Medical Image Transmission on Low-Speed Networks

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AT PRESENT, teleradiology and picture archiving and communication system (PACS) technology is widely used to save physicians' time for reviewing images and to reduce the cost of radiology services. When joined with medical image analysis algorithms, teleradiology could help to improve the quality of diagnosis. The implementation of these techniques is made mostly based on expensive workstations and high-speed computer networks. Nevertheless, additional issues should be considered when the transmission occurs through low-speed networks and low-cost computers are the only available media.

The topics applied in the design and development of a transmission layer to be used in a medical image transmission system are presented here. Several characteristics of the Cuban Health System are taken into account. The hospitals are not connected to the Internet using high-speed links, and in most cases they use nondedicated lines just for receiving electronic mail.

TELERADIOLOGY IN CUBA

Teleradiology is being introduced into the Cuban Health System as a new technology for medical image diagnosis and to extend radiological services outside medical institutions with image technology. Images are generated using modern medical equipment controlled by computers, which are connected to the Internet mostly through modems over low-speed telephone lines. Several hospitals could use the same medical image facility, referring patients to that location and receiving back the resulting images. Low-cost PCs and low-speed modem connections in the referring hospitals are the technology available to receive the images and to visualize them. In some cases, the hospital referring a patient does not have an Internet connection and only electronic mail is available to receive information. Due to the low-speed bandwidth, transmission of large amounts of data should be avoided.

To overcome these limitations, a system is under development in the Biophysics and Medical Physics Center at the University of Oriente in Santiago de Cuba. Several modules outlined in the Fig 1 compose the system.

The system is being developed using Microsoft Visual C++ 6.0 and is programmed to run in an IBM compatible PC using Microsoft Windows 9x/NT as the operating system.

THE TRANSMISSION LAYER

The design of this layer should assure that images arrive at the site where the physicians are located, independently of the kind of connection they have. To achieve this objective, several communication protocols were implemented. Digital Imaging and Communications in Medicine (DICOM) storage and query/retrieve was used for network connections with good bandwidth; SMTP and POP3 protocols were used to support transmission of images to sites with only electronic mail capability; and HTML is used to exchange study reports. Use of the proper protocol is a matter of selecting the suitable target address; everything else happens transparently to the user.

A study report consists of images and comments inserted into an HTML page. An Internet browser is available as part of the interface to visualize reports and users can also navigate through Internet resources. Several templates for reports are offered by default. HTML reports could be published on web servers, if available, and E-mail messages containing the HTML report are used when electronic mail is the only choice for sending information.

If an on-line connection is available between several hosts using the system, a debate can be established through a chat. Users can exchange images during the chat, as well as comments about the images, and any modification is shown to every participant.

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Fig 1. Modules that compose the system.

DICOM storage and query/retrieve services are implemented using Mallinckrodt CTN public library. When electronic mail is the available transport of information, DICOM objects and commands are encapsulated in mail messages. It is supposed that a similar system at the other side interprets this kind of message, performs the actions to a configured DICOM server, and responds with the resulting images using E-mail. This way a user without Internet access could query remote PACS in a similar fashion to web mail servers available on the Internet.

If a message has a large amount of data, images are compressed and a mechanism for splitting the message is used. After splitting, the parts of the message that have been sent or received are precisely controlled. Standard file formats such as JPEG and PNG are used for compression of

images. Software available publicly on the Internet is used to implement these algorithms, including lossy and lossless versions.

A multithreading scheme is used to control different tasks in the transmission layer. Input and output of mail messages, DICOM storage, query/retrieve, and compression of information are scheduled concurrently. The proper synchronization is guaranteed using operating system mechanisms.

RESULTS

This transmission layer has been integrated in a system that is introduced in several hospitals of the eastern region of Cuba. At the same time it is being used as a PACS in the radiology departments. It has been accepted as a good choice for hospitals with low-speed connections to the Internet or just electronic mail access.

Through the implementation of several protocols in the transmission layer, users connected to the Internet by different forms can communicate. The transmission layer has proved its proficiency and is useful for implementing automatic selective distribution of information. Low-cost PCs have been used at the hospitals with good performance rating.

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