



THE ROLE OF DCM4CHEE AS AN OPEN SOURCE PACS IN THE RADIOLOGY DEPARTMENT OF PRIMAYA HOSPITAL SEMARANG

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ABSTRACT

This research explores the potential use of DCM4CHEE as an open-source Picture Archiving and Communication System (PACS) that is highly flexible for development in the current era. Despite being open source, DCM4CHEE has proven to be effective and reliable in healthcare settings, particularly in radiology department. Primaya Hospital Semarang has successfully implemented DCM4CHEE as an integrated archive system directly connected to CT Scan and Conventional X-Ray modalities. Direct observations were conducted over a significant period at the radiology installation of Primaya Hospital Semarang, which utilizes DCM4CHEE. This provided direct insights into how the system is implemented and used in practical situations. Furthermore, in-depth interviews were conducted with radiographers to gain their perspective on the experience of using DCM4CHEE. The research results indicate that the use of DCM4CHEE contributes positively in various aspects, including user-friendly operation, adequate utility, workflow improvement, and cost savings in healthcare services. The implementation of this software not only aids in the efficient management of radiological data but also reduces dependence on traditional filming systems, supporting the transition towards a paperless workflow. In conclusion, DCM4CHEE is reliable and highly beneficial in the context of healthcare services. Its adaptability allows seamless integration with Hospital Information Systems (HIS) and Radiology Information Systems (RIS), enhancing overall interoperability and efficiency. This research provides a foundation for recommending the use of DCM4CHEE as a customizable PACS solution that can positively contribute to improving the quality of radiology services in various healthcare department.

Keywords: dcm4chee; pacs workflow; primaya hospital; open source pacs

Introduction

Lately, there has been significant progress in the development of Open Source PACS. Open Source PACS is a system that is freely available and can be utilized by

healthcare services or other users. Support varies, ranging from community forums to support from product distributors or volunteers. This enables healthcare services to adopt PACS solutions that can be

customized to their needs. The quality of support depends on the respective open-source projects, which typically provide forums and user mailing lists to assist users in utilizing Open Source PACS (1).

The survey results indicate that the costs associated with the use of Commercial Picture Archiving and Communication System (PACS) can vary significantly, depending on several factors, including the scale of diagnostic usage and the size of the medical practice in question. In existing literature, the implementation costs of commercial PACS can range from \$5,000 to \$100,000 or more, depending on various variables that need to be carefully considered by healthcare providers. In addition to the initial payment costs, when assessing the total cost of PACS, we also need to take into account all other aspects related to the use of this system throughout its lifespan. This includes costs for customizing PACS to meet the specific needs of medical practices, as well as expenses that arise with the use and maintenance of the system (1).

The website medevel.com has compiled a list of ten open-source PACS/DICOM servers highlighted as excellent solutions for storing and transferring medical images in DICOM format. These projects are aimed at meeting the needs of various stakeholders, including medical institutions, researchers, and individuals, with the goal of providing broader access and comprehensive manipulation capabilities for medical image data. DCM4CHEE is included among the top 10 open-source PACS in the world (2).

DCM4CHEE is an open-source application and software utility commonly used in the healthcare industry. This software has several functions, including data compression and decompression, image

conversion, as well as DICOM protocol testing. DICOM is a standard used for transmitting, storing, retrieving, and sharing medical images in various healthcare facilities. DCM4CHEE plays a significant role in various open-source PACS systems aimed at facilitating the management of medical image data (3).

DCM4CHEE can run on various operating systems, including Linux, Windows, and others. This flexibility makes it a versatile choice for various healthcare and medical research environments. DCM4CHEE has been widely used by various institutions worldwide. The use of DCM4CHEE includes healthcare service providers, research projects, open-source applications, and even commercial applications (4).

In the context of radiology department at Primaya Hospital Semarang, Indonesia, DCM4CHEE has been adopted as an integrated archive system for CT Scan and Conventional X-Ray modalities. With the advancements in healthcare technology, the use of DCM4CHEE has become an interesting subject for further exploration. Initial observations conducted at the radiology department of Primaya Hospital Semarang indicate that DCM4CHEE has been effectively integrated into their workflow cycle.

The results of these initial observations provide an overview of how DCM4CHEE is used in daily practice in the radiology environment. The use of this system in CT Scan and Conventional X-Ray modalities at Primaya Hospital Semarang forms the basis of interest in this research, considering its implications for efficiency, utility, and potential cost savings in radiological data management.

A deeper understanding of the implementation of DCM4CHEE in radiology department can provide valuable insights into the impact of this technology on improving the quality of healthcare services. Therefore, this research aims to further explore how DCM4CHEE can be integrated into the context of radiology services, uncover its benefits in the workflow cycle, and evaluate its contribution to operational efficiency and effectiveness.

Methods

The research method employed in this study is qualitative, implemented through direct observation and interviews with users, radiographers at Primaya Hospital Semarang. Interviews were conducted with three radiographers as key informants, discussing aspects such as User Experience, Ease of Use, Interoperability, Workflow Efficiency, Data Security, and System Changes and Improvements as references to gain a profound understanding of the implementation of DCM4CHEE in the radiology department environment.

Results and Discussion

Topology of System Integration

DCM4CHEE functions as a Picture Archiving and Communication System (PACS) that not only plays a crucial role in the archiving and communication of medical images but also serves as an element directly integrated with the Hospital Information System (HIS) and Radiology Information System (RIS). The main advantage of this integration is the streamlining of traditional radiographer activities, bringing significant efficiency to their scope of work. This process is illustrated in Fig.1 below.

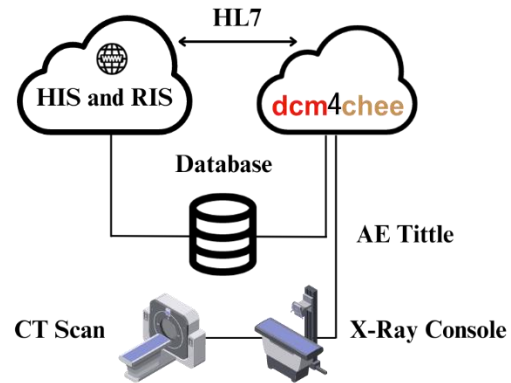


Figure 1. Pacs Topology Primaya Hospital Semarang

With the integration of DCM4CHEE, HIS, and RIS, radiologists can access and analyze medical images (DICOM) and perform expertise processes through a single gateway, namely HIS. This not only enhances connectivity between various systems but also simplifies the daily workflow for medical professionals. The cost-cutting approach advocated by this digital system, translated as a step toward a paperless workflow, provides economic benefits while supporting the shift towards greater efficiency in healthcare services.

PACS is a medical imaging system that provides an economical way to store and access images from various imaging devices. PACS is designed to integrate with the Radiology Information System (RIS), which manages patient information, schedules, and billing details. Additionally, this architecture involves the use of DICOM servers, which are an industry standard for transmitting, storing, retrieving, and sharing medical images (5).

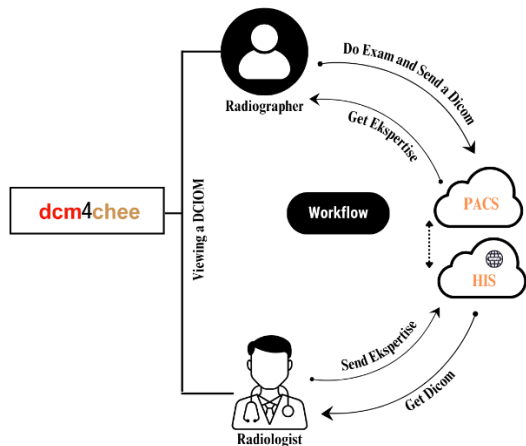


Figure 2. Pacs and HIS Workflow
Primaya Hospital Semarang

Therefore, the integration of DCM4CHEE with HIS and RIS not only brings technological innovation but also forms an ecosystem that supports convenience, efficiency, and progress in modern radiology practices. DCM4CHEE serves as the backbone of comprehensive radiological information technology, ensuring fast and secure access to necessary medical information while contributing to a positive transformation towards more modern and integrated healthcare practices.

Benefits of using the System

The use of the PACS system at Primaya Hospital Semarang has brought numerous benefits and significant positive impacts, ushering in fundamental changes in radiological data management and operational efficiency. Firstly, the examination ordering process no longer involves manual patient data input, eliminating time-consuming activities. The direct integration between the PACS system and the Hospital Information System (HIS) at Primaya Hospital enables the automation of the ordering process, allowing radiographers to handle tasks more efficiently and respond promptly to patient needs.

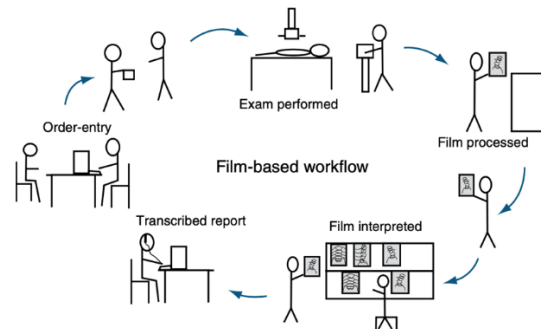


Figure 3. Film based workflow

Figure 3 above represents a workflow that still relies on the use of conventional film, indicating a lengthy and complex process. Such a workflow model creates significant barriers for radiographers and radiologists, posing challenges in terms of efficiency and timeliness. The utilization of a workflow involving conventional film not only extends the time required to complete the process but also creates obstacles in delivering patient readings, which cannot be promptly followed up by the radiologist (6)

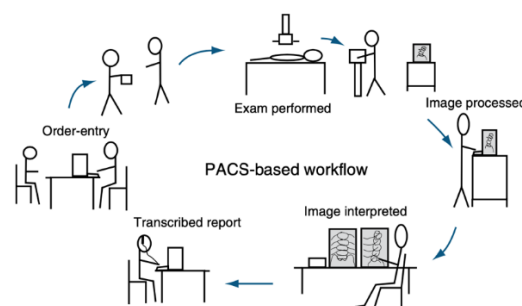


Figure 4. Pacs Based Workflow

This process begins with receiving examination orders, resembling steps in film-based methods. However, there are significant changes in the PACS-based process, as clearly depicted in Figure 4. Primaya Hospital Semarang has directly adopted and implemented this system, leading the digitalization journey that advances the efficiency and effectiveness of their healthcare service system.

Secondly, a notable positive impact is cost savings. The PACS system, especially with the use of DCM4CHEE, has

championed the digitalization of radiology services, replacing the use of conventional film systems. All activities related to monitoring medical images are now centralized in the PACS system, directly integrated with HIS. This not only reduces operational costs associated with the procurement and management of conventional films but also brings efficiency to the management and distribution of medical images.

Survey results prove that the cost of using Commercial Picture Archiving and Communication System (PACS) varies significantly depending on factors such as the scale of diagnostic usage and the size of medical practices. According to the literature, the implementation costs of commercial PACS range from \$5,000 to \$100,000 or more, depending on several variables that healthcare providers need to consider. In addition to the initial costs, the total evaluation of PACS expenses also includes system customization to meet medical practice needs and maintenance costs during the system's lifespan (1).

PACS has also successfully addressed common issues, such as the loss of diagnostic studies requiring reexamination and the reduction of time hospital staff spend searching for physical films. Additionally, the system has an advantage in enabling multiple individuals to simultaneously review the same examination from different locations, something not possible with film usage. Beyond these benefits, PACS also positively impacts patient care by providing the ability to adjust patient treatment plans more promptly. Study results indicate a decrease in the average length of hospital stays in facilities that have adopted PACS (7)

The implementation of DCM4CHEE as a PACS system at Primaya Hospital to date

proves that its use has a positive impact on radiographers and radiologists. By eliminating inefficient manual steps and adopting digital technology, the PACS system has become a crucial pillar in enhancing productivity and providing more effective patient care. Overall, this positive experience affirms that investing in technologies like DCM4CHEE in the field of radiology can create meaningful changes in modern healthcare practices.

Currently, the implementation of Open Source PACS DCM4CHEE at Primaya Hospital Semarang has been running without significant obstacles in terms of mobility and use in the hospital environment. Smooth access, minimal disruption to the server, and data security that is always maintained are positive points in its implementation. However, there are some minor constraints that need to be considered, especially related to the process of radiological expertise from outside the hospital's local network area.

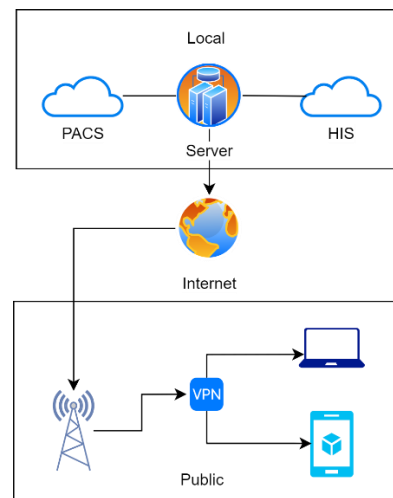


Figure 5. Public access concept

In an effort to enhance the accessibility of the Hospital Information System (HIS) publicly or from outside the hospital's local area, Primaya Hospital Semarang has implemented the Virtual Private Network

(VPN) method. This VPN methodology involves the utilization of both VPN server and VPN client, bringing significant benefits in terms of data security as show on fig.5.

The use of VPN server and VPN client ensures that every access to HIS at Primaya Hospital Semarang is protected and its security is guaranteed. Through this mechanism, data transmitted between the server and client is robustly protected. Users of HIS outside the hospital's network can securely connect via VPN, as access is granted only to those with valid and authorized accounts.

The HIS server can be accessed publicly from outside the network using the available internet access. However, the success of this access relies on the continuity of internet connectivity and VPN stability. Radiologists needing access to HIS can do so from various devices they possess, including laptops, tablets, or their smartphones. This creates flexibility in system usage, enabling radiologists to work efficiently and responsively to patient needs, unrestricted by physical location.

Overall, the implementation of the VPN method at Primaya Hospital Semarang provides a secure and reliable solution for accessing HIS from outside the network. By using VPN server and client, the aspect of data security is ensured, guaranteeing that only authorized parties can connect to the HIS server, thus providing optimal protection for sensitive medical information.

One of the constraints identified was the inability of the HIS system to run smoothly in the process of radiological exams from outside the local network area of Primaya Semarang Hospital. This constraint was caused by a connectivity disruption on a device, which may involve slow traffic between the server and HIS users from public

access, especially for radiology specialists outside the hospital's local area. This is due to differences in the quality of the network used outside the local access location, causing long IP traceroutes and potentially hampering the connection process until it reaches the server (8). Solutions to overcome this obstacle may involve improved network quality or more effective connection strategies to ensure maximum availability of the HIS system in various locations (9).

Overall, the utilization of DCM4CHEE as a PACS at Primaya Hospital Semarang has evolved into a central pillar for the storage and management of DICOM examination data conducted in the Radiology Department. DCM4CHEE not only serves as an efficient archival medium but also functions as a DICOM viewer platform that enables the expertise of radiologists in interpreting examination results.

The integration of DCM4CHEE with the Radiology Information System (RIS) and Hospital Information System (HIS) creates a remarkable advantage. The functionality resulting from this integration provides effectiveness and efficiency in the comprehensive management of data and radiology services. This system is not merely a digital archive, but also a crucial tool in ensuring that the processes of data management and medical imaging run smoothly.

With DCM4CHEE, radiologists can easily access and analyze medical images (DICOM) quickly and accurately. The ability to execute these functions through a unified platform, alongside HIS and RIS, creates significant efficiency in the daily routines of the radiology department.

Holistically, the integration of DCM4CHEE at Primaya Hospital Semarang not only meets the basic needs of digital

archive storage and medical visualization but also exceeds expectations by optimizing functions and data management effectively. This advantage reflects the use of cutting-edge technology to enhance the quality of radiology services and positions Primaya Hospital Semarang as a competitive entity in modern healthcare services.

Conclusion

This study demonstrates that DCM4CHEE, as an Open Source PACS, provides positive contributions in various aspects of usage in radiology department, particularly at Primaya Hospital Semarang. User experiences reflect the reliability of this system in facilitating mobility and usage in hospitals, with smooth access, minimal disruptions to the server, and maintained data security. The user-friendly nature of DCM4CHEE is evident in the improved workflow efficiency, making radiographer tasks quicker and more responsive to patient needs.

In conclusion, DCM4CHEE proves itself as a reliable and beneficial PACS solution in supporting healthcare services. Recommendations for using DCM4CHEE as a PACS solution can be confidently made, with the note that the minor deficiencies encountered do not significantly impact connectivity outside the local network. The implementation of DCM4CHEE can serve as a foundation for improving the quality of radiology services in other healthcare department.

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