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Professional article ■

Web Technology in Health Information System

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SUMMARY

The paper gives a concise review of the implementation of the web-based systems in teleradiology, radiological information system, hospital information system and in other modern medical information systems. The paper presents PACS (Picture Archiving and Communication System) and DICOM (Digital Imaging and Communications in Medicine) that have been domesticated in the vocabulary of radiological terminology and beyond. It points to the basic characteristics and objectives of PACS systems and DICOM standards, accentuating the needs for appliance of methods for digital signal processing and machine intelligence. It is concluded that assotiated medicine and information technologies lead to the progress of the mankind.

Key words: **web technology, radiology, medicine, PACS, DICOM, information system**

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INTRODUCTION

Web technologies are all technologies used to create web sites. With web technology, a number of technologies is integrated (1, 2).

With the development of Internet technologies and the simplified versions of programs for the development of web-sites it has become possible to develop a web-site without the help of professional companies dealing with it. However, in order for the sites to attract more visitors but also to leave a positive impression and in this way generate more profit, their creation should be left to the company which has projects that guarantee the quality.

The advantages of a professionally developed website are: optimized site for search engines, professional and unique design, implementation of support for existing standards, an intuitive user interface, increased robustness of the site, easy maintenance, time saving and support.

PACS is based on web technology (Picture Archiving and Communication System). PACS is directly connected with the DICOM (Digital Imaging and Communications in Medicine). Today, it is hard to imagine modern medicine without PACS and DICOM (1, 3-5).

The aim of this paper was to show the implementation of web-based systems in teleradiology, radiological information system, hospital information system and other modern medical information systems and to clarify what the PACS and DICOM are.

PACS (Picture Archiving and Communication System)

Picture Archiving and Communication System (PACS) is a modern system for archiving and communication. It is designed as a computer system for paper and film archive. It is based on the web technology. It manipulates with medical records and information. PACS provides archiving, viewing and distribution of medical images to radiologists, physicians of other specialties, doctors of other hospitals (1, 4, 5).

PACS is mostly used in radiology. PACS includes all the functions of teleradiological services and systems for archiving, browsing and viewing of medical records and patient data.

PACS makes it possible to access data from different locations inside one medical institution or outside it.

PACS can be integrated into the radiological information system, hospital information system or into some other medical information system. Owing to this integration, PACS provides communication with the hospital information system (HIS), radiological information system (RIS), departmental information system (OIS), medical information systems (MIS) and other information systems (IS). For example, PACS is integrated into the information systems of Military Medical Academy, Clinical Center of Serbia, Clinical Centre of Vojvodina, Clinical Center Niš, Pulmonary Hospital "Dr. Sava Savić" Zrenjanin, Institute in Niška Banja and other medical facilities in Serbia (6-11).

PACS Architecture

PACS is an integrated system (Figure 1) which consists of devices for medical diagnostics, servers, workstations, data access, a computer network that connects the system components, databases and interfaces to other systems.

The central computer (server) where the medical files are stored and operating units (modality) such as CT, MRI, ECHO, digital x-ray machine (which sends the processed data to the central computer) as well as other devices are networked in PACS.

PACS stores and saves images obtained from medical devices using the DICOM format.

First, the medical images taken by CT, MRI, ECHO, digital X-ray machines and others operational units are delivered to the personal computer modality. The DICOM Viewer protocol is in the modality that allows viewing of images. With the help of computer tools, the records are processed and sent to the central computer. In the central computer the DICOM C-Store protocol is located. With the help of DICOM C-Store protocol, the records are archived.

Central unit and operating computer units communicate through DICOM C-Store Query & Retrieve protocol. Each computer in a PACS network is identified by its network address. PACS requires hard drives with larger capacity, and modern monitors to display the images in better quality (Table 1) (1). For example, monitors with 3 megapixels are good for the interpretation of standard radiographs, and monitors with 5 megapixels are sufficient to interpret mammograms (1).

PACS system has six main components (Figure 2):

- Acquisition of Image (Image Acquisition) requires the existence of medical devices with the appropriate interface of PACS, such as CT (Computed Tomography), MRI (Magnetic Resonance Imaging), digital X-ray machine and other. These medical devices must be compatible with DICOM (Digital Imaging and Communication in Medicine) which is an international standard for defining the mode of transmission of medical information and images that provides interoperability between different devices. If the standard is not supported on medical devices, then there must be a device for converting medical images (gateway).

- The communication network transmits images and attached data e.g. name of the patient, date of birth, etc. Network structure has a crucial influence on the efficiency of the entire system. Indispensable network infrastructure of PACS system depends on the type of images that are used in this system.

- Patient Data - Hospital Information System HIS (Hospital Information System) and radiological information system RIS (Radiology Information System) must have the interface according to PACS system. The HL7 (Health Level Seven, 7th OSI layer protocol) is the standard that enables it.

- Display of images is done via personal computer in the office. The qualities of personal computers in the office are reflected in the monitor's physical characteristics (Table 1). There are low-resolution monitors (512x512 pixels) and high resolution monitors (about 1Kx1K pixels). Computers need to have an interactive user interface with possibility to adjust image contrast, zoom and move images and display data of the patient and others.

HL7 (Health Level Seven, 7th OSI layer protocol) is a standard for electronic exchange of information between medical applications in the seventh layer of the OSI model (3, 4). It is a protocol for exchanging data that defines the contents of the message that the application uses to process data exchange with other applications. HL7 specifies the data format and content, but does not specify how messages are transmitted through the network. For the transmission of messages the TCP /IP protocol is in use.

- Recording archival - A system for archiving recordings should be centralized, with support for DICOM and HL7 standards.

- Web server - application that resides on a Web server should provide adequate access and display of data to employees in medical institution and distant users.

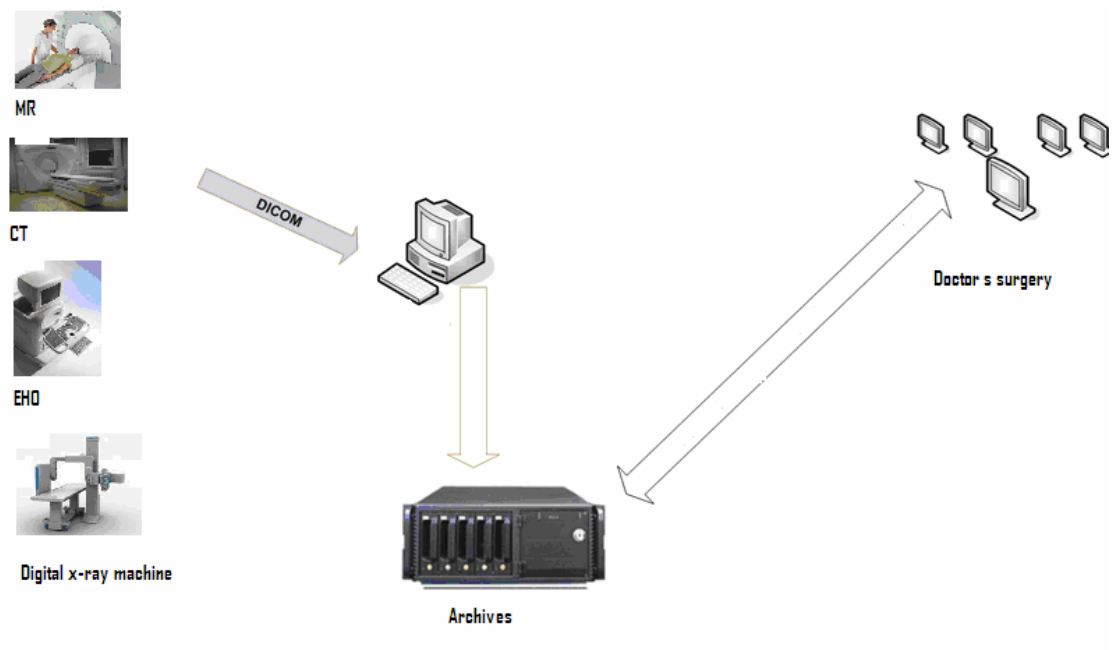

Figure 1. *PACS network*

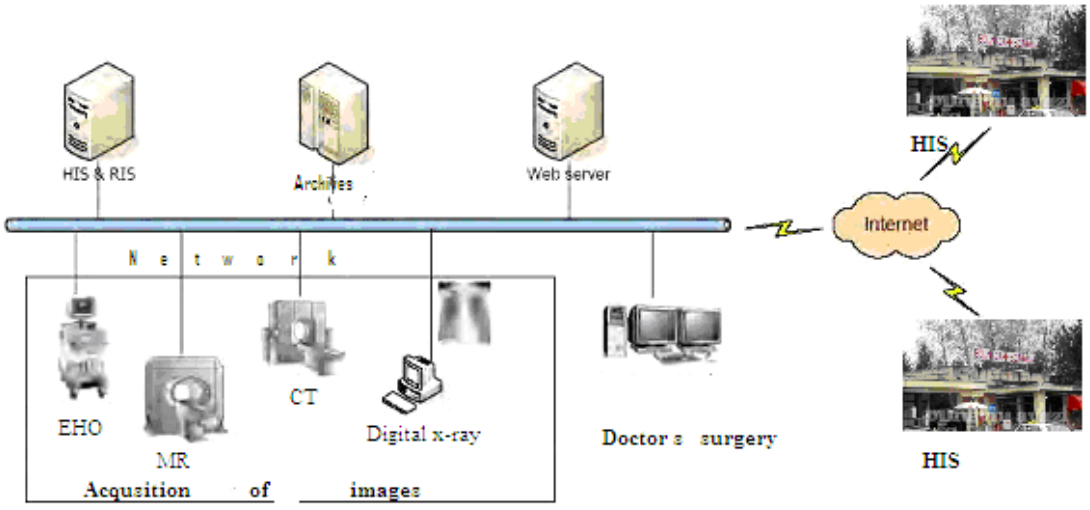

Figure 2*. PACS components*

Table 1. *The resolution and size of digital images (1)*

Modality	Resolution	Palette of colors	Size of uncompressed image
EHO	512x512	x8	256 KB
Digital x-ray machine	512x512	x8	256 KB
CT	512x512	x12	384 KB
MR	512x512	x12	384 KB
Digitalized (scanned) x-ray images	1024x1024	x12	1,8 MB
Digital radiography	1024x1024	x8	1 MB
Mammogram machine	4096x4096	x12	24 MB

The benefits of PACS implementation

Implementation of PACS is reflected in:

- saving space and time for archival of X-ray images, their search for educational purposes, because the x-ray records are stored on computer disks in electronic form;
- significant material saving - there is no need for buying X-ray films because x-ray images are moved on compact disks (CD) which price is lower;
- improved X-ray image quality and speed of diagnostic radiology;
- possibility to view images from remote locations;
- better utilization of human resources;
- possibility to networking computers of one or more health facilities;
- modernization of work;
- reduction in service costs and material consumption, etc.

DICOM (Digital Imaging and Communications in Medicine)

Digital Imaging and Communications in Medicine (DICOM) is a standard for handling, storing, printing and transmission of information in medicine (1, 4, 5).

DICOM is a set of rules that allows exchanging of medical images and information between computers and hospitals (Figure 3).

DICOM establishes a common language that enables the usage of images and information, which are made on one type of manufacturers' equipment, in digital systems of other manufacturers.

Figure 3 shows the DICOM developed by the Dutch company Philips (12), which designed DICOM to enable the data transfer, storage, and to include all functional aspects of medicine in the field of digital recordings.

It should be noted that DICOM is not only a file format; it is directly related to the PACS.

Today, it is hard to imagine modern medicine without DICOM and PACS.

DICOM consists of files, definition and network protocol communication.

DICOM Basic functions are:

- communication and sharing of digital medical images, regardless of the manufacturer;
- to enable PACS to become a part of hospital information system (HIS), radiological information system (RIS) and other information systems;
- to ensure that the database of medical images become available regardless of the browser distance (13).

DICOM - how does it work?

All data in the real world - the patients, studies, medical equipment, DICOM recognizes as objects with appropriate attributes. DICOM calls it IOD (Information Object Definition). Thus, the IOD is a set of information describing a data object. A patient IOD can be described by name, date of birth, weight, etc. In a broader sense, DICOM consists of a set of attributes (over 2000), known as the DICOM data dictionary. The DICOM attributes are formatted according to 27 data types - Value Representation (VR) corresponding to dates, times, names... DICOM data dictionary is necessary so that DICOM could ensure data consistency such as name, date of birth, weight of the patient etc.

When the new recordings are acquired they can be transmitted between different DICOM devices and Application Entities. This process of data "request" and "sharing" DICOM calls a service-rendering model. With this service-rendering model DICOM applications provide services to each other. DICOM calls these association

SOP (Service Object Pairs) and groups them into SOP classes. For example, storage of CT images from a digital CT scanner to a digital PACS archive corresponds to CT storage SOP as shown in Figure 4. In this example, the CT image represents DICOM IOD (DICOM data object). The CT scanner calls the storage service from the archive, and then the archive provides storage service to the scanner. The difference between service requestors and service providers is called Service Class Users (SCUs) and Service Class Provider (SCPs). In this example, the CT scanner is SCU and the digital archive represents a SCP server.

DICOM file contains a header which includes the patient name, record type, image size, etc., as well as information about the image. When it comes to compressing of images for easier and faster network transfer, it must be said that DICOM 3.0 contains the so-called JPEG which reduces the amount of information and accelerates the processing of image compression.

On the other side, on the user's side, the memory space, the space needed to store images is significantly reduced.

Each network data exchange between SCU and SCP is called the association. Each network data transfer begins with an association establishment - DICOM handshake, when the two applications exchange data. Because a lot of DICOM devices and applications are produced by different manufacturers it is important that each device be accompanied by its own DICOM conformance statement from the manufacturers. This statement explains which SOP services the device supports and to what extent (SCU or SCP or both services). The DICOM conformance statement represents the most essential instruction for any DICOM device. For example, if a hospital buys a digital archive that supports only CT storage SCU and does not support CT Storage SCP, the hospital will not be able to store CT images in it. The digital archive will not be able to provide CT storage service.

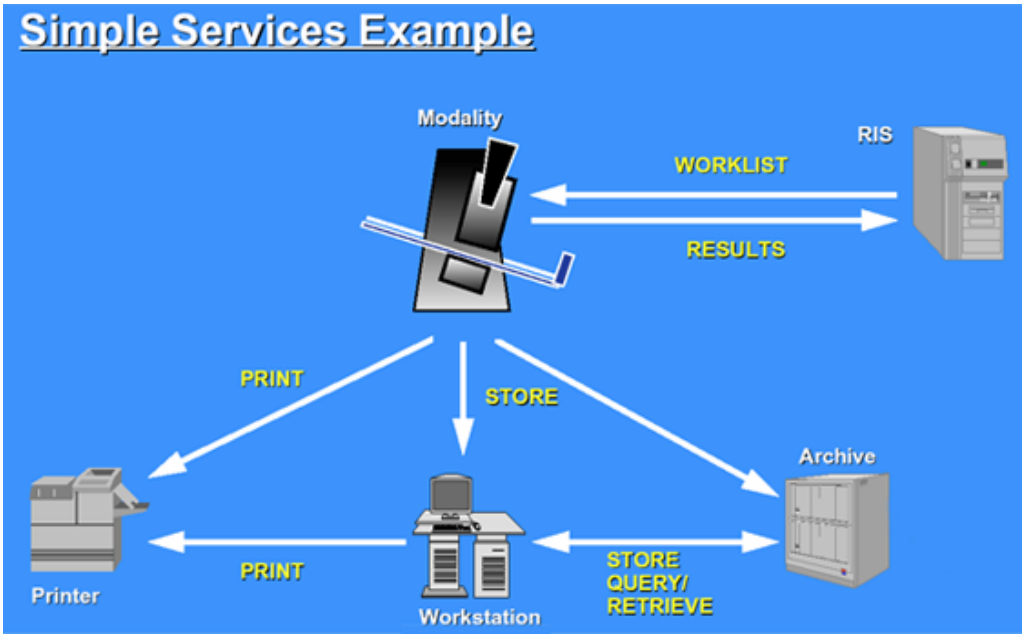

Figure 3. *DICOM (Digital Imaging and Communications in Medicine) was developed by the "Philips" company, (Netherlands) (12)*

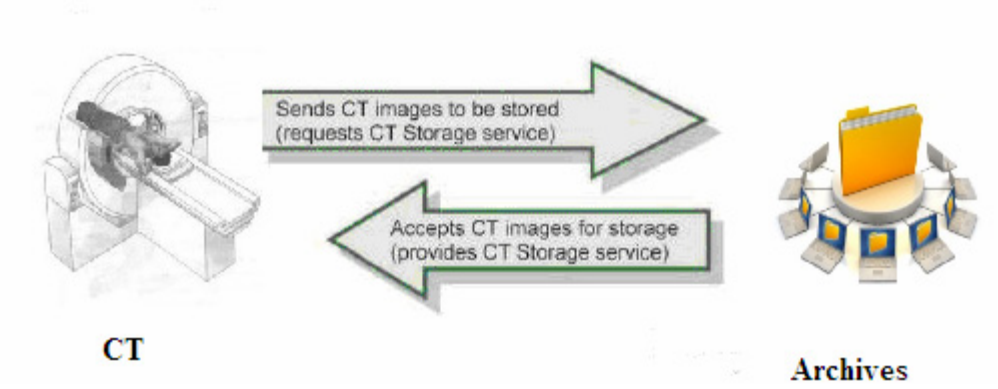

Figure 4. *The functioning of DICOM*

Disadvantages of DICOM

Disadvantages arise at:

- Searching the database and image processing;
- Simultaneous displaying of multiple images on the monitor, when the quality of individual images is decreased or certain segments are cut off;
- Appearance of false coloring that represents the process by which adjacent gray levels are falsely colored into contrasting colors, etc.

CONCLUSION

The basis for the introduction of new technologies in medicine is the digitalization of medical equipment. The appliance of web technologies have made that health services became available to everybody and have enabled the rapid and effective treatment and timely sharing of information, etc.

PACS systems are systems for images archiving and communication. PACS systems are based on web technologies. PACS is directly related to DICOM.

DICOM standard is a set of rules that provides exchanging of medical images and information between computers and hospitals.

PACS and DICOM are the components of any health information system.

It is hard to imagine modern medicine without PACS and DICOM.

The appliance of information and communication technologies have contributed to health services becoming available to everyone, enabled rapid and effective treatment, as well as the saving of funds for the purchase of x-ray film, storage saving, storing and searching for x-ray films etc. United and imbued, medicine and information technologies are leading to the progress of the mankind.

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WEB TEHNOLOGIJE U ZDRAVSTVENOM INFORMACIONOM SISTEMU

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Sažetak

U radu je dat koncizan prikaz implementacije web baziranih sistema u teleradiologiji, radiološkom informacionom sistemu, hospitalnom informacionom sistemu i drugim savremenim medicinskim informacionim sistemima. Prikazani su PACS (engleski: Picture Archiving and Communication System) i DICOM (engleski: Digital Imaging and Communications in Medicine) koji su se odomaćili u svakodnevnom rečniku radiološke terminologije, pa i šire. Ukazano je na osnovne karakteristike i ciljeve PACS sistema i DICOM standarda, sa posebnim akcentom na potrebe za primenu metoda digitalne obrade signala i mašinske inteligencije. Zaključuje se da sjedinjene i prožete, medicina i informacione tehnologije, vode napretku čovečanstva.

Ključne reči: **web tehnologije, radiologija, medicina, PACS, Dicom, informacioni sistem**