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Developing a Wireless DICOM for Osirix

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***Abstract*—This paper presents briefly the Digital Imaging and Communications in Medicine (DICOM) and its applications. Also, it describes the Osirix as freeware program available to the public which can use wireless network for sending the Osirix images. Finally, it recommends orthogonal frequency division multiplexing (OFDM) as a wireless network for sending medical images.**

I. Historical Overview

IN 1983, a joint committee formed by the National Electrical manufactures Association (NEMA) and the American College of Radiology (ACR) for developing a standard which will stop the monopoly made by particular device manufactures in digital medical imaging field. This committee is called digital imaging and communication standards. It started by reviewing majority of the existing standards at that time. [1]

In 1985, the first version of the standards was published. However, the first version contained errors and imperfections. For avoiding this problem, a separated subcommittees specialized in improving specific parts of the growing standard were created and called the working groups (WGs). [7]

In 1988, the standard second version was created. However, it has limitations in communicating medical data between devices. Moreover, it needs to have a variety of digital devices and their communication protocols. [7]

For avoiding the limitations mentioned previously, the third version was created in 1993, and it is called DICOM 3.0 or simply called DICOM. The most update editions can be found at the official DICOM website (http://medical.nema.org).

II. Introduction

Today more than ever, the healthcare industry is getting the benefits of the technological advancing in diagnostic medical imaging. DICOM is an abbreviation of Digital Imaging and Communications in Medicine, which is the most important standard in digital medical imaging. DICOM is not just an image or file format, but it includes data transfer, storage and protocols that control all the functions of the digital images. One important system that majority of DICOM companies made are called Picture Archiving and Communication systems (PACS). [7]

PACS are medical systems which consist of required hardware and software for handling digital medical images. It consists of digital image acquisition devices such as Computed Tomography (CT) scanners, digital image archives or storages and workstation for viewing digital images. PACS process starts with playing the camera for capturing the digital images. Then storing the digital images in the archives. Finally, the required digital images are sent to the right person for reviewing. [5], [7]

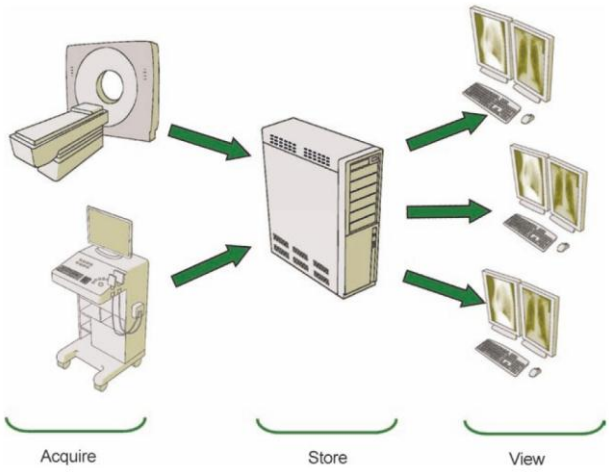

Fig. 1. Picture Archiving and Communication System (PACs) components.

III. DICOM

DICOM is an object oriented principle which is using data and services in medical field. Data is divided into two parts; text data and pixel data. While the text data includes information about the patient like his name and age, the pixel data contain one or multiple compressed or uncompressed pictures. These data is creating DCM files, which are DICOM file extension. [2]

The services in DICOM principles are related to handling DCM files in the networks. The two most important principles are called SCP and SCU. While SCP means the device which is listening or receiving, SCU is the device which is speaking or transmitting in the network. However, the device can be SCU, SCP or SCU/SCP. A good example of SCU/SCP is the DICOM gateway, which can send and receive the DCM files. [2]

Commands are other types of services for DICOM principles. Combining the commands like Get, Store, Find and Move is creating a DICOM session. There are four combinations for these commands.

1) Modality push: DCM files will be sent from Modality to PACS servers. In this case PACS server is SCP, Modality is SCU and the command is Store.

Fig. 2. Modality Push

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2) *PACS Push:* DCM files will be sent from PACS server to modality. In this case, modality is SCP, PACS server is SCU and DICOM command is Store.

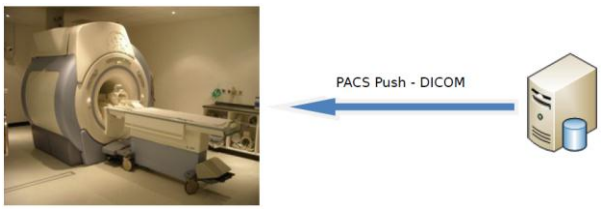


Fig. 3. PACS Push.

3) *Modality Pull:* Modality request DCM files from PACS server, PACS server acknowledge about existing sever. If the file found, it will tell modality about it and modality will request the DCM files. In this case PACS server is SCP, modality is SCU and command is C_Move.

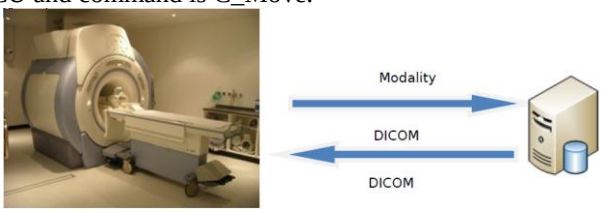


Fig. 4. Modality Pull

4) *PACS Pull:* The same case as modality pull, but PACS is requesting the data. In this case PACS server is SCU, modality is SCP and command is C_Move. [2]

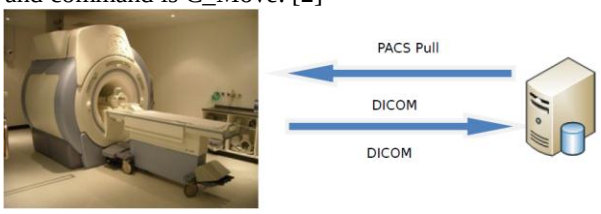


Fig. 5. PACS Pull

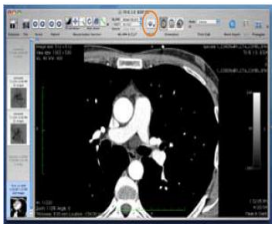
IV. Osirix Application

Osirix is an Apple Inc. freeware program which helps biomedical visualizers to visualize anatomical data sets and keep the information as a reference. [4]

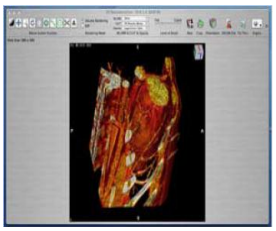
It has three main windows:

1) *Database windows for importing data sets.*
2) *Viewer windows for viewing and manipulating two dimensional (2D) data sets.*
3) *3D volume rendering for viewing and manipulating 3D data sets.*

(a)



(b)



(c)

Fig. 6. (a) Database window, (b) 2D Viewer window, (c) 3D Volume rendering.

A. Osirix File Format

Osirix can handle many file formats, such as DICOM, TIFF, JPEG, PDF, AVI, MPEG and QuickTime. Tagged Image File Format (.tiff) is storing image data in tags. It is a lossless compression, because it does not lose file data during compression. However, Joint Photographic Experts Group (.jpg) is a lossy compression since it may loss data if it saved many times. Portable Document Format (.pdf) is independent of hardware, software or operating system and it contain text and image. Audio Video Interleave (.avi) contains audio and video data. Moving Picture Experts Group (.mpeg) has audio, video and many compression formats. Finally, QuickTime (.mov) is a video, media, sound, text, animation and image interactive file format. All these file formats are imported and tested by Osirix and confirmed their computability. [6]

B. Exporting Images

Osirix can export the images in many different ways. DICOM images can be exported by using export tool in the application. When selecting Export under the main menu an option of selecting the type of QuickTime, jpg, raw, tiff, DICOM, Email and iphoto is appearing. Another way of exporting the image is by burning them into CDs by using burn tool. Also, the images can be exported and stored in an iPod and iPhone by using iPhoto option. [4]

C. Osirix HD

In the beginning of year 2011, Apple Inc. introduced Osirix HD. It can be run on iPad with a simple cost of $29.99. It can display modalities, such as ultrasound, CT, MRI or PET. Also, it can be connected to the PAC server for retrieve images through WiFi or 3G. [8]

D. Osirix Topology

Osirix network consists of central PACS server which store images database, and of multiple of clients that can retrieve and display the images on medical images software.

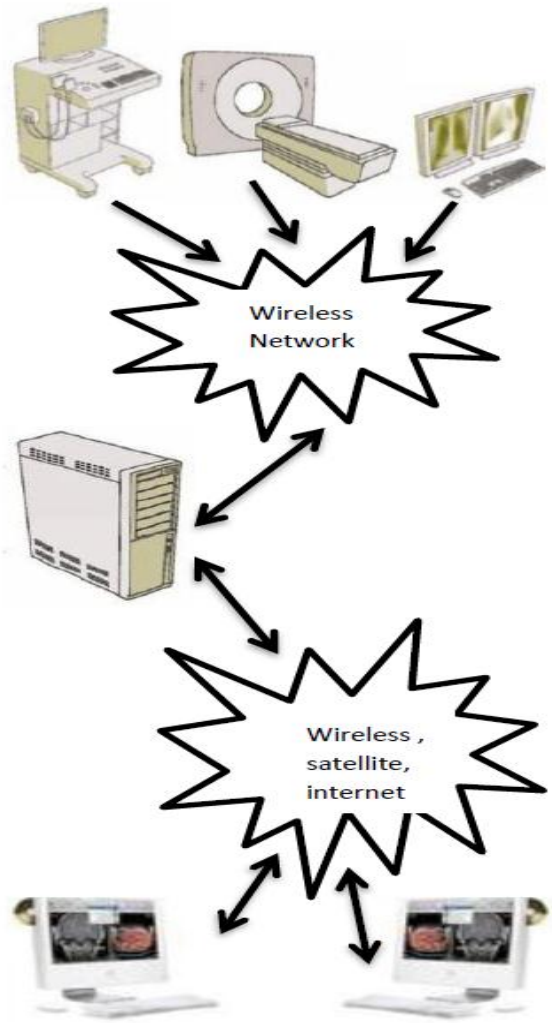


Fig. 7. Osirix Topology

Each computer in PACS network are identified by their network address (IP address), a communication port (TCP/IP port), and a name (AETitle). Each computer is a DICOM node in PACS network. [6]

V. WIRELESS CLINICAL ENVIRONMENT

30 years ago, health care facilities deployed some of the wireless networks, such as cardiac monitoring telemetry systems. Since the demand for electronic medical records increased, hospital settings started to look for suitable wireless devices. Wireless applications have many advantages if it compared with hardwired networks:

1) Mobility: Doctors can roam from one patient to another, while keeping connectivity to the central network.

2) Ease of Installation: installation time is less, because there will be no need to lay cable for each connection point.

3) *Scalability*: Wireless network is easier to expand and reconfigure comparing with hardwired networks.[10]

However, There are some factors that need to be considered whenever, wireless network is decided to be installed in health care applications. The most important two factors are security and reliability.[10]

Security is a very important issue and the patient health information is protected by law in many countries. One the data is transmitted through wireless network, it is much easier to intercept than physically connected into the hardwired networks. Therefore, data encryption is a must.[10]

Reliability is another important key issue due to the potential for interference. The interference come from wide variety of sources such as WIFI devices, military communication, microwave transmission. Therefore a complete survey should be part from any project planning process, in order to reduce the chance of conflicting signals. Moreover, whenever an additional wireless node are added to the existing network, caution should be exercised to ensure that new devices don't interfere with existing traffic.[10]

VI. OFDM

FDM is an abbreviation for Frequency Division Multiplexing, which is a technology for transmitting multiple signals simultaneously over a single transmission channel like a wireless system or a cable. Each signal that is modulated by the data (text, voice, video…etc) has its own unique carrier. Orthogonal Frequency Division Multiplexing (OFDM) is a technique that uses many spaced a part carriers with precise frequency and distributes data over them. This spaced a part feature provide the "orthogonality" which prevents the demodulators from detecting frequencies other than their own. OFDM has some advantages such as high spectral efficiency, resiliency to RF interference and lower multi-path distortion. [3]

A wireless communication where signal propagates on many paths can be best simulated by using OFDM. The receiver will detect a signal from both direct path and a path that bounce off building. Then the receiver will do the opposite process of the transmitter by separating the data into parallel streams. Next, the FFT will convert the parallel data streams into frequency domain data. The data is now presented in modulated form on the orthogonal signal. Then, demodulation converts this information back to the baseband. Finally, this parallel data back into a serial stream to get back the original signal. [3]

OFDM has several unique properties that make it suitable to handle the challenge conditions experienced by wireless data applications. Wireless local area network development continues to thrive for wireless point to point and point to multipoint configurations using OFDM technology. In addition to the IEEE 802.11 standard, IEEE 802.11a was published for allowing OFDM to use 5.8 GHZ band. [3].

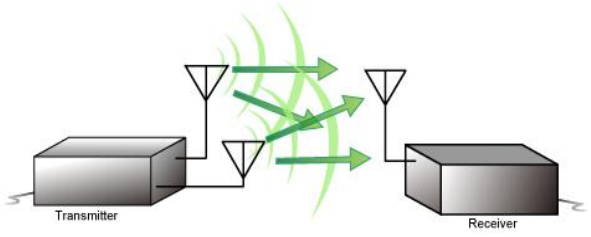


Fig. 8. OFDM

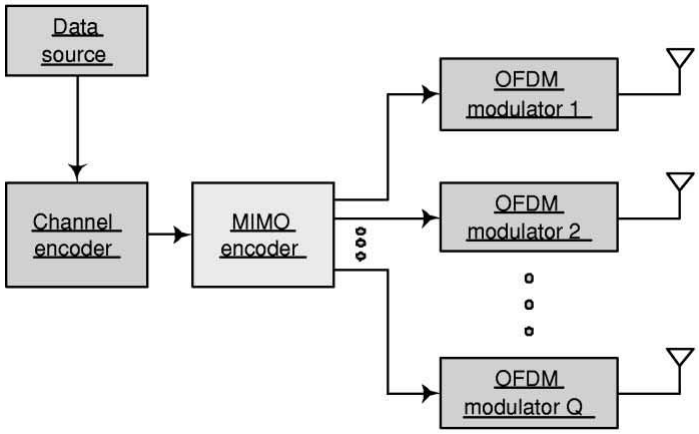
A. Orthogonality

In OFDM, the sub carrier frequencies are choosen so that the sub-channels will not interfere with each other. This will

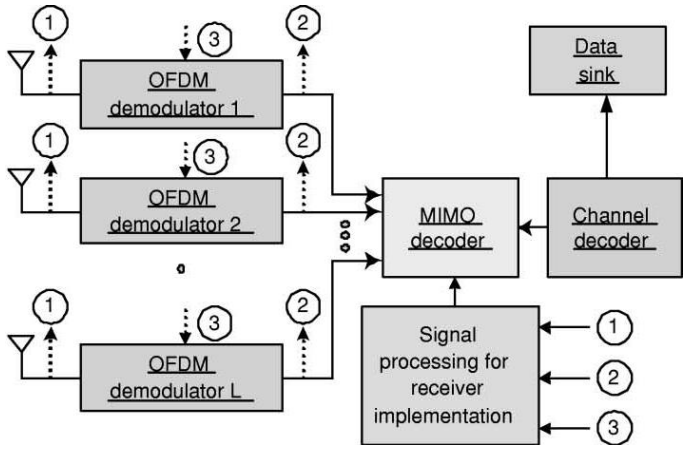
simplified the design of both the transmitter and the receiver, and a separate filter for each sub-channel will not be needed. Moreover, orthogonality gives a chance for using the entire available frequency band. Another benefit of orthogonality is its efficiency in implementing the modulator and demodulator, by using fast fourier transform (FFT) algorithm.[3]

B. Multiple-Input Multiple-Output (MIMO) OFDM

Nowadays, high data rate wireless systems which use multiple transmitters and receivers, i.e MIMO systems, become a hot topic. MIMO system takes the advantage of the spatial diversity, that is obtained by spatially separated antennas in a dense multipath scattering environment.[9]



(a)



(b)

Fig. 9. Q x L MIMO OFDM ; (a) Q number of inputs, (b) L number of output

There are many ways for implementing MIMO systems, such as implementing for diversity gain to compact signal fading or to obtain a capacity gain.

In general, there are three classes of MIMO techniques. The first one is to improve the power efficiency by maximizing spatial diversity. This technique has delay diversity such as space-time block code (STBC) and space-time trellis code (STTC). The second type is using layered approach to increase capacity. V-BLAST is a good example for this type. The third class utilize the knowledge of channel at the transmitter. It decomposed the channel coefficient matrix using singular value decomposition (SVD), and uses these decomposed unitary matrices as pre-filters and post-filters at the transmitter and the receiver to achieve the near capacity.[9]

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