# THE TRADEOFFS BETWEEN TIMESHARING AND DEDICATED COMPUTERS IN A MEDICAL SETTING

Homer R. Warner, M.D.

Department of Medical Biophysics and Computing
LDS Hospital, University of Utah School of Medicine
Salt Lake City, Utah 84143

Recent developments in the implementation of compute-intensive knowledge-based systems for the acquisition of medical data from physicians on the one hand and the rapidly increasing power and availability of the microprocessor on the other make a reassessment of the roles of the large timeshared computer and the dedicated single-user computer appropriate at this time.

1. A centralized timesharing system can:

a. share resources such as cpu, printers, and discs when these are only used occasionally by any one user, b. accept information coming from a variety of sources, store it, and distribute it to thoses who will use it to make decisions, c. share special files such as dictionaries, knowledge bases, and sophistocated programming languages, d. provide improved reliability in a system such as the "NON-STOP" Tandem where mirrored files and backup CPU's are an integral part of the design, e. provide powerful utilities for the programmer and system software and hardware maintenance costs including backing files at a central site using shared personnel.

2. The dedicated machine also offers a number of distinct advantages. These include:

a. complete control of the machine---the programmer can know what is happening in the machine at all times, b. minimal loss of machine cycles to overhead (ie. time spent in controlling and allocating resources among the users, but which accomplishes no useful work for the end user), c. simplication of programs that do not have to provide for multiple users (ie. provide for queueing in the use of I/O devices), d. better response time to the user due to 2a,b,c, above, given comparable (within an order of magnitude) speed of instruction execution, and e. less expensive for single user (does not require a large financial commitment at the outset and additional units effect the cost and response time of the system in a linear fashion).

3. The timeshared system has some real costs that must be taken into account when deciding whether to go this route. Some of these are:

a. timesharing requires a sophisticated operating system to handle resource allo-

cation among the users. b. Management of virtual memory, swapping of programs, and creating and managing queues for users waiting for access to resources such as discs constitutes non-productive use of machine time that grows non-linearly as more use is made of the system. A point is soon reached where the system is using such a small fraction of its cycles for execution of any user's instructions that the backlog of jobs grows faster than jobs are being completed. Only the failure of users to submit new jobs due to discouragement over the seemingly infinite response time can, at this point, allow the system to catch up and complete some useful work. Unfortunately, even the addition of new resources provide only a temporary relief, since, in the hospital environment, as soon as response time improves, more users are attracted to the system (ie, for example, more people will make use of the data review and reporting services, etc.), and soon the system is once again saturated and response time for the user increases to the point of discouragement. Unfortunately, those who most easily become discouraged to the point of non-use are the professional people whose time is most valuable and who are often most in need of the information the system can provide. c. Limited or no access to assembly-level code is allowed even when significant improvement in program execution speed could be achieved by by-passing some complex system driver. For example, in building our minicomputer handler for multiplexing several terminals into the TANDEM system, duplication of several system routines was required by going through the system drivers that could have been avoided were one allowed to get at the driver and alter it for this task.

4. There are limitations to dedicating a computer to one user, of course. a. It is not in use much of the time unless involved in some continuous function such as arrhythmia monitoring in the coronary care unit. b. There is no automatic backup in case of equipment failure. This may be overcome in an environment where there are many users with identical equipment and the group can afford to have a backup unit available. c. To achieve some of the advantages in 2 above, it will usually be necessary to sacrifice some of the utilities only affordable in a shared resource. Thus, the stand-alone machine may not be as convenient for software development and maintenance.

5. A hospital-based clinical support system needs the advantages of both a central, timeshared system and dedicated processors for the following reasons:

a. The shared system provides the optimal mechanism for accepting data from widely dispersed sources throughout the institution, storing that data for all patients in a central file, and distributing this information to wherever it is needed. With such a central system at the hub of the clinical and administrative data base it is only necessary that each data source (be it an instrument, terminal, or another computer) communicate with only one machine (the central one), in order to communicate effectively with every other machine on the system. To accomplish this,

however, a common data definition file (dictionary and data structure) must be agreed upon, stored in the central system, and be available to all peripheral systems with which it communicates.

b. Direct connection of terminals to the central timeshared system should be for functions requiring only the following: low rates of data transfer, a small amount of number-crunching or other demand on CPU cycles, or, if a significant load is imposed on the system, no demand should be required for rapid response from the machine (ie. no one waiting at the terminal for a response).

c. Dedicated systems with sufficient compute power to rival the larger timeshared system and enough main memory to avoid accessing disc to get data or swap programs during the interaction with the user, can provide the rapid response for the compute-intensive dialog with an 'intelligent' machine. We have clearly shown that such a dialog cannot be accomplished in an acceptable fashion for multiple simultaneous medical users with a timeshared system (TANDEM).

d. That the dedicated system performs well as a preprocessor for analog signals which must be sampled either at high rates (ie. ECG or pressure monitoring) or at precise times (ie. EEG waveform averaging), is well known, and are commonly incorporated into the instrument or transducer itself.

e. If the peripheral system is designed to control its interaction with the timesharing central machine, it can be made to poll the central system for new patient data at times when no dialog with a user is taking place. Thus, it will not have to lose machine cycles during this time for receipt of data from the central machine that is very unlikely to be at all relevant to the dialog that is taking place with the user. The transfer of new patient information between the two systems can occur as a batch operation at low speed, and at the convenience of the dedicated peripheral system.

## Conclusion

With no deceleration forecast for the rise in compute power per dollar, it is already apparent that the financial advantage of dedicated computers over the large time shared facility will soon reach the point where a computer at each hospital bed will be the best solution. This conclusion is even more attractive in light of the computing requirements being imposed on the medical computing system by attempts to build in medical knowledge (artificial intelligence) using sophisticated software to make the dialog with the physician or nurse more interesting and useful. The timeshared central machine, however, will provide the communications link to the sources of data needed for decision-making in an environment where this is possible, thus relieving the nurse and doctor of most of the tedious task of data input now imposed by many computer-based consulting systems.