DATA MANAGEMENT IN A HOSPITAL ENVIRONMENT.
THE USE OF A MINICOMPUTER. (DONNEES
D'ADMINISTRATION DANS EN ENVIRONMENT
D'HOPITAL.   L'EMPLOI D'UN MINCOMPUTEUR)

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ABSTRACT

An interim solution to our need for data
management of medical information was to
design under FORTRAN IV on a PDP-10 a
relatively flexible data management program
to handle specialized areas. More recently
our work has shifted in the direction of
creating a language with functions similar
to those used in Massachusetts General Hospital's
language "MUMPS". Our approach has been to
develop this as a new version of FOCAL.
FOCAL-11 has been incorporated on a PDP-11/40
under RSX-11/D and is being modified to
permit multi-terminal access, string
manipulation and access to the data management
facilities of RSX-11/D. Work is underway
in creating flexible data management routines
callable by FOCAL and FORTRAN and on a
report generator sublanguage. Examples
of the work which we have already completed
include: an Admitting program, a storage
and retrieval system for treatment evaluation,
and a report generation system for optical-
mark check-list patient records. (Une solution
temporaire à notre besoin de données d'
administration de renseignements médicaux
était de préparer sous FORTRAN IV sur un
PDP-10 un programme de données administratives
plus ou moins flexible afin de manier
des endroits specialisés.
Plus récemment nous avons changé nos efforts
afin de créer un langage aux fonctions
semblables à celles qu'on emploie dans le
langage (MUMPS) de l'Hôpital Général de
Massachusetts. C'était notre intention
de le développer comme une nouvelle
version de FOCAL.
FOCAL-11 a été incorporé sur un PDP-11/40
sous RSX-11/D et on est en train de le
modifier pour permettre l'entrée multi-
borne, manipulation par corde et facilités
d'accès aux données d'administration de
RSX-11/D. Maintenant on travaile pour

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créer des routines flexibles de données
administratives que l'on peut mettre en
action par FOCAL ou FORTRAN, aussi sur
un générateur de rapport sublingual.
Des exemples du travail que nous avons
déjà terminé comprennent: Un programme
d'admission, un système d'emmagasinage
et de rétablissement pour l'évaluation de
traitement, et un système de rapport
générateur pour marques-optiques liste
de contrôle des rapports sur les malades.)

INTRODUCTION

Today's health care delivery systems face a major
problem: the cost of health care is rising uncontrollably.
This is not only because of the rising cost of facilities,
communication and staff, but also because of increasingly
complex medical procedures, greater demands for better
medical care, and the sheer burden of information handling.
One way to quickly and substantially increase the efficiency
with which the health services can handle information is
the intelligent application of any available computer resources
to handle health care data. This should increase the capacity
of the system to meet the current demand.

A huge amount of information has to be kept for hospital
administration, medical records and research, and hospital
services. By using computers, some advantages are foreseeable.
They are:
1) reduction in the clerical work of filing and cross-
    referencing and re-recording information
2) reducing the storage space required by maintaining
    a single copy of the record in the computer, which
    is easily accessed by different departments
3) the provision of fast information retrieval and
    communication
4) easily available and easily used statistical and
    arithmetic computation facilities
5) test and examination interpretation
6) and, report generation, reducing typing and retyping
    of reports.

To achieve such goals, several computer programs have
already been written by the Medical Development Group at
University Hospital, London, Ontario. An Admitting Program
reduces clerical work and provides information retrieval and
maintainence on patients being booked, admitted and discharged
(Scase 1975). A Respiratory Function program calculates routine
respiratory parameters and prints out results in a report form
(Scase 1975). A Psychological Test Battery scores and interprets
psychological tests of the following types (presently):
1) WAIS-Clarke Vocabulary Test
2) Raven Progressive Matrices

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3)   Trail Making Test
4)   Minnesota Percepto-Diagnostic Test
5)   16 PF
6)   and the MMPI (nearing completion)
filled out by patients and outputs appropriate diagnostic state-
ments. A Report Generator creates reports from a psychiatric
admitting record for patients admitted to the psychiatric
ward. A batch-oriented data management program stores
information and provides reports for a study which is
intended to evaluate the cost and effectiveness of an out-
patient in-community novel treatment program. Programs
are also available or in the final stages of development
to create reports from our Psycho-physiology laboratory
and to handle nursing schedules and departmental finances.

All of the above basically require a flexible data
management system. We have, to date, developed all of our
applications in FORTRAN IV, but the facilities required
for data management are not easily created in FORTRAN.
Thus a data management system (DMS) using a data management
sublanguage is proposed to fill the need. This will run
on a PDP-11 type processor.

A medical data management system must be able to
meet the variety of requirements exemplified by the studies
mentioned above: it must be flexible. Flexibility in
medicine means the ability to structure files according
to the specific needs of a group or department. A truly
useful data management system must incorporate a sublanguage
accessible by higher level languages, which creates files
and allows user programs to interact with them without
programmer knowledge of the disc structure. There must
exist adequate facilities to map one structure into another
as the needs of an area change. Needless to say, this must
be accomplished without major reprogramming. Very few
minicomputer system provide resources of this type.

In the hospital, reports are used as the tool for
communication between and among the medical care peronnel,
the administration, and referring and following physicians.
Any adequate DMS should be able to produce and communicate
reports to the appropriate departments and individuals
requiring information. A statistical package providing
continuous monitoring of treatment and activities would be
useful for evaluating, for example, the result of treatment
with drugs or the level of use of a particular service.

The amount and type of information collected varies
from one patient to another. The system should be able to
handle variable length patient records. Deletion and appendage
of information to a record should be easily accomplished by
the system. In order to make the system accessable by all
professionals in the hospital, the feature of on-line enquiry

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must be included and must be simple to use. Error diagnostics given by the system should be clear and errors should be recoverable.

USING PROCEDURE LANGUAGES IN CREATING A DMS

Advantages

Presently, the two most active programs running on our PDP-11/40 system are the Admitting and Respiratory Function programs. They are written in FORTRAN and have a few FORTRAN callable assembly language routines. FORTRAN and MACRO were chosen because:

1) both FORTRAN and MACRO come with the RSX-11/D monitor which we are running
2) FORTRAN is good for arithmetic computation needed by the Respiratory Function program
3) FORTRAN is machine independent
4) most programmers are familiar with FORTRAN, and
5) the assembly language is flexible and is required for implementing special features not supported by FORTRAN, for instance, file management.

Disadvantages

1) Under the RSX-11/D system, the editor, the FORTRAN compiler and MACRO assembler are single-user programs.
   This significantly reduces the access to the machine for program development. This is, however, to be overcome in an upcoming revision of the operating system.
2) To install a program, the time consuming process of creating (editing), compiling and linking must be followed.
3) Once an error is found in the program, the whole procedure of editing, compiling and task building must be repeated.
4) MACRO is an assembly language requiring a relatively sophisticated programmer.
5) There are no string manipulation features in either FORTRAN or MACRO.
6) Neither of these are designed for the purpose of data management.
7) Comparing FORTRAN or MACRO to either FOCAL or BASIC, the former two are more difficult to learn and use, and in addition, require a knowledge of an editor and linker.
8) Programs written in MACRO are machine dependent.

FOCAL - THE FIRST STEP TO OUR OWN DMS

To overcome these drawbacks, a multi-user FOCAL-11

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has been implemented under RSX-11/D. String manipulation and access to a data management sublanguage are being added at this time. FOCAL has a simple and easily learned instruction set. Since it is an interpreter, program creation, modification, and debugging can be accomplished in one step. A large library of FOCAL programs suited for many applications can be easily converted and run under RSX-11/D.

LIMITATIONS OF FOCAL

Several limiations also exist in FOCAL. They are:
1) Programs are not directly transportable. FOCAL is only implemented on computers manufactured by Digital Equipment Corporation (DEC). Once the DMS is written in FOCAL, it can only be run on DEC machines.
2) Slower Speed Compared to a Compiler Language. It is recognized that the execution speed of an interpretive program is slower than the corresponding code generated by a compiler or assembly language system.
3) Smaller Instruction Set. FOCAL has a relatively small instruction set compared to BASIC or FORTRAN. It does not have the capability of matrix operation as in BASIC. Also, it is not nearly as sophisticated as FORTRAN for scientific applications.

Since, however, FOCAL is only one of the languages which have access to the data management sublanguage, languages may be selected suited for a particular application. The ease of programming in FOCAL and its flexible input/output features make it still a very attractive language for implementation in a medical DMS.

BRIEF DISCUSSION ON CHOICE OF LANGUAGE

An interpretive language is chosen because a typical program written in it occupies less core than the object code generated by a similar program written in a compiler or assembler language. In addition, as long as the interpreter is reentrant, all programs written in that language can share the same utility routines which also effectively reduces the memory required. An interpretative language is more popular and can be used by much less sophisticated programmers.

BASIC was preferred to FOCAL, but was not chosen because the single-user FOCAL has been easier to modify and BASIC was not available to run under the RSX-11/D Executive. We did not create a language of our own since it is much easier to build the DMS by adding new features to an existing program rather than to start from the very beginning. On the other hand, the DMS implemented in FOCAL is just a proto-type system in a long-term project. Other languages will be used wherever

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necessary. The language chosen will depend on the function
of the routine. It is also possible to write programs under
a compiler and to call them in FOCAL through a call statement.

REASONS FOR WRITING OUR OWN DMS

There are quite a few data management systems available
on the market, for example: TOTAL, GIS, IMS, MUMPS, IMAGE
and so on. Most of them are for industrial applications
(TOTAL, GIS, IMS), are stand-alone systems, and are expensive.
Most require large-scale hardware. The only two data base
systems available from the computer manufacturers for
minicomputers are IMAGE (Hewlett-Packard) and MUMPS (Digital
Equipment Corporation). IMAGE is a multi-user system on
Hewlett-Packard machines.

MUMPS is a multi-user, medical oriented (Gabrieli 1970),
single language, data base management system. It is a stand-
alone system and runs on PDP-11 and PDP-15 computers. Arithmetic
calculation in MUMPS is poor, and modification of the language
itself is difficult. Also, MUMPS has no capability of
handling real-time tasks simultaneously with data base management.

PROPOSED FEATURES OF OUR DMS

1.   It Should Operate in a Multi-task Environment

In hospitals, different departments and different
projects often share the same resource, for instance, a PDP-11.
Data management does not require full-time use of that
resource. For example, the Admitting and Respiratory Function
programs are running concurrently on our system now. The
Admitting Program is used whenever a patient is booked for
admission or admitted to the hospital, and the Respiratory
Function program is used throughout the day after routine
respiratory analysis. We cannot afford to have a data base
system that supports these activities but which does not allow
real-time tasks, for instance, our Psycho-physiology laboratory
to run concurrently (Covvey 1975).

2.   Arithmetic Computation

In the field of medical research, arithmetic computation
plays an important part. Most of the routines in the Respiratory
Function Program involve arithmetic computation. Surveys of
patients' records, inventory control, and treatment method
requires a fast and flexible arithmetic package.

3. Callable Sublanguage

In order to make the DMS flexible and useful, access
to this system via callable routines must be available.
It must be callable by any language. The user should be able
to incorporate the data management features in the language
of his choice without having to develop his own access methods.

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4. Ease of Modification

Adequate data base management in the medical area is relatively new, especially on smaller machines in the distributed environment. Since it is difficult to specify its exact requirements in its application to such a huge area, the system should be easily modified and added to and flexible enough to allow many implementations, for example, of different storage methodologies.

5. Ease of Use

The system must be designed to be used by hospital personnel. Few know what a computer is, let alone know about the concept of data management. Hence, access to the system should be easy and in natural language format. Operations of insertion, deletion, replacement and so on have to be simple and described in simple terms. This dictates enquiry-level implementation.

6. Multi-User

The system should be designed to handle many users simultaneously. When one user is doing the updating, the record being updated should be protected from access by other users, while the condition of deadlock should be prevented.

7. Security

Information in the system should be secure. Only authorized personnel should be allowed to update and obtain information.

8. Access

The system should function in both on-line and batch modes. The on-line mode provides interactive response to the user and is good for query functions. Using batch mode for large scale information updating reduces the input/output time required. Also, batch mode is essential for inputting mark-sense forms.

CONCLUSION

Multi-user FOCAL-11 is now running under the RSX-11/D Executive at our centre. The features of string manipulation and file management are being added to FOCAL. The full-scale development of the data management sublanguage was begun in January 1975 and portions will shortly be operational. Although development will continue over a long period of time, a basic system will be operational in late spring, early summer 1975.

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In support of the development of the system, a variety of file handling routines are being created providing flexible file structuring. Work in the future includes developing a language to supplant FOCAL and in allowing other existing languages, for instance BASIC, access to the data management sublanguage.

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