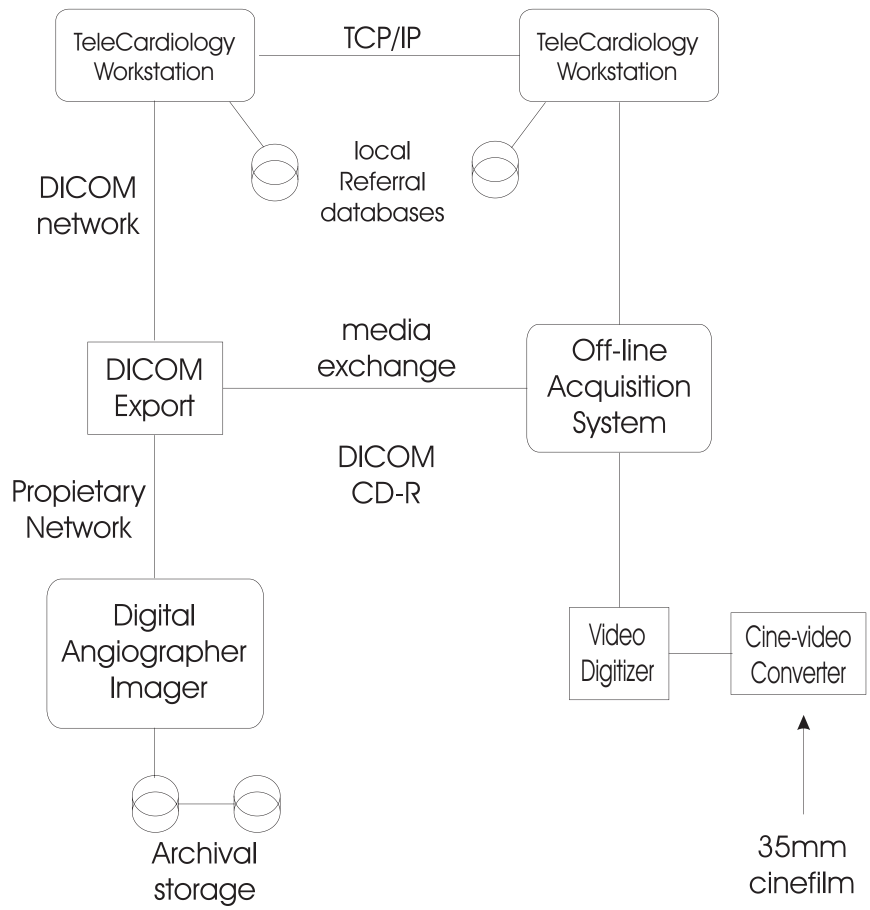

Figure 4.9: Conceptual Model of image interchange between clinical cardiovascular imaging systems.

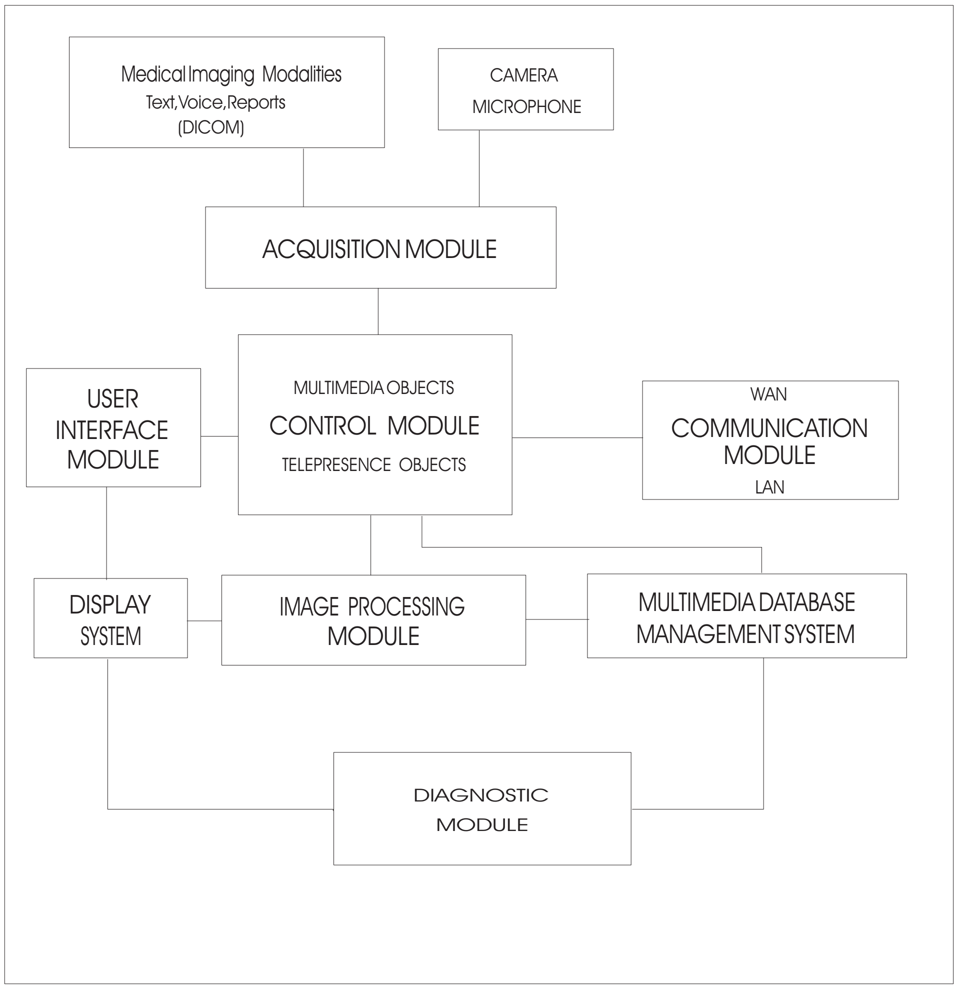

Figure 4.10: Care Radiology Workstation Block Diagram.

4.5.8 Specific requirements for cardiology

The following sections describe how the hardware and software requirements were defined for the Telecardiology Demonstrator, and provides a justification for the decisions taken. The changes made in Care radiology are indicated for each requirement.

Interfacing to X-ray angiographic image acquisition systems

In order for an off-line telematics application to be able to transfer medical images between two clinical sites, it must first have some means of accessing the images which are to be sent. This implies that the off-line system must somehow interface to the imaging equipment to be able to import the images and related acquisition parameters stored there. Given the number of different device manufacturers and the diversity of their installations, there are many different ways to realize a connection to medical imaging equipment [116].

Acquisition of X-ray angiograms

Before we begin looking at interfacing to angiographic imaging equipment, let us first examine the process of how these medical images - in this case, cardiac X-ray angiograms -are produced and handled.

A typical X-ray angiographic imaging system consists of a number of parts:

1. A generator and X-ray tube,
2. A patient table on which the patient lies in a prone position,
3. An image intensifier which converts the X-ray shadow which passes through the patient, into a visible image, and
4. A gantry system which is used to rotate the X-ray tube and image intensifier to various angles with respect to the patient.

The X-ray source

Unlike applications such as Computed Tomography which use a thin pencil beam X-ray source for high resolution imaging, cardiac X-ray angiography must balance the trade-off between high spatial resolution and high temporal resolution. High spatial resolution is required to visualise the fine detail in the coronary arteries, and to provide sufficient precision when determining the severity of arterial obstructions. High temporal resolution is required to capture the motion of the heart and avoid image blurring. These are conflicting requirements, which are limited by the ability of the system to process the quantity of information being produced, and the limitations of the X-ray tube. To balance these requirements, cardiac X-ray angiographic systems use fan-beam X-ray sources, which provides the ability to image at a high frame rate at the expense of a small amount of image distortion, but are less sensitive to motion artefacts.

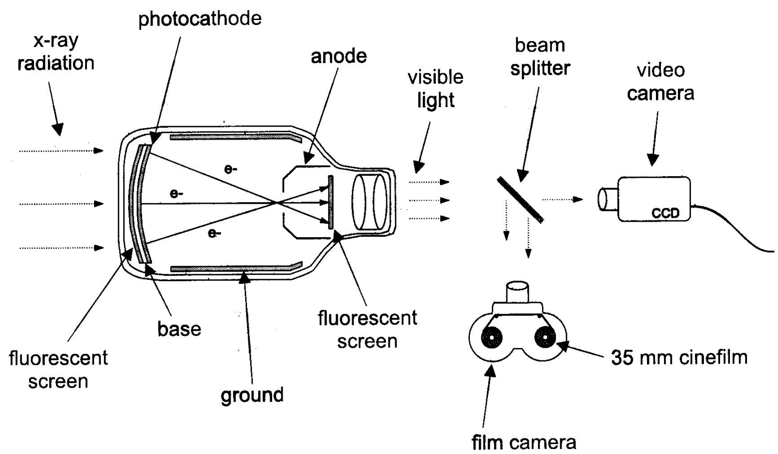

Figure 4.11: X-ray imaging chain for the acquisition of angiographic images.

The image intensifier

The image intensifier operates on a property known as fluorescence, or scintillation in which a screen is coated with a granular or crystalline compound that has the property of absorbing incident radiation, and re-emitting that radiation at a different wavelength. Using specific compounds that absorb X-rays, and re-emit visible light, a fluorescent screen may be constructed which enables the visualisation of X-ray radiation. If the incident radiation is sufficiently intense, the fluorescent image may be bright enough to be viewed directly. In medical imaging applications, this image is normally amplified in order to reduce the radiation dose to the patient while still obtaining an image of sufficient quality for diagnostic purposes. It is the image intensifier that performs this amplification. As can be seen in Figure 4.11, the image intensifier consists of an input fluorescent screen which is mounted onto a thin transparent base in an evacuated tube. Scintillations, produced by the incident X-ray radiation, pass through the base to a photocathode from which electrons are liberated. These electrons are accelerated along a focused electric field toward a positively charged anode, and then pass through an aperture where they strike a second fluorescent screen. This produces an image of the incident radiation which may be up to 10,000 times brighter than primary screen [103].

To record the images being produced, a camera is mounted behind the output screen of the image intensifier. In angiographic applications, this image may be viewed in fluoroscopic mode to assist the cardiologist with the insertion of a catheter into the blood vessel to be imaged, or the image may be recorded onto film during injection of a contrast agent. Digital imaging systems capture the signal which is delivered from a video camera, and digitise this signal for instant on-line review.

4.5.9 Analogue Exchange Media

There are several different methods available for gaining access to the images produced by an angiographic imaging system.

35 mm cinefilm

Traditionally, X-ray angiograms were acquired and stored onto 35 mm film rolls by means of a film camera which was attached to the image intensifier. This camera would be triggered to shoot images synchronously while the X-ray generator was running. After the patient examination, the film would be developed and reviewed on a specially designed 35 mm film projector. This method of acquisition and review quickly became the adopted standard since the film had sufficiently good spatial resolution, the film rolls were easily transported and stored, and the projectors were widely available, facilitating exchange of the image data between hospitals. Today, many angiographic systems still use this method of storage and review, although on newer digital acquisition systems, cinefilm is optional. To import 35 mm cinefilm images into an off-line imaging workstation, it is first necessary to digitise selected image frames. This can be achieved by means of a cine-video converter and video digitiser.

Direct video

On newer digital angiographic acquisition systems, the hardware required to acquire a video signal, digitise the video images in real-time, and store these images to disk is built into the equipment itself. This is achieved by installing a video camera to capture the images coming from the image intensifier. In many systems, a beam splitter is used to allow the installation of both a 35 mm film camera and a video camera. Basically, this consists of a partially silvered mirror which is inserted at a 45 degree angle to the output of the image intensifier. The film camera receives the majority of the light (typically 85% [41]), while the remaining light is directed towards the video camera. In this way, the digital system may be used for viewing images on-line while maintaining the possibility to review, archive and exchange the 35 mm cinefilms. Systems which have built-in video cameras offer a means of direct interfacing with off-line imaging workstations. By connecting a standard video output of the acquisition system to a video digitising board in the off-line workstation, it becomes possible to digitise image sequences off-line as they are acquired. Some high resolution digital angiographic systems do not use broadcast standard video output for their acquisition, opting instead for high resolution progressive scan or CCD cameras. These systems can be used to acquire to a 1024^2 digital matrix. This creates a problem for off-line acquisition, since the lower cost video frame grabber boards used in off-line workstations usually do not support capture of this high resolution video in real time. One of the prerequisites for using the off-line workstation is that it provides a low cost solution for processing acquired images off-line while the acquisition system may be used for other purposes. Although it would be possible to design an off-line workstation with the same digitisation capabilities as the on-line high resolution digital system, this would be counter-productive, since the price would approach that of a second on-line system. This would also require the duplication of the parallel transfer disks, proprietary bus technologies, and dedicated image processors that are incorporated into the acquisition system. When connecting to a high resolution video output, a video scan converter may be used to adapt the high resolution video signal from the digital acquisition system, to a standard 525/625 line video signal which can be digitised by the off- line workstation. The video scan converter offers a viable solution to enable the connection of an off-line workstation to a high resolution digital acquisition system. Evidently, the high resolution image information available to the acquisition system is not retained off-line, but in many applications, the broadcast standard video image still has sufficiently high resolution. Interfacing the off-line workstation to an angiographic acquisition system via a direct video connection has one major drawback however. Since the off-line workstation is physically removed from the acquisition system, it becomes difficult to synchronise the off-line digitisation of the video signal with the acquisition of those images in the catheterisation laboratory. The image acquisition system is normally synchronised through a footswitch that the cardiologist uses to initiate fluoroscopy or to store an actual image run. Manufacturers of angiographic imaging systems generally discourage such connections to third-party workstations, and doing so might even void the customer's warranty or service contract.

S-VHS video tape

Many digital angiographic systems do not use cinefilm as their off-line review medium, nor for long-term archiving. Instead, these systems connect a video cassette recorder to the video output of the imaging chain, and record the acquired image sequences onto Super VHS tape. The video recorder is synchronised to the acquisition of the digital images so that the video tape contains the same images as the digital image sequence. To import images from S-VHS tape to an off-line workstation requires the connection of the video output signal from a video cassette player to a video digitising board installed in the workstation. The use of S-VHS tape has the advantage that it is very easy to exchange between hospitals. Video cassette players are very common and inexpensive, and making copies of a video tape is quite simple. Video tape has quite poor image quality relative to on-line digital images or to 35 mm cinefilm however, due to the poor signal to noise ratio and low bandwidth of the S-VHS tapes. This low image quality complicates the task of off-line review for diagnostic purposes, and studies have shown that off-line quantitative analysis of X-ray angiographic images from S-VHS tape is unacceptable [88, 37, 94]. Video tape players also deliver a poor video signal when in pause mode, and this makes digitisation of selected image frames quite difficult without the addition of a video signal conditioner such as a time base corrector - additional hardware that adds to the cost of the off-line workstation.

4.5.10 Digital Exchange Media

Besides the exchange methods based on analogue carriers, when dealing with digital image acquisition equipment, options also exist to export acquired data in digital form. This method has the distinct advantage that no information loss occurs during the exchange, unlike analogue media which suffer signal degradation at each step in the imaging chain. Once in digital form however, there are a multitude of options for storing, archiving and exchanging the image data. These include magneto-optical rewritable and WORM disks, magnetic tape cartridges, removable hard disks, CD-R, and digital video disks, among others. The major drawbacks of using digital media for the exchange of image information between acquisition and off-line workstations are the hardware and software compatibility issues, and difficulties in interpreting the information content of the stored data. The compatibility issues are caused mainly by the diversity and rapid evolution of the computer industry. An acquisition system might use a particular physical drive and digital exchange media format, but there is no guarantee that this hardware will be supported on the hardware / operating system platform of the off-line workstation. The hardware used in creating digital archives from the acquisition system might become obsolete in a relatively short period of time. Finding the appropriate device driver software for these drives then might become very difficult under newer personal computer operating systems, or it could prove very expensive to implement new software drivers to support this hardware. The second obstacle to exchanging digital information between heterogeneous systems is the issue of interpretation. Different systems use different media formats and file system structures, and the host processors used may have different byte ordering. Each of these problems poses a barrier to the ability to exchange data between heterogeneous systems.

To ensure a low cost solution using a digital exchange medium requires:

1. A physical drive medium which is widely supported by the computer industry, with the availability of support and driver software for a wide variety of computer hardware / operating system platforms.

2. An internationally recognised file system standard.

3. A standardised file format enabling storage and retrieval of medical image data as well as related administrative and acquisition parameters.

In some countries, laws also require that any digital storage medium used for archiving patient data has a useable life span of up to 10 years [71].

4.5.11 Network Communications

Network Transmission

Most digital angiographic imaging systems have closed networks for the transmission of acquired images from the acquisition system to the real-time disk for storage. This is done primarily to ensure that external network traffic does not interfere with the critical process of real-time image acquisition. Closed networks also serve commercial interests, obliging clients to purchase additional workstations from the equipment manufacturer in order to gain access to the stored digital images. Non- native workstations must be connected to a "Spooler export" device which must be purchased from the original equipment manufacturer

Communication Protocols

Once an interface to an angiographic image acquisition system has been established, and selected patient images have been imported into the Telecardiology workstation, it becomes possible to communicate this information to a remote workstation for consultation. Within our region, two main communication methods exist for the exchange of information between partner sites in the TeleRegions project - ISDN, and a Metropolitan Area Network.

ISDN

Integrated Services Digital Network is a set of digital transmission protocols defined by the CCITT (Consultative Committee for International Telephone and Telegraphy which was renamed the Telecommunications Standards Sector of its parent, the International Telecommunications Union). The protocols are accepted by virtually all the world's communications carriers as standard. ISDN uses switched digital connections. Perhaps the most important single feature of ISDN, however is that it offers inexpensive dialed digital access to the world-wide telecommunications network. It is no longer necessary to lease costly dedicated lines for high-speed digital transmission, or to limit data speed and accuracy by using modems to convert digital signals to analogue pulses.

Transmission speeds

Transmission speeds are most often measured in bits per second (b/s or bps). ISDN is delivered from a digital switch through two types of user interfaces: the Basic Rate Interface (BRI) and the Primary Rate Interface (PRI). Each consists of a number of $64Kb/s$ bearer, or B channels, coupled to one data, or D channel. As defined, B channels are $64Kb/s$ clear-channel connections, and can be used for dial-up voice and data connections. The D channel is defined as a packet-switched call set-up and signaling connection shared by all users of ISDN.

The Primary Rate Interface or PRI consists of $3064Kb/s$ Bearer (B) channels and one $64Kb/s$ Data (D) channel, or a $30B + D$ connection. With a total bandwidth of $2.048Mb/s$, it is designed for transmission through a standard $E - 1$ channel.

PRIs are dedicated trunks that connect medium and large locations to a telephone company central office. Virtually all modern telephone and computing systems can be connected to ISDN through a PRI including mainframe and distributed systems, LANs and WANS, multiplexers and ISDN controllers, videoconferencing units, and more. PRIs are designed to maximise the use of these systems by allocating dynamically, or call by call, the number and type of channels (e.g.: data, voice in, voice out) required for each application.

Metropolitan Area Network

For high bandwidth applications such as the transfer of angiographic image sequences, a Metropolitan Area Network (MAN) known as the Scientific Ring is available. This network is sponsored by the Catalan Foundation for Research (FCR), and comprises universities, research centres and some large hospitals. The FCR initiated the development of this network in April 1993 for high speed data transmission applications. This network provides Catalan institutions (hospitals and universities) with an advanced digital communications network, equipped with a high transmission capacity ($34Mb/s$)[1].

4.5.12 Hardware Requirements

To keep hardware and training costs to a minimum, it is highly desirable to make use of generally available "off-the-shelf' components, and a software interface which is familiar to a wide range of end-users. Based on this goal, the following system hardware requirements have been established:

- The Telecardiology demonstrator shall be first implemented to run using a SUN Workstation (the same platform as Care Radiology) and there is a plan to adapt the system to a personal computer based on the Intel Pentium Processor under the Windows $95/98/NT$ operating system.
- For image sequence viewing and short-term data storage, the minimum systems requirements are:
  - 64 MB RAM,
  - 2 GB hard disk drive,
  - $17 - inch$ multi-sync monitor, and
  - a graphic adapter capable of displaying at least 800x600 pixels at 8 bits depth.
- For communication an implementation of the TCP-IP protocol and related hardware (ethernet card and / or ISDN card).

The hardware requirements are met by the SUN workstation and are also met by a PC platform.

4.5.13 Functional Requirements

For clinical sites where cardiac patients are treated, but advanced procedures such as interventions or cardiac surgery are not available, it is common to have referrals of patients to other sites. If the patient's clinical record is to remain intact across this transfer between sites, a mechanism must be devised to manage the transfer of patient information.

Several scenarios may be identified which require such a transfer:

1. A patient is transferred from a secondary care hospital to a remote tertiary care hospital for diagnosis and possible intervention, and the clinical results including selected images are returned to the primary physician.

[1] http://www.fcr.es/anella.html

2. A patient is diagnosed locally in a secondary care hospital, and the clinical history including diagnostic images are transferred to a tertiary care hospital for intervention. The clinical results including selected images are returned to the primary physician.

3. A patient study is transferred to a central core laboratory for analysis following the protocol of a multi-centre clinical trial. Results of the analysis may be returned to the centers contributing to the study.

To support these scenarios, the following requirements may be identified:

- Open architecture to allow information transfer to/from third-party systems such as image acquisitions systems and Hospital Information Systems;
- Secure information transfer to ensure only authorized access to confidential patient data;
- Reference system to follow the status of referrals and clinical reports as they pass between collaborating centers;
- Database of related information contained in referrals.

User Requirements

To realize digital image communication between hospitals for the purpose of Patient referral, several fundamental user requirements can be identified:

- Systems should use inexpensive equipment which is easy to use for medical professionals.
- Rapid data transmission should be available to avoid delays when dealing with high priority transfers and remote collaboration.
- Image transmission should be achieved with a minimal loss of information, while ensuring maximal diagnostic image quality. In other words, any image compression techniques used to minimize transmission time should not do so at the expense of image quality to the extent that this affects diagnostic interpretation of the images.
- Systems dealing with image transmission should provide large archival capabilities
- Communication links must be established between hospitals involved in patient referrals.

The first prototype is running on workstations already available. The data transmission infrastructure is enough. The archival cost is falling and today the feasibility of a large archive is high. There are two existing options for communication links: metropolitan area network and point to point ISDN, both already supported by Care radiology.

Information Management

To manage the information flow in the field of clinical cardiovascular imaging, any system must be able to deal with vast amounts of images and related data. This requires the integration of many different types of data, currently residing in multiple incompatible formats and systems. Integration of these sources of information is crucial in order to improve the efficiency of the clinical decision making process. Specifically, we can define the following requirements:

- Integration of multiple sources of data in a multi-media framework, including: digital image sequences; selected still images; bio-signals such as ECG, and pressure readings; patient records and clinical reports in the form of text and/or audio; and graphical data such as analytical results;
- Modular design in order to incorporate various information types and formats not foreseen in the framework;
- Communication with the various sources of clinical information via digital pathways, to incorporate information regardless of its physical origin;
- Open implementation to facilitate the incorporation of information from existing clinical databases and information systems.

The requirements are already covered in Care Radiology but many data structured specific for cardiology have to be added. The DICOM folder specification is developed for angiography.

Image Viewing

Because of the dynamic nature of cardiovascular image data, support for dynamic image sequences is necessary. In order to replace the existing analogue viewing medium (cinefilm), a digital implementation must provide at least the same functionality. This includes:

- Real-time viewing of cardiovascular image sequences (at a frame rate at least as high as the original acquisition rate);
- Stop-frame, slow forward and slow reverse cine-loops;
- Side-by-side viewing of related image sequences, such as biplane acquisition, pre- and post-intervention, or baseline and follow-up studies;
- Zooming of selected regions of interest.

Image viewing requirements not already present in Care radiology had been done. The main development effort was in the image sequence facilities for real time viewing. Also, the incorporation of analytical modules made additional demands on the viewing interface, including:

- Support for graphical overlay information for the display of analytical results;
- Superposition and synchronisation of bio-signals and related image data;
- Selection of specific images within a sequence for use in analytical modules.

Image Exchange

Digital image exchange is not a problem unique to cardiovascular imaging applications. Over the past several years, a considerable amount of work has been done in this area in the field of Radiology. The result of this work has been the development of the Digital Imaging and Communications in Medicine (DICOM 3.0) standard, see section 4.5.5. Recently, this standard has been adopted by the major Cardiology associations, including the American College of Cardiology, and the European Society of Cardiology. Working groups of these associations have worked closely with the DICOM standard to extend its functionality for cardiovascular applications. Following the recommendations of the American and European Cardiology societies [28, 70, 94], any new implementation dealing with digital image exchange in Cardiology should conform to the DICOM standard. This would involve the following requirements:

- Support for the DICOM X-ray Angiographic Image Object Definition (IOD)
- Conformance to the DICOM Cardiac X-ray Application Profile for media exchange using CD-R media.

Database Requirements

To store information related to the state of referrals between clinical sites sharing patient data, a database shall be used. This database will be responsible for locating referred patient information, tracking the status of the referral process, and maintaining a directory of referral sites. This database will be referenced to resolve referrals, as well as to extract common referral information when two sites are performing an interactive session. When a sequence of diagnostic images is sent to a remote site for referral, the sender must record the information that was sent, to whom it was sent, and whether or not a reply has been received. On the receiving end, the database must do the opposite: record the information that was received, from whom it was received, and whether or not a reply has been sent. This organization is managed by two local databases which are updated based on the information passed across the communication interface between the two systems. The two databases are not identical, since a referring centre may send requests to multiple referral institutions, and more likely, a referral institution may receive requests from multiple referring centers. The database records that any two centers have in common, will be the same however. The database structure shall be organized into three areas: patient data, a consultation record, and a physician directory. The patient data is organized in the same manner as the DICOM information model (see section 3.3) in order to facilitate references and the transfer of information between the database tables and DICOM image files. The physician directory contains a listing of physicians that the site may send referrals to, as well as information about how that referral is to be transmitted (network address, communication protocols, etc.). Finally, the consultation record maintains the links which specify what patient information was sent, and to where it was sent.

Hardware Considerations

The system hardware requirements for Telecardiology Demonstrator have been derived from figures which are indicative of telematics requirements in the region [85]. On average, medium size regional hospitals in our area submit 4 patients per week to larger metropolitan tertiary care hospitals. If we assume a typical patient study contains 3000 image frames, comprised of multiple image sequences of not more than 8 seconds each, it is possible to calculate the storage requirements to archive these images. Given that several days may pass before an interactive consultation is held between the two hospitals to discuss their referral status, the local database at each side must retain this information until the referrals are resolved. For the smaller referring hospital, several days worth of image data might only occupy $1.5 - 2$ GB, although the larger tertiary care hospital could serve a number of referring hospitals so their data storage requirements could easily reach tens of gigabytes. Given the number of patient referrals, and the amount of system memory which each patient study requires, the hardware requirements were calculated. To allow rapid access to the entire image set of one patient, the viewing station should be able to store the entire image set in RAM. If a typical image series contains 50 MB of image data (200 image frames or 8 seconds of video at 25 frames per second), then the requirement of 64 MB of RAM should be adequate. The minimum disk storage capacity of 2 GB provides sufficient space for a referring hospital to archive the referrals sent to a remote site for one week. This figure is based on a work load of 4 patients per week with typical studies of 3000 images stored using $2:1$ lossless compression (total: 1500 MB). A referring hospital would require more storage space depending on the number of sites it receives images from, and the amount of time required to respond to these referrals. For the visualization of coronary arteriograms - digitized to a matrix of 512^2 x 8 bits - the graphics adapter chosen for display should provide the ability to show an entire image frame without resorting to scrolling. This would require a minimum resolution of 800x600 pixels at 8-bit depth, requiring at least 1 MB of VRAM. The 17-inch multisync video monitor at this display resolution produces a comfortable viewing angle without making fine details in the angiogram too small to see, as can occur at high screen resolutions. The decision to change the demonstrator from SUN/solaris to Windows 95/98/NT/2000 as the operating system for the telecardiology demonstrator was due to its large user base, and intuitive user interface, making it easy for medical professionals to learn and operate. The future use of personal computers (instead of unix workstations) for this project also fulfills the requirement that the demonstrator workstation be inexpensive, and use commercially available "off-the-shelf" hardware.

Non-functional Requirements

All shared software developed for the Telecardiology Demonstrator has been implemented in the proposed ANSI standard C++ programming language.

The following requirements are concerned with the implementation of the DICOM software support:

- A software interface for the storage and retrieval of medical images shall be developed which makes use of the DICOM standard. This interface shall be referred to as the DICOM tool-kit.

- The DICOM tool-kit shall provide a simplified interface, implementing only those services which are necessary for the identification of a DICOM image object, and the storage and retrieval of image pixel data and administrative data. In other words, the DICOM tool-kit is not a complete implementation of the DICOM standard.

- The DICOM tool-kit interface shall be implemented in the C++ programming language. For the software development work related to this kit, the Standard Template Library [67, 75, 99] was chosen.

4.6 Care Cardiology User interface

Through this section, we are going to describe the graphical user interface and also emphasize on the modules worked for cardiology.

4.6.1 Patient management

The user interface shows the implementation of part of the real world model proposed in DICOM (see figure 4.2). In figure 4.12 there is a patient list, for each patient a study list and for each study, image series. The facilities provided through this main window let the cardiology query about patient case review and acquire image series for a patient. The image series can be accessed (viewing and enhancement) using the image tool provided (see figure 4.16). The information objects developed are:

- patient object
- study object
- image series object
- image object
- result object
- audio object
- text object
- graphic object
- patient list object
- study list object
- image series list object
- result list object

where the patient, study, series, and images are considered multimedia because they can hold audio text and graphic objects. Also the lists have been developed as objects and they take the responsibility of the interface with the data bases. List objects offer search and edit capabilities for the contained objects, including methods for adding, deleting and updating the database records. There are a pair of objects for each concept to account for local and referred patients respectively.

4.6.2 Patient and image referral

Remote consultations are provided through the request concept. Figures 4.13 and 4.14 shows the user interface implementing the consultation scenarios proposed in figures 4.7, 4.8 and 4.9.
The information objects developed are:

- request object
- remote request object
- request list object
- remote request list object

The objects developed use all the objects developed for the patient management and adds data necessary for consultation, for example the reason for the consultation and referral doctor. There are four levels of consultations depending on the exchanged information:

- patient level: all the data available for the patient is involved.
- study level: only the data of one study is used.
- series level: the data of one image sequence is used.
- image level: one image of a patient is exchanged.

At any level the relevant patient data for a correct identification is also communicated.

Most of the user interface remain the same as in Care Radiology. The main differences are in the image tool facilities added and in the image acquisition aspects. The image acquisition software is accessed thought the result object. The result object has been designed keeping in mind the changing nature of the different image modalities with the aim to facilitate the customization to a new image modality. For the cardiac imaging, the DICOM file format for X-ray angiography has been developed the main interface, however, a previous interface to an analogue video system was also been set up.

For a detailed discussion on the whole system the reader is remitted to the documentation of Care Radiology in [104].

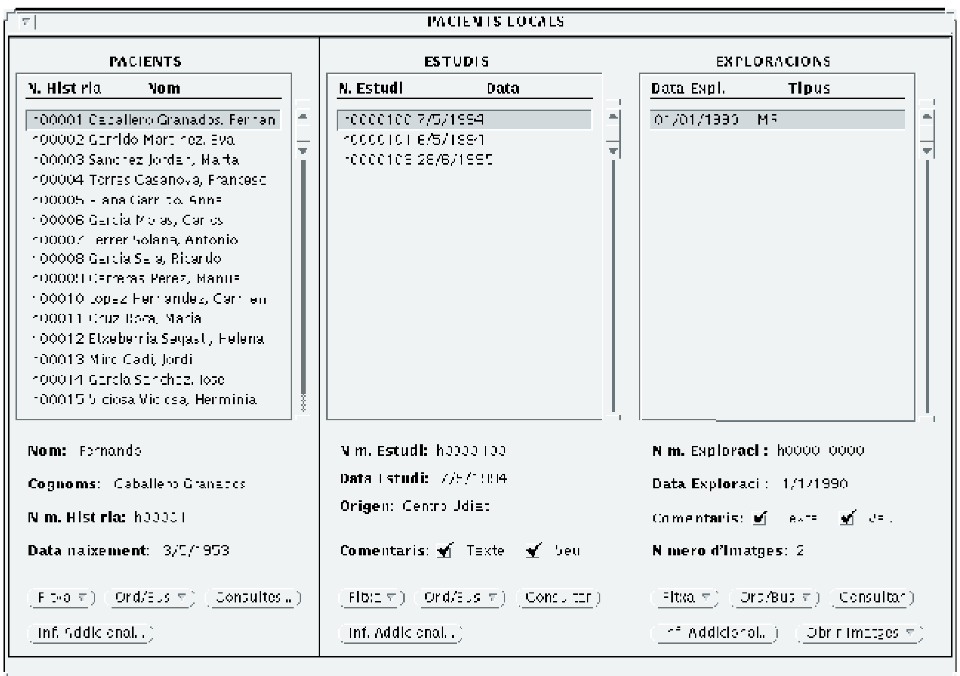

Figure 4.12: Local Patient Management.

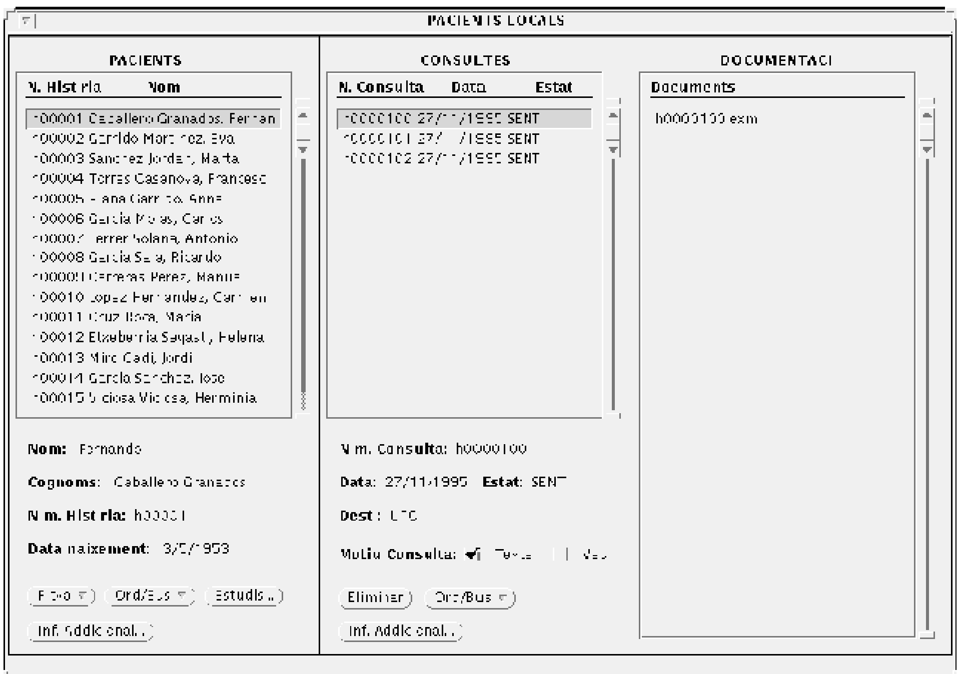

Figure 4.13: Local Patient Consultation Management.

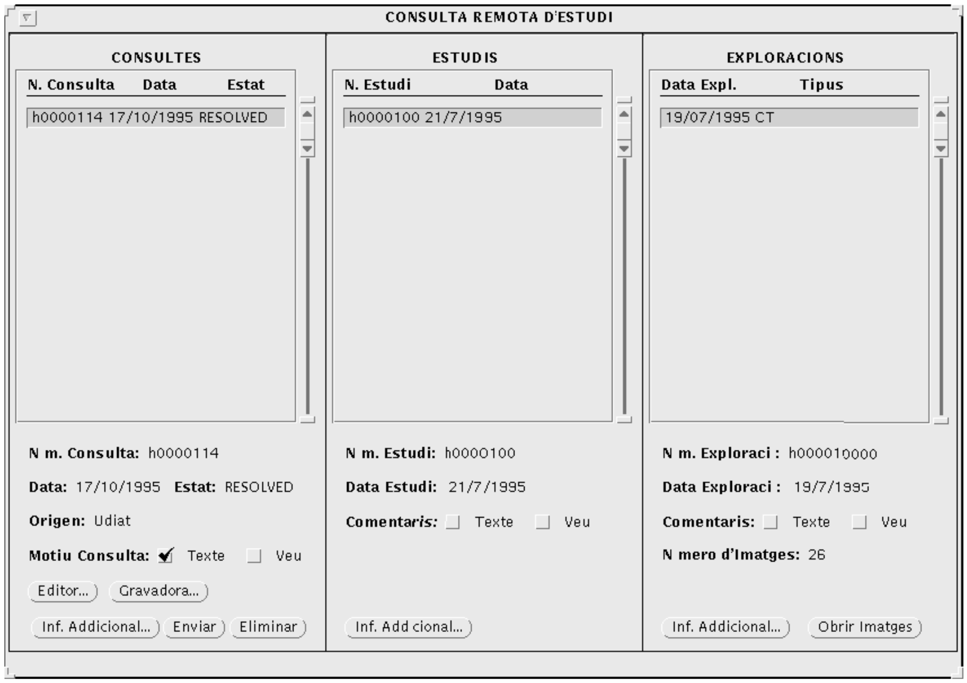

Figure 4.14: Remote Patient Management.

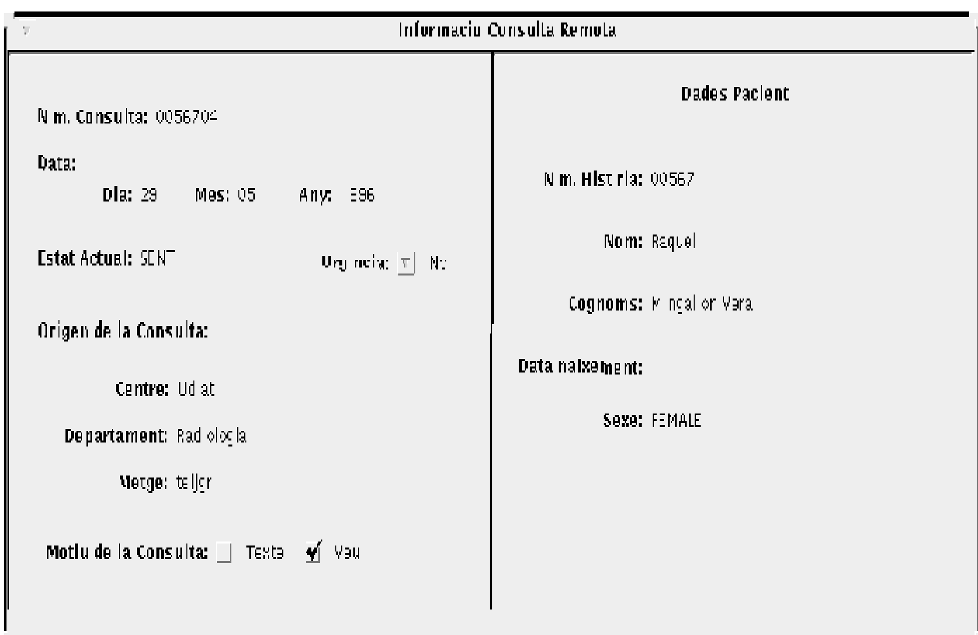

Figure 4.15: Remote Request Management.

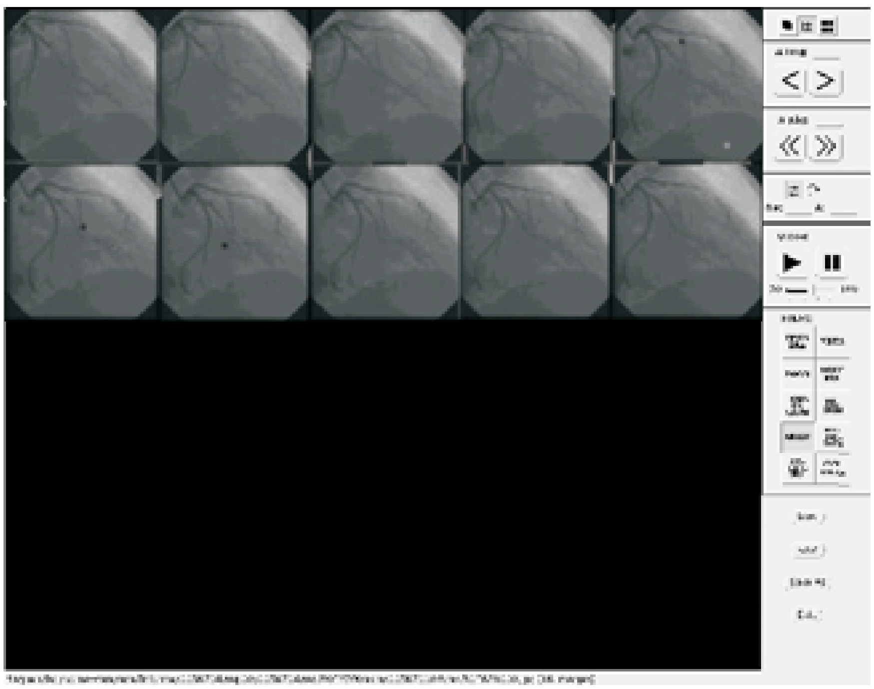

Figure 4.16: Image display and processing tool.

4.7 Summary

A cardiac imaging workstation was presented. From an existing radiological imaging workstation, the evolution process has been explained. The focus was on the particular aspects regarding the international standard and acquisition of coronary angiography.