DISTRIBUTED SYSTEMS AND THEIR USE IN HOSPITALS: PROBLEMS AND SOLUTIONS.

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ABSTRACT

Small and medium scale computers are slowly proliferating in hospitals. They are used in virtually any area which can obtain a system. Observing this growth we created a group called the Medical Development Group (MDG) whose goals include:

1. the design and specification of systems for use in hospitals
2. experimentation in specific problem areas both hardware and software
3. program design, production, and software support
4. co-ordination of resources
5. creation of viable distributed systems
6. development of new areas.

The group is composed of five members and it has a relatively large PDP-11/40 system. We are engaged presently in connecting this to a variety of other systems including other PDP-11's, a 370/168, a PDP-10, and smaller systems including a microcomputer. Our special interest has been support of data management under a real-time executive. We have in operation: a booking and admitting program, a package to create reports based on Respiratory Function measurements, an automated Psychophysiology laboratory, a system for RJE of electrocardiograms to a large computer, and many others. (Des computeurs de petites et moyennes tailles sont de plus en plus nombreux dans les hôpitaux. On les emploie vraiment dans tous les cas où l'on peut établir un système. En observant cette augmentation nous avons crée un groupe appelé le "Medical Development Group" (MDG) dont le but comprend:

1. Le projet et les caractéristiques de systemes à employer dans les hôpitaux
2. Expériences dans les cas de problèmes specifiques de quincaillerie et autres marchandises
3. Raison de programme, production, et support pour autres marchandises.
4. Co-ordination des ressources.
5. Creation de systèmes distribues viablement
6. Developpement de nouveaux cas.

Le groupe est compose de cinq membres et possede un systeme PDP-11/40 relativement large. En ce moment nous sommes en train de lier ceci a une variete d'autres systemes comprenant d'autres PDP-11's, un 370/168, un PDP-10, et des plus petits systèmes comprenant un microcomputeur. Nous nous intéressons surtout à soutenir les données d'administration sous un exécutive responsable. Nous avons en vigueur: un programme d'enregistrement et d'admission, un assemblage de détails pour la création de rapports sur les mesures de la fonction respiratoire, un laboratoire Psycho-physiologique automatisé, un système pour RJE d'electrocardiogrammes à un grand computeur, et bien d'autres choses.

INTRODUCTION

An immense literature exists detailing the application of computers to medicine. Most recently the Science Council of Canada stated in report No. 22 Science for Health Services, that "computers will assume a crucial role in keeping Canadians healthy".

That computers are important, at least in certain areas, cannot be denied, for we are witnessing their application and success. That computers will be important has been predicted for many years. Just how important and how all-pervading their presence will be in medicine, has to do with a yet-to-be-seen co-ordinated and well planned effort to introduce computers into medicine on a large scale.

What we presently have is the relatively uncoordinated and piece-by-piece addition, or even accretion of processors into areas which could hardly avoid computers any longer.

The problems we see in the introduction of computers are partially due to the immense difficulties in creating effective medical computing systems. The area has very specific needs seldom met by existing equipment, operating systems and languages available through industry. It has been said (Gardner, 1975) that "systems must be custom-made to fit into the local practice of medicine. At the moment there are virtually no applications where a 'canned' system will fit".

Thus, computers proliferate in medicine, especially at the bare processor level. The proliferation has been due to the attitude, until recently, of granting agencies to allow each researcher to purchase his own computing equipment. This has been especially true if the researcher's requirements are for a small computer with little or no peripheral equipment or a large calculator. In addition, processors have found their way into hospitals by virtue of their attachment to instrumentation, with GEMSAEC instrumentation, the EMI scanner being examples of this. Very frequently, these basic processors are later expanded to permit the user the ability to perform statistics, plotting or similar functions.

A few processors have actually made their way into hospitals for the expressed purpose of data processing. Mostly, however, the government's attitude has been emphasis on the regionalization of computing facilities, and thus it has been a "big computer" pusher.

Our purpose here is to present a manageble alternative to the centralization of computer facilities (as a whole) and similarly of the developement teams associated with these facilities. To look toward development teams and a distributed processing environment appears to us to be a mandate from researchers and industry. The point is, in fact that this is the only way to proceed in an area where research and development and service are inexplicably mixed, regardless of semantics concerning centralization and its benefits.

PERSPECTIVE

Very few competent workers in industry can deny that the mini-computer, its availability, its low cost, and its effective integration into adequate data processing systems has been the primary driving force in a reorientation away from computer centralization and toward distributed systems. Distributed systems might be defined as the "computer in the application" while centralization is more of "the application in the computer". For the doubters: in a recent issue of Datamation magazine an article "Beyond 1984: Technology Forcast" made the point that "the mini-computer will in both 1977 and 1985 be able to support a fully capable data processing system."

A problem in communication when relating with government has been the definition of a mini-computer. We would like to separate the following: calculators, bare mini-computers, and mini-computer systems. Without becoming involved in the distinction between calculators and bare mini-computers, if such is possible, we will simply state that a viable mini-computer system will contain all the elements necessary to perform adequate data processing in the particular environment of application. This means that it may include small or large discs, perhaps magnetic tape drives, perhaps analog-to-digital converters, and various I/O peripherals. In addition, it will support an adequate and efficient operating system, higher-level languages, and all the facilities for one or more of the following: real-time data processing with simultaneous foreground and background operations, time sharing, or multi-stream batch. At the smaller end this might mean a PDP-8. In the middle range a PDP-11/40 or /45 system, or an ECLIPSE S/100 or others would be the processor of choice. At the larger end this would be a large PDP-11/45 or 11/50, an HP-3000, a large ECLIPSE or the new PDP-11/70. What is common about these processors is that they support complete systems whether small, medium, or large. Nevertheless, they are meant for a relatively small or limited environment and are not themselves meant to be the much touted "Hospital Information System" or HIS. Groups of these systems networked together would be called a distributed processing system, or computer network, and when one of these meets the various needs and intentions of that often used term, then we may christen it "the HIS". If we must.

It is this development of distributed computer systems which has boggled the collective mind of government, apparently. There has been a total absence of adequate standards, specifications and guidelines for implementation.

Recently, a directive from the Ministry of Health Information Systems division in Ontario contained a reference to "micro-mini computers". This is not a industry-meaningful term and it is difficult to determine exactly what is meant by it.
The directive considers such machines as those with total system values up to $80,000.00. It is really unknown precisely what is meant by this directive and what, if any, guidelines it contains for the implementation of computers in hospitals.

It has also been the stated policy of government to, wherever possible, have system-houses perform required work. This is impossible in the medical area, as even the definition of the project itself requires preliminary work. There has been an excessive emphasis on the transportability of programs, i.e., programs must be written in a language which will run on a multitude of systems. In fact, transportability may not be a particularly relevant consideration in a valid distributed computing system, where a language can be utilized according to the particular need of the particular area, often with the first developments occurring merely to discover the relevance, ease of accomplishment and workability of an idea.

Another problem is the excessive emphasis on laboratory computer systems. The idea of the implementation of an information system in a hospital brings nothing but the rejection of the idea, while the possibility of implementing laboratory computing systems to cover the data handling needs of instruments receives consideration much more easily. Since one of the main problems in hospitals is the handling of information at the medical records level, this emphasis is obviously lopsided. Another facet of this problem is that mini-computers are recognized as being a solution to the laboratory instrumentation handling problem, while it seems to be beyond the ken of the planners to realize that a similar need for focused systems, under the control of individual groups, and with optimized characteristics, are needed in the general medical information arena. In fact, a point might be made that the concept of distributed systems is most often discussed today within the general context of file and record management systems.

It is not often realized that there exist very few competent medically-oriented systems people. This includes those competent in hardware, software, system analysis, and even clinical research and development. It appears to us obvious that one of the great needs in medical computing is the development of groups of people with the above skills who can operate in the environment of medicine while being susceptible to the subtle influences which must take part in creating and structuring effective systems in this area. Very frequently systems fulfill an individual specification, but it is a much repeated disaster in the field of computers in medicine not to realize that the problem of defining the precise area for the application of the computer is itself the first problem requiring a solution. Our argument is that only a fully integrated-into-medicine team is likely to be competent to this degree.

At first, when computers were considered for introduction into the hospital, they became the property (or rather theoretical thinking about their introduction became the property) of the management engineering group. Very frequently these were people whose previous experience was merely as systems analysts and, even more frequently they had no previous experience in computing as other than a batch user. For this reason, slowly but surely computers have evolved from being within the snares of this particular group. Overall this has been a valuable exercise, in that an inappropriate function has been removed from this group of people. Nevertheless, it now becomes necessary to invest an appropriate group of people with the responsibility for computer development. Such groups do not normally exist, at present, within medical institutions. Therefore, there is the necessity of creating this new genre of engineer-scientist-designer-programmer team with the professional and technical capacity for handling the rather complex introduction of this problematic technology into the area of working medicine.

So as not to forget, one must realize that, in medicine more than most places, the area of "human engineering" and of "human factors" is extremely important. It is not enough to simply design a system to solve a problem. Often, in fact, what is necessary is to involve a group in the design and creation of a system, in order that it not only be successful and in fact solve the problems of that group but also be used by them. This after all, is the reason for the introduction of computers.

Computers have become a political item. The purchase of computers, and their ownership has become a form of "conspicuous consumption". The creation of large centralized computer facilities with their concomittant software and hardware groups creates a new, encysted, un-integrated department within other such encysted, un-integrated departments. While medicine is attempting to "bring it all back together" and to work in multi-disiplinary teams, the computer groups are attempting to create their beautiful, expensive, and very separate facilities. This results in the medical people becoming frustrated with attempting to formulate their priorities within the context of other users', and with attempting to reach the computer staff on its plane. The argument is, that such a situation should not be permitted to come into existence, and where it does exist it should be abolished. One of the benefits of the concept of distributed computer systems, networks and their effective implementation is that development and priorities are in the hands of the individual area and consequently focusing, optimization, responsiveness, priorities and, ultimately, utilizability rests in the department or area of application.

It appears to us that many of those in the government in the position of creating large-scale centralized facilities, (and who, again rather inappropriately, seem to have their hands on the policy mechanism relating to other types of computers) left industry anywhere from three to ten years ago. The changes which have occurred in industry relating to distributed computer systems have occurred in the last several years. It may well be that some of the resistance we see to this type of technological and conceptual innovation is simply that these people have not been part of the evolutionary change which has radically altered

the perspective of those in industry. A problem of education may, in fact, exist, and toward this we should proceed with no further adieu.

Lastly, although it proceeds repetitously in multiple uncoordinated efforts, there is occurring an attempt by government to assess the present status of computers in health care systems. The two most noteable attempts at this are the Health Computer Information Bureau established by Dr. John Walter. The attempt here has been to create a compendium of all active programs and systems being developed in medicine in Canada. At the Ontario level, a similar, although overlapping, survey is occurring from the Ministry of Health Systems Management and Coordination Branch. It should soon be possible, with the assistance of these various studies, to see what is already happening in hospitals in terms of computing, and with this to obtain a perspective on the present. One would hope that part of the educational process mentioned above would be that the policy makers in government recognize that, in fact, what they have laid out before them is the start, albeit uncoordinated and unstructured, of distributed computer systems in medicine. It has been established by default and inaction, which may be, in this case, the mothers of invention.

MEDICAL DEVELOPMENT GROUP IN COMPUTING

It is with these and other considerations in mind that we launched what we called our "Medical Development Group" in computing. This group has, at present been given temporary funding by the Ministry of Health. It's future, frankly, is in doubt. Nevertheless, we would hope that the concept itself and perhaps even the group will live beyond the temporary status.

The group is intended to be a research and development team. It is composed in our case of a systems programmer, an applications programmer (although no necessary immediate distinction need be made between these people), a person familiar with forms development, and an administrative secretary. The team is backed up by members of the department of Computer Science at the University of Western Ontario, and has a number of graduate students doing Masters and Ph.D. level projects as part of the team. The team has a director who himself is a designer of hardware/software systems and who acts as the goal setter and manager of the group.

The group is thoroughly integrated into a number of departments. These include the departments of Psychiatry, Psychology Cardiology, Respiratory Function, and others. By far the strongest involvement of the group is in Psychiatry and Cardiology. The thorough integration is formalized by cross-appointments at the University of Western Ontario, the director of the group having appointments in Computer Science, Psychiatry, and Cardiology. The result of this type of team effort, in full consort with the various involved departments is that the user and the developer are effectively one.

The types of support offered by this group include: service, for instance the running of statistics programs for users; research applications, for instance, the creation of new languages; and the development of new systems.

The overall responsibilities of a team of this type should include:

1. the design and specification of systems for use in the hospital
2. the experimentation in specific problem areas both hardware and software
3. program design, production, and software support
4. co-ordination of resources
5. creation of viable distributed systems
6. the development of new areas for both the research and service environment
7. provision of consultative backup for groups becoming involved in computing.

If groups of this type are available it is possible to use them as a central resource group for information on available hardware, software, and personnel. They may also serve as a reference group to other workers in the field of application about which information is being requested.

The writing of proposals to government, to granting agencies, and even for budgeting within the hospital may also fall within the services which can be offered by this type of group. A well written, well supported, and feasible development application can mean the difference between a proposal being accepted or rejected.

An important area for the activity of groups of this type is in the coordination of the development of facilities within the hospital and perhaps among hospitals. This means that if such groups were available they would be able to vet proposals and either reccommend that a system be installed, that an existing facility be shared or expanded in order to be shared, or that particular applications would be unsuitable.

In short, the groups should be a center of expertise for all matters relating to clinical computing whether they be the purchase of hardware, contacting of workers already doing a particular type of work, or the development of new systems or plans for future applications of computers.

Such groups do not in general exist, and, in order for there to be successful applications of computers in, medicine such groups must be created.

FACILITIES

It is important the Medical Development Groups of this type have available adequate facilities for the purpose of developing systems. At University Hospital in London, Ontario we have available to us a large PDP-11/40 mini-system developed for the particular needs of the medical development group. In addition we have access to via time shared terminal a PDP-10, and via batch entry to other computers.

The creation of our PDP-11/40 facility was dictated by the need for a large shareable processor within a number of departments. In addition we have been experimenting with a variety of operating systems, developing new languages, and beginning planning for even the development of extended hardware, for instance, a valid network, and a multi-processor arrangement.

We feel it is now possible to write specifications concerning the types of computers which are needed in various medical areas. We are proceeding to do this and in this respect are beginning to "get the ear of" government. We have termed our processor an Experimental Medical Processor (EMP). It has facilities necessary for many test applications within the area of medicine. This includes everything from real-time applications through information management and straight FORTRAN job running. We are attempting to develop systems in University Hospital around this EMP and to network these facilities together allowing a measure of distributed processing and program development.

We feel that the eventual success of our work rests upon our ability to define and to develop a network of computers, large-scale calculators, and microprocessors. In addition, we are making use where possible of existing large-scale facilities. The PDP-11 is directly connected by low-speed line to the PDP-10 at the University of Western Ontario. In addition our PDP-11 system is connected by a high-speed synchronous communication line to a 370/168 at another facility. A smaller PDP-11/10 system for the EEG laboratory is being installed and this in turn will be connected to the PDP-11. A microprocessor system for the control of the Rat Behavioural Laboratory is presently in the final stages of development and it will become another node in this network.

We are attempting to offer the inter-connection of facilities and the services of our team. Needless to say, the history of computer processing in medicine to date is working against us and the task is not easy.

Nonetheless, inroads have been made, a staff does exist and a facility is available for at least major applications. It is our contention that the expansion of this type of activity and the coordination and utilization of existing resources will lead to an important improvement in the availability and useability of computers in medicine.

RELATION TO LARGE CENTERS

It is important that it at least be mentioned that no facility which is available should be ignored. This includes the establishment and soon to be established regional computing facilities for primarily administrative purposes. It also includes the above mentioned type of resource available at universities. There are a number of government facilities which may also be brought into play in certain applications. Lastly, the new Health Science Centers have available or will have available to them certain computing resources. All of these facilities, in as much as they all rest in the field of medicine, should be utilized, and the network which exists at individual institutions should be extended to include communications to these processors.

The larger facilities are not, however, the final answer, nor would a multiplication of them be the final answer. But it must be understood that they, as much as the smaller computers, have their purpose. We feel that by creating such a communication system, by utilizing facilities at the departmental level in hospitals and by gaining access to larger facilities where needed, the situation will ultimately harmonize, in that the larger facilities will be available where needed, and the focused applicati of the smaller facilities will have satisfied the need of the local environment.

AREAS OF APPLICATIONS

Our group has been involved in many departments within the hospital. In addition, we have been involved in departments across a number of hospitals. Our primary activities have been in Psychiatry, Cardiology, and Psychology. We have also developed programs for a Respiratory Function Laboratory, an Admitting department, for an outpatient treatment program, for a Biochemistry Laboratory, for various research groups and for the use of many other departments.

Our special interest has been in the real-time environment, especially our work on our Psychophysiology Laboratory. Because of our involvement in real-time systems, we have recognized the need for a good real-time system, a need seldom met by industry-available executives. In addition, since the second most important group of applications made to us is for data base management functions we have become, recently, extremely involved in this particular area. Since we have the equipment to handle the real-time work, however, it has been necessary to develop our data base management system as a package under the real-time executive. We feel that this is an important and necessary step in hospitals, where a processor is often used to meet a real-time requirement, but nonetheless has a great deal of time available which could be well utilized by a data based management system.

We do not consider any clinical application of computers to be outside our mandate, and consequently we are becoming involved in new areas virtually every day. We obviously, however, have a limited capacity, and it is for this reason that we should, in coordination with other groups, limit our activities to certain areas while these other groups proceed to implement them.

With many centers working in these different areas, and with the various interests of these centers providing a form of collective expertise, it should be possible, when properly managed, to obtain or to develop most programs and systems which we presently would like to have.

CONCLUSION

In closing, we are attempting to bring the distributed computing concept into the hospital and the general medical environment. We are attempting to establish teams, fully integrated into the medical department, whose tasks are research, development and service relating to medical computing. These groups are composed of experts in the field of computing and experts in the research and development areas of medicine.

We are attempting to develop, where needed, adequate facilities to carry out the implementation of computers in specific areas, or to create general purpose systems which can be shared by multiple areas. We are attempting to make use of existing resources both computing and personnel. We are pushing government to become involved in this activity at an organizational and financial level.

In doing this we hope to establish a new area of expertise along the same lines as has been established for management engineering, biomedical engineering and other such resource-type professions which are available in hospitals. Our activities are presently being carried out in University Hospital in London, Ontario, although a similar effort is beginning at Toronto General Hospital

in Toronto, Ontario. With the provincial Ministry of Health beginning to move in this direction, there is new hope that this type of activity will succeed and that the fruitful application of computers to medicine can become a reality.

REFERENCES

GARDNER, R. M. 1975 The place of computers in medicine. Computer, 8 (1): 19

WITHINGTON, F. G. 1975 Beyond 1984: A technology forecast. Datamation, 21 (1): 54-73.

SELECTED BIBLOGRAPHY

"A Semi-Automatic Left Ventricular Size and Shape Measurement System Employing Video Techniques". Fourth Scientific Meeting of Society for Experimental Biology and Medicine, June (1974).

"Techniques for Routine Left Ventricular Function Studies Suited for a Variety of Laboratories", Canadian Cardiovascular Society, October (1974).

"Two Years of Experience in Computer Assisted Follow-Up of Pacemaker Patients", Canadian Cardiovascular Society, October (1974).

"Data Management in a Hospital Environment. The Use of a Mini-computer", Proceedings of the Digital Equipment Computer Users Society, January (1975).

"Analysis of Electrocardiograms on a 370/168 IBM Via a PDP-11/40 Data Acquisition System", Proceedings of the Digital Equipment Computer Users Society, January (1975).

"A Booking and Admitting Program on a PDP-11/40", Proceedings of the Digital Equipment Computer Users Society, January (1975).

"Complete Cardiac Medical Record", Proceedings of the Digital Equipment Computer Users Society, January (1975).

"Respiratory Function Data Processing", Proceedings of the Digital Equipment Computer Users Society, January (1975).

"Automated Psychophysiology Laboratory", Proceedings of the Digital Equipment Computer Users Society, January (1975).

"Remote Psychiatric and Psychological Services Via the Communications Technology Satellite (CTS)", Proceedings of the Digital Equipment Computer Users Society, January (1975).

"Forms Development on a Large Scale the Optical Mark-Sense Approach. A System Designed Around a PDP-10 and PDP-11/40", Proceedings of the Digital Equipment Computer Users Society, January (1975).