2.6.2 Race Timing

Many forms of RFID race timing have been in use for timing races of different types since the early 1990s. The practice began with pigeon racing, introduced by a company called deister electronic Gmbh of Barsinghausen, Germany. It is used for registering race start and end timings for animals or individuals in a marathon-type race where it is impossible to get accurate stopwatch readings for every entrant.

In foot races, racers wear passive tags which are read by antennae placed alongside the track. UHF based tags instead of Low or high frequency last generation tags provide accurate readings with specially designed antennas. Rush error, lap count errors and accidents at start time are avoided since anyone can start and finish anytime without being in a batch mode.

RFID is being adapted by many recruitment agencies which have a PET (Physical Endurance Test) as their qualifying procedure especially in cases where the candidate volumes may run into millions (Indian Railway Recruitment Cells, Police and Power sector). An Indian Software company Software Outsourcing Services has perfected the system for the same using UHF tags for the first time and they are able to process more than 30,000 candidates per day.

2.5.3 Passports

The first RFID passports ("E-passport") were issued by Malaysia in 1998. In addition to information also contained on the visual data page of the passport, Malaysian e-passports record the travel history (time, date, and place) of entries and exits from the country.

Other countries that put RFID in passports include Norway (2005), Japan (March 1, 2006), most EU countries (around 2006) including Ireland and UK, Australia and the United States (2007), Serbia (July 2008), Republic of Korea (August 2008), Albania (January 2009).

Standards for RFID passports are determined by the International Civil Aviation Organization (ICAO), and are contained in ICAO Document 9303, Part 1, Volumes 1 and 2 (6th edition, 2006). ICAO refers to the ISO/IEC 14443 RFID chips in e-passports as "contactless integrated circuits". ICAO standards provide for e-passports to be identifiable by a standard e-passport logo on the front cover.

In 2006, RFID tags were included in new US passports. The US produced 10 million passports in 2005, and it has been estimated that 13 million will be produced in 2006. The chips inlays produced by Smartrac will store the same information that is printed within the passport and will also include a digital picture of the owner. The US State Department initially stated the chips could only be read from a distance of 10 cm (4 in), but after widespread criticism and a clear demonstration that special equipment can read the test passports from 10 meters (33 ft) away, the passports were designed to incorporate a thin metal lining to make it more difficult for unauthorized readers to "skim" information when the passport is closed. The department will also implement Basic Access Control (BAC), which functions as a Personal Identification Number (PIN) in the form of characters printed on the passport data page. Before a passport's tag can be read, this PIN must be entered into an RFID reader. The BAC also enables the encryption of any communication between the chip and interrogator.

Security expert Bruce Schneier has suggested that a mugger operating near an airport could target victims who have arrived from wealthy countries, or a terrorist could design an improvised explosive device which functioned when approached by persons from a particular country if passengers did not put their cards in an area close to their body (high liquid and saline content) or in a foil-lined wallet.

2.7 RFID Asset Tracking

- The Canadian Cattle Identification Agency began using RFID tags as a replacement for barcode tags. The tags are required to identify a bovine's herd of origin and this is used for tracing when a packing plant condemns a carcass. Currently CCIA tags are used in Wisconsin and by US farmers on a voluntary basis. The USDA is currently developing its own program.

- High-frequency RFID or HFID/HighFID tags are used in library book or bookstore tracking, jewelry tracking, pallet tracking, building access control, airline baggage tracking, and apparel and pharmaceutical items tracking. High-frequency tags are widely used in identification badges, replacing earlier magnetic stripe cards. These badges need only be held within a certain distance of the reader to authenticate the holder. The American Express Blue credit card now includes a HighFID tag. In Feb 2008, Emirates Airline started a trial of RFID baggage tracing at London and Dubai airports.

- BGN has launched two fully automated Smartstores that combine item-level RFID tagging and SOA to deliver an integrated supply chain, from warehouse to consumer.

- UHF, Ultra-HighFID or UHFID tags are commonly used commercially in case, pallet, and shipping container tracking, and truck and trailer tracking in shipping yards.

- In May 2007, Bear River Supply began utilizing Intelleflex Corporation's ultrahigh-frequency identification (UHFID) tags to help monitor their agricultural equipment.

CHAPTER 3
METHODOLOGY

System development methodology is a framework that is used to structure, plan and control the process of developing and information system. Waterfall, Spiral and Prototyping are three basic patterns in system development methodologies. In this project, the preferred method to develop Medical Laboratory Specimen Tracking System is *throwaway prototyping methodology,* which emphasizes on thorough analysis on the information gathering and concept. The prototype based model will be used to enhance the refinement process during the development of the Medical Laboratory Specimen Tracking System. This methodology is chosen because it's good since we can observe and made some changes to the prototype if any.

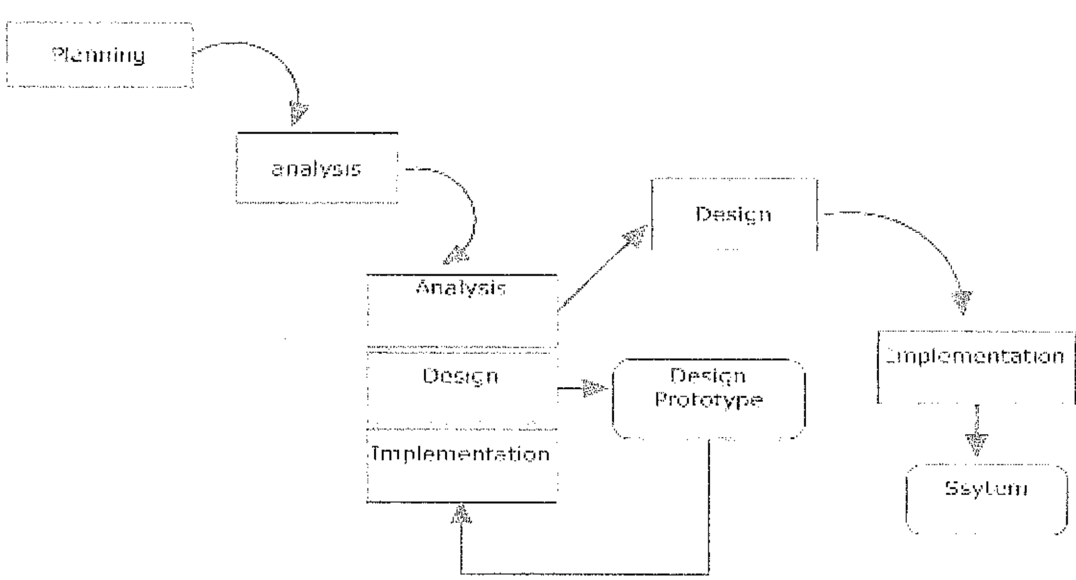

Figure 3.1 Throwaway-Prototyping Methodology

3.1 PLANNING AND ANALYSIS

The feasibility study is used to determine if the project should get the go-ahead. In this phrase, I need to determine the project budget and the acceptance of it by the users for future stage of development. I also need to understand the syllabus given in sure meet their requirements.

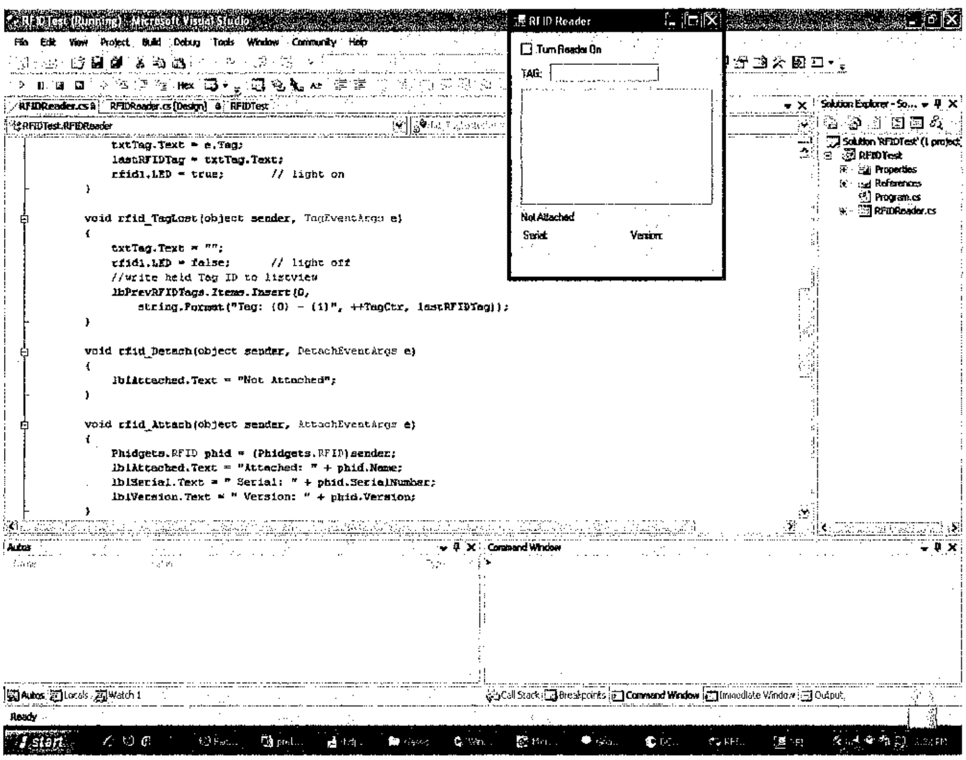

Figure 3.2 Designing program using C# Language.

3.2 DESIGN

I will start developing the system, design the specimen bottle that attached with RFID and design the back-end application on using C#. The database also was started design on this stage using Microsoft Access.

3.3 IMPLEMENTATION

After done with designing stage, I need to develop a prototype of back end system that merged between a read/write program and the database. The prototype will be tested on this stage and the result will assess either it meet the system requirement or not. If the prototype meet the system requirement, the real system will be develop based on that prototype. If it is not meet the requirement, I need to start develop the prototype again.

3.4 SYSTEM & TOOLS

From my further research for this project, I have chosen the tools to be used for NFC Smart Poster.

3.41 HARDWARE

Figure 3.3 Phidget EM4102 RFID Reader (RFID-RDR-P1023).

a) Phidget EM4102 RFID Reader (RFID-RDR-P1023).

This RFID reader easily can be installed to PC and connect via USB. It is use for read EM4102 RFID tag. The read range on the reader is 4 inches or less depending upon the tag used. It is used fir read only, not for write on the chip.

Figure 3.4 : RFID Tag ISO 14443, Sticker Type

b) RFID Tag ISO 14443, Sticker.

This RFID sticker will attach together with specimen bottle.

3.42 <u>SOFTWARE</u>

a) Microsoft .NET 2.0+ Platform

b) Microsoft Visual Studio 2005

c) Microsoft Access 2000

CHAPTER 4
RESULTS AND DISCUSSION

4.1 System's Architecture.

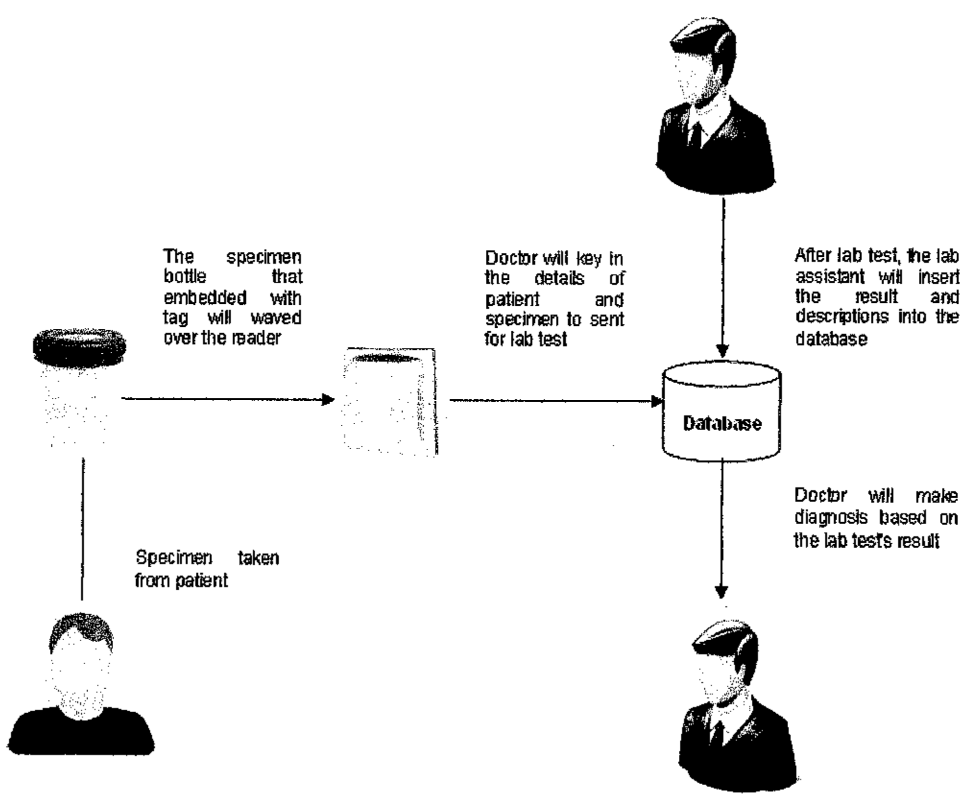

Figure 4.1 Medical Laboratory Specimen Tracking Systems (e-Specimen) Architecture

Passive 13.56 MHz RFID tags, complying with the ISO 18000-3 standard, are affixed to the sides of specimen bottles. After placing a specimen inside a bottle, a nurse waves it over a pad containing an RFID interrogator, then enters into a computerized database the patient information and the instructions for that specimen. That data is correlated with the RFID tag's unique ID number. An adhesive paper label is printed out and affixed to the side of the bottle, and the electronic record with the RFID tag number is automatically sent to the pathology lab.

When the pathology lab receives the specimen bottles they are waved over a pad with an RFID reader that captured its tag's unique ID number. That number is then reconciled with information in the database and the lab pulls up the electronic record

The tag's memory will send the data and it will be transmitted by the coil antenna to the reader using the radio wave ISM band of 13.56 MHz at 424 kbps transfer rate. When the from received the wave from tag, the reader readers typically return the raw HEX or binary representation of an Electronic Product Code (EPC), values which must then be decoded using bit-level programming to derive a useful representation of the information that a tag holds. As an example, an RFID reader may read and output of some HEX value. This value must be converted to binary, then decoded programmatically according to the EPC specification to extract the decimal field values, and finally, formatted to return a meaningful representation of the EPC called the Uniform Resource Identifier (URI) representation.

The binary representation of the tag HEX value shown above;

```
0011000001110000000000000010010000100010000000001100
1100100000000000000010111000011000010101010100100011
```

The EPC tag specification outlines the decoding process, which we can follow by interpreting the binary string bit by bit to get more useful information.

The back end system was developed to interpret the binary string to useful information. To convert the HEX value, the Phidget's library needs to be installed together in Microsoft Visual Studio. Finally, after the HEX value was converted, the information will be kept in the database.

4.2 Use Case Diagram

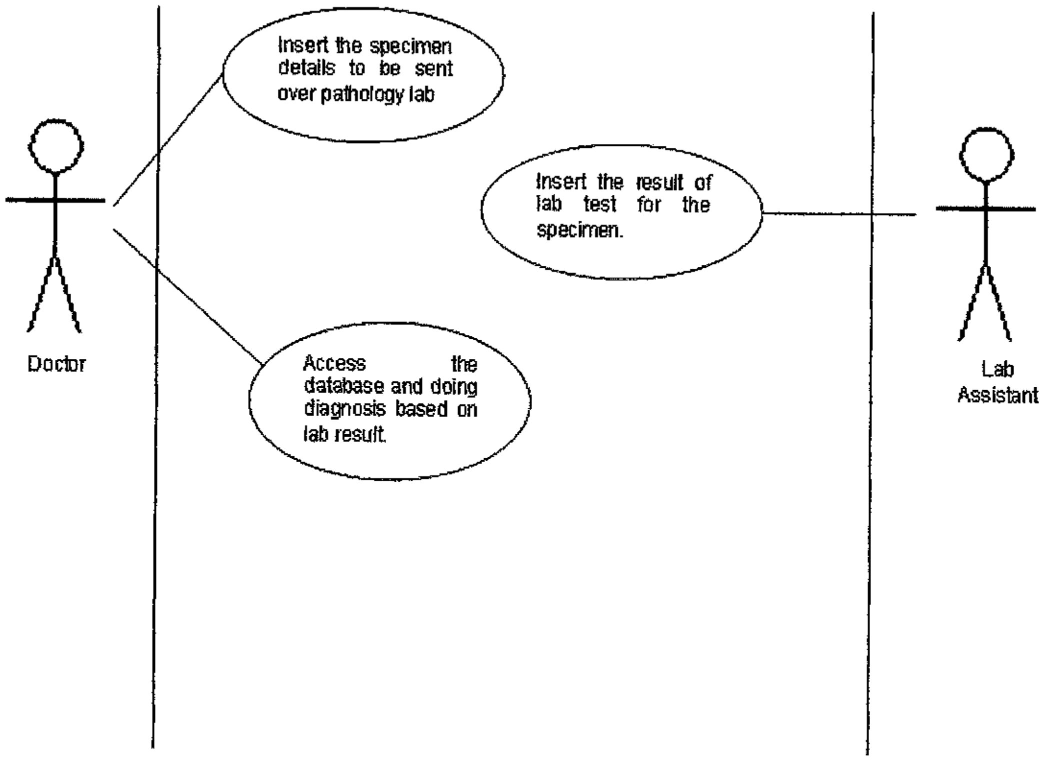

Figure 4.2 Use Case diagram for Medical Laboratory Specimen Tracking System

The use case diagram shows the actor; user and activities that involved in Medical Laboratory Specimen Tracking System. At first, after the doctor taking specimen from patient, he need to insert the details of specimen such as; blood type into program and it will be keep in the data base. Then the specimen will be sent over pathology lab to be tested. Then after doing the lab test, the lab assistant will insert the result of test into system and it will be keep in database. Finally, the doctor can make a diagnosis based on the pathology lab test.

4.3 Desired Features

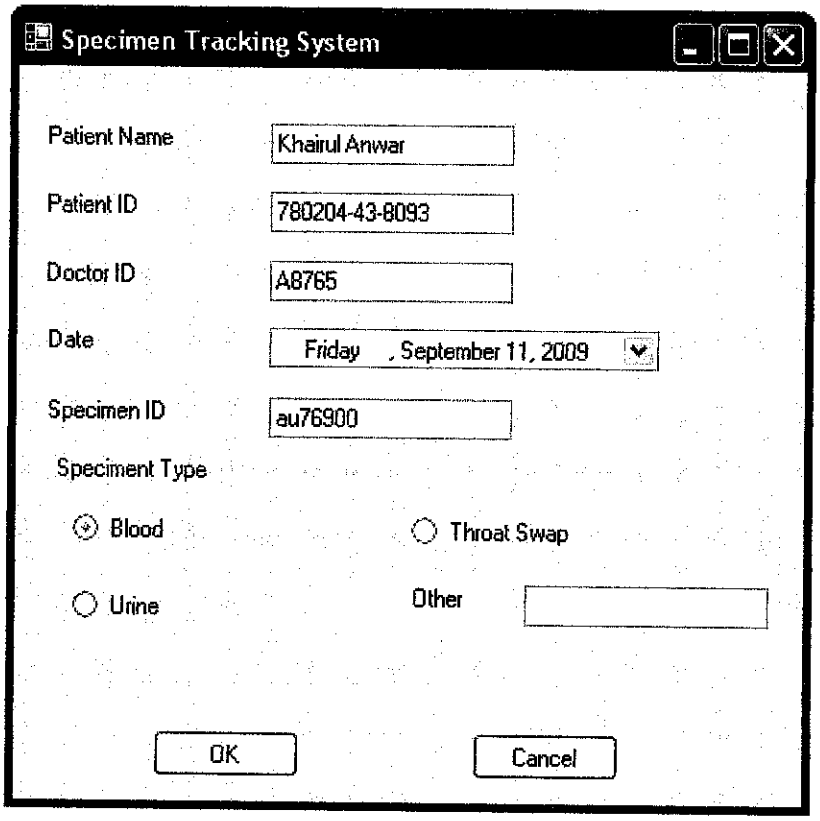

Figure 4.3 Medical Laboratory Specimen Tracking System (e-Specimen)

User of the application will be most likely can expand more features in Medical Laboratory Specimen Tracking System, such as uploading the diseases into the database. Thus, this application directly can link together to the patient's database. This will help the hospital increase their efficiency.

Figure 4.3 shows the first interface of system, this system is for doctor and the doctor will key in the details of patient and specimen and it will be kept in database.

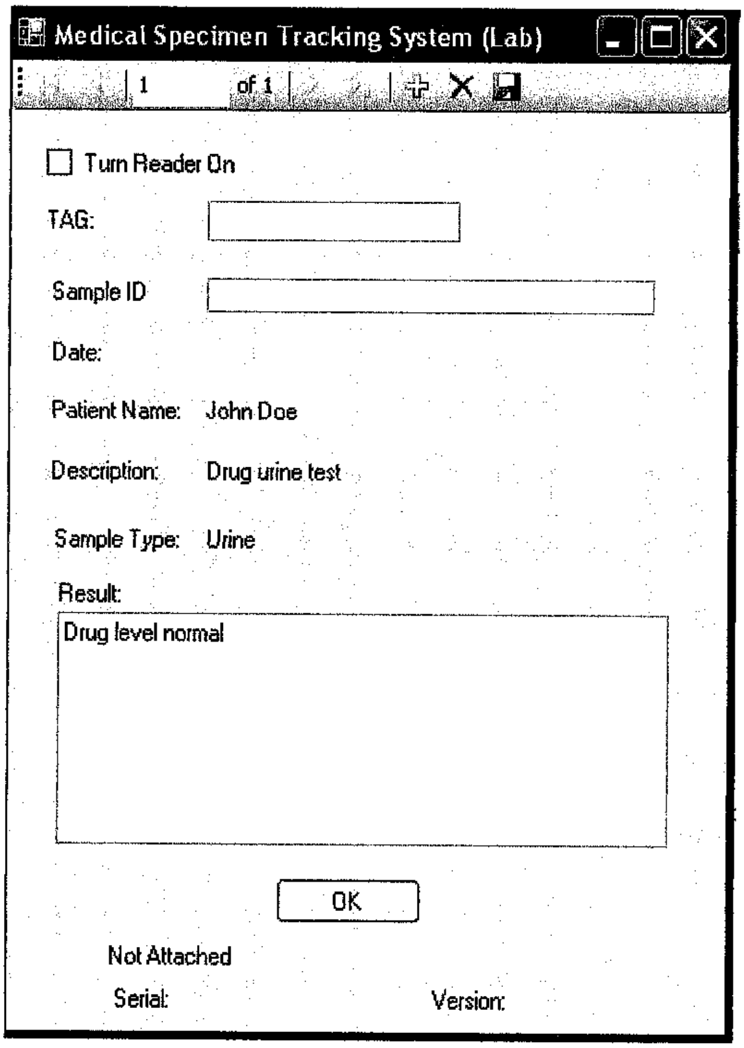

Figure 4.4 e-Specimen for pathology lab.

Then after the pathology test, the pathologist or lab assistant will key in the result of the specimen into system. That result is automatically updated into the database.

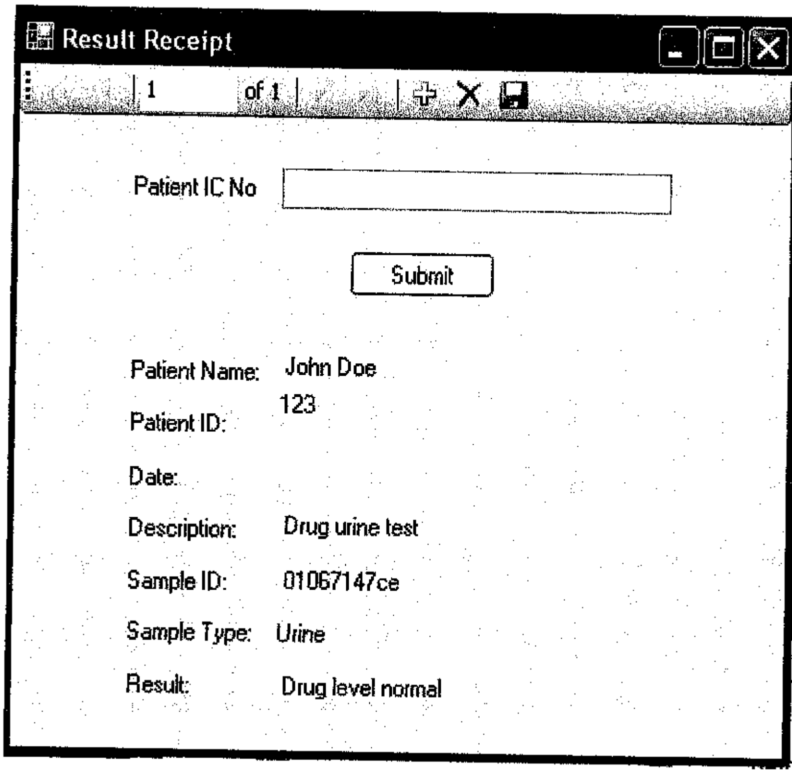

Figure 4.5 e-Specimen for doctor view result of pathology lab test.

After all the test process, the doctor can access to e-Specimen system to view the result. The doctor just need to key in the Identification Card numbers of patient to view the result to be used in diagnosing the disease.

CHAPTER 5
Conclusion and Recommendations

As a conclusion, the purpose of this report is to give an overview of the main aspects of this project such as the problem statement, objectives, and scopes of project, literature review, methodology, and results. The project relies on extensive research on an application that can help business advertisement and make it more appropriate.

The second phase of the project is to focus on the architecture on the solution which is program the RFID tag and develop back-end system for authorize person. The application must be able to provide the solution of error of manual procedure at the simplest way. Thus, the application will be developed using for tracking of specimen in hospital.

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Appendix

1.0 Gantt Chart