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The Effect of Wireless LAN-Based PACS Device for Portable Imaging Modalities

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The aim of this study was to develop wireless Picture Archiving and Communication System (PACS) device and to analyze its effect on image transfer from portable imaging modalities to the main PACS server. Using a laptop computer equipped with wireless local area network (LAN), the authors developed a wireless PACS device with DICOM modality worklist and DICOM storage server modules. This laptop computer could be easily fixed to portable imaging modalities such as ultrasound machines. From May to August 2007, 112 portable examinations were evaluated. Of these, 62 were done with wireless LAN-based PACS device, and 50 were done without wireless PACS device. To evaluate the impact of the wireless LAN-based PACS device on productivity and workflow, we analyzed the mean time delay and standard deviations (SD) both in cases where wireless LAN-based PACS device was used and in cases where it was not used. Statistical analysis was performed using a *t* test. The mean time interval from image acquisition to storage in the main PACS when the wireless LAN-based PACS device was used was 342.4 s (5 min and 42.4 s, SD = 509.2 s). When the wireless PACS was not used, the mean time interval was 2,305.5 s (38 min and 25.5 s, SD = 1,371.8 s). The mean time interval was statistically different between the two groups (*t* test, $p<0.001$). The wireless LAN-based PACS device could help in reducing the storage intervals of images obtained by portable machines and in promoting effective and rapid treatment of patients who have undergone portable imaging examinations.

KEY WORDS: Wireless LAN, portable modalities, productivity, workflow

INTRODUCTION

Many hospitals have adopted the Picture Archiving and Communication System (PACS) for effective handling of medical images. With the advent of PACS in a filmless hospital environment, there is an increasing demand for rapid or immediate access to patient images. In most hospitals, clinicians and radiologists can only retrieve relevant images and patient information via workstations with fixed locations using restricted local networks.[1]

Many hospitals now have access points for wireless communications. In the wireless local area network (LAN) environment, the need for interface between PACS and the wireless network has increased.

However, past studies have mainly focused on retrieving PACS images using the wireless network. If the wireless network is used in the transfer of images to PACS, it could help shorten the time interval for image transport.

The aim of this study was to develop a wireless PACS device for rapid delivery of DICOM modality worklist from the PACS server and images to the PACS server and to analyze its

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effect on image transfer from portable imaging modalities to the main PACS server.

MATERIALS AND METHODS

Wireless PACS Device

Using a laptop computer equipped with wireless LAN, the authors developed a wireless PACS device with programming language C# and Microsoft Visual Studio 2005. This laptop computer can be easily fixed to portable imaging modalities such as ultrasound machines. The protocol used in the wireless network was IEEE802.11b. We used static IP address for PACS device.

Figure 1 shows the components of the PACS device. The PACS device program was divided into three portions: server, client, and gateway. The server part included a Digital Imaging and Communications in Medicine (DICOM) Storage Service Class Provider (SCP), DICOM Modality Worklist SCP, DICOM Query/Retrieve SCP, Database, and Image Parser. The client part included a DICOM Storage Service Class User (SCU), DICOM Query/Retrieve SCU, and Image Viewer. The Gateway part included Storage Broker and Worklist Broker.

Figure 2 shows an image capture of DICOM Gateway, which is one of the Server Modules receiving the images generated from the portable modality. Figure 3 shows an image capture of viewer program.

Evaluation of Wireless PACS Device Efficacy

From May to August 2007, 112 portable ultrasound examinations were evaluated. Figure 4 shows the portable ultrasound machine equipped with PACS device. Of the examinations completed, 62 were done with the wireless LAN-based PACS device, and 50 were done without wireless mini PACS. To evaluate the impact of the wireless LAN-

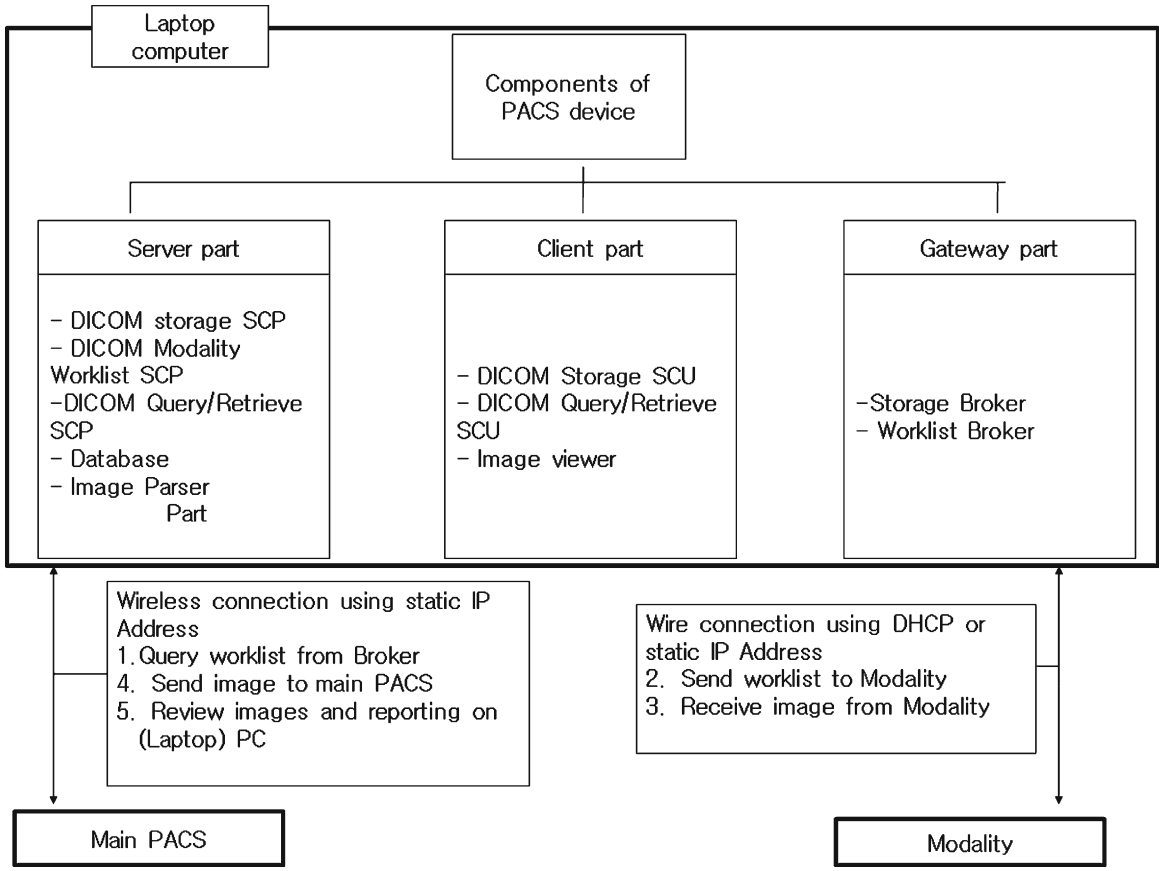

Fig 1. A schematic drawing of components of PACS device. The PACS device is composed of three portions: server, client, and gateway.

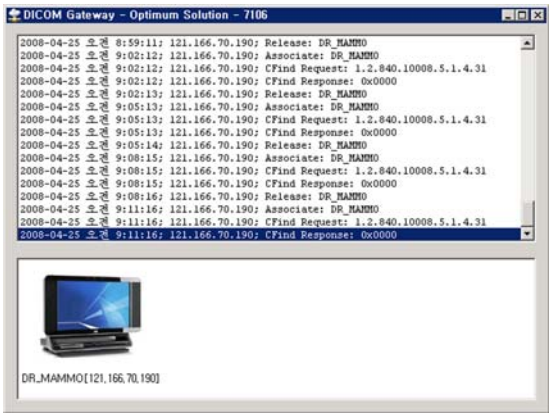

Fig 2. Image capture of DICOM gateway. It is one of the Server Modules receiving the images generated from the modality.

based PACS device on productivity and workflow, we measured the time interval between image acquisition by the portable imaging modality and storage in the main PACS. We analyzed the mean time delay and standard deviation (SD) in cases using wireless LAN-based PACS device versus those that did not use it. Statistical analysis was performed using a *t* test. Statistical significance was defined as $p<0.05$.

RESULTS

Figure 5 is a schematic drawing of workflow. Our PACS device acted as a Broker connecting the portable modality and the PACS main server, which it can do through wireless connection. The PACS device plays a role not only in retrieving worklist but also in storage of the images.

Figure 6 compares present workflow and workflow with the wireless PACS device. With the PACS device, the manual input of patient ID, order name, and accession numbers, which should be done before portable examinations, can be

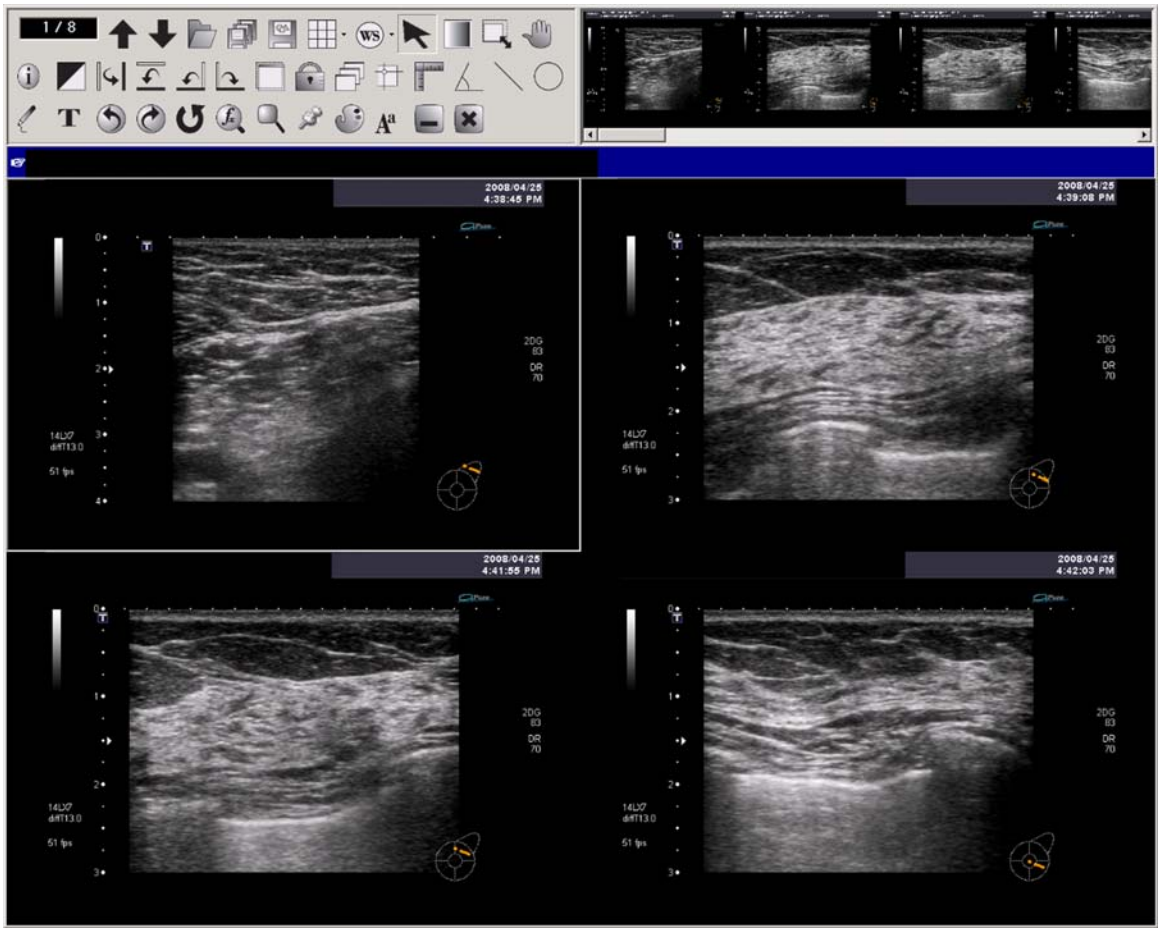

Fig 3. Image capture of image viewer program.

Fig 4. Portable ultrasound machine equipped with PACS device. The PACS device program is installed in a laptop computer fixed in portable ultrasound machine.

eliminated. In addition, because the images obtained from the portable imaging modalities can be transported immediately via wireless LAN, immediate interpretation by radiologists and clinicians is possible.

Table 1 and Figure 7 show the mean time interval from image acquisition to image storage in the main PACS server. The mean time interval when the wireless LAN-based PACS device was used was 342.4 s (5 min and 42.4 s, SD=509.2 s). When the wireless PACS was not used, the mean time interval was 2,305.5 s (38 min and 25.5 s, SD=1,371.8 s). The mean time interval was statistically different between the two groups (t test, $p<0.001$).

Discussion

It has been shown that mobile computing technologies can facilitate the communication of radiological exam results to requesting physicians in an urgent care setting.[2–4] According to the reports of Tellis and Andriole, the wet-read module was developed to provide access to wet-reads and radiology reports at the point of care using wireless devices. The expectation was that the physician's first encounter with the radiology

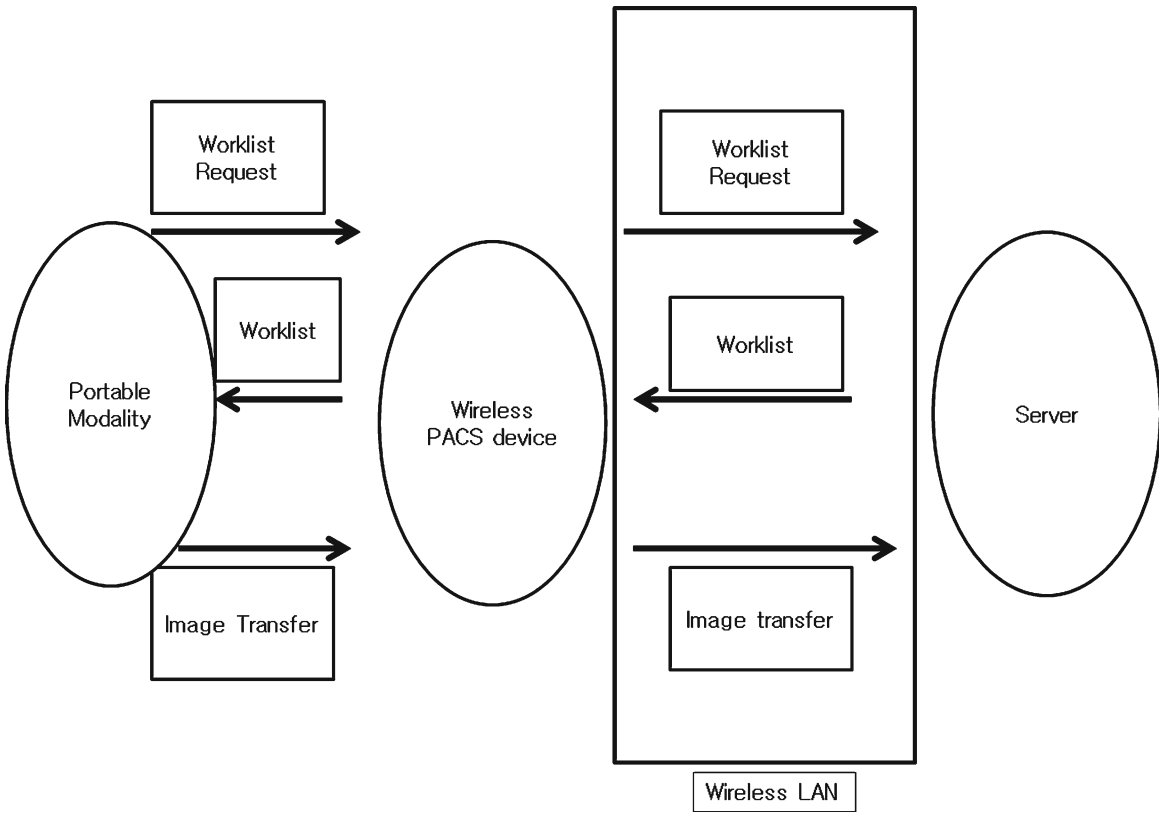

Fig 5. Schematic drawing of workflow with wireless PACS device. The PACS device can connect the portable modality and main PACS server using wireless connection.

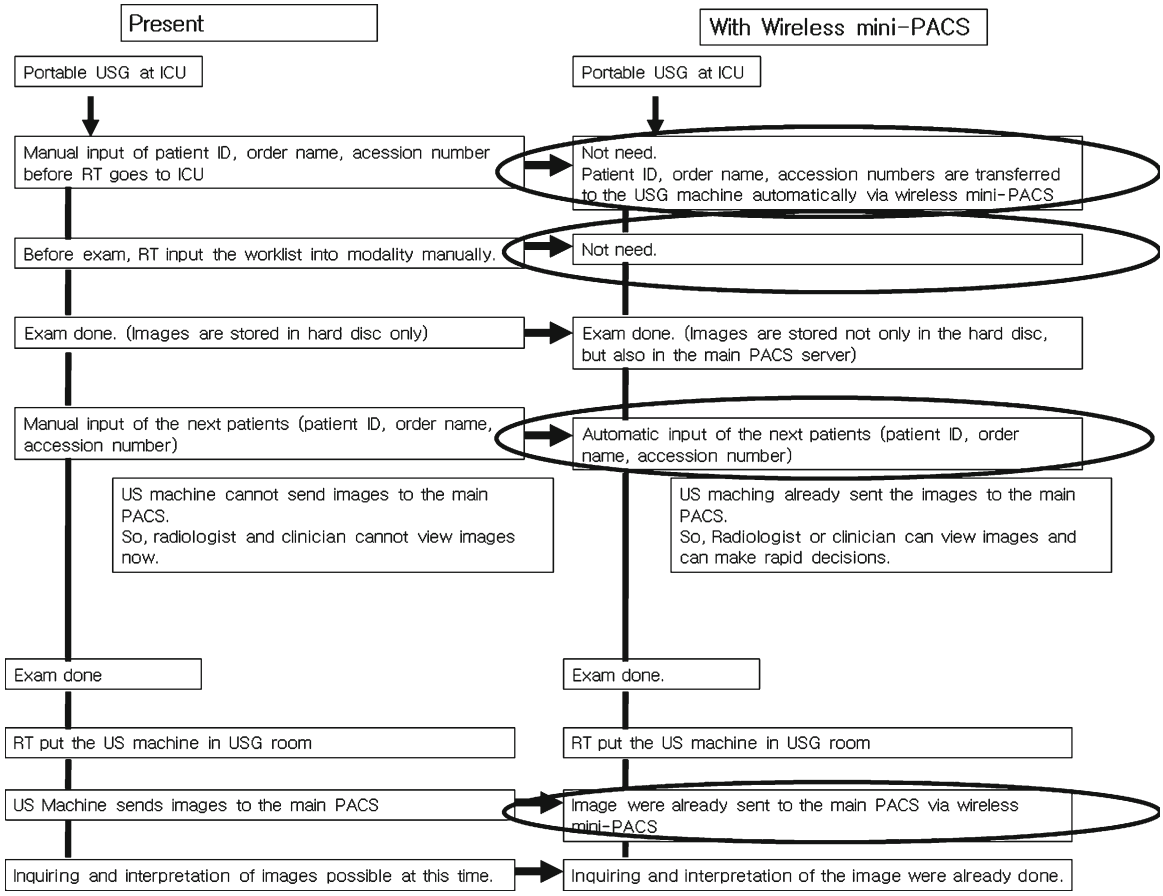

Fig 6. The comparison between present workflow and workflow with wireless PACS device. With the use of PACS device, many steps can be shortened.

results via portable devices would be faster than the traditional method.[5]

IEEE 802.11 wireless local area network (WLAN) has a greater coverage radius (up to 100 m) and supports higher data rates (up to 11 Mbps), making it more suitable for the transfer of large files such as images.[6] With the rapid development of information technology (IT) infra, WLAN is commonly used in the hospital. In the field of digital radiology, ubiquitous access to patient records and images using WLAN is becoming a functional necessity.[6]

Accessing PACS through a mobile phone network provides the advantages of mobility. Such

Table 1. Time Interval from the Image Acquisition to Image Storage in Main PACS Server

Time interval from image acquisition to image storage (s)	With wireless mini PACS	Without wireless mini PACS
Range	2–1,770	457–4,844
Mean	342.4	2,305.5
Standard deviation	509.2	1,317.8
p value	<0.001	

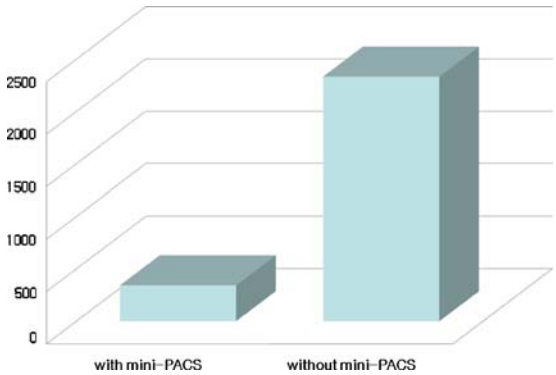

Fig 7. Graph showing the mean time interval from the image acquisition to image storage in main PACS. The time interval with wireless PACS device was 6.7 times faster than that without wireless PACS device.

a system may also allow patients to receive images and related reports through their mobile phones. The system enhances delivery of imaging and health care information. This mobile-phone-enhanced controller creates flexibility for clinicians by offering them a situation with nearly no restrictions in time or location. With this technology, clinicians and other healthcare professionals can remain in touch with medical images, image reports, and imaging workflow status both inside and outside the hospitals, without the need for designated computer platforms or facilities.[1]

Most studies have been focused on the retrieval of PACS images using a wireless network. If wireless networking were used to transfer images to the PACS, it could improve the transporting intervals. Portable imaging modalities, including portable ultrasonography and portable radiography systems, are delayed in sending images to the PACS server because they require a network connection for image transfer. This ultimately leads to delays in medical decision making related to patients in intensive care unit or emergency room.

The current study is meant to improve the workflow related to portable examinations by using wireless intra-hospital networks. We developed software including a DICOM modality worklist and DICOM storage server modules, which can be easily installed on laptop computers. PACS associated with wireless network and laptop computer, so called PACS device, is connected to a portable machine such as an ultrasound or radiography machine. The PACS device easily transfers the worklists for each examination to the portable machine using wireless communication. After or during portable examination, the images obtained from the portable modality are transferred to PACS device. The PACS device then sends the images to the main PACS server using a wireless network. So, the wireless PACS device can transfer the worklist from the server to the modality and transfer the images from the modality to the main PACS server regardless of the situation of the modality.

The current study showed that, with the use of PACS device, the time delay in transferring images to the main server is markedly reduced. We obtained 6.7 times faster image storage (5 min and 42.4 s with PACS device versus 38 min and 25.5 s without PACS device) when we used wireless PACS device.

There are many emergency cases in which a delay in image analysis is capable of delaying much needed clinical care. Clinicians and radiologists cannot access patient images obtained with portable modalities if the portable machines were not connected to the main server.

Sending PACS images on the enterprise wireless LAN would adversely impact other image applications due to network latency during the time of image data transfer. If the wireless PACS is used in whole hospital, there would be concerns about impacts to the other system.

Our system was developed to improve work throughput and efficiency. It will allow radiologists, physicians, and technicians to review current radiology images from portable modalities instantly.[7] Rapid display of radiological images on the client's screen is critical in the application of emergency teleradiology. Besides timely and fine-quality displays of radiological images, location limitations are also important in emergency teleconsultation, and our system allows for much flexibility in physician location.

CONCLUSIONS

The wireless LAN-based PACS device can help reduce the time interval required for image storage and transfer to the main PACS, especially when it comes to transfer and storage of images obtained by portable modalities. Our PACS device could help reduce the storage intervals of images obtained by portable machines and could be integral in the rapid assessment and treatment of emergent patients.

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