THE RITA NETWORK. HOW THE HIGH ENERGY TOOLS CAN BE USED IN ORDER TO TRANSMIT CLINICAL HADRONTHERAPIC DATA

M.FERRARIS, P.RISSO and S.SQUARCIA

Dipartimento di Fisica e Sezione INFN di Genova
Via Dodecaneso 33, 16146 GENOVA, Italy

We present the realization done for the organization, selection, transmission of Radiotherapy's data and images. The choice of a standard healthcare records, based on the stereotactic and/or conformational radiotherapy, the implementation of the healthcare file into a distributed data-base using the World Wide Web platform for data presentation and transmission and the availability in the network is presented. The solution chosen is a good example of technology transfer from High Energy physics and Medicine and opens new interesting ways in this field.

1 The hadrontherapy project TERA

The hadrontherapy project TERA (TERapia con Adroni) was launched in the Istituto Nazionale di Fisica Nucleare (INFN) in 1991 by Ugo Amaldi (physicist) and Giampiero Tosi (radioncologist)[1].

The Project aims is bringing to Italy, in a time scale up to 2000, the most modern tumour radiation-therapy techniques, which make use of beams of protons, ions and neutrons. Proton and ion beam allow the "conformal" treatment of tumours and brain malformations with the advantage of sparing the surrounding healthy tissues more effectively than what it is possible with conventional radiations. This property is particularly important in the irradiation of tissues which are close to critical organs (eye, brain, spinal cord, gonads, etc).

The Project is divided in three main activities :

- National Centre for Oncological Hadrontherapy: This centre (CNAO, Centro Nazionale di Adroterapia Oncologica) will be probably located in Novara. It will have a synchrotron accelerator with a diameter of 18 m producing protons and, at a second stage, carbon and oxygen ions till a maximal energy of 250 MeV.

- Compact Accelerator Project: This project (PACO, Progetto Acceleratore COmpatto) is devoted to the design and the costruction of *compact proton accelerators* with a diameter of less than 5 m to be installed in existing Centres and Hospitals. The maximal energy will be 200 MeV.

- Italian Network for Hadroterapy Treatments: The RITA (Rete Italiana Trattamenti Adroterapici) Network proposal is for exchanging informations and clinical data via multimedia connections among all the Centres Associated to the Project.

2 The RITA Network

The RITA Project[2] was launched in October 1993 and is still in an evolution stage, but it has been decided to start a first activity, long time before the availability of protons treatments, in a promising field of innovatory radiotherapy such as stereotactic and conformal therapy. This project, named STEREO, in fact may be considered very close to hadrontherapy, both in intent and technology, even if based on traditional radiation sources.

In the years 2000 RITA will be a nation-wide, and possibly international, informatics and organisational network whose main purpose is to establish the communication between the staff of CNAO, the personnel of the Centres equipped with compact protons accelerator (Protontherapy Centres) and the staff of peripheral hospitals and universities, which will decide to be associated to the TERA Project. Such a network is part of a widespread international activity that, allowing remote medical consultation, is effective in reducing costs, improving efficiency and decreasing dead times. This is expected to be particularly true for the Hadrontherapy Project, given the novelty of the approach, the rarity of the treated diseases and the inevitable lack of shared experience in its early stages. It is possible to specify six main functions of the network:

- Remote consultations for the selection of patients.
- Real-time support for planning and optimising the patients flow to the National Centre of Oncological Hadrontherapy (with protons and ions beam) and to the Protontherapy Centres.
- Remote transmission of the treatment planning.
- Exchange of information about pathologies and treatments.
- Management of research activities.
- Exchange of information with radiotherapy (including hadrontherapy) Centres in the world.

Every hospital who wants to access hadrontherapy facilities has to link to the National Centre of Oncological Hadrontherapy and the Protontherapy Centres. In the long term hopefully all Italian radiotherapy centres (about 100) will be involved. In this network the most important radiotherapy centres could be the first filter to select cases from the peripheral hospitals. It is thus useful to envisage a network with different rates and capabilities:

- higher speed and larger capability between CNAO and the Protontherapy Centres and the most important radiotherapy centres,
- lower speed and lower capability between the above centres and the peripheral hospitals.

Data and images should be sent in real-time for every consultation. Moving images with synchronised audio are useful in order to make the consultation more

interactive. It is reasonable to foresee about 10-20 consultations/day towards CNAO and the Protontherapy Centres. Treatment plannings should be elaborated by the same software in every collaborating Centre and the transmission, usually not urgent, could be made by night. The images of every treatment planning could be about 70-80 and no more than 2-3 treatment planning/day would be transmitted to CNAO.

It is necessary to foresee the transmission of all digital diagnostic images usually used in medicine: CT, MRI, digital radiology, ecography, nuclear medicine. All images should be available with a matrix of at least 512x512 pixels with, possibly, 4096 colours or tonalities of grey. About 10-20 images could be transmitted in real-time for a consultation and up to 100 in background, without any operator, to complete the documentation.

3 The STEREO prototype

Technologies and their applications to the health system, are developing very fast and it is not possible to decide now what is the hardware system to be used more than five years from now, when the Hadrontherapy Centre CNAO and the Protontherapy Centres will be available. On the other hand, as underlined above, the project STEREO on conformal conventional radiotherapy has been initiated in order to test the multimedia connections, focus the main problems and find optimal solutions. For this step a (provisional) choice has to be made. In the case of the RITA prototype STEREO the choice to be made is between systems in which each single connection is paid, in terms of duration (as in ISDN[3]) or in terms of traffic (as in the public packet switching network), and systems based on dedicated lines (as it is realized by INFNet, the network built by INFN for transmission of information and data on subatomic physics).

The purposes of the STEREO Project are:

- The coordinated selection of patients for conformal conventional radiotherapy among the participating Centres.
- The discussion and comparison of the treatment planning procedures and of the results among the Centres.
- The consequent spreading of knowledge and techniques also to Centres not initially involved.

A second choice is needed between a centralized and a distributed data base. It is natural to choose for STEREO a distributed data base since the patients and doctors are distributed over the whole country. The principal features for the distributed data base structure that allows an inexperienced user to use the application programs are:

- User friendly programs.
- Fast consultation of data through the network.
- Easy transmission of documents and images.

4 Technical solutions

To realise the STEREO connections in a short time it has been decided to use INFNet, very effective and high-speed dedicated network, and the World Wide Web (WWW) approach[4]. World Wide Web represents a useful tool to create a distributed data base for its capability of retrieving and exchanging documents through networks, and for this reason, the prototype STEREO project is based on an hypertext data-base developed using World Wide Web and its data model.

Documents can be retrieved from a remote user in a simple and immediate way: the Web server, via suitable programs, performs the management of the data-base and gives access to the remote client. Of course appropriate safety system have to be implemented to protect confidential information. The purpose of the Project STEREO will be reached through several steps:

1. Creation of standard-based healthcare records such as standard data definitions, data sets, thesauri, specialised messages, message formats and basic functions for accessing and communicating data and images. The standardised healthcare records are based on the stereotactic and/or conformal radiotherapy records used in Milano by the Istituto Nazionale per lo Studio e la Cura dei Tumori (INT). They are now available on the Web.

2. Implementation of the standardised healthcare records into a distributed data-base and use of the World Wide Web platform for data presentation. The visualisation of the transmitted information (data plus image) on a low-cost terminal (like a PC/IBM compatible) of at least 1024 x 1024 pixels.

3. First test phase: technical checks among the INFN Sections for data transmission and verification.

4. Second test phase: healthcare records validation among the Clinical Centres. At this step the medical certification is compulsory. The experimentation is now at this level.

5. Utilisation of the prototype for real healthcare record data transfer and comparison among the Centres.

In order to transfer the required informations from the storage centre to the utilisation centre a distributed data-base with centralized and automatically update index has been chosen in the WWW framework. At this stage an image compression and/or an image filtering can be necessary. A relevant part of the clinical data, in fact, will be represented by radiological images documenting the status of the patient at treatments and controls as well as treatment plannings. Image data sets need a relevant amount of transmission and archiving resources and are essential both for reference and documentation.

Furthermore administrative data regulating patient identification, scheduling of activities, inter-centre communication and so on, have to be considered by keeping in mind their general accessibility and the integrity of the clinical data. All these constraints should dictate the structure of the Data Base Management System (DBMS) supporting the system as well as the needed hardware.

We are trying to pospone both for data-base and image transmission the final choice as last as possible.

The prototype STEREO project is based on an hypertext data base developed using World Wide Web and its data model. Documents can be retrived from a remote user in a simple and immediate way; a Web server performs the management of data base and gives access to the remote client. Connection to data base requires a login procedure: the server asks username and password in order to control access and to check the identity of the user. The first data base screen shows the two different ways of looking to the data: consultation, introduction and modification. Introduction and modification allow the user to read and change clinical data: the single patient is identified by name, surname and birth date. At this step data base distinguishes among three different situations :

1. Patient not present in data base: the user can introduce the patient in a temporary list or booking list compiling a personal data table of the patient.

2. Patient in booking list: the user can introduce the patient in the data base list compiling the tables containing the required clinical data.

3. Patient in data base: the user can consult and update clinical data.

Every clinical table follows the medical specifications useful for the stereotactic radiotheraphy and contains the date of introduction and the name of the user. During the consultation the user can retrieve all clinical data of patient but can't modify or update the clinical tables. It's important to underline the possibility of consulting diagnostic images and asking for the trasmission of a set of them; this procedure could be used, in future, to perform a treatment planning by a remote node.

5 Organisational and economic evaluation

The cost of creating and using RITA will depend on the chosen hardware technology. For the prototype STEREO project, the dedicated INFNet has been chosen. The final selection between the other various alternatives will be made as late as possible by considering not only the technical characteristics but all the variable and fixed costs too. It is obvious that the project STEREO, based on INFNet, will give information on the data transfer rates and on the general features of the project, but not on the cost of data transmission. The cost for a single connection depends on its duration and on the physical distance between the connected centres. As for telephone calls, rates vary according to the time band (ordinary rate, night rate, reduced rate, rush hour rate). With reasonable assumptions on the number of images per treatment planning (100), it has been estimated for an Associated Centre performing a maximum of 10 consultations/day per 200 working days a year an annual cost of about 20'000 $. The annual cost estimate for CNAO (1000 treatment plannings per year) is about 70'000 $.

The comparison between these costs and those of a dedicated line cannot be carried out as the variables are still too many (number of images to be transferred, images size, use of data compression techniques, etc.). It has been roughly estimated

that a dedicated line is more advantageous when centres are connected for more than 3-4 hours per day.

6 Conclusions

RITA creation is an innovative choice within the Italian National Health System enabling the diffusion of hadrontherapy as a therapeutical opportunity but also as a new technological knowledge in many Italian hospitals

RITA allows the patient to be treated as much as possible by the hospital of his district (although the treatment is decided with specialists of other health units and it takes place technically in another centre), thus minimising the inconveniences to the patient.

The realized prototype, shown in **http://www.ge.infn.it/rita**, is a good example of how tools commonly used in high energy physics can be fruitfully applied in different fields. The data and images transfer instead of the patient transfer, here envisaged in the cancer radiotherapy domain, will change completely, in the next few years, the public health reality.

References

1. The TERA Collaboration, *The TERA Project and the Centre for Oncological Hadrontherapy*, ed. U.Amaldi and M.Silari (INFN Divisione Ricerca, 1994).
2. The TERA Collaboration, *The TERA Project, the RITA Network and the Design of Compact Proton Accelerators*, ed. U.Amaldi, M Gandolfo and L.Picardi (INFN Divisione Ricerca, 1995).
3. William Stallings *ISDN an introduction*, (Maxwell Macmillan International Editions, 1991).
4. Kevin Hughes *Entering the World Wide Web: a Guide to Cyberspace*, (Enterprise Integration Technologies Editions 1994).