COMPUTERS IN RADIOTHERAPY AND ONCOLOGY

Edited by
R F Mould

Computers in Radiotherapy and Oncology

Proceedings of the Workshop on the Use of Computers in Data Handling in Radiotherapy and Oncology in Europe held at the Headquarters of the World Health Organisation, Geneva, 26–28 March 1984

Edited by R F Mould

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Organising Committee

Miss M D Snelling (Chairman)
Professor R J Berry and Dr R Morrison (Organising Secretaries)
Dr T Möller (Scientific Secretary)
Dr P Minet (Treasurer)
Dr J Yarnold (ESTRO representative)
Dr J Gary-Bobo, Professor H-P Heilmann, Professor A Laugier (Members of the Commission Informatique)

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Foreword†

On behalf of the Director-General I have great pleasure in welcoming you to Geneva to participate at this Workshop of the European Association of Radiology on the Use of Computers in Data Handling in Radiotherapy and Oncology in Europe.

The subject of this Workshop is not only interesting but of great topical relevance at a time when microcomputers are becoming an accepted and integral part of professional life. I hope that your discussions here will have a positive effect on patient data management in therapeutic radiology.

Cancer treatment has made rapid progress in the last two decades but the lack of good records in many cancer treatment centres has hampered the accumulation of valuable statistical information on an international basis. It is vital to have comprehensive and accurate data on the results of various therapeutic procedures, objectively measured in terms of survival, recurrence or complication rates. Such statistics do not tell the whole story because the quality of life of the patient is also a factor of primary importance.

In addressing subjects such as:

recent developments in microcomputer technology relevant to oncology;
software applicable to oncology;
interface, data communication and networks;
content of the oncological data base;
statistical evaluation and presentation of cancer treatment results;
data validity, confidentiality, legal and ethical aspects,

your workshop is attempting to find a way which could lead to better communication between various radiotherapy–oncology centres in Europe, thus contributing to improved collaboration on a wider scale for the benefit of the patients.

Greater uniformity in data collection and evaluation is a vital step towards obtaining larger statistical samples, on which treatment results can be assessed, and as a basis for suitable action to improve a given therapeutic procedure.

WHO, in its role as a catalyst in the promotion of new health technologies, is continuously evaluating such technologies in order to identify those which are most promising for global use. We therefore have a great interest in the discussions which will take place here during the coming three days and in the conclusions which you will reach. This is one of the reasons why the Organisation has been glad to make available its meeting facilities for the second time to the European Association of Radiology.

I am quite convinced that your deliberations will make a real contribution to the better management of cancer patients and that WHO will be able to benefit from your achievements.

I should like to wish you a very happy stay in Geneva and most fruitful discussions.

Lu Rushan
Assistant Director-General of the World Health Organisation

†This Foreword formed the opening speech for the Workshop.

Chairman's Preface

It is a great pleasure to introduce this third Workshop, which follows the first Workshop on the Use of Computers in Radiotherapy in Europe held in Vienna in 1976 when we discussed the use of computers in data handling, and the second held here at WHO in 1979, when we talked of the place of CT scanners in radiotherapy, and when it was decided that we should return to data handling as the subject for this third meeting. Perhaps I should go a little further into the history of these meetings and the origin of the Commission Informatique (Thérapeutique) of the Association Européenne de Radiologie which is partnered by a similar Commission Informatique (Diagnostique). We stem from a Round Table held at an AER Symposium on Computers held at Brussels in 1971, when some of the present members were among the few present who had actually introduced the use of computers into their departments and were enthusiastic enough to continue discussing them in National Societies and in the Computers in Radiotherapy Conferences held by our physicist colleagues. Since then a few others have joined us in the Commission, and we would welcome others with practical experience of the use of computers and with sufficient energy to join us in our meetings and correspondence. On this occasion it has been a great pleasure to be joined by ESTRO in sponsoring this meeting, and we look forward to continued collaboration of the two societies in the future. You will have noticed that the names of our Workshops have always emphasised our position 'in Europe'—both our Societies have primarily a European membership—25 National Radiological Societies are members of the AER while ESTRO, although not limited to Europe, has a membership of some hundreds of personal oncologist members, the majority of whom are European. While Radiotherapy and Oncology are similar all over the world it was thought best to limit the number of delegates in this meeting (in which we hoped they would all take part) to about one hundred, and to expect a large majority to come from Europe where culture, social conditions, health problems and the organisation of health services are similar, and where international communications and understanding are good. We hoped that in such a group problems would be easily understood and that useful discussions and conclusions would result. As at our previous meetings, the Headquarters of the World Health Organisation seemed particularly suited to such a meeting, and we were very anxious that members of that organisation should join in our discussions. We welcome them heartily, and also would like to thank them for their hospitality and for allowing us to use this beautiful and well-equipped room and the amenities of this building. We would like to thank Dr Lu Rushan, the Assistant Director-General, for joining us and also Dr Racoveanu of the Radiation Medicine Unit and his Administrative Assistant, Miss Daphne Fresle, for a great deal of assistance in the organisation of this Workshop, as well as for participation in the discussions.

This meeting will, we hope, interest not only those oncologists working in large departments already equipped with computers for data handling, but will also be of help to others as yet inexperienced in their use, but ready to start. There is no doubt that the introduction in recent years of modern desk-top or minicomputers has greatly increased the activities of the small oncological department whether concerned with the treatment of disease or with research projects as well, and that

they have also proved useful additions to the equipment of large general hospitals and to Departments of Health planning regional oncological programmes. The larger memory now available in modern small computers has greatly increased their work potential. It is now possible to cover with one such machine the records information and analysis of a department treating some hundreds of new patients each year, while software is now available providing the programmes necessary for the presentation and analysis of results. Small departments can now combine to produce quickly the statistics necessary for advances in practice, in research and in the planning of services.

Advances in software have followed closer collaboration between manufacturers and user clinicians and physicists, while the falling price of computers (and intense competition) now puts them within the range of even small centres. Increased general education in the use of computers has made their use by departmental staff more acceptable. The saving of time makes possible additional worthwhile activities in the departmental programme; many uninteresting chores associated with departmental activities can be bypassed, and there are increased possibilities of studies concerning efficacy and cost effectiveness.

This possibility of increasing participation in combined activities of radiotherapy and other oncology departments throughout Europe (and elsewhere) makes increasingly urgent decisions on an agreed data base, on criteria, on validity and on confidentiality, all of which are included in the programme for this workshop.

Margaret Snelling

Workshop Organiser's Preface

The Commission Informatique of the European Association of Radiology (AER) organised in July 1976 its first Workshop meeting on 'The Use of Computers in Radiotherapy in Europe'. The meeting was held at the Headquarters of the International Atomic Energy Agency in Vienna and was a resounding success. The Proceedings of this Workshop were published in the *British Institute of Radiology Special Report Series* (**13** 1976). In 1979, a second Workshop meeting 'The Use of Computerised Tomographic Scanners in Radiotherapy in Europe' was organised at the Headquarters of the World Health Organisation in Geneva, and was attended by over a hundred participants from 17 countries. It was again a great success and Proceedings were published as a Supplement to the *British Journal of Radiology* (Supplement 15 1981).

The increasing availability and decreasing cost of small computers has brought about a revolution in the handling of information, and it has now become clear that these tools have great promise for application to many facets of the work of oncological departments, not only in treatment planning and tumour imaging, but also in handling patient data. The Commission Informatique therefore felt that it was time to organise another Workshop meeting on the subject of the use of computers in Europe for data handling in radiotherapy and oncology. We were joined in organising this meeting by the European Society for Therapeutic Radiology and Oncology (ESTRO). Once again, we were grateful to be able to accept the invitation of Dr N Racoveanu of the Department of Radiation Medicine of the World Health Organisation to hold this meeting at WHO Headquarters in Geneva. The Organising Committee for the meeting was:

Miss M D Snelling (Chairman)
Professor R J Berry and Dr R Morrison (Organising Secretaries)
Dr T Möller (Scientific Secretary)
Dr P Minet (Treasurer)
Dr J Yarnold (ESTRO representative)

and other members of the Commission Informatique—Dr J Gary-Bobo, Professor H-P Heilmann and Professor A Laugier.

The bulk of the practical organisation of this Workshop fell upon the capable shoulders of Mrs Anne Mason and upon Miss Daphne Fresle, Department of Radiation Medicine, WHO. They were assisted at the Workshop by Miss G Andersson, and to them the Organising Committee owes a tremendous debt of gratitude.

These Proceedings include concise versions of the invited and contributed papers, and rapporteurs have been appointed to summarise the discussion in each session; these rapporteurs' reports are also reproduced here.

The meeting attracted 102 participants from 16 countries. We hope that you will feel as we did that this was a timely meeting reflecting the state of the art and foreshadowing a positive revolution in the way we do our work; a revolution which can bring benefits to our patients and to the science of medicine alike—and which is truly cost-effective.

R J Berry

Editorial Note

The Workshop Proceedings are arranged in session order as they occurred during March 26–28 1984. The participants were requested to produce their manuscripts as camera ready copy and 38 of the 42 speakers obliged during the meeting. The remaining 4 submissions were received within the next two weeks and this has aided rapid publication of the Proceedings. Since speed of publication was considered to be a priority, and so long as the essential meaning was obvious, some phrases which might not be considered to be 'Queen's English' were unaltered to avoid retyping a manuscript.

Rapid publication has also been due to the secretarial and production expertise of Mrs Anne Mason and the Editorial Staff of Adam Hilger Limited, to all of whom I am most grateful.

R F Mould
May 1984

Contents

The Use of Microprocessors in Oncology

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Abstract. The availability of microprocessors simply permits 'intelligence' to be provided directly to the user, rather than remotely. The result has been not a change of scale but a change of kind. The major uses of microprocessors have been (as part of Local Area Networks), for data base management and information distribution about patients, treatments, tumour registries:for statistics, report generation, and indeed, word processing. Microprocessors have also been used as part of so called 'smart' instruments and in simulation. 'Expert' systems, permitting enhanced access to knowledge are an essential step forward.

1. Introduction

It is important not to be sidetracked by technical glamour. Computers are only of value when they perform useful work. There is now, from the software point of view, increasingly little difference between microprocessors, minicomputers, or even large main frames. The essential features of a microprocessor are that it is small (e.g. comprising a small number of integrated circuits) and cheap. However the availability of microprocessors has caused a major change in the way in which computers are used.

Whereas not long ago, a typical computer system could be described as a kind of star network around a central main-frame, it is now common to find many other patterns of distributing intelligence (or rather computer power), one of which is illustrated in Fig 1. It is now practical and economic to place directly in the hands of the user significant amounts of computing power, rather than merely providing access to some central facility, e.g. a modern micro might well have 1Mbyte of central memory, and 40Mbytes of backing store.

This short paper will discuss some of the implications of this change, with some specific references to oncology. In particular, the following topics will be treated:

1. Local Area Networks (LANs) and the provision of communications between a series of terminals and microprocessors all located at one site.
2. Management, or the use of microprocessors as an aid to managing data and patients within a department.
3. Wide area networks and the provision of access between users, LANs, and the outside world.

4. Instrumentation: the use of microprocessors to enhance equipment, and in particular for image processing.
5. Simulation and modelling: the use of microprocessors backed by remote systems to model biological systems.
6. Expert systems: the use of computers as intelligent aids in diagnosis, research, and especially interaction with data bases.

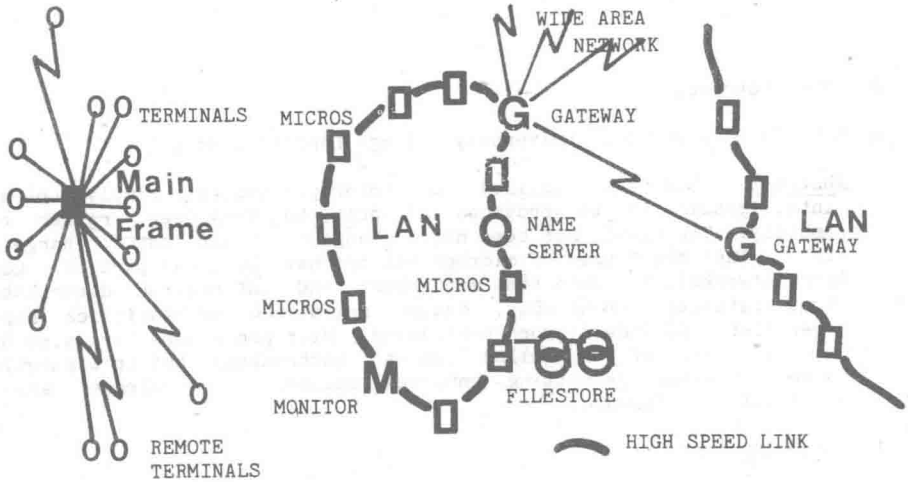

Fig 1. Changing configurations. On the left, a star type system, comprising a central main-frame and surrounding terminals, is shown. On the right, a Local Area Network of micros is indicated, with gateways to another LAN and a Wide Area Network.

One reason that microprocessors appear to have been so well received is their availability. The micro can be switched on at any time of day or night, and is generally very robust, unlike many main-frame systems. However, the provision of such enhanced facilities directly to the user has at least one important implication. A relatively unskilled person (in computer terms) must be able to make full use of it. The barrier of the 'computer expert' between the user and the computer has disappeared. While the use of ergonometrically improved operating environments such as LISA has helped, more effort must be given to providing local 'intelligence' to guide and assist users. The availability of microprocessors has changed not only the type of facilities available, but must change also the way in which users interact with systems.

2. Local Area Networks (LANs)

The initial stage of installing microprocessors was normally to establish small isolated machines, each with a processor, display, and with some backing store (typically floppy disks). The availability of graphics facilities was welcomed. However, often severe limitations were experienced. Little software existed (other than games). Programming was far from easy and the amount of backing store and memory on the micro itself was found to be severely limited. One way to extend the power and flexibility of such systems is by using Local Area Networks (LANs). The considerable increase in the power of current micro systems does not negate

these requirements.

Basically, almost all micros have a port (e.g. an RS232 link) through which the machine may be connected to a network. Examples of such networks are: Ethernet, the Cambridge Ring (Hopper 1980), and many proprietary systems such as IBMnet, ZNet, Econet, etc. Two types of communication need to be performed:

1. File transfer: the transmission of blocks of data from one place to another, possibly to be routed via intermediary systems.
2. Terminal access: to permit the local system to behave as if it were a terminal on some other remote system.

Both of these require several layers of protocol underneath the File Transfer Protocol (FTP) and Virtual Terminal levels. In particular, several specialised functions are normally required on a LAN. A LAN 'Monitor' ensures the correct transfer of data between stations, a 'Name server' translates local names known to a particular station into true 'addresses', and a 'File server' manages any data base used commonly on the LAN.

When data can be transferred from the local micro to some remote system, and vice versa, then, when other occasionally required facilities are needed (such as fast printers, plotters, and in particular 'number crunching'), these may be provided remotely. Thus it is not necessary for any given system within a network to be able to perform all possible tasks itself.

3. Management

However, no mention has been made so far about how such a LAN might be used in oncology. One important type of application is that of departmental management. Having established a patient data base a series of microprocessor workstations distributed within the department can have common access to it. One or several workstations could be used for updating patient records and other such secretarial functions. Another could be used for computer aided report generation. When diagnostic information is recorded using, for example, the American College of Radiology codes, the burden of follow-up can be greatly simplified. A third workstation can be used for appointment handling, assigning staff, rooms etc. Retrieval of (and prompting for) test results, tracking patients, generating statistics etc. become relatively simple. Thus, the state of each patient, their radiotherapy treatment plans, course of chemotherapy etc. can be continuously monitored and in principle, resources used much more efficiently. In addition, such a system provides at no extra cost all the facilities needed for word processing and of course (in many countries) patient billing. A number of packages, normally based on a central mini-computer often programmed in MUMPS, exist. Their implementation as complete packages for use on distributed micros is currently in progress.

Many applications revolve around the use of the microprocessor to manipulate both local and remote data bases. These range from simple lists of patients and diseases, drugs and drug trials, to major epidemiological surveys. While many packages for handling small data bases exist on micros (e.g. dBASE2) there is a great need for a more general approach. There has been extensive investigation of the design of query languages for the

efficient use of such information (see for example Onuegbe, Rahimi and Hevner 1983). In particular Larson (1983) has looked at the problems of accessing data bases through networks.

4. Wide area networks

However, such Local Area Networks are often still insufficient. Access is required to other resources, for example central hospital records, tumour registries, and indeed International databanks. This facility may well be provided by the use of a gateway (see for example Benhamou and Estrin 1983) between the LAN and what is termed a wide area network (as shown in Fig 1). Thus by use of X25 and PSS, and IPSS (International Packet Switching System), it now is possible to transfer data to and from the humble micro on the clinician's desk directly to almost any other system in the world. Clearly, a problem of privacy and data protection exists. However, a more immediate problem is posed by the difficulty in finding out both what is possible in the way of such transfers and how to do it. Not all of us are gifted 'computer freaks' and some HELP is required.

One particular tool of major value is to be able to investigate local data bases and set up a file of data for some statistical analysis. It might then be most appropriate to use a package such as SAS, SPSS or BMDP, and transfer of the file of data to some remote large system permits the analysis to be made. Such use of the local system for data preparation and a remote system for the use of large well established packages is very convenient. It is well known that the error rates observed in surveys where data is gathered on paper is very high. The use of micros to automate the data gathering process is highly efficient, if the system is continuously available for that purpose, and sufficiently simple to use.

5. Instrumentation

The availability of computers in general and microprocessors in particular, has made it possible for systems such as X-ray CT, Magnetic Resonance, Digital Radiography, real time Ultrasound etc, to exist. Similarly, some progress has been made using computational tools to improving the performance of therapy systems. Linking all such systems on to networks is currently in progress (Maguire et al 1983). Already trials for 'filmless hospitals' are well advanced (Nudelman et al 1982), where ALL images are transmitted from workstation to workstation rather than stored on film. A desirable future goal would be that the microprocessor workstations used within departments such as oncology could receive, display, and to some extent manipulate images transmitted on some hospital wide image network.

One implication is that some standardisation is highly desirable. Not only should it be possible to have a common image format, but it is obviously economically sensible to use similar hardware in different imaging systems, normally comprising clusters of microprocessors and chunks of high speed memory. In addition, it would be very helpful if the user interface (how the user interacts with the computer) could be standardised in some way. This can only be achieved by pressure from the clinical users.

On a much smaller scale, it has been found to be easy to interface micros to experiments within labs for control purpose. In this research