A Time-Sharing System for Laboratory Computers

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Abstract

DAL is a timesharing system which has been developed by the Biophysics Laboratory of Dalhousie University. It makes the computing power of a large computer available to the individual laboratory user. Convenient and economical means are employed for interactive communication between users and computer. The software system permits assembly of program packages from existing general routines. Effective means have been implemented to guarantee user and monitor integrity.

1. Introduction

During the last few years the digital computer has taken its place as a versatile laboratory instrument for data acquisition and control of experiments. There can be no doubt that in the future as more sophisticated hardware and software become available it will become an even more important tool for everybody doing experiments of any kind.

There is still some debate about whether the laboratory computer should be realized as a small dedicated system or as a large time-shared system. In our opinion no one system provides the ideal solution for all circumstances; the choice depends very much on the specific requirements.

It is the purpose of this paper to describe the hardware and software of the laboratory computer system installed in the Department of Physiology and Biophysics of Dalhousie University. A central time-shared computer system was chosen over the alternative of a number of small, dedicated systems for a number of reasons including the following:

a. The experimental conditions in a physiology laboratory usually do not remain fixed for too long a period of time. It is therefore highly desirable to be able to quickly change computer programs. This is much easier on a large computer with its fast I/O devices and more sophisticated language translators.
b. The speed and computing power of a larger computer normally offsets the disadvantage of having to share the facility with other users.
c. It is easier to attract competent systems and applications programmers to a sophisticated system.

2. Computer Configuration

The Dalhousie laboratory system is based on an XDS Sigma 5 as a central processor. It is equipped with a core memory of 32k words of 32 bits each. A 6.3 Mbyte (1 byte=8 bits) fast access disk acts as the secondary storage medium and 3 magnetic tape drives with transfer rates of 60 kbytes are available as bulk data storage. Additional I/O devices, which are available only to the background users, are card reader, line printer and graph plotter.

The laboratory system contains a 32 channel multiplexed A/D converter with an overall data rate of 100,000 fifteen bit words. Each channel has as an input terminal a high impedance differential receiver (for elimination of ground loops) and the option to route the incoming signals through analog filters for band width correction.

A special controller for the A/D converter permits four independent users to specify independently,

a. sampling rate,
b. channels to be sampled,
c. area in core to save sampled data.

Thus time-sharing of the converter is possible between the four users with each user having a quarter of the band width of the converter available for his exclusive use.

Sixteen external interrupt levels are available for response to service requests from the laboratory user. The requests have to be communicated to the computer through a set of thumbwheels.

For communication of information from the computer to the terminal user in the laboratory the following output devices are available:

a. storage oscilloscope with character and graph capabilities, which can also be used as a three channel monitoring scope,
b. a set of 8 indicator lights,
c. an external trigger pulse, to start stimulators or similar laboratory equipment.

These I/O devices were selected to provide an economical solution for the requirements of data acquisition and on-line data analysis. For control of experiments a more elaborate set of output functions would be necessary.

3. DAL Philosophy

The most critical demand on a laboratory computer system is for uninterupted, undisturbed data acquisition. This can be satisfied by a priority system in which data acquisition is always performed with the top priority and any data analysis is done on a lower priority level. As a result of such an arrangement the request for computer time of a data-acquisition program will always be satisfied. All the remaining computer time is available for programs performing data analysis and for monitor services.

A time sharing principle is applied by analysis programs in the sense that one program may temporarily terminate processing and allow other programs to be executed. Reasons for such temporary termination might be:

a. request for user response
b. incomplete input-output operations,
c. calculations requiring excessive computer time.

It is realized that this system is potentially dangerous since it makes it the user's responsibility to free the computer and allow the rest of the users to get a fair share of the system. It has, however, the big advantage that very little monitor overhead is involved and a user with a critical time requirement can get the computer time he needs.

Great emphasis has been put on the design of the protection of one user from another and the monitor from all the users. Especially critical is monitor integrity since collapse of the system may result in loss of irrecoverable data. The scheme which has been implemented for user and monitor protection takes full advantage of the available hardware features of the Sigma 5 computer. User interaction is eliminated by assigning each individual user his own set of arithmetic and index registers. Immediate termination of any program is possible without interfering with operations of other users.

4. Programming Considerations

The user may write his real time programs in either the Sigma assembly language or a subset of the Fortran IV language. The possibility of writing analysis programs in Fortran makes it especially easy for the researcher to adapt his data analysis to changes in his laboratory experiments.

If core storage is available each user may have three programs acting simultaneously. A very simple relocation scheme is used so that at the time a program is requested it will execute in any location in core memory. These programs can be completely independent from each other or they may communicate and exchange data.

The DAL system makes provision for complex analysis procedures which require a large amount of core storage. The user has to write these programs in segments and through a very simple scheme may link the different segments at execution time.

The system has been in operation for approximately 9 months. During this time programs have been implemented for use in the areas of

a. ECG analysis
b. respiration research
c. intensive care monitoring
d. EEG averaging

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