Research Report

On

The Use of Computer Technology to Improve Medical Information in Thailand

By

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This research has received a research grant from

Dhurakij Pundit University

2015

รายงานผลการวิจัย

เรื่อง

การใช้เทคโนโลยีคอมพิวเตอร์เพื่อพัฒนาสารสนเทศทางการแพทย์ของประเทศไทย

โดย

รองศาสตราจารย์ ดร. วราพร จิระพันธุ์ทอง

รายงานการวิจัยนี้ได้รับทุนอุดหนุนจาก

มหาวิทยาลัยธุรกิจบัณฑิตย์

พ.ศ. 2558

Abstract

Abstract. Building hospital applications based on services allows hospitals and other organizations to cooperate and make use of each other's business functions. Therefore the hospital information systems that involve extensive information exchange across hospitals and organizations boundaries, such as patient profiles, can be easily automated. Service-based applications can be constructed by linking services from various providers using either as standard programming language or a specialized workflow language. Our research is to analyse and design a web service that supports medical staffs and tools in hospitals in Bangkok. We also developed a prototype tool to facilitate the demonstration and evaluation of the approach. Two cases are created to demonstrate different situations of the web service, involving different types of documents, and patients and medical staffs. The experiments of document creation have been evaluated by considering criteria i.e. easy, correctness, and completeness. Also, the precise and recall measurements are used.

Keywords: Web Service, E-Hospital, XML

Acknowledgments

I am grateful to Dhurakijpundij University for the financial support for this research.

Declaration

Some of the material in this report has been previously published in the paper:

- Waraporn Jirapanthong. (2016). E-Hospital Web Service. In Proceedings of 2016 6th International Workshop on Computer Science and Engineering (WCSE 2016), Japan, 17th-19th June 2016.
- Waraporn Jirapanthong. (2016). The Use of Web-based Application to Support Medical Operations in Thailand. Journal of Information System and Technology and, Vol. 6, No.1.

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Contents

CHAPTER III

CHAPTER IV

List of Figures

List of Tables

Chapter I

Introduction

1.1. Research Motivation

Innovative technology and environment has been rapidly changed. People are unavoidably to keep tracks on social network situations since then people's lifestyles have been changed regarding their new environment.

Computer technology has become an essential tool for data and information managing on all subjects, including health professionals. Information and communications technology (Information and Communication Technology: ICT) can be used to improve and develop an approach to restore, retrieve, analyse, and share information. The technology has been used to assist patients remotely, to manage hospital and medical records, to find and retrieve relevant data records for use in research and assist in medical decision making or patients treatment. In particular, medical science and information technology are applied in term of software and hardware devices to support in medicine or hospitals. For example, a body scanner sends electromagnetic rays through a patient's body and sensors detect how much different parts of the body absorb the rays. A computer uses this data to build up an image of the inside of a patient's body. Body scanners allow doctors to find and treat conditions such as tumours in their early stages when the chances of treating them successfully are much greater. Additionally, computers are used in hospitals to monitor critically ill patients

in intensive care units. The patients has sensors attached to him which detect changes in heart rate, pulse rate, blood pressure, breathing and brain activity. If any of these fall below a preset level the computer sounds an alarm and alerts the medical staff. The data is also logged and used to analyse the changes in a patient's condition over a period of time. Computerised databases are used to help match patients who are waiting for organ transplants such as a new kidney, liver or heart, with suitable organs from doctors. Computerized databases are used by every hospitals in Bangkok to store information about patients. Uses of these databases include i) organizing the transfer of patients between wards recording the history of a patient's appointments with a consultant booking outpatient appointments booking ambulances ordering equipment. Currently computer technology is used to support a patient treatment. The idea has been improved and a new model is rapidly changed. The development of medical informatics has been steadily and rapidly increased [11, 14, 23, 31].

However, the development of medical informatics in Thailand is still highly needed because of many factors. For examples of those factors, the ability of users or those related to information technology for health services remains low, costs such as hardware, software and network connections are very high. Although the awareness regarding computer technology in health services is increasing, it is still not enough.

According to the study conducted among physicians in Nigeria [28], it is found that only 0.5 % of physicians do the search on the Internet for information supporting clinical practice or patient outcomes. It is also found that 72 % of respondents has believe that the Internet plays a role in medical practice. But a survey of medical students [12] found that only 26 % of medical students who use computers, and only 27 % who are competent in the use of

computers and benefit to patients. This is different when compared to developed countries like Europe, America and Australia, where medical students use computers, medical equipment and facilities [26]. This research is based on initial results of several interviews conducted with hospitals as well as a literature survey in order to experience the use of computer technology in the hospitals in Bangkok. We focus on how to use the health information and the existing computer systems can support health services in Bangkok.

As described earlier, modern technologies and the environments are being changed rapidly. Life must be updated quickly and continuously to be able to keep track of or in social situations. Many environment factors cause health problems and lead to being sick from disease and symptoms. On the other hand, people have been developing the risk of getting sickness. Some of the sickness leads the eventual symptoms or diseases.

Many hospitals in Thailand, even in Bangkok, still lack of sophisticated information-based systems due to some difficulties in practical. In addition to, legacy systems are old software systems that are used by a hospital. Usually, they rely on obsolete technology but are still essential to the business. It may not be cost effective to rewrite or replace those systems and many organizations would like to use them cooperating with new systems. Web service becomes a solution to enhance computer systems. Using a web service, organizations can make their information accessible. Other software systems can access the information by defining and publishing a web service interface. This allows the data being accessed. Although a lot of applications have been converted to allow connecting though web services, computer systems that support health services are not completely satisfied. Our research is also to analyse and design a web service that supports medical staffs and tools in hospitals in Bangkok.

1.2. Research Objectives

This research aims to achieve the following objectives:

1) Survey the use of computer technology which supports health service in Bangkok;

2) Survey the health services in hospitals in Bangkok, in which focus on the attitude and competency of medical students and physicians, and availability of health services equipment; and

3) Analyze and provide guidance a web service supporting on health services.

1.3. Assumptions

How computer technology used in hospitals can support health services in public hospitals Thailand.

1.4. Definitions

- *Computer technology* is the design and construction of computers to better help people at work, school, home, etc.

- Patient is a person who receives medical care or treatment.

- *Implementation of the clinical diagnosis* means consulting, analysis and diagnosis the results for the disease including medical treatment of the sickness.

- *General Clinical Practice (GCP)* is an international quality standard that is provided by ICH, an international body that defines standards, which governments can transpose into regulations for clinical trials involving human subjects. A similar guideline for clinical trials of medical devices is the international standard ISO 14155, which is valid in the European Union as a harmonized standard. These standards for clinical trials are sometimes referred to as ICH-GCP or ISO-GCP to differentiate between the two and the lowest grade of recommendation in clinical guidelines.[13]

1.5. Scope of Research

- This study focuses on medical doctors and medical students who work for public hospitals in Bangkok i.e. Ramathibodi hospital, Siriraj Hospital.

- This study was to explore the factors associated with the use of computer technology that supports the treatment and diagnosis of sickness.

- Participants have experiences with the use of computer-based devices and tools.

- This study has developed the prototype of a web application to simulate situations of the use of computer-based devices to support the operation of the clinic.

- This study has created a case study of stoke symptoms, particularly, an indicator of disease severity in patients before, during and after symptoms through the brain and heart.

- The prototype has been to support medical staffs, particularly on first-aid treatment for stroke patients by applying the indicators.

1.6. Conceptual Research

The study is focused on the study of the environment and the actual behavior of physicians. We also focus on how data is used in patient treatment by studying on sample cases from public hospitals in Bangkok. Assumingly, the sample hospitals will reflect similar situations to other hospitals. The study involves 12 medical doctors and 3 patients.

1.7. Benefits

While the global information and communications technology are evolving rapidly. The application of such technology to operation of the clinic is to provide effective support. The results of this study are expected to be able to continue the development of computer technology to perform the clinical efficiency further.

Chapter 2 presents the background of the management of information, information technology, and knowledge management that support treatment activities in hospitals. It also presents the master plan of Information and Communication Technology (ICT) by department of Medical Sciences and the status of the use of ICT in the Ministry of Health. Moreover, the background of data mining and web service are presented.

Chapter 3 describes the approach for this work.

Chapter 4 contains research findings and a description of the experiments and analyses the experiences on the case study.

Chapter 5 discusses the conclusions and directions for future work.

Chapter II

Research Background

This chapter provides the research background of management of information, information technology, and knowledge management including related work in medical areas. It also provides the background of data mining and web services that are applied for a prototype in this work.

2.1 Management of Information, Information Technology, and Knowledge Management

The hospital and health care standard [7] has included the management of information, information technology, and knowledge management as describe in the following section.

The organization ensures the quality and availability of needed data, information, software and hardware for staff and patients / customers. The organization builds and manages its knowledge assets to improve organizational efficiency and effectiveness.

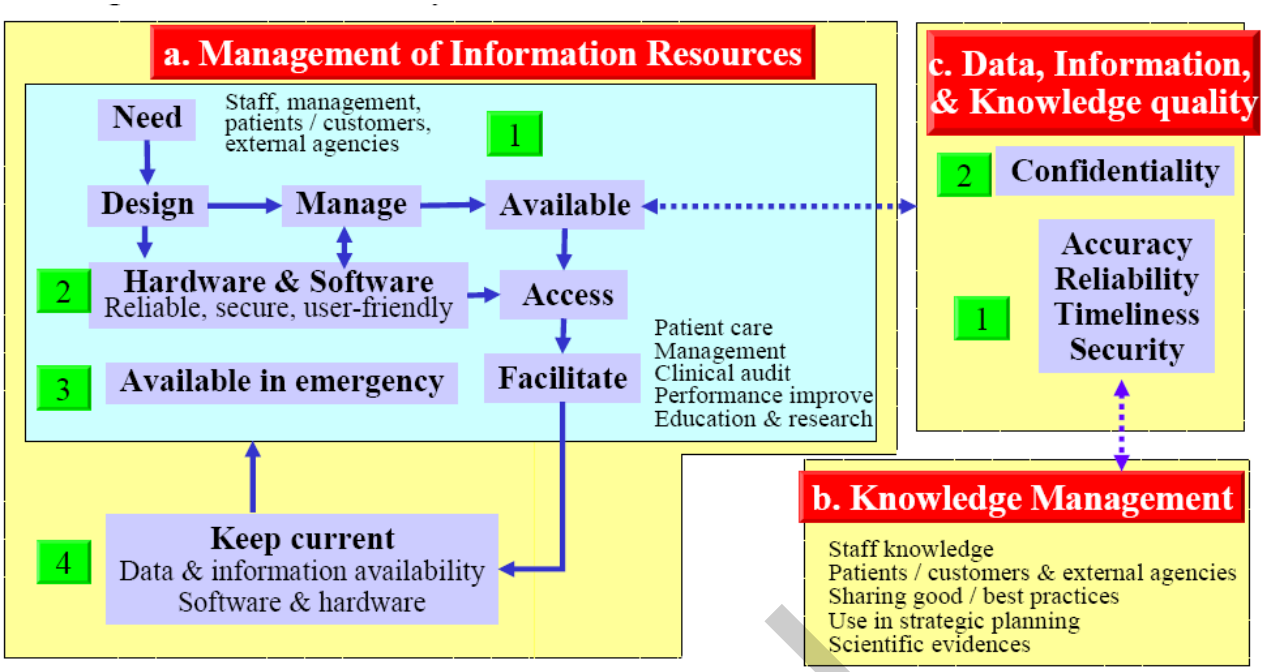

Figure 2-1. Management of Information, Information Technology, and Knowledge Management

a. Management of Information Resources [8]

(1) Needed data and information are made available to staff, management, patients / customers, and external agencies to facilitate patient care, organization management, clinical audit and performance improvement, education and research. Information plan and management[1] are appropriate to the organization's size and complexity.

(2) The organization ensures that hardware and software are reliable, secure, and user-friendly.

(3) The organization ensures the continued availability of data and information, including the availability of hardware and software systems, in the event of an emergency.

[1] Information plan and management includes data standards, technology standards, operational protocols, criteria for data collection, duration and method for data retention, criteria for data updating, security and confidentiality.

(4) The organization keeps its data and information availability mechanisms, including its software and hardware systems, match with current health care service needs and directions and with technological changes.

b. Organizational Knowledge Management [8]

Organizational knowledge is managed to accomplish: the collection and transfer of staff knowledge, the transfer and sharing of relevant knowledge with patients / customers and external agencies, the sharing and implementation of good / best practices, the assembly and transfer of relevant knowledge for use in the strategic planning process, and the adoption of scientific evidences on effectiveness of healthcare intervention.

c. Data, Information, and Knowledge quality [8]

(1) The organization ensures accuracy, reliability, timeliness, and security of its data, information,

and organizational knowledge:

(2) The organizational ensures confidentiality of data and information.

2.2 Related Work

Recently, there are requirements on information and computer technology such as telemedicine systems that have been applied as an alternative to provide public health service [4].

According to [4], Thailand's medical systems now focus on the use of new technologies to support more effective medical treatment. The information and computer technology has

played an important role to leverage the public health in Thailand, in particular, it supports providing medical services. New technologies have been added and enhanced health services in Thailand, especially, people who are far away and inconvenient to access the public health service. Network technology and telemedicine have been a part of medical treatment in some regions within upcountry. Some experimental projects for telemedicine are developed to provide consultation and communication between doctors, hospitals or provincial public health office. For example, experiments with health centers in nine provinces in the North and Northeast of Thailand are created. The health centers have participated in 45 projects and those have received the support from the Ministry of Public Health, Telecommunications Of Thailand, and the company *QualCom* which provides notebooks for provincial medical and health centers. The project has been operated for two years.

Princess Mother's Medical Volunteer Foundation [2] is an important pioneer to drive basic health services to local areas, particularly, to enable local people who have difficulties to access health services. Telemedicine is also used as an alternative way to serve the public.

Moreover, Chulabhorn Research Institute [6] also drives and supports public health services. They have brought up new technology to improve medical services. The institute has worked with the National Electronics and Computer Technology Center (NECTEC) in agreement technical cooperation for research and development. The first phase of telemedicine systems focus on the preparation of the telemedicine system. For example, they try to build up a broadband network to transmit images from the PET-CT to medical professionals. The system facilitates medical staffs to read the results and diagnostic images of cancer cells through computer networks. This is expected to make higher standard of medical technology and more efficient healthcare system in Thailand.

The telemedicine systems have been continuously and steadily developed. One of those is called *Medical Grid* allows telemedical treatment more powerful. It takes advantage and build a high-speed processing power without high cost of purchasing a computer server. It makes *Virtual organization* which allows searching information faster and richer.

2.3 Master Plan of Information and Communication Technology by Department of Medical Sciences [5]

Cabinet resolved that all ministries, departments, enterprises and local governments including related business units provide its own master plan of information and communication technology in accordance with the contents and details of the second information and communication technology master plan of Thailand from 2009 to 2013. Although there is no announcement of new edition of master plan, the department of Medical Sciences is necessarily driven to develop the guideline of implementation regarding the contents and details of information and communication technology.

The third information and communication technology master plan (AD 2557-2561) has been set up. The main objective is to provide the guidelines for the guidelines for the implementation and development of information and communication technology during fiscal year AD 2557-2561. The master plan by department of Medical Sciences is outlined to be consistent with the master plan by the Ministry of Health and under the policy framework of information and communications technology of Thailand during AD2554-2563 (National ICT Policy Framework 2011-2020: ICT 2020). This is aimed that the operation or development of information and communications technology is going on the same direction including being

appropriate with change policy on information and communications technology regarding present economic and social factors.

2.4 Status of the Use of Information and Communication Technology in the Ministry of Health [10]

In this section, the overview of the use of information and communication technology in the ministry of health is given.

Center for Information Technology and Communications Ministry of Health is responsible for the administrative network of the Ministry of Health which is connected in order to send/receive data and reports to/from local and regional departments/divisions. This includes all levels of networks from provincial to village levels. The network of the Ministry of Health is a large scale network comparing with ISP (Internet Service Provider) regarding Internet bandwidth and speed. Moreover, there are a number of electronic equipment and network devices to support the security of networks and servers. This is to serve data transferring among official units across the country, authenticating the right of healthcare and information, and disbursement of funds from the national health insurance system and Government Fiscal Management Information System (GFMIS).

1) Using a network of ICT in Early age (Host Based)

About the year AD2526, the Ministry of Health has provided computer systems to store data regarding public health statistics and epidemiology. The division of health statistics and of Epidemiology used PRIME and PDP-11 computers which were mini computers connected to terminals which were available in local units. And the network was extended to provide other

functions and systems. The system was upgraded by integrating with VAX6000 and has been used until AD2544.

2) Second generation (Downsizing)

To reduce the budget of the supply and maintenance of computer systems, the Ministry of Health has adjusted the computer network framework by using personal computer (PC). The network was based on LAN by using a Novell Netware as Network Operating System (NOS). More specifically, the host-based network has been migrated to be client/server on DOS mode and the communications protocol (IPX / SPX) by Novell Netware has been applied with decision support system). The network was connected among personal computers from every executive ministry officers' rooms. New systems were developed such as STAT, documentation system, budget system.

3) Third generation (Client Server)

There was a trial on the connection between the Ministry of Health and Internet from AD2534. This was operated by NECTEC and considered as the beginning of the communication network of the Ministry of Health by using TCP / IP protocols. Later, data transferring among official units under the ministry of health are based on Wide Area Network (WAN) systems. However, there are issues on "Bandwidth Overhead" on networks. The client/server platform has been applied to get rid of the problems. Many systems were developed.

4) Forth generation (Web-Based)

The critical issue on client/server networks was that they are vulnerable to attack from viruses. The new platform "Web -Based" using HTTP protocol has been highly appreciated. Many systems were migrated to support web-based framework. XML and SOAP technology has been introduced to allow data exchanging between various platforms and venders.

5) Fifth generation (Service Oriented Architecture).

"SOA" technology is extended based on web service technology. It focuses on the concept of service outsourcing. Modules are collaborating through TCP/IP network. So, the stability of computer networks becomes a key factor.

2.5 Data Mining

In this work, we have employed data mining techniques and web services to implement the prototype for conducting the research data. The types of data mining techniques can be categorized differently. However, the most well-known data mining techniques fall into three methods which are association rule mining, classification and prediction and clustering. Details of each method are as follows:

1) Association Rule Mining

Association Rule Mining (ARM) is a method for discovering interesting relation between variables in a transaction databases. ARM is a famous technique for market basket analysis, introduced by Agrwal, 1993. There are many application areas including web usage, intrusion detection, and bioinformatics. Popular ARM algorithms are Apriori and FP-Grow.

2) Classification

This technique is a supervised learning technique that classifies data item into pre-defined class label. This appropriate technique builds model that predict future data trend. There are several algorithms for data classification such as Decision Tree, CART (Classification and Regression Tree) and Back Propagation neural network.

3) Clustering

The clustering technique or unsupervised learning technique is a division of data item into similar group without training of class labels. Clustering algorithms have been used in a large variety of applications, including image segmentation, construction the prototype of classifiers, understanding genomics data, market segmentation, etc. There are several clustering algorithms such as K-means, hierarchical agglomerative clustering and Self-Organizing Map.

a. Classification Techniques

Classification is one of the most useful techniques in data mining to building classification models from an input data set. Techniques for supporting building classification models are such as decision tree classifiers, rule-based classifiers, neural networks, support vector machines, and naïve Bayes classifiers. Each technique employs a learning algorithm to identify a model that best fits the relationship between the attribute set and class label of the input data. The model generated by a learning algorithm should both fit the input data well and correctly predict the class labels of records it has never seen before. The key objective of the learning algorithm is to build models with good generalization capability.

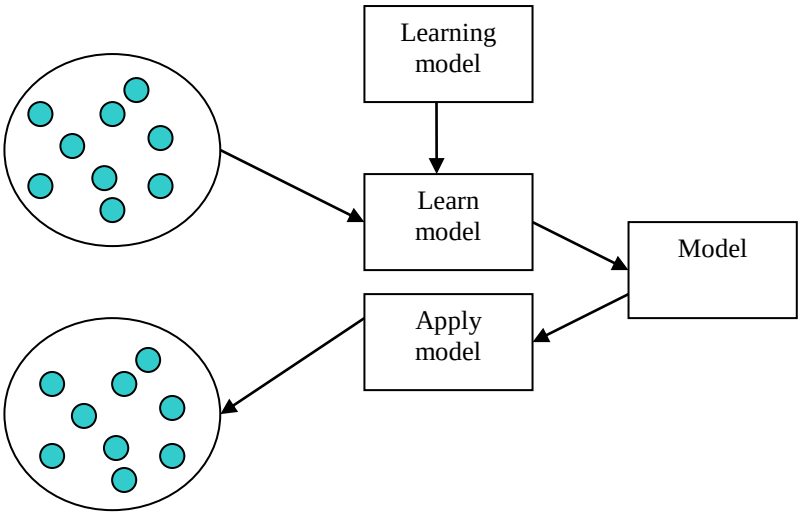

Figure 2-2. general approach for building a classification model

b. Clustering Techniques

Clustering is one of the most useful techniques in data mining for partitioning large data set into groups according to their similarity and focusing on a particular set of future analysis. A definition of optimal clustering is a partitioning that minimizes distances within clusters and maximizes distances between clusters. The optimal clustering is shown in Figure 2-3. In this section, Euclidean distance and two clustering algorithms: Kohonen's Self Organizing Map and K-means applied in this research project are described following.

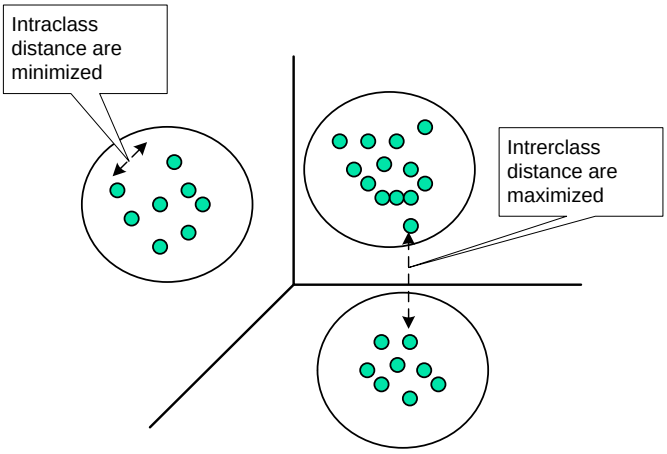

Figure 2-3. Optimal clustering

c. Euclidean Distance

Euclidean distance is the most popular distance measure to calculate the dissimilarity (similarity) between two data objects from same space is to clustering procedures. Euclidean distance is defined as the equation (2.1).

$$d(i,j) = \sqrt{(x_{i1} - x_{j1})^2 + (x_{i2} - x_{j2})^2 + ... + (x_{in} - x_{jn})^2} \quad (2.1)$$

Where:

i = (xi1, xi2,...,xin) are two n- dimensional data objects.

j = (xj1,xj2,...,xjn) are two n- dimensional data objects.

d. Kohonen's Self Organizing Map Algorithm

The Kohonen's Self Organizing Map (SOM) algorithm, widely also known as Kohonen network is a popular algorithm for unsupervised learning. The SOM algorithm based on neural network structure in two layers [21].The first layer represents the input data, the other one

show output map. The goal of SOM is to represent all point in a high dimensional source space by points in a low dimensional target space. Figure 2-4 illustrates architecture of SOM.

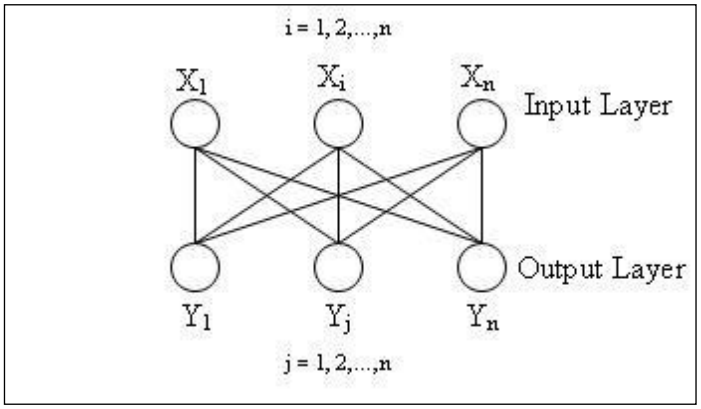

Figure 2-4. A typical Self-Organization Maps architecture

The concept of Kohonen's Self-Organizing Maps Neural Network is iterative for each data to find weight according number of clusters as follows:

1) Initialize the weights vector of all the output neurons.

2) Determine the output wining neuron m by searching for the shortest normalized Euclidean distance between the input vector and the weight vector of each output neuron, by using the equation (2.2).

$$|\mathbf{X} - \mathbf{W}_m| = \min_{j=1\ldots M} |\mathbf{X} - \mathbf{W}_j| \qquad (2.2)$$

Where:

X is the input vector,

Wj is the weight vector of output neuron j, and

M is the total number of output neuron.

3) Let Nm (t) denote a set of indices corresponding to a neighborhood size of the current winner neuron m. The neighborhood size needs to be slowly decreased during the

training session. The weights of the weight vector associated with the winner neuron m and its neighborhood neurons are updated by the equation (2.3)

$$\Delta W_j(t) = \alpha(t)[X(t) - W_j(t)] \text{ for j E Nm(t)} \quad (2.3)$$

Where is a positive-valued learning factor, E [0, 1]. It needs to be slowly decreased with each training iteration. Thus, the new weight vector is given by the equation (4)

$$W_j(t+1) = W_j(t) + \alpha(t)[X(t) - W_j(t)] \text{ or j E Nm(t)} \quad (2.4)$$

Steps 2 and 3 are repeated for every exemplar in the training set for a user-defined number of iterations.

e. K-means Algorithm

The k-means algorithm was introduced by Mac Queen in 1967. The k-means algorithm is well known for its efficiency in clustering large data sets. The k-means algorithm takes the input parameter, k, and partitions a set of n objects into k clusters [18] so that the overall sum of square error is minimized.

A major limitation of k-mean is to determinate the number of k clusters that is to affect the accuracy of the data partition and the efficiency of the clustering processing. As the k parameter increase, the data item will be divided into clusters and the processing will need large computational power. On the contrary, the k parameter is small, the data item will be divided into less clusters and some significant characteristic of data may be lost. The k-means algorithm is described as follows:

1) Determinate the number of k clusters.

2) Randomly selects initial represent point a cluster mean.

3) Assign each object to the closest cluster center, based on similarity measure.

4) Computes the new mean for each cluster. This process iterates until object is no change group (cluster).If object change group go to step 3.

2.6 Web Services

As said earlier, we also apply web services techniques to enable the prototype environment for conducting the research data. Web services are distributed application components that are externally available. It can be used to integrate computer applications that are written in different programming languages and run on different platforms. Web services are language and platform independent because vendors have agreed on common web service standards. A lot of related standards are developed and proposed by different vendors. For example, Oracle has developed a java.net project called Metro [22]. Metro is a complete web service stack, covering all of a developer' s needs from simple "Hello, World" demonstrations to reliable, secured, and transacted web services. Metro includes Web Services Interoperability Technologies (WSIT) [33]. WSIT supports enterprise features such as security, reliability, and message optimization. WSIT ensures that Metro services with these features are interoperable with Microsoft .NET services [30]. Within Metro, Project Tango develops and evolves the codebase for WSIT.

Several programming models are available to web service developers. These models fall into two categories, both supported by the IDE:

i) REST-based (REpresentational State Transfer) [30] is a new way to create and communicate with web services. In REST, resources have URIs and are manipulated though HTTP header operations.

ii) SOAP/WSDL-based [30]. In traditional web service models, web service interface are exposed through WSDL documents (a type of XML), which have URLs. Subsequent message exchange is in SOAP. Another type of XML document.

REST-based ("RESTful") web services are collections of web resources identified by URIs. Every document and every process is modeled as a web resource with a unique URI. These web resources are manipulated by the actions that can be specified in an HTTP header. Neither SOAP, nor WSDL are used. Instead, message exchange can be conducted in any format e.g. XML[34], JSON[19], HTML, etc. In many cases a web browser can serve as the client.

HTTP is the protocol in REST. Only four methods are available: GET, PUT, POST, and DELETE. Requests can be bookmarked and responses can be cached. A network administrator can easily follow what is going on with a RESTful service just by looking at the HTTP headers.

REST is a suitable technology for applications that do not require security beyond what is available in the HTTP infrastructure and where HTTP is the appropriate protocol. REST services can still deliver sophisticated functionality. For example, Flickr[16], Google Maps and Amazon all provide RESTful web services.

In SOAP-based web services, Java utilities create a WSDL file based on the Java code in the web services. The WSDL is exposed on the net. Parties interested in using the web service create a Java client based on the WSDL. Messages are exchanged in SOAP format. The range of operations that can be passed in SOAP is much broader than what is available in REST, especially in security.

SOAP-based web services are suitable for heavyweight applications using complicated operations and for applications requiring sophisticated security, reliability or other supporting features. They are suitable when a transport protocol other than HTTP has to be used. Many of Amazon's web series, particularly those involving commercial transactions, and the web services used by banks and government agencies are SOAP-based.

The Java API for XML Web Services (JAX-WS) is the current model for SOAP-based web services in Metro. JAX-WS is built on the earlier HAX-RPC model but uses specific Java EE features such as annotations to simplify the task of developing web services. Because it uses SOAP for messaging, JAX-WS is transport neutral.

As mentioned earlier, a traditional web service is based on SOAP. A web service is an instance of a more general notion of a service, which is defined (Lovelock et al., 1996) as: "an act or performance offered by one party to another. Although the process may be tied to a physical product, the performance is essentially intangible and does not normally result in ownership of any of the factors of production".

As shown in Figure 2-5, the web service consists of

1) SOAP (Simple Object Access Protocol). This is a message interchange standard which facilitates the communication between web services. The protocol is provided for communicating among diverse platforms or programming languages. This is supported by XML technology.

2) WSDL (Web Service Definition Language). This is a standard for service interface definition. It defines how to use web services and describes types of sending and receiving messages.

3) UDDI (Universal Description, Discovery and Integration). This defines the components of a service specification, which may be used to discover the existence of a service.

The web service is available at a web service server, which internally connects a database server and externally connected to the Internet. The web service can be accessed by client computers via the Internet.

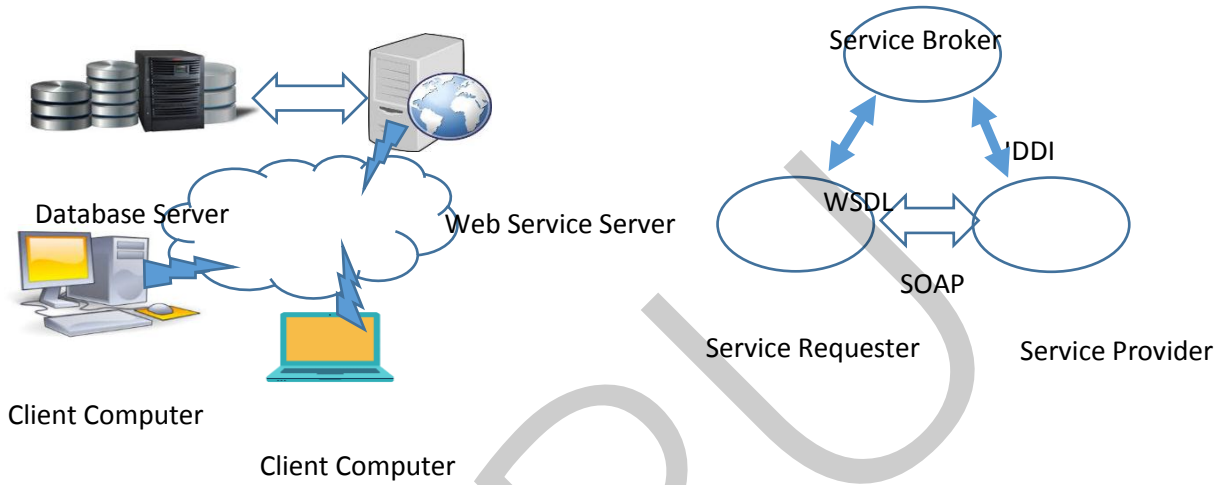

Figure 2-5. Service-oriented architecture.

As shown in Figure 2-6, it shows the stack of key standards that have been established to support web services. Web service protocols cover all aspects of SOAs, from the basic mechanisms for service information exchange (SOAP) to programming language standards. The standards are based on XML which allows the definition of structured data and meaningful tags. The technology includes other documents such as XSD for schema definition, XSLT for document presentation, et al.

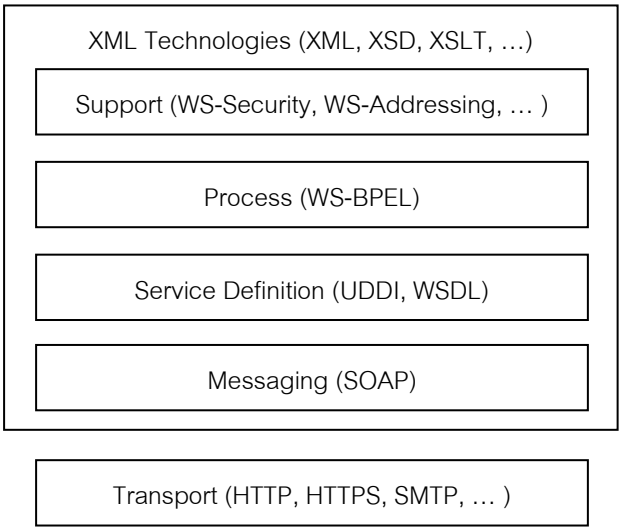

Figure 2-6. Web service standards.

a. Software Development with Services

Building applications based on web services allows companies and other organizations to cooperate and make use of each other's business functions. Thus, systems that involve extensive information exchange across company boundaries, such as supply chain systems where one company order goods from another, can easily be automated. Service-based applications may be constructed by linking services from various providers using either a standard programming language or a specialized workflow language. Many companies and organizations are now converting their enterprise applications into service-oriented systems, where core functions is a service rather than a component. As, in practice, the process of service construction is performed as follows: we firstly elaborate the business process as sequence of separate steps in term of workflow. The workflow is a simple and straightforward idea to elicit the system requirements. Next, we discover the service list and specify those services. Some of possible services are refined. This involves adding detail to the abstract

description and adding/removing workflow activities. Later, the abstract workflow design and the service interface are implemented. Finally, the integration and testing of service are performed.

2.7. Summary

This chapter described the management of information, information technology, and knowledge management that support treatment activities in hospitals. It discussed about related work. The master plan of Information and Communication Technology (ICT) by department of Medical Sciences was described. Also, the status of the use of ICT in the Ministry of Health was discussed. Moreover, the background of data mining and web service are presented. In next chapter, we present the research methodology for this work. Particularly, the design of approach is described.

Chapter III

Research Methodology

3.1 Population and Sample

In this study, the target population was a group of medical doctors. We planned to develop a survey of the use of computer technology which supports the health services in Bangkok. The survey has taken in public hospitals in Bangkok and participated by medical doctors from those hospitals.

This study focuses on medical doctors who work for public hospitals in Bangkok i.e. Ramathibodi hospital and Siriraj Hospital. Since it concerns with legal and ethics factors including time constraints, we have conducted the study with a small number of participants. The study includes the process of collecting data from medical doctors or staffs who are related to the use of computer systems at work. Those consist of:

1) For the first part, we randomly distributed the questionnaire to 100 people; however, there are 23 respondents who give the complete feedback.

2) For the second part, there were 12 medical doctors and 3 patients who agreed to experience with the prototype.

3) For the third part, the same group of participants including 12 medical doctors and 3 patients are agreed to complete the experiment.

3.2 How to Collect Data

We have done practical survey on 3 public hospitals in Bangkok. It consists of three parts.

I. For the first part, we performed an observation and used a questionnaire to collect primitive data. From the observation, it captures the details of working environment that was taken four places (departments) in two hospitals. From questionnaire, the primitive data includes personal and working profiles of respondents, the attitude and behavior towards working environments, and the use of computer systems at work, especially the use of Internet applications regarding medical perspectives. The distribution of questionnaire was randomly performed and there were 23 respondents. The questionnaire consisted of open and closed questions.

II. For the second part, a research team has studied for an indicator of disease severity in patients before, during and after symptoms through the brain and heart. The data from the survey is used to develop a tool to distinguish the important indicators in the brain. We have proposed to apply those indicators in the prototype. Particularly, we have developed a web service that supports medical staffs, particularly on first-aid treatment for stroke patience by applying the indicators.

III. For the third part, we have performed an observation and used a questionnaire to collect data and feedback on the use of the prototype. The prototype is our proposed web service. From the observation, it captures the emotional perspectives on the use of prototype. From questionnaire, the primitive data includes personal and working

profiles of respondents, the attitude and feedback on using the prototype. The questionnaire was selectively distributed and there were 12 respondents. The questionnaire consisted of open and closed questions.

3.3 Research Methods

We have performed the research as described below.

a. **Develop the survey on public hospitals.**

The objectives are to

i) To collect the primitive data includes personal and working profiles of respondents

ii) To acquire the attitude and behavior towards working environments, and the use of computer systems at work, especially the use of Internet applications regarding medical perspectives.

iii) To identify a set of indicators of disease severity in patients before, during and after symptoms through the brain and heart in order to be applied in the prototype.

b. Create and define the system requirements.

The requirements are further used for developing the prototype.

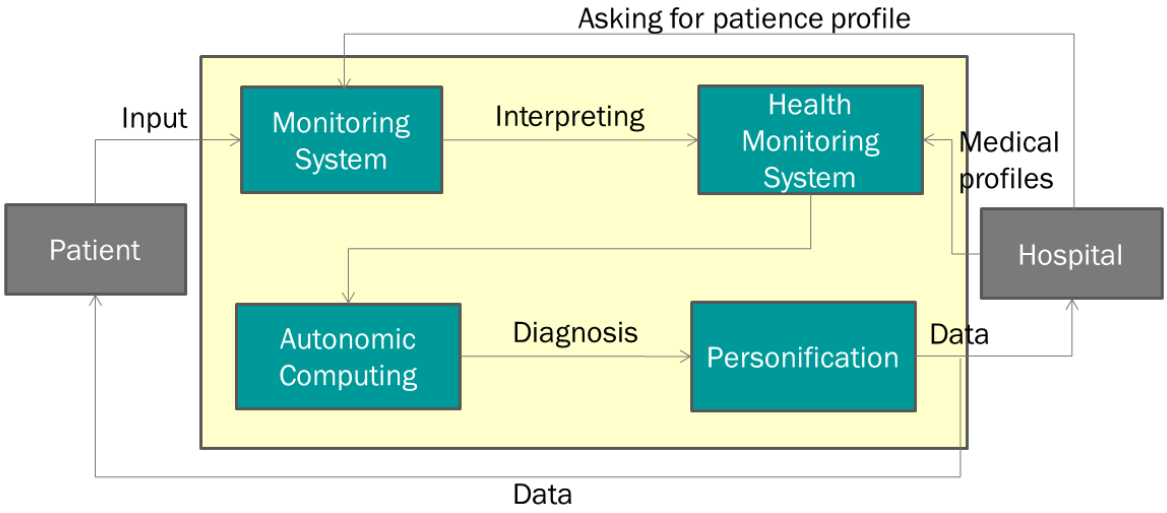

Figure 3-1. E-Hospital Web Service

As shown in Figure 3-1, an E-Hospital Web Service is designed to support different providers in different places in which offer facilitating services. A legacy system of hospitals are analysed and the design of e-hospital web service. One of objectives of the service is that it is not necessary to decide when the system is programmed or deployed what service provider should be used or what specific services should be accessed. As the hospital system is operated, the information system uses the service to find the most appropriate information service and binds to that. Because of the use of Health monitoring system, it can access database systems across hospitals and therefore make local information available to medical staffs who do not personally contact the hospitals.

The first subsystem is monitoring system which serves as an elementary monitoring system that is responsible for reviewing all telemetry orders to determine if the patient meets criteria for hard telemetry or soft telemetry. This is based on established guidelines. And this requires thorough review of a patient's current condition and previous medical history.

For the second subsystem, Health monitoring system will serve medical staff as a consultant for cardiopulmonary technicians who monitor and interpret cardiac physiological data, detecting and documenting any changes in hear rhythm and arrhythmias according to department standards.

The next subsystem is the autonomic computing. This subsystem computes the cardiovascular system that maintain blood supply to vital organs, particularly the brain. This requires information regarding blood pressure, which can be maintained in the short term by altering systemic resistance and cardiac output.

The last subsystem is a part of decision support system to assist the medical staffs to make a decision to maintain or cover the patient's urgent sickness situations.

Based on the survey of hospitals in Bangkok, we found that there are information systems available in the hospitals. However, those systems lack of data continuity. It becomes difficulties to follow patients profiles and medical records.

Our approach, for the part of database, we have designed two main parts. Firstly, patient profile- the data is aimed to identify patients. Secondly, patient behaviour- the data is aimed to monitor and automatically diagnose the patient disease. The steps of e-hospital web service can be described as follows:

i) authentication – this step is to identify and grant the access right for a user. This step is performed via web server service.

ii) collect data from database server. This step is performed by database server through web service broker.

iii) SOAP data encryption.

c. Develop a prototype

In our approach, we have developed a web service which is applied with web service protocols including SOAs and service information exchange (SOAP). We have also applied programming language based on XML. The templates of elementary artifacts are created i.e. XSD and XSLT.

WSDL Specifications can be automatically generated. Service Requests do not need to know the details of a specification. An example of a WSDL specification which provides service show in Figure 3-2. It shows a part of defining some templates used. We assume that the namespace prefix “xs” refers to the namespaces URI for XML schemas and the namespace prefix “hp” associated with the following definition regarding the hospital domain. Moreover, Figure 5 shows the interface for a simple service that, given a contact address, specified such as a first name, last name, and gender, returns the template of data recorded for that patient. As shown in Figure 3-2, it shows the part of the description of the element and type definition that is used in the service specification. This defines the elements firstname, lastname, and gender. In the figure 3-3, it shows how the service interface is defined.

```
<patients>
        <xs:schema targetNameSpace = http://.../ehospital xmlns:hp = http://../ehospital>
                <xs:element name = “BirthDate” type = “patientrec” />
                <xs:element name = “CitizenID” type = “patientrec” />
                <xs:element name = “HN” type = “orgrec” />
                <xs:element name = “SocialInsuranceID” type = “pubrec” />
                …
                <xs:complexType name = “patientrec”>
                <xs:sequence>
                        <xs:element name = “firstname” type = “xs:string” />
                        <xs:element name = “lastname” type = “xs:string” />
                        <xs:element name = “gender” type = xs:string” />
                        …
                </xs:sequence>
                </xs:complexType>
                …
        <xs:schema>
<patients>
```

Figure 3-2: Part of a WSDL description for a web service.

```
<interface name = “patientInfo”>
        <operation name = “getPatientProfile” pattern = “hpns: in –out”>
        <input messageLabel = “In” element = “hpns: Address” />
        <output messageLabel = “Out” element = “hpns: DataTemp” />
        </operation>
<interface>
```

Figure 3-3: An example of defining the interface and its operations.

d. Perform experiments and Evaluate.

We planned to evaluate our approach by using a case study. The case study was created to simulate a situation of system requirements. The details of experiments and evaluation will be described in next chapter.

e. Prepare reports and presentations.

We planned to write-up as a report and publish research papers.

3.4 XML-based Documents

According to the system requirements, we have designed the templates of XML Schema, WSDL description and other XML-based documents. In our experiments, we have created XML-based documents regarding our approach. Examples of WSDL description of a patient-profile service" is shown in below figure.

```
<?xml version="1.0"?>
<definitions name="patient-profile"
          targetNamespace="http://ehospital.com/patient-profile.wsdl"
          xmlns:tns="http://ehospital.com/patientprofile.wsdl"
          xmlns:xsd1="http://ehospital.com/patientprofile.xsd"
          xmlns:soap="http://schemas.xmlsoap.org/wsdl/soap/"
          xmlns="http://schemas.xmlsoap.org/wsdl/">

 <types>
  <schema targetNamespace="http://ehospital.com/patientprofile.xsd"
        xmlns="http://www.w3.org/2000/10/XMLSchema">
   <element name="PatientProfileRequest">
    <complexType>
     <all>
      <element name="patientSymbol" type="string"/>
     </all>
    </complexType>
   </element>
   <element name="patientType">
    <complexType>
     <all>
      <element name="typeName" type="string"/>
     </all>
    </complexType>
   </element>
  </schema>
 </types>

 <message name="GetLastTreatmentInput">
  <part name="body" element="xsd1:TreatmentRequest"/>
 </message>
```


Figure 3-4 (a): An example of WSDL Description.

```
<treatmentType name="TreatmentPortType">
  <operation name="GetLastTreatment">
    <input message="tns:GetLastTreatmentInput"/>
    <output message="tns:GetLastTreatmentOutput"/>
  </operation>
</treatmentType>

<binding name="TreatmentSoapBinding" type="tns:TreatmentPortType">
  <soap:binding style="document" transport="http://schemas.xmlsoap.org/soap/http"/>
  <operation name="GetLastTreatment">
    <soap:operation soapAction="http://ehospital.com/GetLastTreatment"/>
    <input>
      <soap:body use="literal"/>
    </input>
    <output>
      <soap:body use="literal"/>
    </output>
  </operation>
</binding>

<service name="TreatmentService">
  <documentation>My first service</documentation>
  <port name="TreatmentPort" binding="tns:TreatmentSoapBinding">
    <soap:address location="http://ehospital.com/treatment"/>
  </port>
```

Figure 3-4 (b): An example of WSDL Description.

3.5 Summary

This chapter described the research methodology for this work including how to draw population and collect data. The research methods was presented including the design of the approach to tackle the research issue. Examples of XML-based documents were also presented.

In next chapter, we present the overview of research evaluation by applying the experiments. The discussion is also provided.

.

Chapter IV

Experiments and Discussion

In order to evaluate and demonstrate our approach, we have implemented a prototype tool. We envisage the use of our tool as a general platform of dynamic web service for E-Hospital. More specifically, the prototype tool provides some functionality to assist medical treatments for stroke patients.

As described in previous chapter, we have performed practical survey and observation. It consists of three parts.

4.1. General Characteristics of Working People in Hospitals

According to the primitive survey and observation, we captured the personal profiles including attitudes towards working environment supporting with information technology and systems. During the survey and observation, we have followed the checklist-to-do to elicit the data. We also applied with questionnaire and interviewing to complete the primitive survey. As shown in Table 4-1, the details based on the questions in questionnaire, interview, survey, and observation are concluded. The details are described in term of gender, occupation, age, and skills.

Table 4-1. General Profile of Sample Group

Subject	Hospital 1	Hospital 2	Hospital 3
Number of sample size	18	25	22
Male	4	19	7
Female	14	6	15
Doctors	4	7	8
Other staffs	14	18	12
Average age	42	45	41
Average working experience (working years at the hospital)	15	18	15
Skill level in computer technologies (1 = beginner; 2 = familiar; 3 = proficient; 4 = expert; 5 = master)	3	3	3
Comprehension level in information systems at the hospital (1 = beginner; 2 = familiar; 3 = well; 4 = expert; 5 = master)	4	4	4

The numbers of participants from each hospital are 18, 25, and 22. This is due to the time constraint and legal issues. The participants include doctors, medical students, and nurses. Most of them are comfortable to work with computer systems and have good attitude based

on information systems at their hospitals. Both males and females medical staffs had the same learning pattern. Otherwise, the learning pattern is not smooth. Rather, it fluctuates across age groups of medical staffs. The cause of this fluctuation is due to the small population size for each age group.

Moreover, the feedback from participants towards the use of existing information systems at their work is concluded in Table 4-2. The participants gave their opinion and comments on the existing systems available at the hospitals. They were asked to consider in terms of i) usability that the systems support any human factors, help, or documentation, ii) availability that is concerned the ready status to be used, iii) reliability that is concerned the frequency of failure, recoverability, predictability, iv) accessibility that is concerned with the environment to access the systems, and v) performance that is concerned the response times, throughput, accuracy, availability, and resource usage.

Table 4-2. The existing information system

Subject	Hospital 1	Hospital 2	Hospital 3
Usability (1 = poor; 2 = usable; 3 = useful; 4 = desirable; 5 = delightful)	3	3	3
Availability (1 = poor; 2 = low; 3 = fair; 4 = high; 5 = absolute)	4	5	4
Reliability (1 = poor; 2 = low; 3 = fair; 4 = high; 5 = absolute)	4	5	4
Accessibility (1 = poor; 2 = low; 3 = fair; 4 = high; 5 = absolute)	3	4	3
Performance (1 = poor; 2 = low; 3 = fair; 4 = high; 5 = absolute)	3	3	3

Based on the results, it shows that the participants have positive attitude towards the existing information systems. They agree that the systems are useful and have good performance. The systems are highly available and reliable, and can be fairly accessed.

4.2. Towards the New System

We have performed an observation and used a questionnaire to collect data and feedback on the use of the prototype, the web service. The content of the prototype system is

based on the indicators we have collected in the second part of our work as described in Chapter 3. From the observation, it captures the emotional perspectives on the use of prototype. As our third part of our work, the questionnaire was selectively distributed and there were 12 respondents. The questionnaire consisted of open and closed questions. Those questions are based on the perspective of the use of a prototype to support their present job.

Moreover, some medical doctors were interviewed to determine the effectiveness of the existing facilities maintenance management practices and processes. Thirty two questionnaires were distributed to medical staffs in the hospitals. Twelve out of thirty two questionnaires were completed. The distributions of the respondents were from three public hospital and involved three patients.

The questionnaire comprised of seven parameters of equipment life cycle which was adequately answered. The questionnaire had two main parts; Section A and Section B. In section A, the questionnaire defines the goal of the research and outlines the seven main parameters to be interviewed on. In section B, each main parameter had several questions in which the facility maintenance managers were required to answer appropriately. The weighting of each question was answered based on the following: 0 - Very poor (0%); 1 – Poor (20%); 2 – Fair (40%); 3 – Good (60%); 4 - Very good (80%); and 5 – Excellent (100%)

Additionally, we have developed a prototype tool to facilitate the demonstration and evaluation of the approach. The prototype tool has been implemented by applying with Java-based and XML-based technologies. The main functionalities of the tool are implemented according to the design as shown in figure 3-1. Additionally, two cases are created to

demonstrate different situations of the web service, involving (a) different types of documents; and (b) different patients and medical staffs. The experiments of document creation have been evaluated by considering three criteria: (i) easy, (ii) correctness, and (iii) completeness. For the latter criteria, the precise and recall measurements are used.

4.3. Evaluation Results and Analysis

According to the questionnaire, the questions are used to collect feedback on the use of the prototype. From 20 questions of questionnaire with different weights per each question, 12 respondents gave slightly similar feedback. The average weighted score of 20 questions from 12 respondents are 60.2727%. The figure shows that the satisfaction of the use on the prototype is good. We have also concluded the results based on the question topics. We stereotyped the questions as terms of usability, availability, reliability, accessibility, and performance. As shown in Table 4-3, it shows that the participants have very positive attitude towards the new information system which is based on web service. They agree that the system is very useful and reliable. They also agreed that system is absolutely available and desirably accessible.

Table 4-3. Feedback on the web service system

Subject	Hospital 1	Hospital 2	Hospital 3
Usability (1 = poor; 2 = usable; 3 = useful; 4 = desirable; 5 = delightful)	4	4	4
Availability (1 = poor; 2 = low; 3 = fair; 4 = high; 5 = absolute)	5	5	5
Reliability (1 = poor; 2 = low; 3 = fair; 4 = high; 5 = absolute)	4	4	4
Accessibility (1 = poor; 2 = low; 3 = fair; 4 = high; 5 = absolute)	5	5	5
Performance (1 = poor; 2 = low; 3 = fair; 4 = high; 5 = absolute)	4	4	4

Additionally, we have simulated the situations of the use of computer technology to support the medical treatment and consultation. Particularly, we have established the case study for this purpose. The objectives of two cases are varied.

The main objective of test case 1 is to identify the patient profiles across hospitals via the web service. The data used are collected from 2005-2006 and there are 3,751 records

available. The results of test case 1 show that correctly identified is 87.93% while misidentified is 47.6%. The percentage of correctly identified is high (87.93%). It implies the web service performs the identification of patient profiles with high performance. The percentage of misidentifying is fairly low (47.6%). It implies the service failed to identify some profiles. This is due to imcomplete data e.g. missing some attribute values, incorrect data.

Additionally, the main objective of test case 2 is to use the patient profiles to diagnose the patients' diseases. The data used are collected from 2004-2006 and there are 4,652 records available. The result of test case 2 show that correctly diagnosis is 83.2% while misdiagnosis is 55.2%.

A number of possible directions for further investigations have been identified. We provide in this section future work of the research, what needs to be done to improve the approach and to increase the benefits of the approach. Tools for Document Generation and Visualisation for large number of various artefacts should be implemented. It is therefore believed that the approach could benefit by providing tool fully support for the specification of documents. In addition, sophisticated techniques for visualization could support the use of documents more efficiently.

Chapter V

Conclusion and Future Work

5.1. Conclusion and Discussion

According to modern technologies and the environments are being changed rapidly. Also many environment factors cause health problems and lead to being sick from disease and symptoms. Based on our survey, many hospitals in Thailand, even in Bangkok, still lack of sophisticated information-based systems due to some difficulties in practical. In addition to, legacy systems are old software systems that are used by a hospital. It may not be cost effective to rewrite or replace those systems and many organizations would like to use them cooperating with new systems. Web service becomes a solution to enhance computer systems. This allows the data being accessed. Although a lot of applications have been converted to allow connecting though web services, computer systems that support health services are not completely satisfied.

This research have done the survey regarding the use of computer technology which supports health service in Bangkok and proposed a guidance a web service supporting on health services.

This study focused on medical doctors and medical students who work for public hospitals in Bangkok i.e. Ramathibodi hospital, Siriraj Hospital. And it explored the factors (i.e.

usability, availability, accessibility, reliability, and performance) that are associated with the use of computer technology and supports the treatment and diagnosis of sickness. This study has developed the prototype of a web application to simulate situations of the use of computer-based devices to support the operation of the clinic. Particularly, the study has created a case study of stoke symptoms, particularly, an indicator of disease severity in patients before, during and after symptoms through the brain and heart. Also, the prototype has been to support medical staffs, particularly on first-aid treatment for stroke patients by applying the indicators.

As described in previous chapter, the experiments showed the results in one direction. To conclude, we found that the computer technology in hospitals can support health services in hospitals in Thailand. We believe that the application of such technology to operation of the clinic is to provide effective support. The results of this study showed that it is capable to continue the development of computer technology to perform the clinical efficiency further.

5.2. Future Work

Additionally, a number of possible directions for further investigations have been identified. The future work can be considered in order to improve the approach and to increase the benefits of the approach. Those are:

i) The approach is planned to be expanded to cover all activities in hospitals in order to complete the web service for e-hospital framework.

ii) It is believed that the approach could benefit by providing tool support for the specification of documents.

iii) We plan to improve the algorithm of implementation to reduce of processing time. Since, transactions on web service can take a long time to be processed depending on the size, number, and types of documents and relationships, more work needs to be done to optimize the processing time.

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