TZS402 Final Report

Name:	Tay Kian Hui Dominic Marcus
Student PI:	T0407893
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Abstract

For a standalone Dialysis Centre, data entry into a central patient information database is usually a manual process and can be tedious and prone to error. This work explored the feasibility of implementing a flexible, economical and extensible patient data management system for a standalone Dialysis Centre which shall use handheld mobile devices such as Personal Digital Assistants (PDAs) to provide the staff with mobile access to data entry and management capabilities. A prototype to enable mobile data entry was also developed. It was concluded that it was feasible to implement customised mobile patient data management systems using handheld mobile devices, with adequate requirements specifications from the users.

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1 Introduction

1.1 Background

Dialysis is a process by which toxins and waste products are removed from patients whose kidneys' function has deteriorated or failed completely for any of a variety of reasons. Dialysis Centres are centralised facilities for the management of such patients, providing dialysis machines and medical consultation services. Each dialysis treatment is unique to the patient, and the correct treatment parameters need to be set based on the various measurements, including body function measurements such as blood pressure, body weight and pulse rate[14]. Additionally, additional measurements are recorded throughout the dialysis session so that adjustments can be made while the dialysis treatment session is still in progress. Therefore, the accurate recording of these measurements is essential in ensuring that a proper record of the patients' health status and treatment progress is kept for future reference.

In a small stand-alone dialysis centre, these measurements are usually recorded on paper by the nursing staff at the bed-side, then manually input to a standalone database system by the centre's administrative staff. This process can be tedious, and has the following disadvantages:

1. The nursing staff have to keep track of many record sheets as they make their rounds.
2. The paper record sheets could get torn, damaged or lost.
3. Manual input of the handwritten records is prone to errors from misreading the handwritten values or typing errors.
4. Availability of the records in system depends on the availability of the administrative staff to manually input the records.
5. Measurements for the current treatment sessions are not available to the system.

1.2 Project Statements

This work investigates the feasibility of implementing a flexible, economical and extensible mobile patient data management system, which uses handheld mobile devices such as Personal Digital Assistants (PDAs) as end-user devices. In particular, we will consider the implications of deploying a wireless network in a clinical environment, the ability to store and retrieve data from a mobile device, and limitations of this approach. Additionally, a prototype is designed and implemented to demonstrate data entry and storage using a mobile device over a wireless network.

1.3 Objectives

The objective of this work is to explore the feasibility of implementing a mobile data management system for a dialysis centre, which will facilitate the collection and logging of patient data (such as measurements) at point-of-care.

In particular, we will:

- Identify various technologies available for mobile data management, including wireless networks, mobile devices, data management systems and software, etc.
- Evaluate and recommend appropriate mobile devices, wireless networking equipment, data management systems and software.
- Identify, understand and adhere to the standards for implementing wireless communication and point-of-care in a clinical environment.
- Identify the user requirements for the mobile data management system, to be defined in collaboration with the industry proposer.
- Design and implement a graphical user interface (GUI) for data entry and storage using mobile portable devices.
- Design and implement a suitable database management system (DBMS) to store and organise the data.
- Implement a prototype system to demonstrate proof-of-concept.

Additionally, we will also apply various aspects of project management and system development methodology to plan and manage the project development schedule, resources, finance and communications.

1.4 Scope of Project

The scope of this work is confined to a standalone dialysis centre, i.e. there is no sharing of data with another facility. At this time, we will also limit the mobile capabilities only to data entry and storage. There will not be any data processing by the end user device. Finally, we also assume that the staff of the dialysis centre have the basic skills to handle the use of a mobile computing device such a PDA.

1.5 Project Management and System Development Methodology

At the outset, project activities were defined and a project program plan was drawn up using a Gantt Chart (see Appendix E), which would be used to track the progress of the project using defined milestones. However, due to changes in the programming approach, there were delays to the scheduled start and end of the Implementation (Task 7) and Testing & Evaluation (Task 8) Phases.

Because we would be developing a proof-of-concept before embarking on a full-scale system development, the System Development Methodology (SDM) that would best fit our project would be the Iterative methodology described in [1]. In this SDM, the system is constructed in phases, with each succeeding phase building upon the previous phase, with feedback input from the users.

2 Literature Review

2.1 Mobile Data Management Technology

2.1.1 Overview of Mobile Data Management Technology

Data management can be described as the activity of collecting, storing and organising data in a meaningful and standardised manner. Mobile data management is the ability to perform some (or all) of these activities "in-the-field".

Mobility can be provisioned in a variety of ways. For wired devices, this can mean providing power and hard-wire data connectivity at the required locations. Obviously, this limits overall mobility to the pre-determined locations and is not truly mobile. The most common means of providing mobile access today is the use of wireless technologies with self-powered mobile devices such as laptop/tablet computers and Personal Digital Assistants (PDAs).

2.1.2 Industry Standards for Wireless Technology

[9], [10], [11], [12], [13], and [28] describe various wireless communications technologies. They can be broadly divided into wide-area and local-area network access technologies. The following sections will highlight pertinent facts about each of these technologies.

2.1.2.1 Wireless Wide-Area Networking (WWAN) Technologies

These wireless technologies can be classified as WWAN technologies for the purposes of this work: IEEE 802.16 (WiMAX), 3rd Generation (3G) Mobile Data (UMTS/HSDPA/HSUPA).

WiMAX is a IEEE standard wireless technology that is primarily meant for provision of high bandwidth connections over medium to long distances, classified as a Metropolitan Area Network (MAN) technology. At present, there are just a handful of successful trials of WiMAX and other similar technologies implemented worldwide.

3rd Generation (3G) Mobile Data refers to high-speed packet data technologies built for mobile telephony infrastructure. In fact, even the voice traffic is digitised and carried as digital data over these 3G networks. Network coverage is extremely pervasive and covers anywhere where a mobile telephone signal reception is available. Transfer speeds on these networks can currently reach up to over 7 megabits per second (Mbit/s).

WWAN Technologies are used for remote connectivity to other networks, mostly for mobile Internet access. They are generally not used for connection between peer devices in the same location.

2.1.2.2 Wireless Local-Area Networking (WLAN) Technologies

These wireless technologies can be classified as WLAN technologies for the purposes of this work: IEEE 802.11a/b/g (WiFi), IEEE 802.15.1 (Bluetooth), IEEE 802.15.3 (UWB) and WMTS. At present, however, there are no commercial off-the-shelf solutions for UWB and WMTS technologies to be incorporated into general purpose mobile computing devices.

Bluetooth is a short-distance wireless communication technology, primarily used as wire replacement technology. It is normally used to connect input devices (such as keyboard and mouse), mobile phones and wireless headsets, but it is also possible to use it for peer-to-peer networking between computing devices. In its current specification (version 2), speeds of up to 3 Mbit/s up to a distance of 100m (for Class 1 devices) are possible. Bluetooth requires connecting devices to be 'paired' before data communication is allowed. While mobile devices with Bluetooth connectivity are readily available, Bluetooth-based local area networking devices it is quite difficult to find and expensive to purchase.

WiFi uses the wired Ethernet media access protocol in combination with a wireless physical layer protocol, operating with speeds of up to 54 Mbit/s (for 802.11a and 802.11g devices) up to a maximum operating distance of 300m. In a sense, it is just a replacement for the "last mile" cable that tethers a networked device to the physical local area network (LAN). It is now found in almost all mobile computing devices such as laptops, tablet PCs, PDAs and some Smartphones. Adapters are also readily available in various form factors, as are the wireless base stations which bridges the network between the wireless and wired devices.

2.1.3 Mobile Computing Platforms

Mobile computing platforms are usually found in form factors such as laptops, Tablet PCs and handheld computers, such as PDAs and smart-phones. Laptops and Tablet PCs usually run full-featured operating systems such as Microsoft Windows™ XP or some variant of the open-source Linux. The smaller devices, however, usually run on simplified operating systems, adapted to suit the smaller screens, limited input capabilities, and limited computing capabilities. Of these, the most commonly available devices run either Microsoft's Windows™ Mobile (http://www.microsoft.com/windowsmobile/) or Palm Inc's Palm OS (http://www.palm.com). Originally the more popular of the two, the latter has, in recent years, fallen out of favour with most PDA users due to slow progress in adding new capabilities and features. Most PDAs available commercially are therefore based on the Windows™ Mobile platform. Each of these have their own programming API libraries.

Common to all the mobile platforms, interestingly, is that all of them incorporate a HTML browser, more commonly referred to as a Web browser. This enables us to consider the use of server-side processing to overcome the limited processing capabilities of the devices. The devices will therefore only be used as an Input/Output interface to the system.

2.1.4 Data Storage and Management

Computer data may be stored in a variety of ways. The simplest method is to store it in a simple text file, or what is known as Flat File database (http://en.wikipedia.org/wiki/Flat_file_database) where each record is stored in a single line of delimited text. A variation of this is to store data using tags, such as in the Extensible Markup Language (XML) (http://en.wikipedia.org/wiki/XML). XML is a derivative of a specification known as Standard Generalized Markup Language (SGML).

Data may also be stored in Database Management Systems (DBMS) such as Oracle, DB2 and MySQL. Section 1.3 of [34] describes some characteristics of DBMS, and of particular relevance to our work is that the database approach of data storage lends itself to support multiple views of the data ([34],section 1.3.3). Support for sharing of data and multi-user transactions described in section 1.3.4 of [34] is also another important characteristic of the database approach. Finally, section 1.6 of [34] also highlights some advantages of the DBMS approach, of which particularly note the ability to provide multiple user interfaces.

2.2 Applications of Wireless Data Communications in Healthcare

From [6], [15], [16], [17], [32] and [33], we observe that wireless data communications is increasingly being considered for implementation in the Healthcare industry, and clinical bed-side environments in particular. The publication of guidelines such as [2], [3], [4], [5] and [7] also show that considerable interest and concern exists in the Healthcare industry for the use of wireless communications to enable mobile clinical solutions.

2.3 Security and Reliability in Wireless Networks

For wireless communications in general, the network traffic is carried over the airwaves. This means that the signals are susceptible to eavesdropping and disruption through intentional interference and modification. In order to protect the security and reliability of the data that is transmitted, encryption and authentication mechanisms are commonly implemented in the protocol standards. Redundancy and data checksums are used to ensure that the integrity and reliability of the transmitted data.

In particular, 802.11a/b/g networks implement a variety of over-the-air encryption and authentication mechanisms, such as Wireless Equivalent Privacy (WEP), Wireless Protected Access (WPA), and Media Access Controller (MAC) Address Filtering (ref [27], [29] and [30]). The latter authentication mechanism ensures that only recognised user stations may connect to the network, even though they may possess the necessary encryption passkeys.

WEP is the original wireless encryption mechanism, and is implemented with various key lengths starting from 64 bits. Officially, the standards only defined WEP with key lengths of up to 128 bits, but various manufacturers have implemented their own proprietary WEP extensions to support longer key lengths. This was before the adoption of WPA as the next generation of wireless encryption, as it was found that the WEP encryption routine was susceptible to brute-force decryption due to a weakness in the Initialisation Vector (IV), and longer keys were harder to crack. Being proprietary extensions, these stronger WEP mechanisms would only work among base stations and adapters from the same manufacturer.

WPA is the next step in wireless encryption, employing a stronger and more robust mechanism than WEP. Unlike in WEP, the secret key was used only during association and not to encrypt the entire communication and hence was not prone to being 'sniffed' over-the-air. WPA has 2 variants, WPA Enterprise and WPA-Personal (also known as WPA-PSK). The more secure WPA Enterprise requires the use of a separate authentication server, so most home and small business users will elect to use WPA-PSK instead. WPA-PSK is reasonably secure against intruders if the network key is sufficiently complex (to guard against brute force guessing attempts) and kept secret.

In terms of reliability, we see from [23] and [31] that the use of the TCP/IP protocol over the wireless network provides some measure of control over the reliability and integrity of the transmitted data through the use of checksums, packet sequencing and acknowledgement. If a packet is lost or fails the checksum, the receiver can request a retransmission. Likewise, if an acknowledgement is not received for a particular packet, the sender will assume the packet was lost and send it again.

2.4 Our Analysis and Perception

From the above literature and information gathering, we can see that the basic elements that are required for implementation of a mobile patient data management system are available.

There are suitable mobile computing platforms, which can operate over a standardised secure and reliable wireless network to store and retrieve data from a centralised database. The use of a database management system enables multiple users to access and update data at the same time and is adaptable to various user interfaces to manipulate and organise the stored data. There are also no regulatory prohibitions or licensing requirements that will stand in the way of implementing such a system.

It is therefore our opinion that it is feasible to implement such a system, and therefore a prototype of the system should be developed to demonstrate the system to its potential clients.

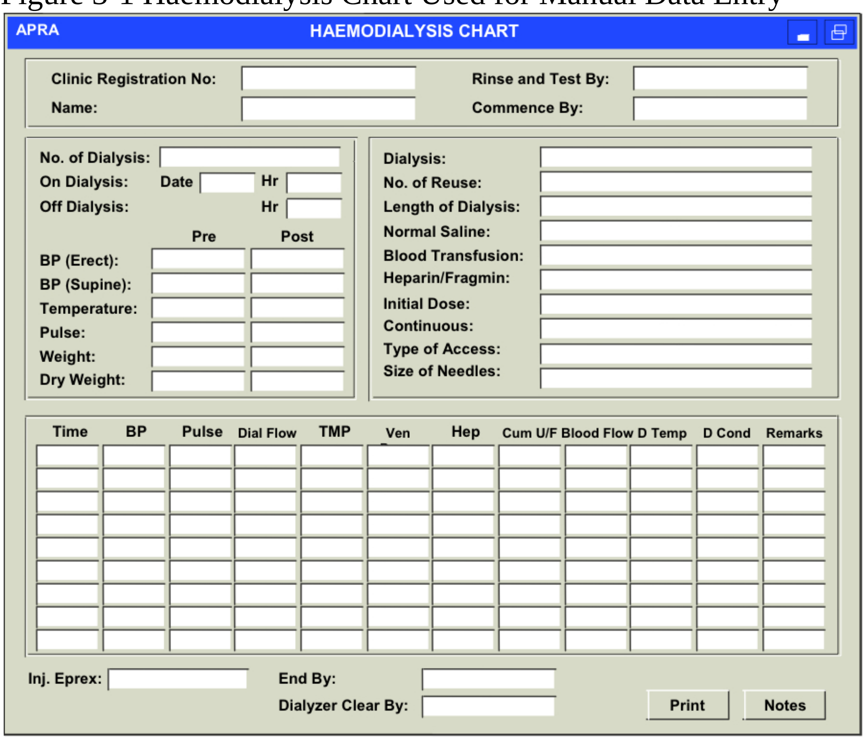
3 Design of the Mobile Data Management System

3.1 User/Information Requirement and Specifications

The following are the User and Information requirements and specifications based on the materials provided and in discussion with the user representatives.

i. The system must be safe for use in a clinical environment.
ii. The system should be economical to implement.
iii. The system must support multiple mobile devices.
iv. The system should be as maintenance-free as possible.
v. The system should be simple to use.
vi. The minimum information recorded in the system shall be according to the existing records (see Fig 3-1).
vii. The system shall be protected from unauthorised access.

Figure 3-1 Haemodialysis Chart Used for Manual Data Entry



3.2 Our Approach

- Literature review to determine feasibility and safety
- Selection of system components
- Selection of development platform
- Implement a Proof-of-Concept
- Implement a Prototype

3.3 Overview of System Architecture

The mobile patient data management system uses mobile devices (such as PDAs) with HyperText Transfer Protocol (HTTP) browser capability. Using the browser, users will access a HTTP Server through a wireless local area network (WLAN). The HTTP server supplies the Graphical User Interface (GUI) elements, processes the user supplied data, and communicates with a SQL Relational Database to store and manage the data in the system. Data input by the users will be through the browser using HyperText Markup Language (HTML) form elements.

Details of the System Architecture will be elaborated in Chapter 4.

3.4 Data Format and Protocol

Analysis of the data fields that need to be recorded and stored shows that they can be classified into three main types.

i. Numerical data which is discrete, i.e. without decimal values, which can be stored as Integers;
ii. Numerical data which is not discrete, which can be stored as Floating Point numbers; and
iii. Textual data, which can be stored as text. For text data with known sizes, appropriate text data sub-types can also be used to optimise the database usage.

All data will be input as text on the mobile device and transferred to the server encapsulated in a HTTP POST request. The server will process and convert the numerical data in text format to the actual data type before they are stored in the database.

Details of the data fields and type are described in Chapter 5.

4 System Configuration and Hardware Setup

4.1 Specification of System Components

The following are the recommended specifications for the system components in the mobile patient data management system.

4.1.1 Web Server

The Web Server shall meet or exceed the following requirements:

Intel/AMD 32-bit or 64-bit Processor running at least 1 GHz CPU Clock Frequency
512 MB of Random Access Memory (RAM)
10 GB of available permanent storage (e.g. Hard Disk Drive, Disk Array, etc.)
Ethernet Interface running at 100Base/T
Linux Operating System is recommended, but Microsoft Windows may also be used

Note: If desired, the Web Server and Database Server functions can reside on the same hardware, which must meet the higher of any individual specified requirement.

4.1.2 Database Server

The Database Server shall meet or exceed the following requirements:

Intel/AMD 32-bit or 64-bit Processor running at least 1 GHz CPU Clock Frequency
1 GB of Random Access Memory (RAM)
40 GB of available permanent storage (e.g. Hard Disk Drive, Disk Array, etc.)
Ethernet Interface running at 100Base/T
Linux Operating System is recommended, but Microsoft Windows may also be used

Note: If desired, the Web Server and Database Server functions can reside on the same hardware, which must meet the higher of any individual specified requirements.

4.1.3 Wireless Networking Devices

The wireless network shall utilise equipment adhering to the IEEE 802.11g standard, and have the following features:

IEEE 802.11g with simultaneous backwards compatibility with 802.11b devices
Support 128-bit WEP and WPA-PSK wireless security protocols
Support Wireless Media Access Controller (MAC) white-listing
Optional support for variable transmission power

4.1.4 Handheld Mobile Device

The handheld mobile device shall meet or exceed the following requirements:

Display resolution of 320 by 240 (QVGA)
IEEE 802.11b/g Wireless LAN with support for 128-bit WEP or WPA-PSK
Web (HTML) browser which supports HTML 4.0 Specifications
Optional integrated physical keyboard for data entry

4.2 System Configurations

4.2.1 Development and Testing Environment

The system architecture used to develop and test the proof-of-concept and prototypes is shown in **Appendix C.1**.

The Development/Testing Workstation is a Apple MacBook with 2 GHz Intel Core 2 Duo Processor and 2 GB of RAM running Mac OS X 10.4. It is used to do the PHP and HTML coding, using Adobe GoLive CS2 as the Integrated Development Environment (IDE).

The Web Server Virtual Machine, which also houses the development database, is a VMware Fusion virtual machine that is running on the Development/Testing Workstation. It is bridged to the network and appears as a separate host (different Ethernet MAC address and IP address) on the network from the Development/Test Machine. It is configured with 256 MB of RAM and runs Red Hat's Fedora Core 7 Linux Operating System, Apache 2.2.6 HTTP Server, PHP version 5.2.4 and MySQL Database version 5.0.45 Community Edition.

The network switch is an unmanaged 10/100Base/T Ethernet Switch. A typical model is shown in Fig 4-1.

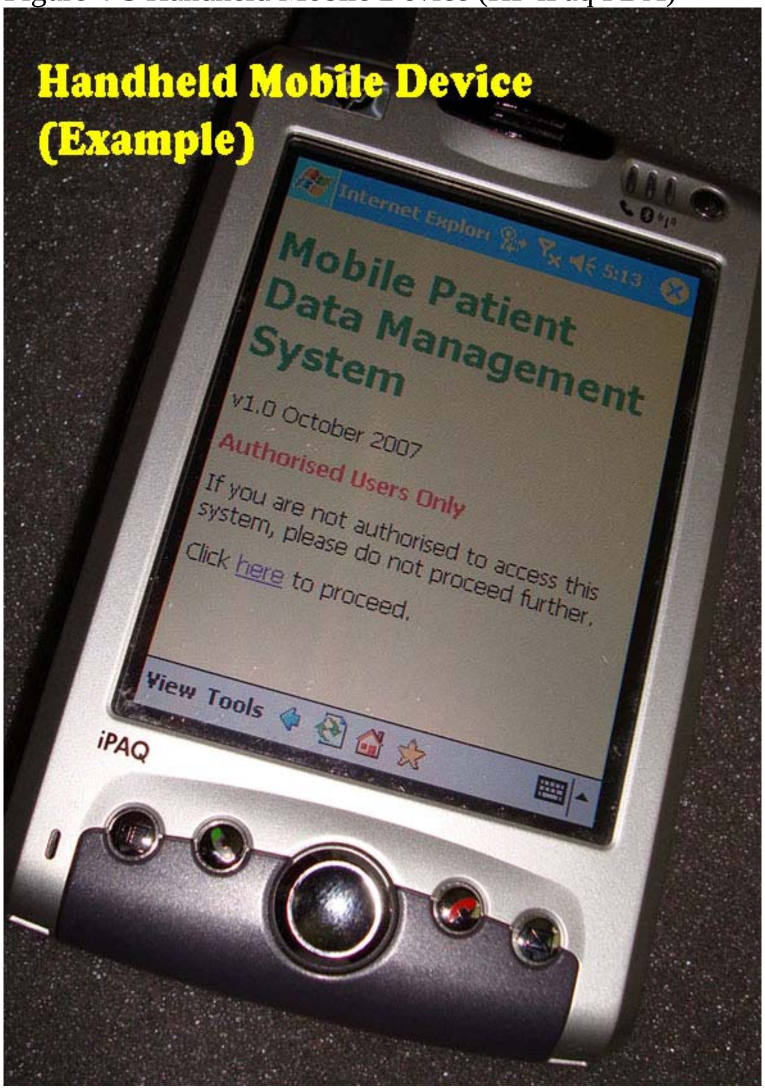
The wireless network is set up with an IEEE 802.11b Wireless Access Point, which supports 128-bit WEP, shown in Fig 4-2.

The handheld mobile device used is a HP iPaq PDA with IEEE 802.11b Wireless LAN capability, shown in Fig 4-3.

Figure 4-1 Typical Unmanaged Network Switch

Figure 4-2 Wireless Access Point

Figure 4-3 Handheld Mobile Device (HP iPaq PDA)



4.2.2 Proposed System Architecture for Final Deployments

The proposed system architecture for the actual deployed system is shown in **Appendix C.2**. It is quite similar to the set up used for development and testing of the system, except that the wireless network is recommended to be deployed with a WPA-enabled IEEE 802.11g access point for increased security and data transfer capacity.

The recommended configurations for the core system components have already been specified in Section 4.1. The system architecture diagram also shows how existing workstations can be integrated into the proposed system by connecting to the LAN switch, and how it can be expanded with a Remote Access/Telemedicine Option if desired.

4.3 Electrical Requirements

All equipment specified in the proposed system are consumer products which use ordinary UK-plug 13 Ampere sockets. If the dialysis centre already has Uninterruptible Power Supply (UPS)-protected outlets, it is recommended that the servers and network equipment be connected to these outlets to prevent loss or corruption of data due to power failure. If UPS-protected outlets are not available, standalone UPS should be deployed.

5 Data Protocol and Programming

5.1 Data Types and Formats

The following are the information that are required to be stored in the database and their corresponding data type are tabled in Table 5-1.

Table 5-1: Data List and Type

Information	**Data Type**
Staff ID (usually NRIC number)	Text
Staff Name	Text
Patient ID (usually NRIC number)	Text
Patient Name	Text
Staff performing rinse and test	Text
Staff commencing dialysis session	Text
Staff ending dialysis session	Text
Staff clearing dialyzer	Text
Dialysis Session Number	Integer
Date of Dialysis	Text
Dialysis Starting Time	Text
Dialysis Ending Time	Text
Pre-/Post-Dialysis Erect Blood Pressure	Integer
Pre-/Post-Dialysis Supine Blood Pressure	Integer
Pre-/Post-Dialysis Temperature	Floating-point
Pre-/Post-Dialysis Pulse	Integer
Pre-/Post-Dialysis Weight	Floating-point
Pre-/Post-Dialysis Dry Weight	Floating-point
Type of Dialysis	Text
Number of Reuse of Dialyzer	Integer
Length of Dialysis (in minutes)	Integer
Normal Saline level	Floating-point
Blood Transfusion level	Floating-point
Heparin/Fragmin level	Floating-point
Initial Dosage	Floating-point
Continuous Dosage	Floating-point
Type of Access	Text
Size of Needles	Text
Injected Eprex amount	Floating-point
Interim Reading Time	Text
Interim Reading Blood Pressure	Integer

Interim Reading Pulse	Integer
Interim Reading Dialysis Flow	Floating-point
Interim Reading Temperature	Floating-point
Interim Reading Ventricular Pressure	Floating-point
Interim Reading Heparin level	Floating-point
Interim Reading Cumulative Ultra-filtration level	Floating-point
Interim Reading Blood Flow level	Floating-point
Interim Reading Dialysate Temperature	Floating-point
Interim Reading Dialysate Conductivity	Text
Remarks	Text

The above fields are broken down into the following tables:

Table 5-2: Database Tables

Table Name	**Description**
mpdm_staff	Staff Information (Name, ID, Presence in the Centre)
mdpm_patients	Patient Information (Name, ID, Presence in the Centre)
mpdm_prerecords	All Pre-Dialysis Measurement Records
mpdm_sessionrecords	All Intra-Dialysis Updated Measurement Records
mpdm_postrecords	All Post-Dialysis Measurment Records
mpdm_otherrecords	All Miscellaneous Information Records

The detailed Data Dictionary for the project database can be found in **Appendix D**. We would, however, like to highlight some additional fields introduced which are not part of the user requirements, but which are required for the system to function.

For the Staff and Patient Information tables, we have added a field name "Present" to indicate whether the staff or patient is present in the dialysis centre. In our application, only staff and patients who are indicated as present in the centre will appear in the respective selection list. The administration staff can use the Admin Module (see Appendix B.1) to update the presence of staff and patients in the centre, in addition to being able to add and remove staff and patients from the system.

Additionally, each Staff and Patient record is given a unique ID, which is the Primary Key and is reserved for future use in expansion of the system.

For the other tables, which contain records for each patient's dialysis sessions, we have added a "recid" field to store a unique Record ID (again as Primary Key) for each set of stored data. The Record ID is a concatenated string of the Year, Month, Day, Hour, Minute and Second (based on the Server clock) that the record was stored. It is can be used in combination with the Patient ID to retrieve patient records in chronological contexts.

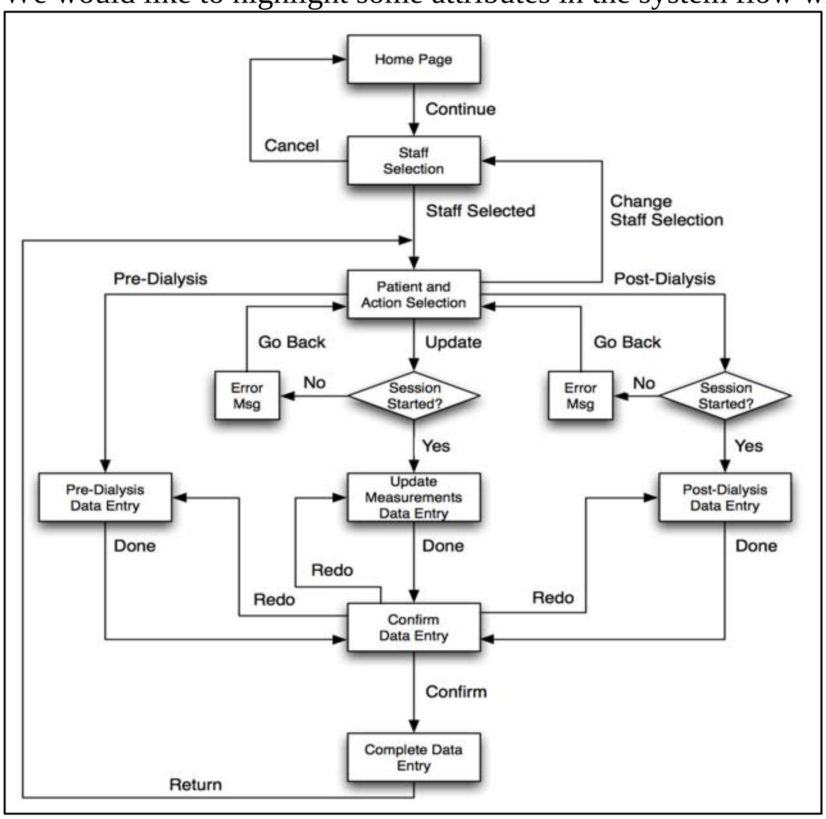
The other field that has been added to the records tables is the "confirm" field, which serves as a Confirmation Indicator. Every time data is submitted by the staff member through the application, it is written to the database immediately , but with the Confirmation Indicator set to "0". Upon confirmation, this field will be updated to "1" by the system. This preserves all data entry by staff, but at the same time allows the retrieval of only confirmed data entry.

5.2 System Flowchart

In consultation with the user, the system flowchart in Fig 5-1 was drawn. The programming logic will be done according to this flowchart.

Fig 5-1: System Flowchart

We would like to highlight some attributes in the system flow which need to be



addressed during the design and implementation of the system software.

Firstly, at all points in the data entry process, the user should be allowed to return to a previous step while retaining all previously confirmed information. Our application is web-based and uses HTTP as our data transfer protocol, therefore care must be taken to hand all necessary state information to the next web page since HTTP is a stateless protocol – the next page has no way of knowing anything about the previous page unless the information is passed over.

Secondly, when selecting to enter intra-dialysis updated and post-dialysis data, the system must ensure that there is an active dialysis session to update. We have implemented this by ensuring there is a pre-dialysis data record with no matching post-dialysis data record for the patient before allowing data entry. Note that the staff is always able to enter pre-dialysis data, just that the Session Number would be incremented.

5.3 Programming

PHP HyperText Preprocessor (PHP) server-side processing is used to generate the dynamic content in the HTML-based graphical user interface (GUI). The full PHP Source codes can be found in **Appendix A**.

PHP code is interleaved within a HTML document and is processed by the server before the results are returned to the user. Therefore, all the user will see on the browser is the HTML code used to render the page.

The PHP code is used to interact with the database, process user-submitted data for further processing or storage in the database, and control the system flow. Database access in our application is for data retrieval, storage, update or removal.

Database access for data retrieval is done by forming a standard Structured Query Language (SQL) statement, executing the query and storing the results in an array variable. Individual values are then retrieved via iteration through the array. All the other database interactions do not return relevant results.

6 Discussions and Future Direction

6.1 Advantages and Constraints of Our Approach

Our approach to designing and implementing a mobile management solution has a number of advantages:

1. Measurement data is stored instantly to the database upon submission by the staff and is immediately available for retrieval and processing;
2. Nursing staff does not need to keep track of paper records, which can translate into increased productivity and efficiency;
3. Administrative staff is no longer required to perform error-prone data entry;
4. Wider choice of mobile device as the requirements are simple; and
5. Software changes and upgrades only need to be applied once at the server and takes effect immediately.

We have also identified the following constraints of our approach:

1. There is currently no sign-on or authentication mechanism for staff;
2. The data is not validation at client end before it is submitted and stored to the database. We have however mitigated the impact of this by restricting the range of input values wherever possible; and
3. We have not considered how the devices should be protected against the elements and rough handling.

6.2 Future Direction

In addition to addressing the constraints we have identified above, the future direction would be to build other modules around the database to provide analysis and reporting capabilities to the system. For example, a charting module could be developed to provide visual representation for each patient’s historical measurement records to aid the doctor in monitoring and prescribing treatment regimes. Additionally, the system could also be adapted to suit other medical fields to provide some form of Electronic Medical Record (EMR) facility.

7 Conclusions

As proven by the successful implementation of the prototype, it is possible to implement a mobile data management system using handheld computing devices. Concerns about data integrity and reliability are addressed by the choice of devices and technologies employed, but will still ultimately have to be field-proven. We have also demonstrated that through the use of open source tools, it is possible to achieve flexible, economical and extensible systems. Additionally, the concept can be extended and adapted for use in other clinical applications.

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Appendices

A. PHP Source Code for Mobile Patient Data Management System

B. Screenshots for Mobile Patient Data Management System

C. System Architecture Diagrams

D. Data Dictionary

E. Gantt Chart for Project Plan

Part 2: Critical Review and Reflections

A. Critical Review

The following is a critical review based on the Key Skills Framework:

Am I able to identify and analyse the activities I need to do?

I felt I was able to do this to a certain extent, but I did not break it down further to specific tasks. This is an area which I will still require improvement.

Am I able to schedule my work?

I had quite a lot of difficulty with this. Although I had a schedule drawn up, in the actual running of the project I was unable to keep to the schedule due to work and other personal commitments. Many changed to the schedule had to be made and at some points I even realised I was just grasping at straws just to be able to carry the project activities forward.

Am I able to agree criteria and targets for the different stages of the project and monitor my work?

As the project objectives were well-defined, I felt it was easy to do so. This helped to identify the skills and equipment that were required to complete the project.

Am I able to assess my progress against the criteria, and identify potential problems in achieving them?

I was able to assess my progress against the criteria and identify the problems I would face achieving them. Active steps were then taken to learn skills or acquire software or hardware to overcome these problems.

Am I able to record and review my decisions and activities throughout the project?

This is another weak area, as I tended not to document my decisions most of the time. As a result, I had to rely mainly on memory when writing the technical report on why certain things were done in certain ways.

B. Reflections

Working on this project has been an interesting, fruitful and at times difficult experience. It has allowed me to discover some of my strengths and weaknesses in conducting and managing a project on my own.

While the industry user specified the overall requirements and objectives, there were many uncertainties as to the way to proceed. In fact, it was initially planned to use National Instrument's LabView as the user interface framework for our project, but during the course of exploring its capabilities and usage, it was found that it was not entirely suited for our purpose. Additionally, when considered in hindsight, it would have been rather costly for a small dialysis centre to licence the necessary software from NI. However, that lead me to consider the use of open source technologies to implement a web-based solution, after realising that most computing devices had a web-browser built into them. This would also mean that in an actual implementation, there would be a wider choice of equipment and would mean lower implementation costs.

My strong areas in doing this project are the ability to assimilate and put new technical knowledge to innovative use, the ability to work around the given requirements and constraints, as well as having the necessary background knowledge and skills. These have helped me to produce a working solution, although it needs more refinement before it is ready for actual deployment

Coming into this project, I identified Literature Review and Project Management skills as my weak areas. I believe I have made significant improvements in the former area as compared to when I first started, but did not really gain much improvement on the latter. I suppose I had been too caught up with the technicalities of implementing the solution and did not really put in much effort into the management activities.