PACS Development in China and the Component PACS System*

Jie BAO, Jun GAO

Dept. of Computer and Information, Hefei University of Technology
(Hefei University of Technology, Hefei, Anhui, P.R. China, 230009)
imageinfolab_bob@263.net, jun_gao@mail.hf.ah.cn

Abstract: PACS is a system need for great investment and high technology, its development in China should give consideration to the national conditions of China. We propose the component PACS that rely on the component technology and can be developed synergicly, implement flexibly. We implement PACS by distributed component technology, use Internet browser to construct client-side, and design an open programming interface. Component PACS reduces the total cost in development and application.

Keywords PACS, Radiology Information System, DCOM

1. The Development of PACS in China

PACS (Picture Archiving and Communication System) is a system based on high-speed computer and network to connect various imaging devices and departments and store, manage, transmit and display medical images and their relevant information using high content magnetic and optical storage. It has advantages of high imaging quality, high fidelity in storage, transmission and copy, high-speed transmission and shareable database.

In fact, PACS is one kind of special Telemedical Information Systems (TIS)[1]. The appearance and development of PACS is impelled by telemedicine. "A new center of healthcare is emerging where the hospital, physician and the financial health plan are coming together in a single integrated organization. Information is the essential element that allows disparate entities to function as one highly integrated and coordinated virtual health organization. We believe as these health organization form, they will make substantial financial commitments in the years ahead to information systems and, at the same time, realize substantial economic benefits through the elimination of redundant medical services."(Illig, Cerner Inc., 1995).

The development of PACS was greatly accelerated by the development of high-content and low-cost optical storage media technology, network and the establishment of DICOM in recent years. Although the PACS did not developed in China until just a few years ago, its developing speed was striking quick.

During the past decade, hospitals in China have purchased many advanced imaging equipments, such as CT, MRI, PET, DSA and so on. For example[9], the Guangdong Province now owns more than 180 CT, 40 MRI, 70 NM, 40 PECT and SPECT, 90 ultrasound cardiograph, 200 Doppler ultrasound, 1400 B-ultrasound, 1100 fiber endoscope, 180 X-ray machine high than 800mA and 1600 X-ray machine below than 800mA. But because of the weak network basis and the restriction of traditional workflow in Chinese medical organizations, those imaging devices are used as detached islands while valuable digital image information is still outputted by original film printing with great inconvenience in storage and insufficiency in application. Integrated digital imaging system must be established to resolve those problems, to reform the original workflow and to enable the patent information including medical image can be managed and exchanged efficiently among medical organizations via electronic media.

The government of China has paid great attention for the informatization of medical industry and launched "Golden Health Project" at the national level. Along with the development of medical informatization, PACS had got great progress during the past two years. There are already more than hundred PACS developers in China and can be divided into following types:

A. Professional PACS software developer, medical imaging device manufacturer or software branch of big companies. Typical example for former is Balance Tech.(www.balance.com.cn) , and for latter is Langchao Guoqiang Software Co. Ltd. with "Medical Image System PACS".

B. Some system integration companies, especially network construction companies or system integration department in big companies, are cooperating with hospitals to construct RIS or PACS for given user. For example, the system integration department of Legend Company had cooperated with a hospital in Beijing to construct its PACS in 1999.

C.   Many small companies researched and produced various peripheral products for PACS, such as the assistant management software for specific medical department, such as X-ray, CT, MRI and endoscope, especially the video acquisition software and image archiving software. They are not PACS under strict criterion but still have part feature of PACS.

But there still no integrated and applicable PACS system having been approved by the Ministry of Health in China until now [15].

The understanding of PACS was also undergoing the process of deepening in the academic community. The main work from 1995 to 1998 is to introduce PACS[2]-[6]. Since the latter half of 1998, the academic community had summarized the experience in the practice of PACS[7]-[14]. *Computer World* had organized two issues of special subjects for PACS. During the "National Symposium of Computer and Radiology Management" sponsored by Journal of Radiology of China and Journal Of Medical Imaging in Yantai, Shandong, in July 1998, the PACS was a discuss focus. During the 9th annual conference of the Radiology Society of the Medicine Society of China, Prof. Liu Yuqing proposed: "the development of information science, electronics and computer brings PACS, telecommunication and network radiology into realty, it will be the main trend of the development of medical imaging in the next century." Many Companies are also taking part in the popularization and improvement of PACS. They provide a lot of technology information on their web site and compete each other with various designs. So PACS is a young but promising field in China both in theory and in practice.

2.   Some important issues in the construction of PACS in China

As PACS is a system required great investment and advanced technology, it need careful analysis and applicable planning. The construction of PACS in China should also pay attention to the specialty of China. There are some important issues:

1.   System inclusion

Traditionally, a large PACS should include at least following modules [1]: Medical Image Acquisition; vast volume data storage; image display and processing; database management; local or wide area network to transmit image and video. But a integrated work environment is required by the operation practice of imaging departments and a computer aided diagnosis and report system is also very necessary for medical imaging departments. According to the extant developing conditions of the PACS in China, an applicable PACS system may also include these subsystems: 1) Direct, friendly and attractive information navigation system; 2) computer aided report system for medical imaging diagnosis; 3) image analysis system or expert system for special disease; 4) intelligent assistant handbook for diagnosis.

A frequently asked question is: must a PACS have 3D image processing function? 3D image processing is used in medical image analysis while the PACS is mainly used in archiving and management, so they have quite different application aims. PACS should have simple function of 2D image processing at least to facilitate the display and search of images. Common PACS developer has great economic stress in developing 3D system because of the competition with international developer and high-performance 3D workstation. So 3D reconstruction visualization system and surgical operation locating system and path display system are not obligatory, but optional.

Another FAQ is that should every PACS have a DICOM3 interface? DICOM3 standard is the basis of PACS, but there are still many DICOM3-incompatible devices although the total number of DICOM3 device is increasing in recent years. Usually, DICOM are not required by the PACS system that connecting them. We should not think PACS is only suitable for machines compatible to DICOM. However, even when the DICOM interface is not used, the developer should still provide some modules that can communicate with DICOM to ensure the long-term investment validation. It's also very important to attach DICOM compatibility statement by Chinese.

In the practice, the task distribution between server and client should be well defined. The modules at the server include database management, medical image archiving, peripheral interfaces (such as HIS interface, Web interface) and the management of Web and SQL server; modules at the client-side will concentrate on preprocess, query, display and diagnosis.

2.   HIS interface

A complete PACS shouldn't be isolated form HIS. While the main hospitals in the developed countries had built their HIS as early as in 1980's, Chinese hospitals was also establishing their HIS in recent years. However, digital imaging technology was always a difficult problem in the information construction. Today, there still very few hospitals which can establish a applicable PACS (integrated medical imaging system) at the hospital level. This problem is due to the absence of integration of PACS to HID and other systems in certain extent.

The international standard of the PACS interface to HIS is HL7 (Health Level 7), a standard to specify the electronic data exchange in the medical environment, especially the communication between HIS (Hospital Information System) and RIS(radiology information system) including ADT(Admission /Registration、 Discharge、 Transfer), diagnosis record,

booking, operation arrangement and finance information. Most of HIS and RIS developed by foreign companies are compatible to HL7 standard so the PACS can communicate with HIS through DICOM/HL7 gateway. HISs produced by native developers (RIS is not popularized in China) have serious problems for their non-standard interfaces.

The integration of PACS with HIS is also depended on the development of Electronic Patient Record (EPR). Electronic Patient Record is a set of patient records based on special electronic and computer system, it enables the users accessing data, warning, advice and clinical decision support system. The register and report module in current PACS is actually a transitional method with the construction of a lot of redundant data when the integration of PACS with HIS has not been fully developed. The maturity of EPR will resolve this problem.

3. Department optimization

Image is very important to medical diagnosis and various departments can produce images. Although those departments are similar to each other in information management, each subsystem still has its own feature in imaging method, image feature, data precision, assistant information, diagnosis focus and diagnosis method[17]. It's necessary to optimize system performance to specific department. The key points are: optimization according to the feature of each imaging department while enable the interconnectivity and data sharing among subsystems; the modules having been optimized can own their independent user interface but still have uniform interface feature and database connection. Some common algorithm, such as image processing and annotation methods, can be reused among different modules while being modified according to the department feature, such as the bit number of a pixel.

Film scanning will be eliminated in several years. The scanning and archiving of X-ray film is a time-consuming and device-consuming work. A professional mono monitor or a scanner will cost several ten thousand RMB. Scanning time is very long and the scanned image size is very big. The requirement of computer and network is very high to ensure the medical value of those images. The developing trend is the digitization of image and network. With the price-reducing and popularization of DR, the archiving and communication of common X-ray imaging will have higher performance/cost ratio.

Video acquisition is still a very important department and cannot be abandoned immediately. A recent statistics indicates the common X-ray examination contributes 40% examination cases and 70% data volume in the whole medical imaging department. It's still necessary to improve the speed and quality of video acquisition[16][19].

4. Telecommunication

Although the traditional PACS has already included the image transmission by local or wide area network, most PACSs in current Chinese market didn't provide applicable telemedicine function. Besides, the rapid development of wide area network in recent years has provide a good platform, along with new requirement for the remote transmission of medical image. To transmit multimedia information (including not only image, but also text, video and voice) by the network efficiently and interactively, the network interface of PACS should be strengthened.

Further more, system should provide distributed database service to enable remote terminals could access acquired or stored data real-timely as local terminals. While the Client/Server(C/S) architecture can be adopted for medium-sized and small PACS during the initial stages in design, it is impossible to require every client-side terminal to buy a copy of client-side software for the Internet application. A reasonable solution to this problem is distributed application architecture based on Internet, such as DNA (Distributed Internet Applications Architecture) or CORBA, which is advantageous to the distributed processing of transaction, the concentrated maintenance of software codes and the integration with HIS.

5. Flexible implement

It's unpractical to implement PACS in one stage, as PACS is a system engineering required great investment of technology, fund, management and human resources in practice. Further more, the demands of different hospitals are not same, not only between center hospitals and local hospitals, but also among same-level hospitals because of different conditions on device, management and finance. An applicable PACS design should can be implemented flexibly in that:

    A. Implement by stages. System could be constructed by stages and transition between stages should be ease and smooth.

    B. Developing cooperatively. Because of the hugeness of a large-scale PACS, the system design should enable cooperative developing by many groups and companies independently.

    C. Customizing by user. Some components should can be added or removed according to the demand of user with no serious affection to the normal work of other functional modules.

The PACS developers in China have to face hot market competition with local and international rivals, especially after the entrance of China to WTO. It's very disadvantageous for vulnerable PACS developers of China. So the PACS developer

in China must understand the particularity of Chinese PACS market and take native advantage to survive and then defeat foreign rivals in market competition, following the success of Chinese in the field of financial software.

Therefore, in addition to those important problems, we should also pay attention to following specialties in the construction of PACS in China:

1. Great pressure from foreign PACS developers. Foreign PACSs have some serious weakness, such as the Chinese interface. The subsystems of register, statistics and report also need strong Chinese feature. Another important factor is the price. A possible result may be the high side of the market for management will be occupied by foreign products while the low side of market for device connection will still be occupied by Chinese products.

2. Limited investment and high demand for effect and speed. Almost all projects are implemented by stages because the hospitals have no enough fund to construct it in one stage and there will be great waste if constructing the system in stages while no adequate application demand. So the design of PACS should be flexible and economical.

3. Even when the PACS had been completed, it may not be utilized efficiently because the hospital stuffs are used to traditional work custom and workflow. So the after-sale service and customer support and training are very important problems.

4. The traditional management system of Chinese hospitals is different greatly to that of foreign hospitals in that the administrative stuffs are highly regarded in that system. The reformation of this system will take a lot of time. PACS developed by foreign companies cannot be fully adapted to this system. While Chinese companies can take advantage of national predominance, they should also acclimatize to, even impel the medical system reformation actively.

3. Component PACS Orienting to the Internet

In a word, PACS and its peripheral assistant subsystems compose a large group of software and are involved with a lot of advanced technology. So the cost of PACS is very high. A medium-sized PACS in the international market usually will cost more than one million US Dollars. If we take the requirement of Computer Aided Treatment and tele-treatment into account, the development will be prohibitive high. Traditional developing method require the system be developed by a single developer with long developing period and high investment. It's not suitable to the national speciality of China.

To resolve this problem, we put forward the concept of *Component PACS Orienting to the Internet*[17][18] and emphasize on following issues:
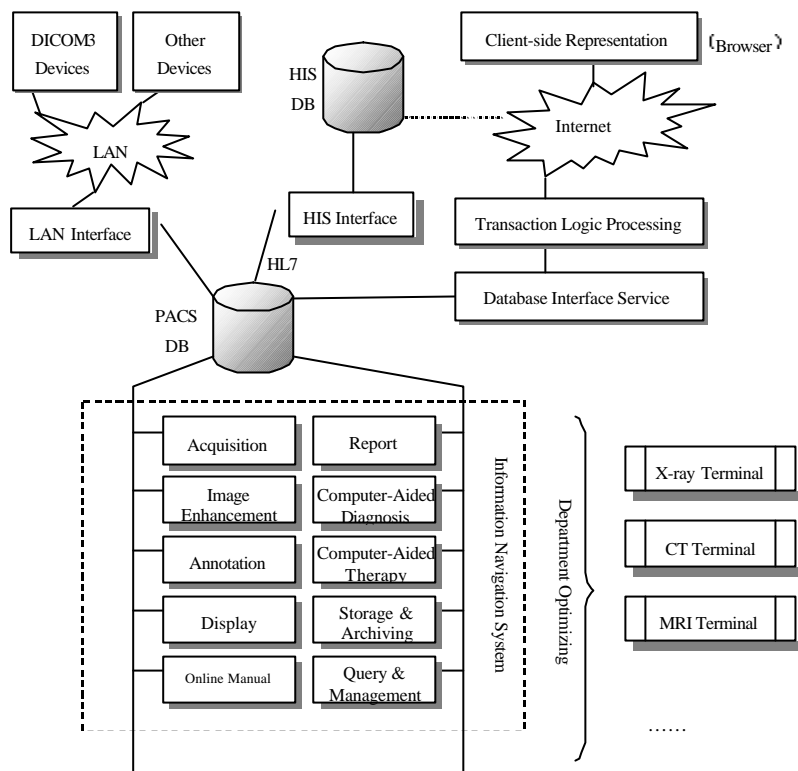
Fig1　System Structrue

- Design different user interface for different imaging department at interface level and integrate them by uniform interface to the common parts of PACS;
- Design and implement system function by DCOM technology at functional level.
- Using distributed database system design orienting to Internet, such as the DNA architecture of Microsoft;
- Open Structure, enabling and client and third part enhance some functions through programming interface.

According to those philosophy, we propose the component PACS as shown in the Fig 1. Every module in this system is implemented by one or several components.

4.　Conclusions

PACS has already achieved some progress in China but is still not full-develop. Because of the specialty of the medical system of China, the development of PACS in China must take the national conditions of China into account.

Component PACS Orienting to the Internet is a solution suitable to national conditions of China. Its primary innovations are: implement PACS with distributed components; implement client-side using Internet browser; open programming interface. It meets the requirements of system inclusion, HIS interface, department optimization, telecommunication, and flexible implement very well.

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