The Feasibility Study of the Picture Archival Communication System (PACS) Application in Thailand

By

Mr. Piyaphong Kobbundith

A Final Report of the Three - Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
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Project Title	The Feasibility Study of the Picture Archival Communication System (PACS) Application in Thailand
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The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

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ABSTRACT

The Picture Archival Communication System (PACS) is a very useful system that can replace the conventional X-ray system. It is the high technological combination of computers and electronics, particularly with the concept of making filmless diagnostic images, or softcopy. While images can be archived as medical records and used for communicating among people involved. The PACS can not only make tremendous cost saving compared with the existing system, but also efficiently and effectively enhance diagnosis imaging.

The feasibility study of the PACS application in Thailand was conducted through cooperation with many people involved with the PACS project in hospitals. The results of the analysis were obtained through the gathering of pertinent information and the adoption of suitable solutions to find out whether or not it is worth the investment and, the study of how it can be efficiently and effectively used.

The cost analysis in engineering economy is used to analyze feasibility of the investment on the PACS, and analysis results show that PACS is a worthy investment. Hospitals will gain a lot of benefits from PACS compared with that of the existing system. However, there are some barriers of having PACS in Thailand, such as lack of budgets for the investment, lack of expertise in this field, resistance from people using the existing system, etc. The PACS in Thailand should be implemented under the cooperation from many hospitals and organizations involved to make it become synergy.

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I. INTRODUCTION

The Feasibility Study of the Picture Archival Communication System (PACS) Application in Thailand is a very interesting and popular topic among Thai Physicians and Radiologists. There are many hospitals having problems of not being able to efficiently provide health care services to patient due to limited physicians, radiologists, nurses, and staffs, especially in the X-ray department. They not only have to face the problem of escalating price of the X-ray film each year, but also the large amount of money is wasted on processing film, travelling expense, and purchasing redundant medical equipment.

The major purpose of processing a film is to get an image from the patient's body. The film will then be examined and archived. It can be used to communicate with patients or physicians so as to recommend appropriate actions. After that the film will be kept as medical records. The PACS is supposed to be the first priority to replace the existing system, processing of film, as it can let physician make diagnosis, communicate with patients or physicians and also be able to archive in database format. It can efficiently make the workflow faster and save cost compared to using the existing system. The PACS is totally new for Thai medical institutions but is supposed to be installed in Thailand soon. Nevertheless, there are many arguments and resistances against PACS.

The study of this project defines the weak points of the existing system, and shows how the new system can efficiently solve problems with appropriate investments. Engineering economy and financial analysis will be used to find the benefit of cost ratio and the worth of the investment comparison between the existing systems' and the PACSs'. The scope of this report is the collection of information of the existing PACS

installed, the feasibility study of the PACS in Thailand, analyses of the system output and their benefits, and recommendation. The status of medical area in Thailand and the trend of the PACS to be installed in Thailand will also be described.

II. LITERATURE REVIEW

2.1 History and Definitions

Roentgen firstly discovered the Medical Imaging of X-ray in 1895. X-ray was used for making diagnosis five years later. There has rarely been changed in the concept of medical imaging until the introduction of CT scanner (Computer Tomography) in 1972 which is a combination of the X-ray, computer and cathode ray tube (014inti 2540).

Basically there are three technologies involved in the diagnostic imaging: (Meschan and Ott 1984)

(1) The transmission of ionizing radiation through an organ or anatomic part and a record made of the beam emitted on film, a cathode ray oscilloscope, or a television apparatus.

(2) The emission of ionizing radiation from the patient after he has had an injection of an appropriate pharmaceutical' solution. The emitted image is recorded on a special camera device and this camera (nuclear medicine) renders a photograph.

(3) Using the same technology as ultrasonic, the passage of a sound beam through the body or anatomic part, with a recording of the reflected echo (ultrasonography).

Picture Archival Communication System (PACS) is a computer network system designed to transmit, store, and retrieve digital medical images. It makes the possibility of making diagnosis on monitor, as called "a soft copy". The user can enhance images with the soft copy; in addition, images are available for viewing at multiple stations at the same time. The brightness, contrast levels and magnification may be manipulated

when he images are in a digital format. Soft copy reading not only decreases film usage, but also leads institutions toward a completely filmless environment in the future. (http://medical.agfa.com 1999).

Telemedicine can be defined in many ways but its goal is definitely the same, to provide medical treatment for patients that live far away from the health center. Anyway here below are some definitions of Telemedicine:

"Telemedicine "began" in the 1960s as medical treatment rendered over the telephone and by wire by physicians who were physically remote to the patient. Although today, the principles are largely the same, the technology and milieu of contemporary telemedicine are vastly different. In the age of high-speed data lines, advanced data compression technologies, the privatization of defense technologies, and computerization of patient records, clinical outcomes and physician practices, telemedicine promises to be the next milestone of health care advances." (Manning 1999).

Telemedicine and Telehealth are defined as the application of information and communication technologies to the practice of medicine and health education (http://www . catehealth. org 1999).

Telemedicine is the use of the integrated electronic communication devices into networks and is used for the transmission of information and data related to the diagnosis and treatment of medical conditions (http://www.catehealth.org 1999).

Digital Imaging Communication in Medicine (DICOM) presents a communications standard set by the American College of Radiology (ACR) and National Electronic Electrical Manufactures Association (NEMA). All images acquired at the host modality must be in a digital format so that they can be sent over a computer network. The DICOM is used to provide uniformity and compatibility between medical

imaging equipment vendors. DICOM allows images to be exchanged between various vendors at the same time still maintaining standard patient demographics and image information (http://medical.agfa.com 1999).

Fuji commercialized phosphor-based CR in 1983, some three years after the Tokyo company patented the process. The process is basically the same today. After an exposure, the cassette holding the phosphor imaging plate is placed in a CR reader, where the imaging plate is extracted and scanned with a laser (Freherr 1996).

To make medical equipment vendors share all patient demographic and other necessary image information, the vendors must comply with the DICOM Standard. Without the DICOM communications between different vendors would not be possible (http://medical.agfa.com 1999).

Nowadays, the rapidly improved high technology with the reducing costs also lower the cost of telemedicine technologies to the point where their widespread application is feasible. As a result, telemedicine holds enormous cost-saving potential to its practitioners and patients. This has urged several large medical facilities and plans to build telemedicine networks. Telemedicine will produce substantial cost-savings by avoiding the costs associated with the medical transport of prisoners for specialty care. Increasing numbers of health care providers are finding similar cost-saving applications of telemedicine and realizing that the technology to implement a telemedicine network is proven and affordable (http://www.catehealth.org 1999).

What the PACS can create is no less than a virtual radiology department in which images are never lost, where staff works more efficiently, in which film and chemicals are eliminated, and where patient care is enhanced. It is recommended that you shall firstly have numbers to prove overall cost-effectiveness.

(Cost-effectiveness study done at Baltimore VA 1998)

The University of California, San Francisco, UCSF, has founded that PACS can relief hospitals and enable them to operate more efficiently than the existing way of image storage and distribution. They also think that a commercial vendor is needed for the next step of networking of PACS (Casey 1996).

2.2 Purposes and Goals

The major purpose of having telemedicine is to solve the problems of access, cost, quality, resource distribution and education, especially in medically undeserved communities (http://www.catehealth.org 1999).

The purpose of DICOM is to provide uniformity and compatibility between medical imaging equipment vendors, and make them able to share all patient demographic and other necessary image information (http://medical.agfa.com 1999).

Typical goals of PACS are to reduced film use, reduce film loss, provide connections to critical care areas and connects to remote centers/clinics, and also to radiologists' homes (http://medical.agfa.com 1999).

Both PACS and Teleradiology provide soft copy review of images, and also can be reviewed remotely. The core different between Teleradiology and PACS are the archival and storage. Teleradiology can be simply two or more computers linked together by a network and have the capability to transmit and receive images. PACS, on the other hand, not only has the ability to transmit and receive images, but it also has the ability to archive these images for storage and future retrieval.
(http://medical.agfa.com 1999)

The purpose of phosphor-based is to replace the existing X-ray system. Once the information has been read, the plate is wiped clean with a flood of photons, which release residual energy that would otherwise form a latent image. The plate is then

reinserted in to the cassette for the next X-ray exposure. This is almost the no-wasting system (Freherr 1996).

The improvement in the quality of care is not a good matter of the PACS. Because it is harder to quantify, than be cost-effective. Administrators make analyses of capital priorities, vendor options, and implementation strategies. The advantages of having medical images available anywhere they are needed in a hospital will be recognized (Cost-effectiveness study done at Baltimore VA 1998).

"The PACS revolution also extends to communications between medical practitioners. Hospital-based communications before the advent of PACS were personal and one-on-one. With PACS, more communications are electronic or computer-assisted, so radiologists spend more time on the phone, and e-mail communications abound." Siegel, co-director of the Diagnostic Imaging the PACS conferences (A Catalyst for the transformation of radiology 1998).

The University of California, San Francisco, UCSF clinicians plan to use the PACS to improve their way of practicing medicine, and they have it. They dramatically found that the PACS could effectively improve it. With CR, the number of retakes required dropped to near zero, and the broad dynamic range of CR is useful in enabling radiologists to manipulate images (Casey 1996).

The development of image distribution software, especially doing via World Wide Web browser technology, for referring physicians' project may be the most important in widely separating the PACS technology from the radiology department to the entire healthcare enterprise. Web browser technology will enable radiology departments to get ¡mages to referring physicians without printing film and without installing dedicated workstations (Casey 1996).

2.3 Key Definitions and Specific Names

Benefit-cost analysis. Method of economic analysis that assesses both costs and benefits of an imaging test, assigning a financial value to health outcomes (Bieze 1996).

Decision analysis. The quantitative evaluation of risks and benefits of alternative diagnostics. It also includes the information about all alternative actions, the outcome of each action, the probability of each possible outcome, and the value of each possible outcome (Bieze 1996).

Outcome. The impact of an imaging test on a patient's health. Examples of outcome measures include number of years of improved survival, cases of disease prevented, and quality-adjusted life years gained (Bieze 1996).

Quality of life. Assessment of patient functional status. A variety of methods may be used to quantitatively estimate such outcomes as cognitive, psychological, physical, and social function; level of pain and general well being (Bieze 1996).

Laser film. A specific film used with Laser Imager. There are various types of this kind of film such as Infrared laser film, HeNe laser film, specific wavelength at 670nm Diode laser film, Carbon laser film. Images on laser film can be directly signed by laser beam (Mahidol Medical University 1999).

2.4 Problems

Several fundamental problems continue to impair the delivery of health care (http://www.catehealth.org 1999).

(1) Health care costs keep increasing as hospitals have to face strong inflationary pressures;

(2) Access to medical care, especially specialty care, is limited and episodic in many rural and poor urban communities and is getting worse as health care costs escalate;

(3) Limited access to health care services compromises the quality of health care in medically undeserved communities and efforts to control costs threaten to exacerbate quality concerns.

Although PACS allow radiologists to establish a simultaneous virtual presence at several sites with a single institution or at multiple facilities, some experts caution against over-reliance on technology solutions to the problem of providing timely radiology coverage to critical care units and the emergency department. They emphasize a continuing need to build and maintain a collegial bond between radiologist and referring physician (Stern 1996).

Even after converting to filmless in ultrasound and nuclear medicine, the hard copies of CT and MR images were still requested by clinicians. Generally, the effort and expense have been worthwhile, and it addresses the lost film problems that prompted the initial interest in image management. In fact, the hospital was losing money on films that were not reimbursable as they were produced but never interpreted (Thompson 1996).

2.5 Future Trend

The Internet is rapidly becoming an integral part of health care system. Web-technologies could improve health care services and dramatically lower the cost of communication in services. Although Internet suffers from the provision of sufficient bandwidth, guaranteeing reliable access, and insuring information security, new technologies have been evolved to overcome these drawbacks (Levine 1996).

The store-and-forward Web-based application will be mainly used to exchange high-resolution images. Practitioner or nurse on an embassy can capture an image via high-resolution camera, or X-ray scanner, and upload that image to the Web-based application along with the patient demography and related reports. The application

stores all the information in a relational database and e-mails a physician for a second opinion. That physician then accesses the Web-based application, reviews the case, and sends a second opinion via email or the Website application (Levine 1996).

Rapid improvements in digital, optical and information technologies have made more powerful technologies available to the practitioner, such as high definition video teleconferencing and high-resolution scanners (http://www.catehealth.org 1999).

"Voice recognition is something we are looking into at the moment for the Radiology Information System (RIS), a radiologist would no longer read/record a report onto cassette and get it typed up. The software would convert his dictated report directly into a text on-screen. This will certainly come." Dr. Zuidema, Chief Radiologist, of Ziekenhuis Bethesda in Hoogeveen, Netherland.
(http://medical.agfa.com/adc/hoogeveen.html 1997)

"One hope I have for the future is that the PACS will be able to rationalize data storage such that all data relating to a patient from any kind of exam will be stored together simply under the patient's name and date of birth. At present X-ray, ultrasound and arthroscopy images would be stored separately, and that creates unnecessary complications." Dr. Leixnering, Lorenz Bohler hospital in Vienna, Austria (http://medical.agfa.com/adc/vienna.html 1997).

"Any physician involved with a patient's care can make an initial judgment or determine whether he or she needs to wait for the radiologist's or whether another study is needed," Dr. Arckerstein , ER at Sarasota Memorial Hospital (Stern 1996).

Many observers have noted that the digital technology can have a beneficial impact on the provision of radiological services throughout a hospital, especially when the mix of physical and virtual presence is balanced according to each facility's needs and resources. Viewing images on CRTs can save both time and film (Stern 1996).

Dr.Joseph N Gitlin and colleagues concluded that soft-copy images obtained from a Teleradiology system were not acceptable for primary interpretation of X-rays made in an emergency department after they have evaluated soft-copy reading of emergency room X-rays (Radiology 1995; 195:223-229) (Freiherr 1996).

Radiologists are now able to confidently diagnose patients on the basis of soft copy alone. (American Journal of Roentgenology 1995; 164:387-841) Researchers found that soft-copy portable chest X-rays of coronary care patients provided clinical management information similar to that obtained from the hard copy. The authors concluded that substantial savings in cost and time could be achieved by using soft-copy images presented at 1K x 1K resolution on a workstation, and the value of these images were maintained even when they were transmitted over regular telephone lines (Freiherr 1996).

A recent study at Johns Hopkins demonstrated that soft-copy reading could be effective. "Teleradiology is perfectly adequate for examinations with lesser resolution than plain film, with such modalities as Computer Tomography (CT), Magnetic Resonance (MR), and Ultrasound" (Freiherr 1996).

2.6 Benefit/Cost Analysis and Comparison

It is very important to recognize that the benefits and costs used in the calculation represent the increments or differences between two alternatives. Even though there are multiple alternatives, we still compare in pairs, and then compare the selected choice with another. We cannot forget to compare with the **DO-NOTHING** as sometimes **DO-**NOTHING is an acceptable alternative. The emphases on evaluation technique of only the cost projects are involved. The formula of the benefit/cost ratio is as shown below:

B/C = (benefits — costs) / costs

The result of the benefits/costs ratio should be larger than 1, so that it presents the extra benefits of the higher-cost alternative asserting this higher cost. If B/C is less than 1, then the extra cost is not asserted and the lower-cost alternative is selected. For a single project, the lower cost shall be the DO-NOTHING (Blank and Tarquin 1989).

2.7 Statistical Data and Statistical Forecasting Methods

Thailand inflation rate: (http://www.bbl.co.th 1999)

Year 1995: 5.8% Year 1996: 5.9% Year 1997: 7.6%

Year 1998: 7.8%

Thailand interest rate:

Year 1994: 8.0% Year 1995: 8.7% Year 1996: 9.3%

Year 1997: 10.8% Year 1998: 8.3% Year 1999(2nd quarter): 5.0%

Statistical records of X-ray exposure and film processed are estimated to be double the number of the patients and may be twenty percent more if there are more images needed. (Technicians from hospitals, Thailand 1999)

The average cost, based on the most frequently used film size, of X-ray films both Blue and Green films are approximately 35 — 50 baht per sheet while the cost of the average size of the film printed by laser imager including the chemicals and processor is estimated at 40 — 60 baht per sheet. It also depends on the volume of films that hospitals purchase from vendors, and the brand name of films. On average, there are about 50-75 patients taking X-ray exam a day and, patients need at least two X-ray films per exam plus about twenty percent more for some special cases.

The latest updated, 1998, records of the number of physicians in Thailand is 23,744 persons and 573 persons of all fields of Radiologists (The Ministry of Public Health in Thailand 1999).

The population in Thailand: (Mahidol University 1996)

	Number (in Thousands)
Total population:	59,781
Total population in big cities:	18,879
Total population distributed up country:	40,920

The graduates from medical field in Thailand are not sufficient to provide health care service to people in all areas. That is why Thailand is a country that still lacks expertise and specialists. The number of medical graduates in some fields from 1992-1996 is shown in Table 2.1. (ni5Frnmtim;f11540114161A'Ifiv 1997).

Table 2.1. The Number of Graduates in Medical Field from Public and Private Universities in Thailand from 1992-1996.

Major	Public University					Private University				
	1992	1993	1994	1995	1996	1992	1993	1994	1995	1996
1. Doctor	837	816	826	825	848	-	-	32	20	30
2. Nurse	3139	3355	3134	3136	3037	295	335	322	332	356
3. Pharmacist	471	470	623	602	808	28	78	45	101	92
4. Dentist	289	311	340	351	317	-	-	-	-	-
5. Radiography	245	261	313	295	313	30	30	29	18	20
6. Public Health officers	2233	2245	2230	2332	2300	-	-	-	-	-

The X-ray fee is approximately 350 — 500 baht per patient depending on the public and the private hospitals (Technicians in hospitals, Thailand 1999).

The costs of initiating a digital department have decreased in reality. For example, the price for optical-disk storage jukeboxes dropped 50% between 1992 and 1994 and continues to fall (Thompson 1996).

Forecasting Methods (Heizer and Render 1996):

The time series methods shall be used to estimate the future demand in case those demands relate to an independent variable of time. There are many methods in time series methods such as moving average, weight moving average, exponential smoothing, adjusted exponential smoothing, linear trend line, additive decomposition, and multiplicative decomposition. The moving average is the easiest method to use for forecasting and is suitable for the short-term forecast. Usually, the moving average will use a specified number of the most recent actual data to compute the estimation data. The formula of the moving average is as shown below:

$$MA_n = \frac{\sum_{i=1}^{n} D_i}{n}$$

Where

n = the number of periods in the moving average

D_i = the demand in period i

III. THE EXISTING SYSTEM

3.1 General Status

The process of the existing system used in X-ray department is to bring patients to get exposed to X-ray, then technicians bring the exposed X-ray films to register the patients' names, ages, and dates of exposure. The X-ray machine shown in Figure 3.1. shows an example of a patient being X-rayed. After that technicians take the X-ray film cassette to the darkroom for processing and reload a new film into the X-ray film cassette. The standard time for the film processing is 90 seconds. If the outcome is acceptable it will be bound together with patient records and sent to physicians or the radiologist to use for diagnosis, otherwise patients must be re-exposed. Once physicians/radiologists make diagnosis, a report will be generated and again bound together with the patients records and consigned to doctors so that they can use it to communicate with the patient. This X-ray film will also be used for communication between physicians and physicians. After that, the film will be archived in a storage room for 5 to 7 years or 15 to 20 years for FDA standard. In the case that patients want to keep the film, the physician may make a duplicate for them and keep the master film. There are many factors that will affect the outcomes such as the quality of the X-ray film itself, the temperature of chemicals, the room temperature, the dose exposed, the technique of positioning, etc. Any outcomes that waste films mean the wasting of money and time.

Not all films processed come from the X-ray exposure. Laser film and many other types of film also have to be processed. Laser printer or Laser imager will print out laser films depending on the equipment that it is connected with, such as CT, MRI, DSI, or Digital Mammography, etc. Although the newest printing technology has brought dry printing system, which totally eliminates the chemical usage, its cost is still very high

compared with wet printing system. The dry printing system is most suitable for the less film printing system, as the hospital does not have to keep stock of the chemical used.

For the hospitals that have more than 400 beds, or process more than 250 films per day, they may have to use a Daylight Automatically-loading machine which can reduce the waiting time during film processing. Once they put the exposed film cassette into the machine, at room-light, its film will be picked up and sent to the film processor at the same time a new film will be loaded into the cassette. All these processes need only about 15 seconds of waiting time. Then, the technician can leave the machine and do other jobs. All technicians will have more time to take care of their patients. At this stage, we almost say that it is a no waiting system. However, the problem of space for film storage, cost of film wastage, etc. still cannot be solved.

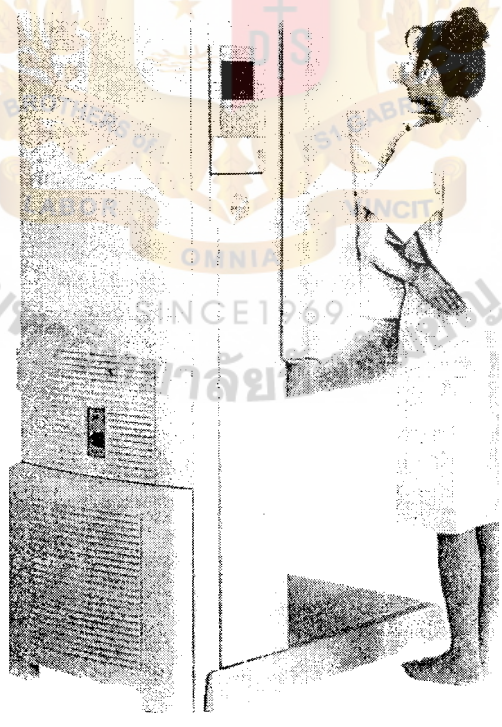

Figure 3.1. A Patient Exposed by an X-ray Machine (Freiherr 1996).

In many countries, they are having limited number of expertise and professionals in the medical field. Generally, experts and specialists are in the capital or big cities, being instructors and professors in medical schools or the heads of X-ray departments in big hospitals. It is not possible for them to arrange their schedule to see all the serious patients in many places. Patients will have to go to the hospitals that have the physicians in the specific field that they have illness. Meanwhile, the medical expense is increasing. Nevertheless, those patients can have first aid by the nearest local hospital, but the hospital may have no existing records of the patient. In the rural or the up-country areas physicians are not adequate to provide medical service to patients far away from the medical center. Those local hospitals or public health centers may have only some technicians and X-ray machines, but they do not have any regular physicians. The physicians from central hospitals may go to the site once, or go only by request. Therefore, the patients may have to wait for nearly a week to see the physician. If the case is really serious, the patient may not be able to wait for the physician anymore.

3.2 The Advantages of the Existing System

(a) All physicians and technicians are familiar with the system (user friendly).

(b) Simple and no additional training is needed.

(c) The films can be brought to any physician at any location for making diagnosis.

(d) Everyone uses the same format, world standard.

(e) There is no huge investment in the initial state.

(f) The labor cost is not so high.

3.3 The Disadvantages of the Existing System

(a) About 5%-10% of film wasting cannot be avoided.

(b) Larger and larger space for film storage is needed.

(c) It is difficult to search for the film recorded.

(d) Many staffs are doing redundant job.

(e) The quality of image is not stable.

(f) It is time consuming to have acceptable film.

(g) Duplication of film will lower image quality.

(h) The hospital needs to keep stock of chemical and films.

(i) Physicians must travel for long distance to study the film and diagnose the patient.

(j) Physician and medical equipment must be in the same area.

(k) Physician cannot control the contrast and brightness of the image.

(1) No backup if the original film gets lost or damaged.

(m) Patients get double exposure from X-ray machine.

3.4 Medical Services in Thailand

Thailand is a developing country that has a population of nearly 61 Million people, and has many hospitals that have high technology medical equipment. As in other developing countries, most of the hospitals are not distributed into all areas but are located in Bangkok and big cities. This means it is very hard for the patients from the rural that faraway areas from the hospital to have good health care service when they are ailing. The statistics collected by the Ministry of Public Health in Thailand shows the number of expertise and specialists in Thailand not to be sufficient to provide medical service to the patients. Although the Ministry of Public Health has started the project of telemedicine, they can only exchange the idea via phone or videoconference that is not enough for the case that they need the examination image. To transmit the examination image to the other location is not a problem for the computer technology and communication system of today. Anyway what we really need is the standard

format for the image that will be transmitted and sent. Otherwise, the image may not enable diagnosis to be made, as there is a lack of information about the length, the soft tissue, the quality of the image, etc.

IV. THE PICTURE ARCHIVAL COMMUNICATION SYSTEM (PACS)

The Picture Archival and Communication System (PACS) is the new system that is being used in medical field to get the image/picture and archiving to the storage in any media types of computer storage, then images can be materials that physicians use for communicating with physicians or patients. PACS can transmit the archive images to any personal computer in the network or even via the Internet in one standard, DICOM 3.0. Figure 4.1. illustrates the images in PACS that can be retrieved and reviewed on any computer in the system. The system brings up various advantages and benefits to patients and physicians. The typical goals of PACS are to reduced film use, reduce film loss, connect to critical care areas, connect to remote centers/clinics and connect to radiologist homes.

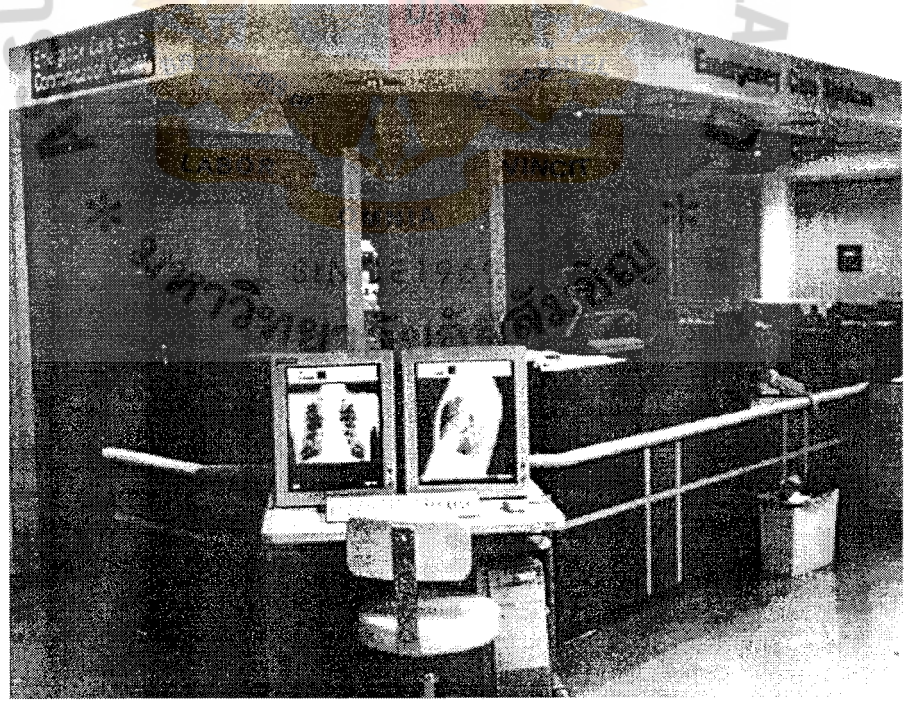

Figure 4.1. Medical Images on Computer in an X-ray Department (Thompson 1996).

The existing standards format being used in PACS to communicate is the Digital Imaging Communication in Medicine version 3.0 (DICOM 3.0). The purpose of DICOM is to provide uniformity and compatibility between medical imaging equipment vendors. Once an image is acquired at the host modality, it must be in a digital format to be sent over a computer network. In order for vendors to share all patient demographic and other necessary image information, the vendors must comply with the DICOM Standard. DICOM allows images to be exchanged between different vendors while maintaining standard patient demographics and image information. Without it, communications between different vendors would not be possible.

Figure 4.2. Physician Making Diagnosis on Softcopy (Stern 1996).

To bring up a new system, PACS, something should be better than the existing system after the change. With the new system, we can have the medical imaging that is not only used for diagnosis, for records, but also can be transmitted to any other area in the network. The same image can be stored for as long as the hospital still wants to keep

in small space. The concept of PACS is a filmless system, but actually it is a less film printing system. Practically, the films still need to be printed. A good example of this is the medical equipment that its image can be reviewed and diagnosis made on CRT such as Ultrasound, DSI, CT, MRI, etc. Normally, physicians can make diagnosis on CRT instead of films as shown in Figure 4.2. Even after converting to filmless exposure, the hard copies of Ultrasound, nuclear medicine, CT, and MR images are still coveted by clinicians. Altogether, the effort and expense have been worthwhile, and it is addressing the lost film problems that prompted the initial interest in image management. Indeed, this is because the hospital was losing money on films that were not reimbursable because they were produced but never interpreted.

4.1 Analog to Digital Conversion

Thanks to Fuji for making the research of Phosphor-based in 1983, some three years after the Tokyo Company copyrighted the process. The process is nearly the same as that of the existing system. Once patients are exposed to X-ray, the cassette holding the phosphor imaging plate is fed to in a Computer Radiology (CR) reader, where the imaging plate is extracted and scanned with a laser. Once the information has been read, the plate is wiped clean with a flood of photons that release residual energy that would otherwise form a latent image. The plate is then reinserted in to the cassette for the next X-ray exposure. An example of the Phosphor-plate is illustrated in Figure 4.2. With the same technology the Agfa Diagnosis Center (ADC) machine, the dream of using the existing general X-ray on the PACS has become a reality. They place the Phosphor-base on X-ray cassette, then the cassette can be used in the same way as the existing X-ray cassette. After the exposure, the cassette will be read by a scanner and converted to electronic data to be digital image on screen. This is the only solution for mobile X-ray unit in emergency use.

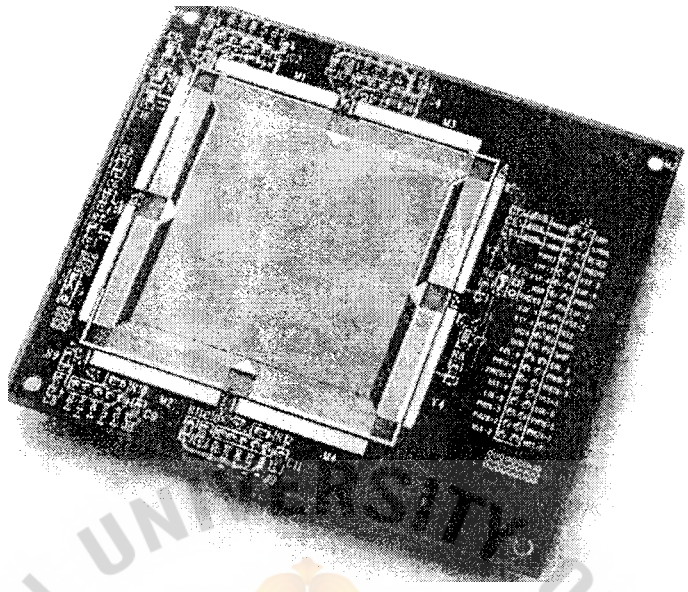

Figure 4.3. A Sample of Phosphor Plate (Freiherr 1996).

4.2 PACS and Telemedicine

At this stage, some may understand that PACS is the other name of telemedicine. Actually telemedicine is the medical treatment provided over the communication system. It can be a very simple telephone line, or the use of high technology such as videoconference by physicians who were physically remote from the patient. Telemedicine is used to solve the problems of access, cost, quality, resource distribution and education, especially in medically under-served communities. But the data storage standard format is not included in telemedicine. What PACS can do has nearly covered all the purposes of telemedicine. No one can justify which one is larger or better. It depends on how efficient they are used.

Although PACS allows radiologists to establish a simultaneous virtual presence at several sites with a single institution or at multiple facilities, some experts caution

against over-reliance on technology solutions to the problem of providing timely radiology coverage to critical care units and the emergency department. They emphasize on a continuing need to build and maintain a collegial bond between a radiologist and a referring physician.

Nowadays, there are over thousands of PACS installed all over the world. Thai physicians have the plan to have PACS in Thailand in the near future. The installation of PACS in Thailand is under the feasibility study from many organizations.

4.3 PACS in the Internet

Nowadays, the Internet has become the cheapest way to communicate between people from long distance. PACS also can be linked to the Internet, so those physicians from other sites can visit and download images or reports.

4.4 The Status of PACS in Thailand

PACS is not a totally new concept for the medical field in Thailand. There is a much new medical equipment installed in Thailand that is DICOM 3.0 ready and some just need an upgrade. Some hospitals have integrated some of the medical equipment together with DICOM 3.0 standard. They can send and retrieve data between each, but the link is still not an ideal system because they do not have the central unit or main system to manage records and database. There is not any cost saving by doing that. Films are normally being printed before they are sent any diagnosis monitor in the network. For the hospitals having various brands of medical equipment without DICOM 3.0 standard, to integrate all equipment is not simple for one vendor to implement. The PACS project needs the coordination from people involved in many departments and many analyses have to be made to support the decision making for the PACS implementation.

Assistance Professor Dr. Ramet, who was the chief radiologist of the X-ray department at Rama hospital, has studied PACS for nearly 10 years and can be one of the PACS experts in Thailand. He has set up a small PACS in the X-ray department, only for the Ultrasound exam. The images are caught via video signal by using Sony Mavicam. He has co-operated with Dr. Suthee, Computer System Technology Laboratory Researcher from National Electronics and Computer Technology Center (NECTEC), and his team is to make the image to be able to communicate in DICOM 3.0 format. Nevertheless the image did not contain the information and the data as the DICOM 3.0 standard did. Up to this point, they still have not obtained image from X-ray exam as they still lack interface equipment. The system is still far from the ideal PACS.

By co-working with Rama hospital and Siriraj hospital, they have already made a link between both hospitals, sharing information, sending and retrieving image from each other. Dr.Thongtum, radiologist from Siriraj hospital, said that the equipment that is in the system is the DICOM 3.0 ready, so there is not any problem of standard format. What we should do and will do in the near future is to integrate all the equipment together. Physicians and Radiologists can make diagnosis at any monitor in the system. Probably Siriraj hospital will have the first phase of PACS within the next three years. Some of the PACS vendors such as AGFA, SIEMENS and GE have started to make introductions of PACS to the Thai market. This is a good beginning of PACS in Thailand.

4.5 Purposes and Goals of PACS

PACS can be used to

(a) Adapt to suit user work preferences

(b) Let radiologists retrieve, diagnose and compare images immediately

(c) Track all information regarding patient, study, and image

(d) Perform data integrity checks and pre-fetches information

(e) Simplify communication with referring physicians

(f) Eliminate dependence on film library and file room staff

(g) Manage the migration of exams between storage tiers

(h) Change the practice of radiology

4.6 Weaknesses of PACS

The weaknesses are as listed below:

(a) A huge investment at the initial stage with long term payback period.

(b) The expense on hire specialists and expertise to implement the system is very high.

(c) No back-up system if the system is down (in the case of fully digital department).

The concept of PACS is not the designation of the system that is the same as the existing system, but to compensate/recover the weak points of the existing system such as:

(a) Totally reduces the waste of X-ray film as the image can be previewed on CRT/screen before printing.

(b) The storage space for medical films will be replaced by large capacity secondary storage in any type of media in computer system.

(c) No need to keep a constant temperature and humidity of the room for film storage.

(d) All the records can be stored as long as the hospital wants to keep them.

(e) Patient data are linked to the RIS/HIS (Radiology Information System/Hospital Information System).

(f) The records of patients can be easily searched by *entering the identification,* name, date or birth, etc on to the computer.

(g) The redundant task in the same area can be reduced.

(h) Images can be processed on the monitor by adjusting the contrast and brightness.

(i) Physicians can directly make diagnosis, write report and summarize of results/diagnosis on one computer.

(j) Images can be transmitted to any physicians in the network with no waiting time.

(k) All images that were printed will be kept at nearly the same standard, almost no loss in quality of image.

(1) There is no need to keep stock of chemical and film.

(m) Database can be backed up in various types of media.

(n) Experts and specialists have no need to waste time for travelling long distance, as the image can be shown on the monitor where they are.

V. A FEASIBILITY STUDY

A feasibility study of the PACS application in Thailand is being done by many Thai physicians, radiologists, or even people involved with the medical field. All people involved want to know whether Thailand is ready to have PACS installed, that is why the feasibility study of the PACS must be done.

The concept of making diagnosis via CRT (Cathode Ray Tube), monitor of computer, is not new. Physicians have used the high technology equipment such as CT, MRI, Ultrasound, etc. and made diagnosis on the computer monitor for more than a decade. The main usage of PACS is, of course, not to convert, from making diagnosis on hardcopy to softcopy, but to find the efficient way of using its application in the medical field. We have run the X-ray department with the existing system for more than a decade and nothing is worse. Everything seems smooth and right. Patients are still being provided health care service by physicians from hospitals, clinics or public health centers. Many films still need to be printed out for making diagnosis on light box at any location that physicians stay, and kept as patients' records. PACS is the revolution of this concept, and it will totally make changes in many X-ray departments once it is installed. The low-speed and long step workflow of the existing system is reduced, some redundancy jobs have been terminated, and a lot of process can be done faster than before. This is not magic or miracle in medical field, but it is an additional benefit from the rapidly improving information and electronics technology. The ideal concept of doing the best thing at the lowest cost becomes true, especially in medical treatment. The reason is because we cannot compare the value of human life with money. No one can measure the outcome of medical treatment into money or any comparable form. When patients are in serious and painful conditions in beds, they will not think any

longer about money or what they have to do to stop the pain. The patient can give almost everything he/she has to the one who can stop it. Now, with PACS, physicians can efficiently provide health care service to the patients. This is a tangible benefit that both of them will gain from the system. There are many benefits that we can gain from PACS, both tangible and intangible.

Many vendors such as Agfa, GE, Philips, SIEMENS etc. are also doing research on and come out with various kinds of products to integrate medical equipment to make a totally PACS equipment. All of them have published that PACS can enhance the X-ray department with work efficiency and effectiveness, but we still have to prove it ourselves.

To make the feasibility study of PACS application, we have to gather much information about the existing system, the new system, the trend of the medical field in the future, etc. After that make comparison between both systems. In this chapter, the first method that will be used to make comparison is the tangible and intangible benefit that PACS gains more than those of the existing system. Then, an Engineering economic and Financial management method will be used to analyze the investment worth. The DO NOTHING also cannot be forgotten to compare with the new system.

The process of analyzing PACS:

(1) Collecting the information about PACS.

(2) Defining the obstacle or difficulty of the system.

(3) Defining both tangible and intangible benefits of the system.

(4) Studying the cost of the system implementation.

(5) Alternating a suitable plan of implementation.

(6) Comparing the cost of replacing the existing system by PACS.

(7) Making benefit to cost ratio based on public health service, benefit to patients, etc.

(8) Making decision whether the hospital is suitable or ready for PACS.

5.1 Tangible and Intangible Benefits of PACS

(a) Tangible benefits.

For Thai government hospitals, normally X-ray departments will have the medical equipment that are produced by various companies. To combine all brand names of medical equipment together, we need a truly open system. The system should not only be able to integrate various brands of equipment but also need to convert the existing medical equipment to be compatible with the new system. Otherwise we will have to discard much of the existing equipment. PACS can integrate all existing medical equipment and the digital equipment. PACS' benefits are listed below:

(1) All patients records can be retrieved and reviewed from any workstation in the network.

(2) Physicians can more conveniently make diagnosis and communicate.

(3) The workflow becomes shorter than before. At the same time, the speed of the process will be increased. Both physicians and technicians can have more time to take care of other patients.

(4) The hospitals can have more income and invest that money to improve in the medical service or subsidize the medicine fee for patients, as they are supposed to be non-profit organizations.

(5) Saving a lot of money by transmitting the medical exam into the network that are available to physicians. The transportation

expense for physicians to go to local clinics or hospitals will then be significantly reduced.

(6) The total volume of medical film used will also significantly be reduced to generate a huge cost saving from film use, chemical storage, film storage, room storage, labor cost, etc.

(b) Intangible benefits.

Some intangible benefits come together with the PACS implementation:

(1) How many people would think that if patients can see doctors earlier then they may get well sooner. Then those people can go to work as usual and improve the economy of Thailand. Of course, only a patient will not affect the economy of the whole country, but if many people can come out from hospitals sooner, then this intangible benefit cannot be ignored.

(2) The improvements of human resource in medical department due to the new system will also be intangible benefits. Human Resource can be considered as assets of organizations. Full ability of staffs would lead the organization to have better performance and higher quality.

At this point, we can see that PACS has various advantages and benefits. Some may suggest that if PACS is such a good system, why don't we implement it sooner. Although this new system can generate many benefits and advantages, it is cost of installation is really high. The rapidly improving technology makes the cost of the system become lower and lower. That means the later we have PACS, the lower in investment and the higher performance we get. But don't forget that some patients

cannot wait that long. That is why the Engineering economic and financial management needs to prove whether PACS is worth the investment now.

5.2 Cost Effectiveness of PACS

Comparing PACS with the existing system, PACS provides more benefits and advantages. PACS not only can do all the same things as the existing system, but it also can perform a lot better. Obviously, we can say that the payback period of PACS is very long because of its' huge investment. But if we consider the provide faster service, and better health care service for patients, or even for serious injures emergency cases then there is no excuse not to invest on the system that can save peoples' life.

Arguing that PACS will improve the quality of care is not usually a good strategy; it is even be harder to quantify than to examine the cost-effectiveness. With more open-minded administrators analyzing capital priorities, vendor options, and-¡mplementation strategies, the advantages of having medical images available anywhere they are needed in a hospital will be recognized.

5.3 Net Present Worth Analysis and Benefit to Cost Ratio of PACS

What PACS can create is no less than a virtual radiology department in which ¡mages are never lost, where staff works more efficiently, in which film and chemicals are eliminated, and where patient care is enhanced. However, if you do not first have numbers to prove overall cost-effectiveness, get those, and you are on your way to success with PACS.

Budget and the scope limitation of project is what we should conceive. For PACS, the budget will be increased if the size of the system becomes larger. Designation is the first step of PACS and its cost of installation will also be high, like setting up a computer center. If there is a new private hospital wishing to go fully digital, they may have to invest much money on PACS. In general, a fully digital system for a 400-bed

hospital will cost at least 50 million baht excluding the annual service maintenance after the installation. But the system can be used for a very long period until an upgrade is needed. With PACS, much cost saving will be created such as the expenses on film storage, chemical stock, film stock, labor cost in doing redundant tasks in the X-ray department, time waste, etc. PACS not only can create cost saving, but it can also gain many benefits to the public such as providing better health service, giving physicians more time to take care of patients, capable of providing more service for more patients compared with what the existing system provides in the same hospital. In the financial point of view, we may need to make a benefit to cost ratio to compare and find out whether it is worth the investment.

We will firstly make a Net Present Worth Analysis and Benefit to Cost ratio to make comparisons between the existing X-ray system and PACS in one private hospital. Then, we will make the comparison for two remote hospitals linked together via PACS and without PACS, and it should be a very good example for the hospital that has many branches in this country.

Here below is the calculation of Net Present Worth and the benefit to cost ratio of a hospital that has 75 patients a day. This number comes from the average patients in the X-ray departments from many private hospitals and the information is provided by technicians in the hospitals. Comparing between the existing X-ray system and PACS, PACS will need two Personal computers, two diagnosis monitors linking together via Ethernet Network with a computer server that uses MO Disk for keeping medical records. The MO Disk storage is used to keep patient medical records for five years. In Thailand, normally the patient medical records will be kept for only five years, if the patient did not come to the hospital within five years, then the hospital will no longer keep the patient's record. On the point of PACS being similar to a computer system, an

upgrade is needed when its performance is not fast enough to support the usage, or the hardware becomes is out of date. The reason that this feasibility study of PACS for application in Thailand does not make a comparison in the case of it being more than a five year project, is because we have no information to support the forecasting of upgrade cost for PACS. Any upgrade makes the performance and capability of providing health care service more effective. That is why we still cannot make an estimation of the volume of patients after the fifth year. By now, in this project, we forecast that after installation of PACS, the hospital will have the capability of providing 20% more patients (90 patients) each day with four technicians. The explanation the data of the comparison of both systems will be shown below.

The inflation rates of Thailand from Bangkok Bank Public Company Limited for the last four years are as shown below:

Year 1995: 5.8%

Year 1996: 5.9%

Year 1997: 7.6%

Year 1998: 7.8%

Forecasting method is most suitable for estimating the inflation rate of the next year, and Moving Average is used as it is not so responsive to demand fluctuations. The formula of moving average can be computed as follows:

$$MA_r = \frac{\sum_{1=1}^{n} D_i}{n}$$

Where

the number of periods in the moving average

Di == the demand in period i

$$MA_4 = \frac{\sum_{i=1}^{4} Di}{4}$$

[5.8% (Year 1995) + 5.9% (Year 1996) +

7.6% (Year 1997) + 7.8% (Year 1998)1/4

6.77%

The inflation rate in the year 1999 is forecasted to be 6.77%, assuming that it will grow at the same rate for the next five years in Thailand. The fact is that the inflation rate of Thailand in the year 1999 as announced by Thai government is less than 1%, approximately 0.3%. However, this number is not taken into the calculation, as it is an irregular case. It is the government policy to reduce the Value Added Tax (VAT) from 10% to 7% for two years and this directly affects the inflation rate of Thailand. I believe that after two or three years, the Thai economy will be nearly the same as that of the previous period, and the inflation rate will be nearly the same as the forecasted rate.

Inflation rate = 6.77%.

Assuming that 6.77 % is the inflation rate in Thailand for five years.

Whenever we make the calculation of money that is related to time, we have to consider the time value of money, interest rate and inflation rate. For this example, we will use the interest rate of 8% annually for the five years based on the average rate and estimate rate by the Thai government.

The records of the interest rate of Thailand since 1994 are as shown below:

Year 1994: 8.0%

Year 1995: 8.7%

Year 1996: 9.3%

Year 1997: 10.8%

Year 1998: 8.3%

$$MA_4 = \frac{\sum_{1=1}^{5} D_i}{5}$$

[8% (Year 1994) + 8.7% (Year 1995) +

9.3% (Year 1996) + 10.8% (Year 1997)1+

8.3(Year 1998)1/5

9.02%

By forecasting method, the interest rate in the year 1999 should be 9.02%. But actually the interest rate of Thailand has now dropped to 5.0% in the second quarter. That is the lowest rate that has ever been since 1994. Although the interest rate of the year 1999 is not taken into the calculation, we cannot ignore it. This is a sign showing the trend of the interest rate in Thailand. This is not the same as the inflation rate. Some banks were taken over by foreign companies, so the interest rate will depend on the policy of the head office of the foreign companies. In stead of using the interest rate of 9.02% for this example, I take the interest rate that is the most frequent since 1994, which is nearly 8%. Assuming that the interest rate is 8% for these five years:

i_t interest rate

8 % per annum.

For the labor cost, we assume that the salary will increase at 10% (inflated rate) each year.

Incomes and Expenses of the existing system:

The incoming case of using the existing system: Assuming that the hospital will have an average of 75 patients per day, each patient will spend the minimum fee of 350 baht for X-ray exam, excluding the diagnosis charge. Double X-ray exposures to patient, and double X-ray films will be processed, one for patient and the other is for the hospital to keep as patient's record.

Daily income:

- 75 Patients x 350 baht (per day)
- 26,250 baht.

Annual income:

- 26,250 baht x 365 Days per year
- = 9,581,250 baht per annum.

As the time value of money must be considered, the inflation must be added to the estimate the income of the next year.

Assuming that annual inflation rate is 6.77%.

The income for the second year will be 9,581,250 baht + 6.77%

- 9,581,250 baht x 1.0677
- 10,229,900.63 baht

For the third year:

10,229,900.63 baht x 1.0677

- 10,922,464.90 baht

For the fourth year:

- 10,922,464.90 baht x 1.0677
- 11,661,915.77 baht

For the fifth year:

11,661,915.77 baht x 1.0677

12,451,427.47 baht

Cost of the existing system:

(a) According to the statistical records collected, the volume of film processed when using the existing system is estimated as double that of the number of patients per day plus twenty percent more. There are 75 patients a day, so the volume of film used should be approximately 180 films a day.

Volume of films used:

= (75 patients x 2) + 20% more

= 75 x 2 x 1.2

- 180 films a day.

The cost of film processed is approximately 3.285 Million baht per year (50 baht/sheet based on the average film size plus chemical used).

- 180 Films x 50 baht (per film based on average size)
- 9,000 baht per day.

9,000 baht x 365 Days per year

- 3,285,000 baht per annum.

Six point seven seven percent of inflation must be included for the expense of film processed for the next four years. In the second year, the cost of film processed will be baht 3,285,000 + 6.77%

= 3,285,000 baht x 1.0677

= 3,507,394.50 baht

For the third year:

= 3,507,394.50 baht x 1.0677

= 3,744,845.11 baht

For the fourth year:

= 3,744,845.11 baht x 1.0677

= 3,998,371.12 baht

For the fifth year:

= 3,998,371.12 baht x 1.0677

= 4,269,060.85 baht

(b) The cost of room for film storage is forecast as 2.19 Million baht a year (calculation based on three rooms for patients, 2,000 baht per night).

= 3 rooms x 2,000 baht (per night)

= 6,000 baht per day.

= 6,000 baht x 365 Days per year.

= 2,190,000 baht per annum.

Inflation must be considered in calculating this cost in the following year. (Inflation rate of 6.77%.)

The cost of rooms' storage for the first year is 2,190,000 baht.

For the second year, it is 2,190,000 baht + 6.77%.

- 2,190,000 baht x 1.0677

  2,338,263 baht.

For the third year, it is 2,338,263 baht + 6.77%

2,338,263 baht x 1.0677

2,496,563.40 baht.

For the fourth year, it is 2,496,563.40 baht. + 6.77%

2,496,563.40 baht. x 1.0677

= 2,665,580.75 baht.

And the fifth year, it is 2,665,580.75 baht. + 6.77%

2,665,580.75 baht. x 1.0677

2,846,040.56 baht.

(c) Six technicians will be hired to take care of the patients in the X-ray department, getting patients to take X-ray exams and processing X-ray films in a dark room at the salary of 15,000 baht that is approximately 1,080,000 baht in the first year.

Expense per month:

= 6 Technicians x 15,000 baht of salary.

- 90,000 baht per month.

Expense on salary for the first year:

- 90,000 baht x 12 Months
- 1,080,000 baht.

The salary is assumed to increase at the constant rate of 10% each year for five years.

For the second year, it is 1,080,000 baht + 10.00%.

= 1,080,000.00 baht x 1.1

= 1,188,000.00 baht.

For the third year, it is 1,188,000.00 baht + 10.00%

= 1,188,000.00 x 1.1

= 1,306,800.00 baht.

For the fourth year, it is 1,306,800.00 baht. + 10.00%

= 1,306,800.00 baht. x 1.1

= 1,437,480.00 baht.

And the fifth year, it is 1,437,480.00 baht. + 10.00%

= 1,437,480.00 baht. x 1.1

= 1,581,228.00 baht.

(d) The cost of X-ray tube maintenance in the fifth year.

This cost is created because it is related to the lifetime of the X-ray tube. The existing system makes double X-ray exposure to the patients, that means the X-ray tube will have only half of the lifetime it is expected. Patients also get more Doses of X-ray. This is not so good for health. This cost is estimated at 300,000 baht. (Information supported by some technicians from a private hospital)

To calculate the Benefit to cost Ratio, Net Present Worth (NPW) must be calculated. The benefit to cost ratio of the existing project is equal to NPW of the total income for five years divided by NPW of the total cost for five years.

Present Value of the Future value can be calculate as follows:

$$\frac{F}{(1 +}$$

The NPW of the total income:

- The summation of the NPW of the income each year.

  $9,581,250.00 + 10,229,900.63 / (1+0.08)^1 +$

  $10,922,464.90 / (1+0.08)^2 + 11,661,915.77 / (1 +0.08)^3 +$

  $12,451,427.47 / (1 +0.08)^4$

- 46,825,972.07 baht.

The NPW of the total Cost:

- The summation of the NPW of the total cost of each year.
- $6,555,000.00 + 7,033,657.50 / (1+0.08)^1 +$

  $7,548,208.51 / (1+0.08)^2 + 8,101,431.87 / (1 +0.08)^3 +$

  $8,996,329.41 / (1 +0.08)^4$

  32,581,761.37 baht.

Benefit to Cost Ratio of the Conventional System:

- NPW of the Total Income / NPW of the Total Cost
- 46,825,972.07 / 32,581,761.37

  1.44

The NPW of the total Profit for five years:

The summation of the NPW of the net profit of each year.

$3,026,250.00 + 3,196,243.13 / (1+0.08)^1 +$

$3,374,256.38 / (1+0.08)^2 + 3,560,483.90 / (1+0.08)^3 +$

$3,455,098.06 / (1+0.08)^4$

14,244,210.70 baht.

All the calculations of incomes and expenses of the existing system have been clearly illustrated in Table 5.1.

Incomes and Expense of PACS

Income when using PACS: By forecasting, PACS not only can make the same hospital provide better health care service but also increase the service performance by 20%. This means that the hospital still can work efficiently although the volume of daily patients have increased to 20% more. By then, the hospital can provide service for about 90 patients per day. Each patient is supposed to spend an average of 350 baht for X-ray exam, each record will be stored in MO (Magneto Optical) Disk. Theoretically, PACS is a filmless system but it is a less film system in practical. If there is no request, no film will be printed.

Daily income:

90 Patients x 350 baht (per day)

- 31,500 baht.

Annual income:

- 31,500 baht x 365 Days per year
- 11,497,500 baht per annum.

As the time value of money must be considered, inflation must be added to estimate the income in the next year.

Assuming that a annual inflation rate is 6.77%.

The income for the second year will be 11,497,500 baht + 6.77%

- 11,497,500.00 baht x 1.0677
- 12,275,880.75 baht

For the third year:

- 12,275,880.75 baht x 1.0677

  13,106,957.88 baht

For the fourth year:

13,106,957.88 baht x 1.0677

- 13,994,298.93 baht

For the fifth year:

- 13,994,298.93 baht x 1.0677

  14,941,712.96 baht

Cost of the film printed by using PACS system:

(a) The information gathered from Thai physicians who are interested in PACS shows that the film still needs to be printed although the hospital has already implemented PACS. Anyway, the film volume is supposed to be only 20% of the film to be printed. Practically, there is no film that will directly be exposed to X-ray dose because for PACS, the image will be stored in the computer and kept as database. Whenever the patient needs a copy of the film, the image will be printed from a Laser Imager with master quality in image on laser

film. Normally, the cost of laser film is higher than that of the existing X-ray film, approximately 70 baht per sheet on an average film size.

Daily patients are estimated to be at 90 persons a day so the expected film to be processed is:

- 90 patients + 20% more
- 90x 1.2

108 films a day.

20% of the film to be processed is:

108 films x 0.2

21.6 films a day.

Approximately 22 films a day.

The cost of film printed per day is 22 films x 70 baht

1,540 baht a day.

The cost of film printed per year is:

- 1,540 Bath x 365 Days

562,100 baht in the first year.

Six point seven seven percent inflation must be included for the expense of film printed for the next four years. In the second year, the cost of film printed will be 562,100 baht + 6.77%

562,100 baht x 1.0677

600,154.17 baht

For the third year:

- 600,154.17 baht x 1.0677

= 640,784.61 baht

For the fourth year:

= 640,784.61 baht x 1.0677

= 684,165.73 baht

For the fifth year:

= 684,165.73 baht x 1.0677

= 730,483.74 baht

The cost of a small PACS for a hospital having 90 patients a day.

(a) A PACS vendor verbally supports the information of the cost of designation and installation of a PACS would be approximately 15 Millions baht for the first year of investment.

= 15,000,000 baht for the first year.

(b) Annually maintenance cost for PACS is estimated to be 8% of the total initial investment (Inflated).

= 8% x 15,000,000 baht.

= 1,200,000 baht per year.

The maintenance cost will be included as expense starting in the second year because the installation of the first year will include the one-year warranty. The hospital will have to spend 1,200,000 baht each year for PACS maintenance.

(c) The cost of room space for Computer system and Database storage would be approximately 730,000 baht per year in case of the uses of

only one room for MO Disk storage instead of using three rooms' storage for X-ray film. (The calculation is based on one room for patient, 2,000 baht per night).

- 1 room x 2,000 baht (per night)
- 2,000 baht per day.

  2,000 baht x 365 Days per year.
- 730,000 baht for the first year.

Inflation must be considered in the calculation for this cost in the following year. (Inflation rate of 6.77%.)

The cost of rooms' storage for the first year is 730,000 baht.

For the second year, it is 730,000 baht + 6.77%.

- 730,000.00 baht x 1.0677
- 779,421.00 baht.

For the third year, it is 779,421.00 baht + 6.77%

779,421.00 baht x 1.0677

- 832,187.30 baht.

For the fourth year, it is 832,187.30 baht. + 6.77%

- 832,187.30 baht. x 1.0677
- 888,526.92 baht.

And the fifth year, it is 888,526.92 baht. + 6.77%

- 888,526.92 baht. x 1.0677

948,680.19 baht.

(d) Four technicians will be sufficient for the X-ray department that has 90 patients a day because PACS can reduce the redundancy works at the same time. It can also speed up the workflow of the department. But, because these four technicians must have a good computer skill so that they can use PACS efficiently, their salary is expected to be higher than that of normal technicians. For this example, we assume that the standard of their salary will be 18,000 baht and it will keep increasing at the constant rate of 10% each year for five years, the cost of hiring these four technicians will be approximately 864,000 baht in the first year.

4 Technicians x 18,000 baht of salary

72,000 baht per month.

72,000 baht x 12 Months

864,000 baht in year one.

The salary is assumed to increase at the constant rate of 10% each year for five years.

For the second year, it is 864,000 baht + 10.00%.

864,000.00 baht x 1.1

950,400.00 baht.

For the third year, it is 950,400.00 baht + 10.00%

= 950,400.00 x 1.1

1,045,440.00 baht.

For the fourth year, it is 1,045,440.00 baht. + 10.00%

- 1,045,440.00 baht. x 1.1

  1,149,984.00 baht.

And the fifth year, it is 1,149,984.00 baht. + 10.00%

- 1,149,984.00 baht. x 1.1
- 1,264,982.40 baht.

Find the Net Present Worth:

$P = F/(1+i)^{\circ}$

The NPW of the total income:

- The summation of the NPW of the income each year.
- 11,497,500.00 + 12,275,880.75 /(1+0.08)^1 +

  13,106,957.88 /(1+0.08)^2 + 13,994,298.93 / (1 +0.08)^3 +

  14,941,712.96 / (1 +0.08)^4

  56,191,166.49 baht.

The NPW of the total Cost:

The summation of the NPW of the total cost of each year.

- 17,156,100.00 + 3,529,975.17 / (1+0.08)^1 +

  3,718,412.41 / (1+0.08)^2 + 3,922,676.64 / (1 +0.08)^3 +

  4,144,146.33 / (1 +0.08)^4

29,772,067.24 baht.

Benefit to Cost Ratio of the Conventional System:

NPW of the Total Incoming / NPW of the Total Cost

- 56,191,166.49 / 29,772,067.24
- 1.89

The NPW of the total Profit for five years:

The summation of the NPW of the net profit of each year.

- $-5,658,600.00 + 8,745,905.58 / (1+0.08)^1 +$

  $9,388,545.47 / (1+0.08)^2 + 10,071,622.28 / (1+0.08)^3 +$

  $10,797,566.63 / (1+0.08)^4$

  26,419,099.25 baht.

All the calculation of incomes and expenses of PACS has been clearly illustrated in Table 5.2.

The hospital can save money in the Bank and get interest.

The decision of whether or not PACS will be implemented is not only to make comparison in NPW, Benefit to Cost Ratio of the PACS with the existing system, but also with the DO NOTHING. Considering the investment on the PACS of 15 Million baht in the first year and 1.2 Million baht of annual maintenance cost, if the hospital continues its existing system and saves the money supposed to be invested on PACS in the bank, it will get Interest each year. The change in time value of money will be illustrated in Table 5.3.

The interest rate used in the calculation of this example is assumed to be at a constant rate of 8% for five years.

In the first year, the money saved in the bank is 15,000,000 baht. Four years later, the 15,000,000 baht includes 8% interest rate compound annually will become 20,407,334.40 baht.

P = Present Value

F = Future value

F1 = P + P,

F, = $P (1+ O^n$

F4 = $15,000,000 (1+ 0.08)^4$

= 20,407,334.40 baht

For the maintenance cost in the second year, third year, fourth year and the fifth year:

F_m2 = $1,200,000 (1+ 0.08)^3$

- 1,511,654.40 baht

F13 = $1,200,000 (1+ 0.08)^2$

- 1,399,680.00 baht.

Fm4 = $1,200,000 (1+ 0.08)^1$

- 1,296,000.00 baht.

Frin5 = 1,200,000 baht.

Total saving money in the fifth year will be equal to the summation of the future value of the 15,000,000 baht in the first year of investment and the 1,200,000 baht for the four year of maintenance cost:

= 20,407,334.40 + 1,511,654.40 + 1,399,680.00 + 1,296,000.00 + 1,200,000.00

= 25,814,668.80 baht.

The future value of money must be calculated back to the present value so that it can be compared with the NPW of PACS project.

P = $F / (1+i)^{'}$

= $25,814,668.80 / (1 +0.08)^{4}$

= 18,973,781.57 baht.

If we consider only the Benefit to Cost ratio, PACS get 1.89 which is higher that the existing systems', 1.44. Anyway, practically the benefit to cost ratio shows only which project is the worthy one, but did not show how much the profit has been made and which one gains more profit. Comparison of the NPW of the net profit for the five years project between the existing system and that of PACS, the existing system makes a profit of 14,244,210.70 baht while PACS gain 26,419,099.25 baht. PACS gains 12,174,888.55 baht more than the existing system.

NPW of the net profit of the existing system

= 14,244,210.70 baht.

NPW of the net profit of PACS

- 26,419,099.25 baht.

Compare $NPW_{(pAcs)}$ with the $NPW_{(Cony)}$

$NPW_{(PACS)} - NPW_{(Cony)}$

- 26,419,099.25 - 14,244,210.70 baht
- 12,174,888.55 baht

According to this NPW analysis, PACS should be the worthy investment.

Is this analysis the same as the comparison made between PACS and the DO NOTHING? There are various methods for making comparison. The method that has been explained is the direct comparison between the net profit of the existing system and PACS. The other method that is also suitable for this situation and to confirm that to implement PACS is the more worthy investment, comparing PACS with the DO NOTHING can show a very clear picture of "What if the hospital didn't implement PACS?" or "Is it better to do nothing, discard the project?". By saving 15 Million baht and 1.2 Million baht in the Bank and getting the yearly Interest at the constant rate of 8.00% for five years, the NPW of the money is equal to 18,973,781.57 baht. Approximately 19 Million baht is the NPW for the DO NOTHING, but it cannot directly compare with the NPW of the net profit of PACS. Another cash flow has been created and shown in table 4. The cash flow in table 4 illustrates the cost saved by implementing PACS.

Table 5.1. Incomes and Expenses of the Existing System.

inflation rate: 6.77% interest rate: 8.00%

	Year 1	Year 2	Year 3	Year 4	Year 5
Income from 75 patients (350 baht each)	9,581,250.00	10,229,900.63	10,922,464.90	11,661,915.77	12,451,427.47
Cost of film printing per year	-3,285,000.00	-3,507,394.50	-3,744,845.11	-3,998,371.12	-4,269,060.85
Three rooms of film storage	-2,190,000.00	-2,338,263.00	-2,496,563.41	-2,665,580.75	-2,846,040.56
Labor cost for six technicians (salary of 15,000 baht)	-1,080,000.00	-1,188,000.00	-1,306,800.00	-1,437,480.00	-1,581,228.00
Cost of X-ray tube maintenance at year 5					-300,000.00
Total cost per year	-6,555,000.00	-7,033,657.50	-7,548,208.51	-8,101,431.87	-8,996,329.41
Net Profit	3,026,250.00	3,196,243.13	3,374,256.38	3,560,483.90	3,455,098.06
Net Present Worth for five years				NPW:	14,244,210.70

NPV of Total Income per year	9,581,250.00	9,471,864.99	9,363,829.16	9,257,228.74	9,151,799.19
NPV of Total cost per year	-6,555,000.00	-6,512,463.48	-6,471,079.16	-6,430,916.62	-6,612,302.12
NPV of Profit each year	3,026,250.00	2,959,401.51	2,892,750.48	2,892,750.00	2,539,497.07

NPW of Total Income: 46,825,972.07

NPW of Total Cost: -32,581,761.37

Benefit to Cost Ratio: 1.44

Table 5.2. Incomes and Expenses of PACS.

inflation rate: 6.77% interest rate: 8.00%

	Year 1	Year 2	Year 3	Year 4	Year 5
Incoming from 90 patients (350 baht each)	11,497,500.00	12,275,880.75	13,106,957.88	13,994,298.93	14,941,712.96
Cost of 20% Films estimated to be printed	-562,100.00	-600,154.17	-640,784.61	-684,165.73	-730,483.74
Investment of PACS in the first year	-15,000,000.00				
Maintenance Cost for PACS per year (8% of the investment in the first year)		-1,200,000.00	-1,200,000.00	-1,200,000.00	-1,200,000.00
Cost of a room for DB (MO Disk) Storage.	-730,000.00	-779,421.00	-832,187.80	-888,526.92	-948,680.19
Labor cost for four technicians (salary of 18,000 baht)	-864,000.00	-950,400.00	-1,045,440.00	-1,149,984.00	-1,264,982.40
Total cost per year	-17,156,100.00	-3,529,975.17	-3,718,412.41	-3,922,676.64	-4,144,146.33
Net Profit	-5,658,600.00	8,745,905.58	9,388,545.47	10,071,622.28	10,797,566.63
Net Present Worth for five years				NPW:	26,419,099.25

NPV of Total Incoming per year	11,497,500.00	11,336,237.99	11,236,594.99	11,108,674.49	10,982,159.03
NPV of Total cost per year	-17,156,100.00	-3,268,404.01	-3,187,794.96	-3,113,820.72	-3,045,947.55
NPV of Profit each year	-5,658,600.00	8,097,833.98	8,048,800.03	7,994,853.77	7,936,211.47

NPW of Total Incoming: 56,191,166.49

NPW of Total Cost: -29,772,067.24

Benefit to Cost Ratio: 1.89

Table 5.3. Save Money in the Bank and Getting an Interest of 8% Each Year.

interest rate: 8.00%

	Year 1	Year 2	Year 3	Year 4	Year 5
Saving 15,000,000 baht in Bank with 10% Interest compound annually.	15,000,000.00	16,200,000.00	17,496,000.00	18,895,680.00	20,407,334.40
Save 1.2 Million baht each year for maintenance cost					
Year 2		1,200,000.00	1,296,000.00	1,399,680.00	1,511,654.40
Year 3			1,200,000.00	1,296,000.00	1,399,680.00
Year 4				1,200,000.00	1,296,000.00
Year 5					1,200,000.00
Total Saving money at year 5					25,814,668.80
				NPW:	18,973,781.57

Table 5.4. Benefits and Costs Saving of PACS.

inflation rate: 6.77% interest rate: 8.00%

	Year 1	Year 2	Year 3	Year 4	Year 5
More income from 15 patients (350 baht each)	1,916,250.00	2,045,980.13	2,184,492.98	2,332,383.15	2,490,285.49
Volume of film use reduced, so hospital saves money	2,722,900.00	2,907,240.33	3,104,060.50	3,314,205.40	3,538,577.10
Saves two rooms of film storage	1,460,000.00	1,558,842.00	1,664,375.60	1,777,053.83	1,897,360.38
Saves the expense on salary of two technicians.	216,000.00	237,600.00	261,360.00	287,496.00	316,245.60
Net cost saving by implementing PACS	6,315,150.00	6,749,662.46	7,214,289.08	7,711,138.38	8,242,468.57
				NPW:	30,928,788.55

NPV of the net cost saving by implementing PACS (each year)

6,315,150.00	6,249,512.47	6,184,810.03	6,121,101.65	6,058,214.40

NPW of total cost saving: 30,928,788.55

(a) More income:

Firstly, the hospital expects to have about 20% more capacity of providing health care service. So, nearly 15 more patients a day will make the hospital have more income.

Daily income:

= 15 people x 350 baht

= 5,250 baht.

Annual income:

= 5,250 baht x 365 Days.

= 1,916,250.00 baht.

In the first year, the hospital can make more income of 1,916,250.00 baht. after implementing PACS.

For the second year, the inflation of 6.77% should be included and also the next year until the fifth year.

= 1,916,250.00 baht. x 1.0677

= 2,045,980.13 baht.

For the third year:

= 2,045,980.13 baht. x 1.0677

= 2,184,494.98 baht.

For the fourth year:

= 2,184,494.98 baht. x 1.0677

- 2,332,383.15 baht.

For the fifth year:

- 2,332,383.15 baht. x 1.0677

  2,498,285.45 baht.

The volume of film supposed to be processed is also reduced. So, the hospital can save a lot of money each year.

(b) Cost saving by reducing the volume of film printed

If they still use the existing system in the first year, the cost of film processing will be 3,285,000 baht while PACS estimated that 20% of film will be printed, 562,100 baht. With PACS, the cost saving from film is nearly 2,722,900 baht.

3,285,000 baht - 562,100 baht.

- 2,722,900 baht.

6.77 % of inflation is included, then in the second year, the hospital can save:

2,722,900 baht. x 1.0677

- 2,907,240.33 baht.

For the third year:

2,907,240.33 baht. x 1.0677

- 3,104,060.50 baht.

For the fourth year:

= 3,104,060.50 baht. x 1.0677

= 3,314,205.40 baht.

For the fifth year:

= 3,314,205.40 baht. x 1.0677

= 3,538,577.10 baht.

(c) Money saved from two rooms of film storage:

= 730,000 baht x 2

= 1,460,000.00 baht. (in the first year)

For the second year:

= 1,460,000.00 baht. x 1.0677

= 1,558,842.00 baht.

For the third year:

= 1,558,842.00 baht. x 1.0677

= 1,664,375.60 baht.

For the fourth year:

= 1,664,375.60 baht. x 1.0677

= 1,777,053.83 baht

For the fifth year:

= 1,777,053.83 baht x 1.0677

= 1,897,360.38 baht.

(d) Cost saving by reducing the labor cost:

And the last saving cost is the expense of salary for two technicians. Anyway, the salaries of the technicians working on the existing environment and PACS are different. So we use the total expense on salary of the existing system to minus PACSs' to get this differenence.

= 1,080,000.00- 864,000.00 baht.

= 216,000.00 baht (in year 1^{st})

The salary is supposed to be increased at the constant rate of 10% each year.

For the second year:

= 216,000.00 baht x 1.1

= 237,600.00 baht.

For the third year:

= 237,600.00 baht x 1.1

= 261,360.00 baht.

For the fourth year:

= 261,360.00 baht x 1.1

= 287,496.00 baht.

For the fifth year:

= 287,496.00 baht x 1.1

= 316,245.60 baht.

The total cost saving of each year:

For the first year:

= 1,916,250.00 + 2,722,900.00 + 1,460,000.00 + 216,000.00

= 6,315,150.00 baht.

For the second year:

= 2,045,980.13 + 2,907,240.33 + 1,558,842.00 + 237,600.00

= 6,749,662.46 baht.

For the third year:

= 2,184,492.98 + 3,104,060.50 + 1,664,375.60 + 261,360.00

= 7,214,289.08 baht.

For the fourth year:

= 2,332,383.15 + 3,314,205.40 + 1,777,053.83 + 287,496.00

= 7,711,138.38 baht.

For the fifth year:

= 2,490,285.49 + 3,538,577.10 + 1,897,360.38 + 316,245.60

= 8,242,468.57 baht.

Summation of these cost savings must be calculated from the NPW:

6,315,150.00 + (6,749,662.46 x 0.9259) +

(7,214,289.08 x 0.8573) + (7,711,138.38 x 0.7938) +

(8,242,468.57 x 0.735)

6,315,150.00 + 6,249,512.47 + 6,184,810.03 + 6,121,101.65 +

6,058,214.40

30,928,788.55 baht.

The 30,928,788.55 baht is the NPW of the total cost saving by implementing PACS. This cost saving is much more than the DO NOTHING, 18,973,781.57 baht. The feasibility study by engineering economy and financial analysis has already proved that PACS is the worthy of investment. Should the hospital immediately start PACS? The results of the feasibility study are not the justification of whether or not PACS should be installed by now. But hopefully, it can be information supporting decision-maker of the PACS project in Thailand.

Thinking of the target of a hospital which is to provide health care service to patients or help people from suffering or pain as fast as possible or as well as they can do, managements should not have the goals to gain as much profit as possible. If we can gain profit on both income and provide better health care service to the public, why don't we do it.

The feasibility study above is one of an example of making comparison of a compact or small size PACS in a private hospital. It doesn't mean that the bigger the size of PACS will be better. It depends on how efficient the users can use it. PACS not only has scope for making less film printing but to provide better medical communication. Patients' medical records can be transmitted to any other site that has the same system and standard. Particularly in the case of making communication

between central hospital with the smaller hospitals that are far away, or the use of PACS in the hospital that has branches in many areas. By using the Centralize system, it would be very convenient for patients to go to any nearest hospitals in the groups because all the medical records can be retrieved from the database center. In the hospitals' point of view, they can have a lot of permanent customers as they can provide better service. PACS can then obviously reduce the travelling expense and time used for physicians to go to hospitals and reduce the redundant medical equipment because hospitals in the capital or big cities can join together and share their medical equipment while the diagnosis report can be passed on to the other hospitals. This would significantly reduce the need of purchasing medical equipment from overseas. This concept will also increase the potential of providing health care service. This solution also can abate the problem of the lack of physicians in up countries.

5.4 Manpower or Human Resources

According to the statistical data that are collected by the Ministry of Public Health showing that the number of graduated physicians, technicians, and nurses still is not enough to compensate for the shortage especially in non-metropolitan areas, Ministry of Public Health in Thailand needs the support from the government as the expense for medical course is very high. Although today we have eight additional private schools producing human resource for medical support, 70% of the graduates are nurses. Statistical data are as shown in table 5.5. According to the statistical records till 1998, Thailand has only about 23,744 doctors and 573 radiologists with approximately 800 doctors who are supposed to graduate each year. These insufficient numbers of doctors are not enough for Thailand that has a population of nearly 60 Million people.

By rough calculation: 60 Millions people / 23,744 doctors

= 2,527 people per doctor

Consider the radiologist in Thailand:

= 60 Millions people / 573 Radiologists

= 104,712 people per radiologist.

Forecasting for the minimum number of patients by estimating that only 1.00 % of the population a day needs radiologists, then a radiologist must support nearly 1,047 patients a day which is almost impossible. Thailand is lacking a lot of human resource in medical field like in many other developing countries.

Pondering specialist of PACS in Thailand, we rarely have specialists in this field. Although some of the radiologists who are interested in PACS have started to learn and collect information, the number of people who know PACS is still small but should be increased once we have PACS installed, and a well trained group of human resource. In many other countries that have PACS in their medical schools, professors can teach medical students by using images on monitor as shown in Figure 5.1.

Dr. Somjai Wongsupachok, chief Physicians of the department of Radiology for diagnosis from Chulalongkorn hospital/university, said that PACS will be one of the practical subjects needed to be added to the medical course once PACS has been installed in the hospital/university. The problem of the lack of computer knowledge of the new technicians and radiologists will be obsolete, as the computer course has already been added to the medical course. But for the existing technicians, they have to start learning and getting familiar with the computer otherwise they will not be able to catch up with the new graduates.

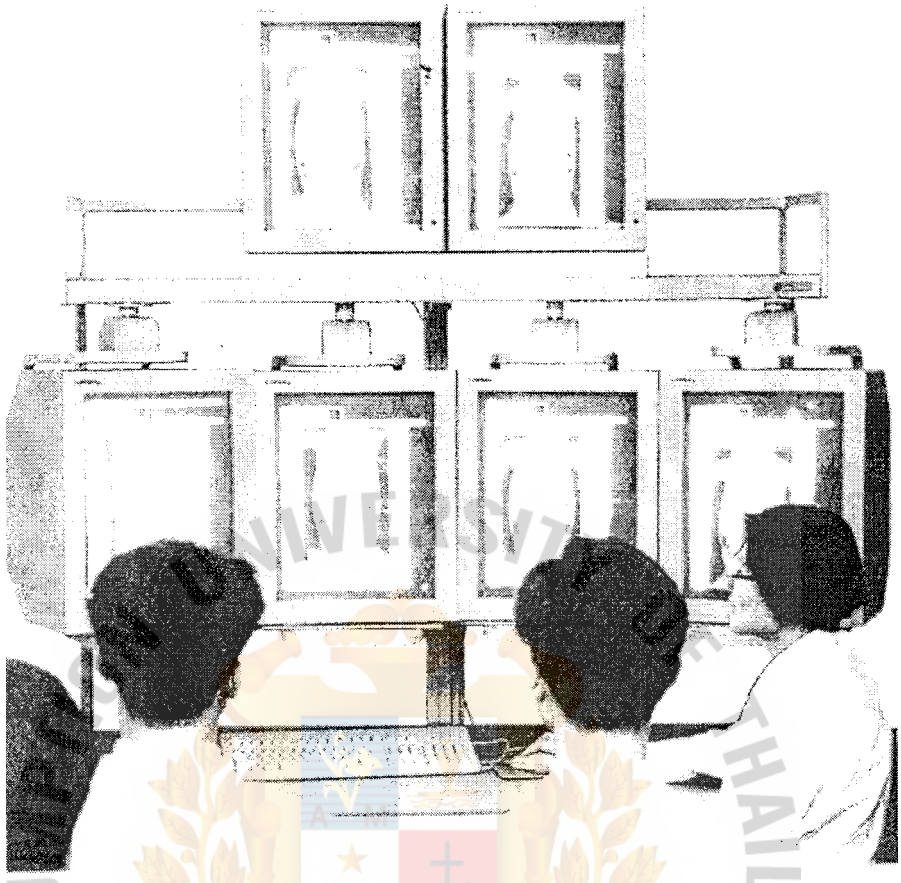

Figure 5.1. Medical Students Learning to Make Diagnosis with CRT (Thompson 1996).

The other problem that may be hard to solve is the resistance of PACS by some traditional radiologists, and technicians who fear change. Therefore, to make the user willing to use the new system is not so easy. As the existing users are already familiar with the traditional X-ray system, it would be hard to convince them to learn the new thing and use it. Anyhow, this is not a problem that cannot be solved. Providing training is the best solution for this. At the initial stage, we need to make the users clearly understand the reason of the change, explain the benefit of the new system, at the same time set a hand-on training so that they can learn it and use it by themselves. There is nothing too difficult to learn and finally they will be able to use the system and like it.

5.5 Sizable Investment

Even though the cost analysis has been done and the result shows that PACS is the worthy of investment, a lot of physicians and people involved still hesitate to invest money on PACS project. This is because the PACS project needs a huge investment and it is a risk for the hospital to go filmless. Firstly, because of the huge investment on PACS, it is very difficult to beg for the approval for budget from the hospital and there is no one who can guarantee for the worth of the investment of PACS. Secondly, PACS is an integral part of medical equipment and computers, so if any error occurs with the system, the X-ray department will be down and unable to provide service to any patients. This is not acceptable. Whereas the hospital that has the old system can keep forward, but the workflow will be very slow. On the other hand, it is a true nightmare for fully digital hospitals. To avoid this risky investment project, many hospitals choose to keep waiting for the first base of PACS in Thailand and to learn from the experience of that hospital.

5.6 The Security of PACS in Thailand

What we cannot ignore when implementing PACS is the security of using the system. Almost every part of PACS is concerned with computer system. Security in computer system then needs to be considered to make sure that the medical records, patients data, and information have been stored in the full secure system.

We also cannot ignore the VIRUS in computer that may infect the important information in the computer system. PACS must be a VIRUS free system, otherwise the VIRUS may destroy medical record database. If these records are damaged without any backup system, then keep in mind that we cannot make any compensation.

The problem of the security of medical records in computer system is not limited to the attack of computer virus, but also the people. Personal medical record is

considered as a confidential information. The computer system must be secure enough to prevent unauthorized person from accessing the system to see, retrieve or even make corrections with the information and data. This is fully related to the legal issue, but Thai physicians do not mention this. If we have a case that the medical record is a must and the only one evidence for suing in the court of law, then people from the opposite side would try their best to make changes to the record to make it advantages to their side. The medical record may then be corrected or even destroyed. Therefore, if the security of the system is not secure enough to protect this valuable information, then PACS may be used in the wrong way. To solve this kind of problem, Thai physicians need co-operation from The National Ministry of Justice in Thailand. Hence, PACS may be more efficient a system and become truly worth investment a project if we manage it in the right way.

VI. CONCLUSION & RECOMMENDATIONS

6.1 Conclusion

The objectives of the feasibility are to define whether or not PACS can efficiently increase performance of the medical treatment and health care service to the patients, and the possibility of having PACS in Thailand. The results of the analyses of the feasibility study of the PACS applications in Thailand are positive. According to the information gathered, PACS gains more of both the advantages and the benefit in comparison to the existing system.

The benefit to cost ratio and Net Present Worth analyses by engineering economic and financial analysis is used to analyze and support that PACS is a worthy investment, and suitable for medical practices in Thailand, especially after the end of the age of the economic crisis. Although the example in this report is just a comparison of the small size of PACS with the existing system in a private hospital, it can prove that PACS is better than the existing system, and can be a good guideline for any other feasibility concerning PACS. Hospitals not only have more incomes but also make their patients gain a lot of benefits and advantages from a better service.

To implement PACS, there are many factors to be considered such as the education and computer skill of the human resource, good management of the system, budgeting, phase-by-phase installation planning, communication system, the security of the system, etc. For Thai medical practices, the most suitable alternative is to have the system phase by phase. As the rapidly improved technology will make the cost of installation become lower with higher performance, once we have the first phase of PACS installed, we can learn the system and use it until we know which point of PACS is a must for the department, then we can both efficiently and effectively continue the

Hospitals should select many vendors to install PACS to avoid the monopoly vendor, so that hospitals will have more bargaining power.

Hospitals should firstly investigate their existing system whether it has been well managed, all the resources have been well used.

Some private hospitals should make an align PACS installation instead of installing a stand-alone system.

Professors in medical schools should start introducing Picture Archiving and Communication System to medical students, and people involved in order to make them familiar with the new system and not feel against the new system if the existing system has to be replaced.

BIBLIOGRAPHY

English References

1. Bieze, Jordana. Diagnostic Imaging: The newsmagazine of radiology, MRL Nuclear medicine and Ultrasound, May 1996.

2. Casey, "UCSF discovers limits of homegrown the PACS, the PACS & Networking News," Diagnostic Imaging monthly newsletter, 1996. (http://www.diagnostic-imaging.com)

3. Freiherr, Greg. "Choosing between hard- and soft-copy viewing," Diagnostic Imaging Asia Pacific, June 1996. (http://www.diagnostic-imaging.com)

4. Freherr, Greg. "Digital X-ray Capture Continues to Evolve," Diagnostic Imaging Asia Pacific, June 1996.

5. Heizer, Jay, and Barry Render. Production and Operation Management: Strategic and Tactical Decision. Fouth Edition. Englewood Cliffs, NJ 07632, U.S.A.:Prentic-Hall, 1996.

6. http://medical.agfa.com, 1999

7. http://www.catehealth.org, 1999.

8. Levine, Betty. "Telemedicine for U.S. Embassies," Georgetown University Medical Center, 1996. (http://www.telemedicine.georgetown.edu/ProjectDepOfState.htm)

9. Manning, William L. Telemedicine & Health Care Informatics Legal Issues. http://www.netreach.net/-wmanning/telmedov.htm, 1999.

10. Medschan, Isadore, and David J. Ott. The Scope of Diagnostic Imaging: Introduction to Diagnostic Imaging. USA.: W.B. Saunders Company, 1984.

11. "PACS: A Catalyst for the transformation of radiology," Diagnostic Imaging Asia Pacific, December 1998. (http://www.diagnostic-imaging.com)

12. "PACS is No Nirvana if numbers don't add up," Diagnostic Imaging Asia Pacific, July 1998. (http://www.diagnostic-imaging.com)

13. Stern, Sheldon M. "Digital enables fuller, faster ER coverage," Diagnostic Imaging Asia Pacific, June 1996.

14. Thompson, Tracie L. "The Digital Department," Diagnostic Imaging Asia Pacific, June 1996.

Thai References

1. otlionf vr1111191fr. f1151151415i0fliStYlflillThrilillt1151.1.11Y16=V1115t11411. 11111 M111-1f11: 1131711 2539.

2. Wfld15f1151155.151f1fl15 1110011551if115aMilttatillIkIldifilaIMVUOlflIV11511V115i114%. 111,11/ 0; VillITIVIAM,IJ51J51959511fl 115:,11511V1115alfp, 2540.