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RESEARCH ARTICLE

PERFORMANCE IMPROVEMENT OF IGS SYSTEMS AND NEW FEATURE ADDITION TO THE HEALTHCARE HARDWARE AUTOMATION PC FOR DATA COLLECTION FROM CA1000 PACS RIS WORKSTATION WHICH WORKS ON DICOM PROTOCOLS

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Centricity Cardiology CA1000 (PACS/RIS Workstation),
Digital Imaging and Communications in Medicine (DICOM).

ABSTRACT

In this paper new feature is added to the Hardware Automation PC at the automation Service Class User (SCU) end to communicate and collect the image, logs and other details from the CA1000 PACS Workstation, Service Class Provider (SCP) for further reliability analysis of the Healthcare IGS systems. There are further performance improvements done to the XMLRPC server Image Processing unit (IPU) and the Hardware Automation PC socket Communication programs for a reliable communication between them.

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INTRODUCTION

The Centricity Cardiology CA1000 is a Cardiac Review PACS Workstations which follow the DICOM protocols for communication between the devices. Hardware Automation PC is a Healthcare automation device which is used for automation of the IGS systems. This PC is connecting to all the moveable and X- ray parts of the complete system through the Hardware Automation PC. The Hardware Automation PC is a device which has many Relays to control the complete system's switches, hence controlling the complete system (Fig 1).

IGS healthcare systems are used for many treatments like Vascular Diseases treatment (Cardiovascular disease), Electrophysiology (EP) Testing, Angioplasty for Coronary Artery Disease, Abdomen and lower limb vascular treatment, soft tissues treatment, Neurologic Diseases (brain related diseases). It has also features like fluoro, record, Roadmap, 3D imaging and many more features which make it more convenient to work with. Hardware Automation PC is a Windows system in which the complete automation software is written in TCL/TK and C++ programming using Mutex programming and Boost libraries for parallel processing of programs. The Hardware Automation PC is connected to all the devices for Automating the movements and X-ray for the reliability analysis by running the testing scripts overnight. The architecture of the Hardware Automation PC and the other parts is shown in Fig 2.

There are few performance improvements done to the XMLRPC connection between the Client (Hardware Automation PC) and the XMLRPC Server (IPU) for a reliable communication. The Hardware Automation PC also uploads the logs to the Hospital networks after completing each Testing. So that it could be analysed and then a reliability check could be done. Usually XMLRPC is a kind of protocol which uses the XML for encoding the message to be sent through a remote procedure call (RCP), and it uses the XML

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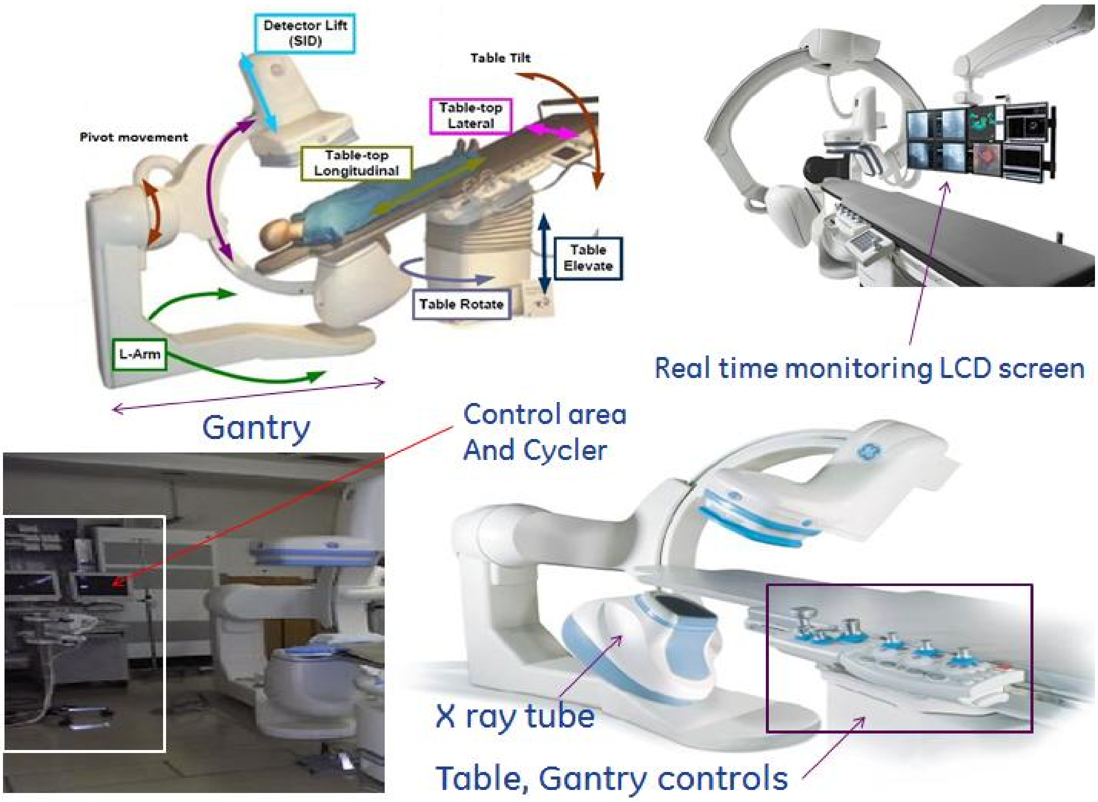

Fig. 1. Types of movements and x-ray controls done by Hardware Automation PC

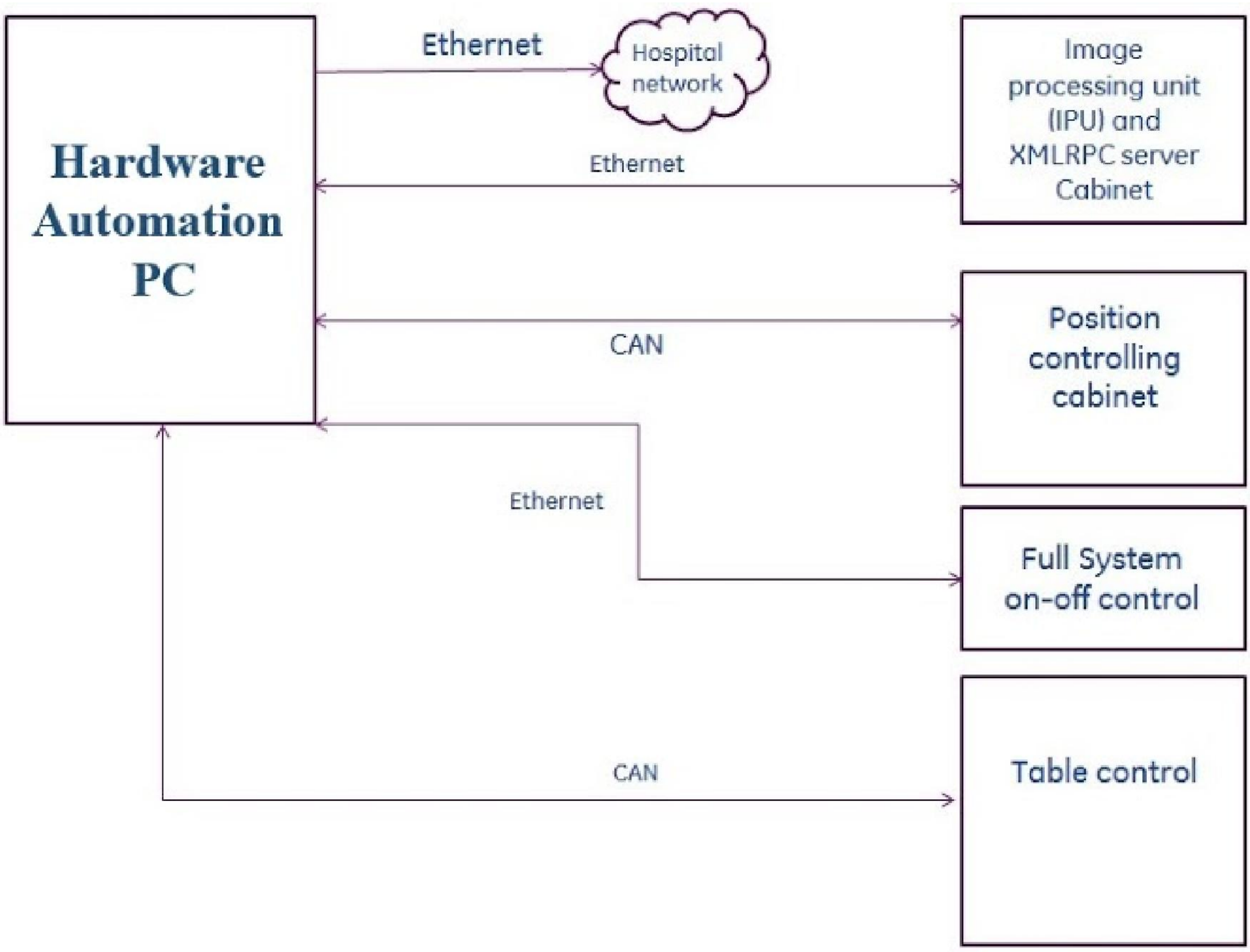

Fig. 2. Hardware Automation PC architecture

protocols to support it in the application layer. The IPU is the Image Processing unit; it is used for the Image acquisition and X-ray control. The IPU communicates with the Hardware Automation PC and sends the logs to it, and also pushes the images to the AW PC or the CA1000 workstation for a proper storage and analysis purpose. The AW (Advantage window) PC is a system which is used to convert the sequence of 2D images acquired by the x-ray detector into a smooth 3D image with a better contrast and clarity, and with a better image subtraction and other image processing capabilities. The CA1000 system also has few of this capabilities but it is mainly used for the image storage for PACS and RIS management in the hospitals. Usually Hardware Automation PC is now currently used for the reliability checking of the IGS healthcare systems.

Related work

Wei Xian Li, Yu Dong Lan *et al*., 2007. This paper gives a clear idea about the DICOM system and its architecture. It also gives a detailed flowchart about the LAN based DICOM SCU – SCP communication. It also shows in detail how the query is sent and received in an ECP device between the client and the server workstation (Oleg S. Pianykh, 2008). This is a Springer based book which is a very good reference for a beginner. It gives complete details about the DICOM protocols like, What is DICOM, How does it work, Where do we get it from, DICOM communication and security basics, DICOM Software Development and Management and its relation with the PACS and many more details about the complete architecture.

Luís A. Bastião Silva, Carlos Costa *et al*., 2014, in this paper a new idea of combining the formal ontologies with the information PACS storage is proposed, in order to improve searching speed and accessibility. It has also a complete detailed UML sequence diagram of the DICOM archiving and storage sequence, and details of the DICOM and ontologies architecture. Elisa MargarethSibarani, 2012. In this paper, there is a detailed explanation about the HIS, RIS and PACS architecture and its interoperability. And also a Simulation is done for trying an integration of these systems together. Y. Kim, H.W. Park, and D.R. Haynor, 1991, in this paper a detailed list of the Requirements for a PACS based system is listed out.

It also explains about some of the major components involved in the PACS systems. Gunjanbhai Patel, 2012, in this paper,a new idea of the cloud based service CaaS is proposed for the DICOM and PACS storage. And it also explains in detail about the problems with the management of the medical Images. And also explains the complete architecture of the CaaS with DICOM is shown. LiweiHao, DongyanJia, Guo Dan *et al*. 2012. in this a method is proposed for increasing the image quality even for a low dose CT images using HTML5 based protocol. It also modifies few features of the WADO based systems for the proposing this model. Frederico Valente, Carlos Viana-Ferreira *et al*. 2012. this paper talks about the security of the Medical images at the HTTP application layer using Representational State Transfer methodology. It also talks about the HTTP requests and the respective XML responses.

Applications

CA1000 has DICOM Send, DICOM Receive, DICOM Review, DICOM Print, and Single Media Archive.CA1000 is proposed for utilization as an essential symptomatic and examination workstation in Radiology/ Cardiology or different divisions. It is likewise proposed for utilization as a clinical review workstation all through the healthcare facility and may be a piece of a bigger PACS setup.CA1000 gets imaging studies and information over LAN, WAN, intranet or internet from a PACS server or straightforwardly from a DICOM - consistent methodology or chronicle using both lossless and lossy compression. The logs collected from such a system can be of very much use for the system developers to do the reliability check on the PACS workstation. Also there is performance improvement done to the IPU and Hardware Automation PC socket communication. And many other issues are solved like “Abort x-ray after 450 frames of record”, “choose sub menu 1” issues in IGS systems and may other issues has been solved for improving the performance and efficiency of the system.

CA1000 PACS/RIS Workstation and DICOM

In the olden days people used the x-ray papers to record their x-ray images. This method was bit difficult and repetitive since, if they forget to bring it to the next sitting, the doctor couldn’t proceed with is treatment. And sometimes there were chances of that sheet to be lost. And the x-ray had to be done once again. This made it difficult for the users as well as the doctors. PACS is a system which was built to eradicate these problems. PACS systems use the DICOM protocol for communication which is a universally accepted standard for communication for all medical images. The PACS system with the HIS and RIS is used together for keeping the patients data online in a workstation and can be accessed from anywhere in the world at any time (Fig 3).

Now a day in well-established hospitals there is a specific way in which the whole treatment procedure is carried out (Fig 4). Sometimes the patients also like to forward their medical details to many other doctors and other relatives. So the images has to be safely transferred to the correct authorized person with high level of encryption, this is done by MIME (Multi-Purpose Internet Mail Extensions) technique (Fig 5).

For communicating with a CA1000 PACS workstation, few network details are required. They are:

- Application Entity Title(AE Title) of the system
- AE IP Address of the system
- AE Port number

After knowing all these details we can set up a successful DICOM communication between the systems (Fig 6)

The communications of the DICOM Application Entities (AE) is based on SCU/SCP model, and SCU/SCP is executed in DICOM Commands with messages of the DIMSE (DICOM Message Service Element) C-MOVE and C-STORE Services exchanged over a secured connection. From the operational

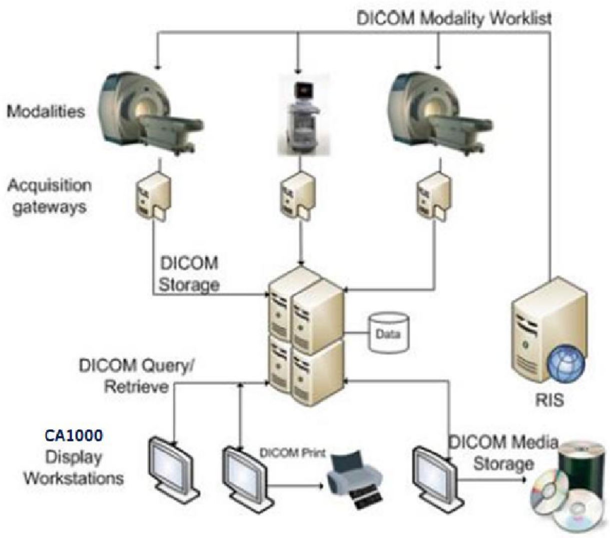

Fig. 3. Common workflow of a PACS system based on DICOM (Frederico Valente, 2012)

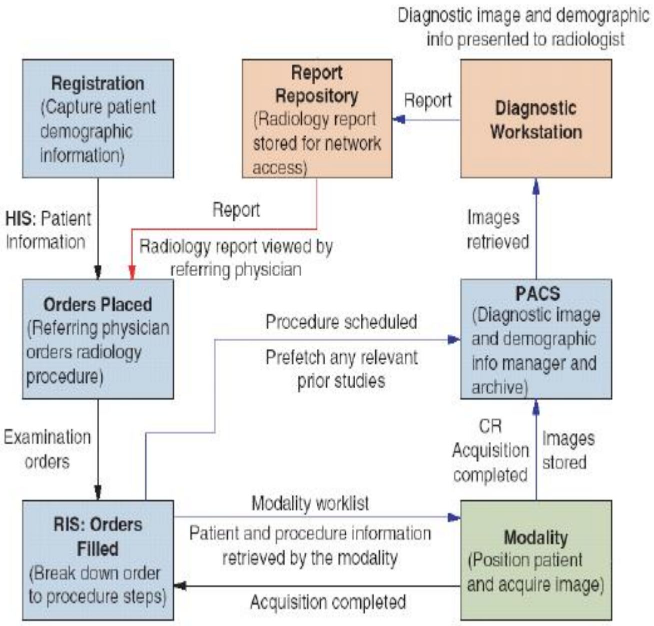

Fig. 4. Interoperability of HIS, RIS and PACS based system (Elisa MargarethSibarani, 2012)

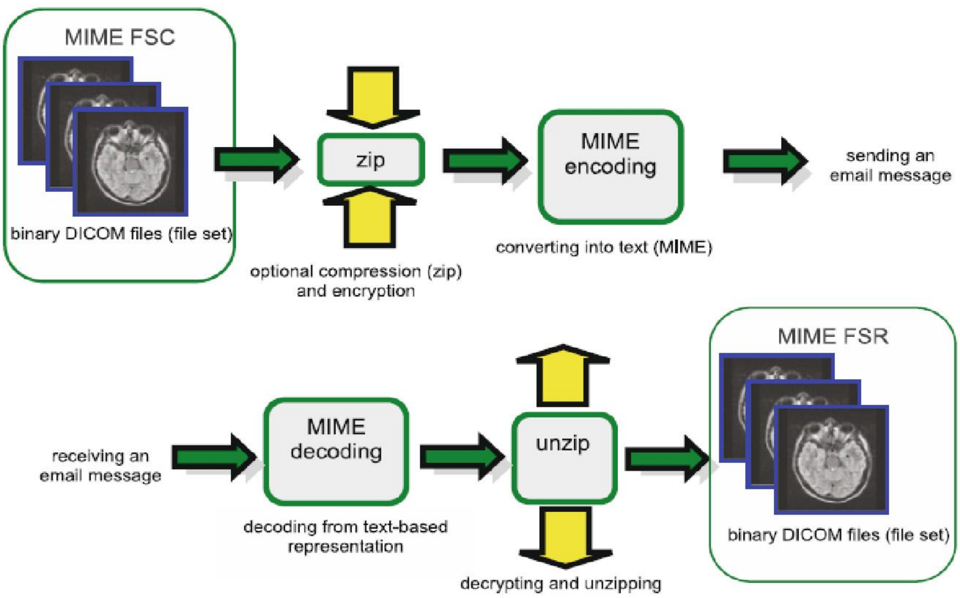

Fig. 5. Safe DICOM over email using MIME (Oleg S. Pianykh, 2008)

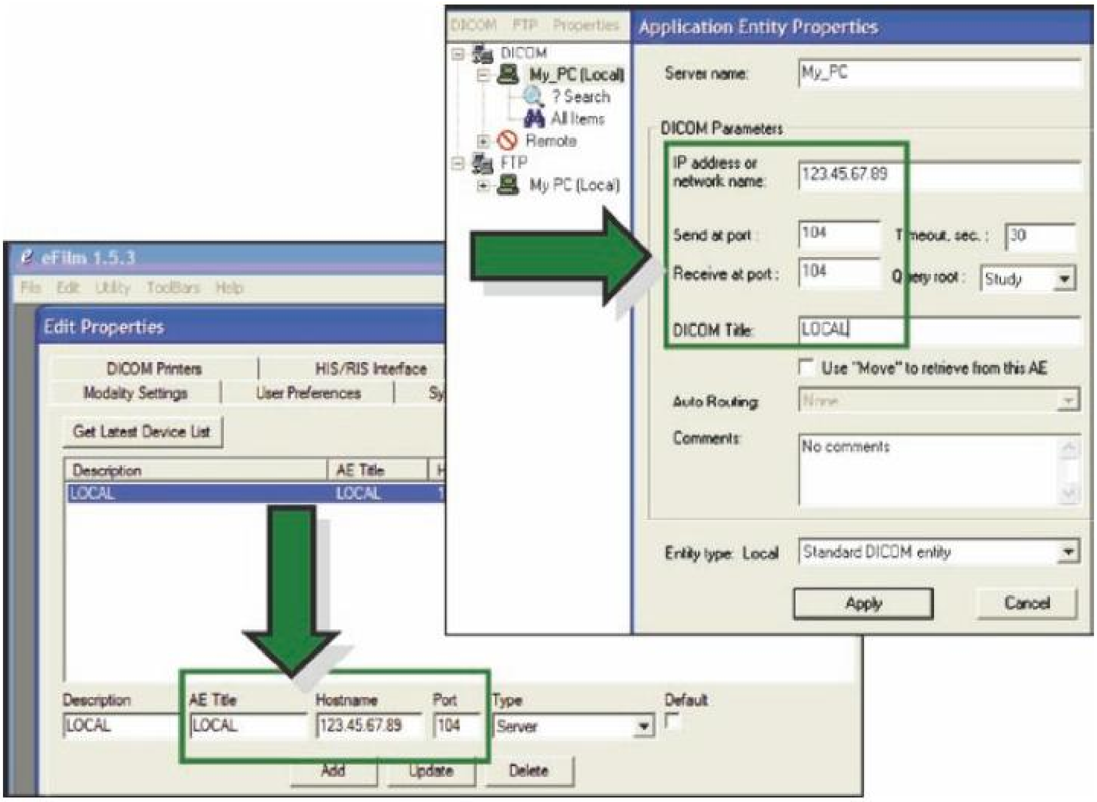

Fig. 6. Example of configuring the AE details for DICOM Connection (Oleg S. Pianykh, 2008)

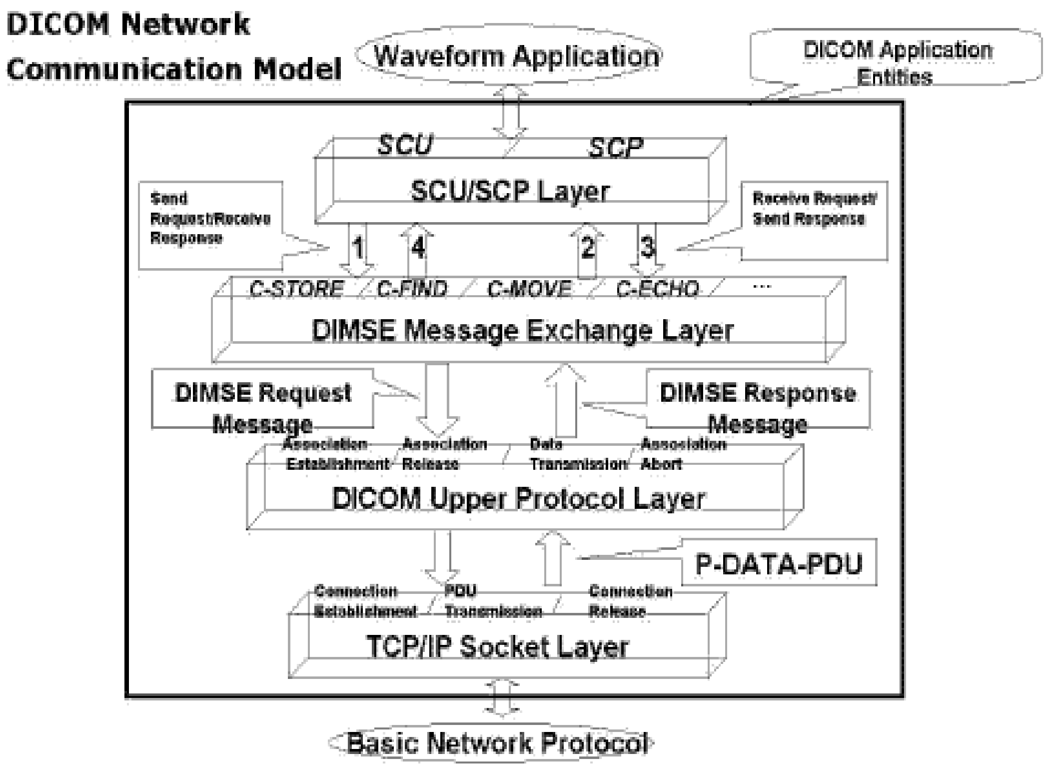

Fig. 7. DICOM network's communication model (Wei Xian Li *et al.*, 2007)

system of DICOM Application Entities and DICOM Application Model, we take this model (Fig 7). The SCP and the SCU has to work together for a successful data transfer between the service provider (CA1000) and the service user (IPU and the Hardware Automation PC). The association of the SCU and SCP is shown in the Fig. 8.

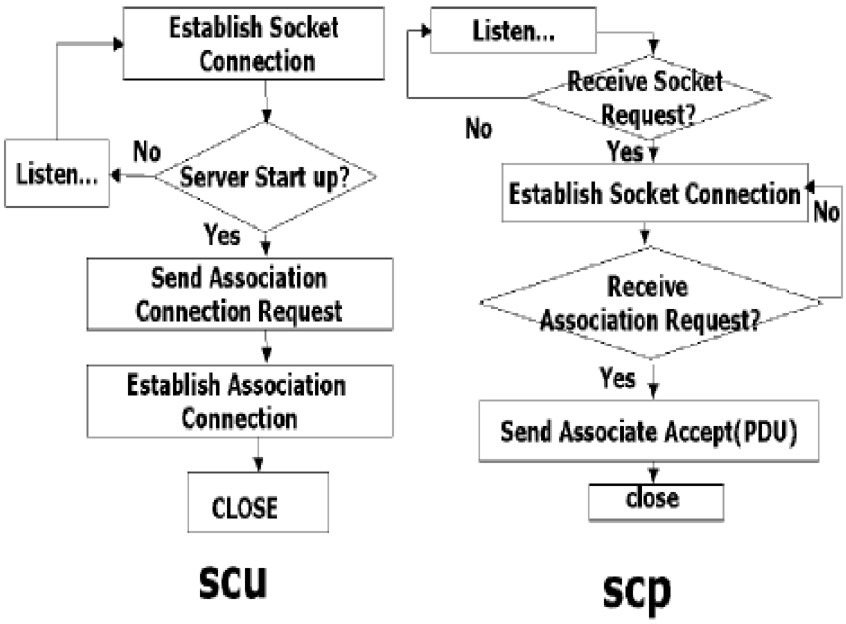

Fig. 8. Association of workflow of SCU and SCP (Wei Xian Li *et al.*, 2007)

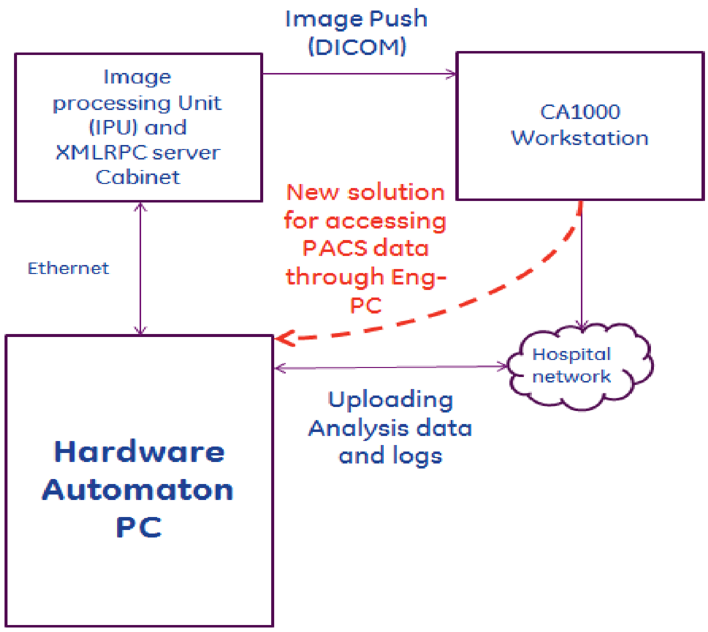

Fig. 9. Brief description of the new feature addition

The problem statement for the log collection from the CA1000 system is that, the IPU pushes the images to the CA1000 system using DICOM protocols. And there is SCP program running at the CA1000 end continuously so that the real time images could be transferred and stored in the CA1000 workstation, and the SCP program in the CA1000 has a special feature of log collection for analyzing whether the images have been successfully received and stored. The point to note is that the CA1000 is a common workstation for many cathlabs and hence many different systems will be accessing this system simultaneously hence there might be few delays or data losses. These logs are essential for the reliability analysis team for analyzing and solving the issues related to CA1000 communication. Hence, there is a need for the log collection from the Hardware Automation PC to automatically upload the logs from CA1000 to the Global hospital Networks. The solution is to Share the folder in the CA1000 workstation to the Hardware Automation PC, and add a new feature for the current automation program to copy the logs from the shared folder and to upload it to the hospital Network at the end of the cycling. The SMB protocol is used for sharing the folders in the CA1000 system to access from the Hardware Automation PC. The Server Message Block (SMB) Protocol is a network file sharing protocol, and as implemented in Microsoft Windows is known as Microsoft SMB Protocol. SMB is usually present in the application layer or the presentation layer, and uses the TCP/IP for supporting it in the lower layers. A TCL scripting program was written in the Hardware

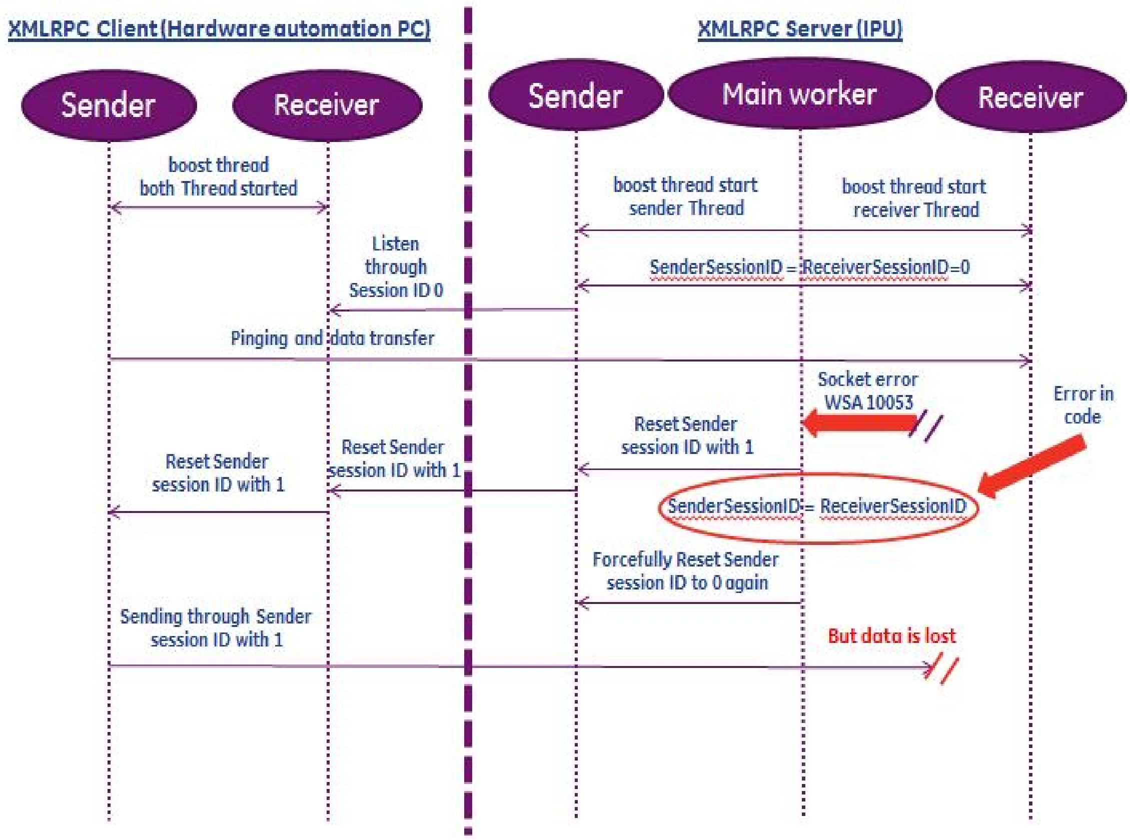

Fig. 10. Brief outlook of the XMLRPC connection problem

Automation PC to connect and to collect the information required to analyze the system. Since the CA1000 is a common workstation to store images from many systems at a time, hence the Hardware Automation PC had to collect only those logs and data related to the current system and in the current testing time, this also was kept in mind while designing. The other challenges faced here are: The CA1000 system should share the folder through a common username and password to all the Hardware Automation PCs connected to it, it's also better to globally login all the CA1000 system with a common ID, but it has again different drawbacks in security so a different method was adopted.

A new feature was also added to the Hardware Automation PC GUI for inputting the CA1000 option, since previously there is only one slot for putting either AE PC or CA1000 IP address at a time. And then add this new software feature in the Hardware Automation PC to collect the data from the CA1000 system and then upload them to the hospital network. This CA1000 connection is a new solution to access the data present the CA1000 system through the Hardware Automation PC and this can be further used for the Image data acquisition and other details acquisition and remote access and further can be used for fully automating the process of testing without any errors. This solution will help the reliability team to analyze the remote CA1000 PACS Workstation from any part of the world and provide the solution to any problem related to PACS and Image storage problems.

Performance Improvement of IGS System

There were few priority problems to be solved and most of them were successfully solved. To name a few, there was a problem with the Functional abort after 450 record frames, and there was also an issue with the selection of submenu 1 in the IGS systems. There were few other issues related to the excess CPU resource utilization which deprioritized few tasks and created a delay to the Hardware Automation program which caused the error. There was another issue with the XMLRPC server (IPU), this problem was analysed completely using UML sequence diagram to find the error flow. From the analysis it was found that the problem was with the XMLRPC server (IPU) sender part of the code (Fig 10). And then a proper plan was made to solve this problem. With few other major fixes integrated to the system, the performance and the reliability of the IGS system was improved.

RESULTS

The reliability and the Performance of the IGS Healthcare systems are improved with the new fixes found for some of the major priority problems of the system. And also a new feature is being added to the Hardware Automation PC to collect data and logs from the CA1000 workstation for the system reliability analysis. This new solution can also be used for collecting images and other important information through the Hardware Automation PC automatically for analysis.

Conclusion and future works

The new feature for logs and data collection from CA1000 is added to the Hardware Automation PC, and also the reliability and performance of the IGS system is improved. In the future the Hardware Automation PC could be made a completely automated device to control the complete system without any human interactions in between. Then the system can also be extended further for automation of other peripherals of IGS systems.

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