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Clinical Applications of an ATM/Ethernet Network in Departments of Neuroradiology and Radiotherapy

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Abstract. An integrated system for the multimedia management of images and clinical information has been developed at the Istituto Nazionale Neurologico C. Besta in Milan. The Institute physicians have the daily need of consulting images coming from various modalities . The high volume of archived material and the need of retrieving and displaying new and past images and clinical information has motivated the development of a Picture Archiving and Communication System (PACS) for the automatic management of images and clinical data , related not only to the Radiology Department, but also to the Radiotherapy Department for 3D virtual simulation, to remote teleconsulting, and in the following to all the wards, ambulatories and labs.

1. Introduction

The main features of the system we are going to describe are the optimization of the data access through the use of advanced network technologies, the effective management of the images archive and its architecture suitable for future enhancements and for new images generation modalities.

The system supports also image processing (for example 3D simulation) , integration with data management and reporting system (Radiology Information System, RIS), connection to remote systems, and integrability with the administration and clinical management procedures, in particular with the ward clinical chart.

2. Communication Network

While at a software level the TCP/IP protocol has been adopted, at a physical level three subnetworks have been developed, based on different technologies: multimodal optical fiber for the subnet connecting visualization workstations and archiving system, coaxial cable for the diagnostic services subnetwork (due to pre-existing constraints).

These two subnetworks are connected with the Radiology Information System through a bridge, where UTP twisted pair wire has been used.

The network works as a combination between ATM (Asynchronous Transfer Mode) at 155 Mbit/sec and Ethernet (IEEE 802.3) 10Base2 and 10BaseT [1].

An ATM switch with up to 16 ports (CISCO Hyperswitch 100) is dimensioned to be sufficient also for the future connections to the other hospital's departments. Such links will be realized connecting an ATM branch to the wards' PCs through ATM/Ethernet switches that guarantee a dedicated 10MB/sec connection to each Personal Computer.

3. Image management system

In order to be included into the daily hospital routine an image archive must supply adequate memory storage and access time, holding in line thousands of images (coming from 2 CT, 1 spiral CT for radiotherapy , 2 MRI, 1 Digital Subtraction Angiography, 1 Digital RX equipment) and ensuring very short time for the image retrieval.

The adopted architecture (HP-SECTRA IMS-2000) consists of two archives: a fast-access one, where recent images are stored, and a secondary one, at a slower access, for the final archiving.

The secondary archive is shared by more visualization stations, and its memory storage is based on an about 200 Gbyte juke-box for WORM optical disks.

The image archiving application is based on international standards (DICOM3 Query, Retrieve, Storage and Print Service Classes) to ensure future developments and integrations.

The visualization package allows the displaying and the processing of clinical images through the X-Windows interface: It is possible to select various image processing functions: size modification, gray scale, zoom, rotation, contour segmentation.

The adopted configuration has been the following:

- image processing server: HP9000 725/100 with 144 MB RAM, 4 GB HD for the primary archive Fast Wide connection (20 MB/sec), Back-up unit DDS 4 GB, Unix operative system and 187 GB juke-box for the secondary archive.
- visualization workstations: 4 HP9000 715/64 UNIX o.s., with 32 MB RAM and 1 GB HD in disk array, 17" high resolution monitor.
- information management system: PC HP Netserver LH5/100 with 32 MB RAM and 3 GB HD in disk array, o.s. Windows NT Server 3.51.

Moreover, the system is completed by two Silicon Graphics worstations, one devoted to treatment planning and one to virtual simulation tasks.

The PACS system acquires images from three workstation devoted to collect images from three acquisition, visualization and processing workstations based on Sun 5 Sparcstation with 128 MB RAM and 8 GB HD, and it is interfaced to an Laser Printer also connected to the network.

A schema of the current communication network [2] is described in fig. 1.

4. The Radiology Information System

RIS is a multimedia information system which manages the data coming from the radiology dept and integrates it with the related images.

The package allows operators having different permission levels to access the patients' admission procedure, the image processing, the patients' reporting, the statistics management.

The system is made up by a Windows NT server and many PC stations endowed with the immediate GUI interface of the Access database.

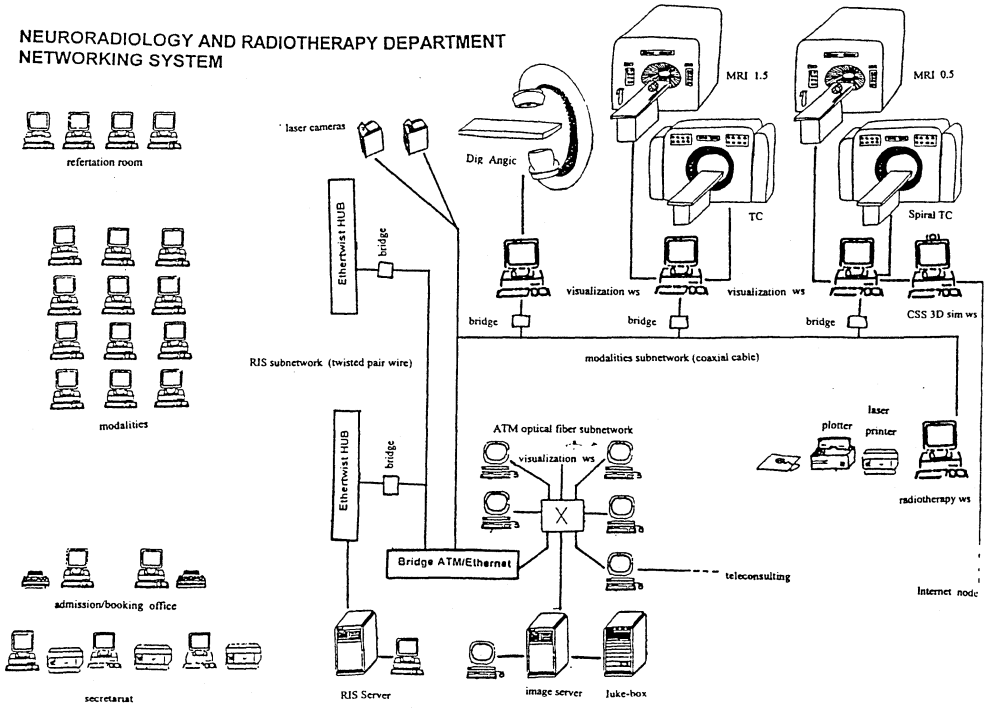

fig. 1

The patients' admission can be made both by the Admission office and by the modality operator, and the information is introduced using predefined and customized tables.

A booking table exists that for each modality looks automatically for the first free date, depending on its execution time.

When images are acquired, they are sent to the PACS system for the optical archiving.

5. Integration between PACS and Radiology Information System

The integration between images coming from the image server and the patient's information coming from the RIS system is the key of the real integration of the whole system into the daily clinical routine [3].

The integration has been realized using the Application Program Interfaces (API) in such a way as to activate the access functions to the archive of the radiology images from the RIS application.

At the admission time the RIS creates a patient's folder in the PACS system, with an automatic search for the past images on the optical archive.

Once accomplished the examination, the images are passed to the image processing and visualization workstations , where the codes associated to the images are used to retrieve the correct patient's folder where the images are to be transmitted.

At the reporting time, the patient's folder is opened to display the images. At the end of this procedure, the folder is closed by the RIS , erased from the current worklist, and definitely archived on optical disk.

The folder creation, the call for past images and the opening/closure of the image folders are activated by the RIS on the PACS system using the API through SQL calls to the database.

6. Functional developments of the PACS/RIS network

The above depicted integrated system allows a complete management of the information flow of the neuroradiology department.

However, the usefulness of an information system consists not only of the possibility of archiving and processing data and images at the local workstations, but also of the possibility of integration with other near and remote systems, to build a virtually unlimited multi-function communication network.

One of the already installed enhancements on the PACS/RIS networking is the integration between different diagnostic modalities and the radiotherapy equipements: CSS 1.0 Simulation System (Silicon Graphics INDY SC, CPU R4600, 128 MB RAM, 2 GB HD), radiotherapy 3D treatment planning system (Silicon Graphics INDIGO XS24, CPU R4000, 32 MB RAM, 2 GB HD) and the linear accelerator (LINAC).

The treatment planning system is directly connected to any imaging modality (CT, MRI, angiography) through an image processing and visualization workstations.

CSS 1.0 is a device for virtual simulation and it is coupled with a spiral TC provided with three ortogonal laser beams automatically driven by a software of CSS 1.0 on the basis of the accomplished processing.

The virtual simulation is a geometric management of 3D radiotherapy treatment (target volume and normal structures contouring and beams arrangements) (see fig. 2).

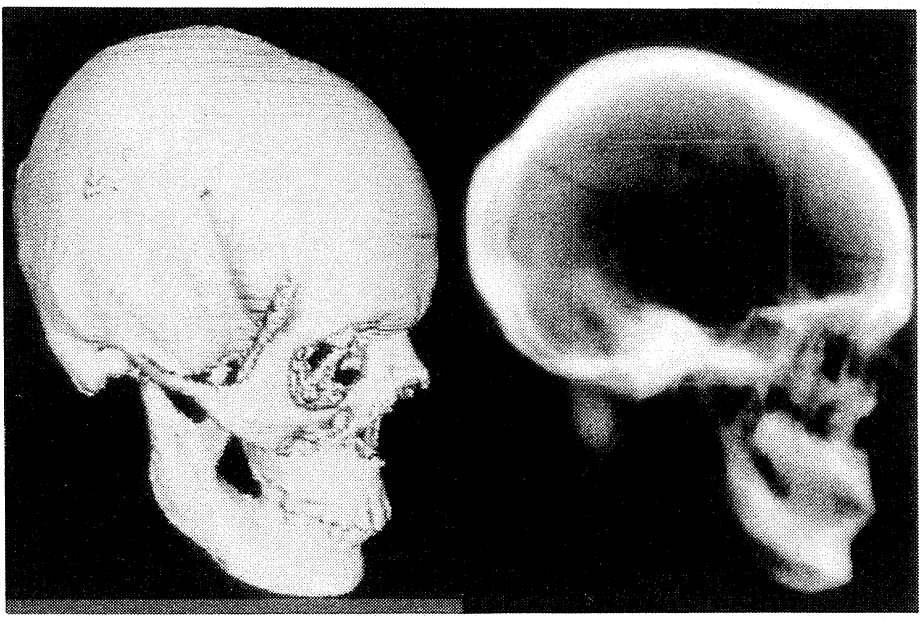

fig.2

Moreover DRR (Digital Recostructed Radiography) are generated and sent to laser cameras.

The CSS 1.0 software has been developed in the frame of the collaboration between the Istituto Nazionale Neurologico C. Besta and the 3D Line s.r.l. company.

Another option already installed on the virtual simulation workstation is a videoconference system that can be used also for the search through remote databanks on the Internet.

Besides, a dedicated ISDN line is at the installation stage to open a teleconsulting connection between the PACS/RIS system and other clinical centers. An HP9000 SECTRA computer analogous to the other visualization stations, but endowed with a software module for the image and information remote transfer, will communicate with other hospitals.

It is however to be stressed that, once the ISDN connection has been established, the Istituto Nazionale Neurologico C. Besta will become a teleconsulting center for any hospital or health care structure which will be able to handle digital images.

As regards the Istituto Nazionale Neurologico itself, the PACS/RIS system is to be seen as the core of a wider system that in the near future will connect also wards, ambulatories, labs, administration offices, transmitting high resolution images, clinical and administrative information [4].

Starting from the above described ATM/Ethernet switch an optical hub will be put, and departing from that three backbone subnetworks will stem, one for each building wing, each compounded by as many optical fibers as the building's floors (five).

From each floor 100MB/sec Ethernet LANs will stem, which will serve several workstations.

Every workstation will thus be able to retrieve images and data from the PACS/RIS system and manage a multimedia clinical workstation whose information will be available on the whole network [5].

The Admission/Discharge procedure and the Unique Booking Center are already at a testing stage, as they will build up the patients' access to the whole hospital information system.

A wide virtual distributed database will be thus developed, and every workstation in the hospital will be able to access to any information included into it.

With the above described opening of the network to the outside, the hospital information system is suitable to become part of a global health information system that in the near future could possibly connect public and private health and administration centers, local health units, emergency mobile units, up to the general practitioners' offices and the patients' houses [6].

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