Timesharing - Its Place In The Working Engineer's Lineup of Tools

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INTRODUCTION

Timesharing systems are those new computing systems that have the capability of permitting many users to share the same computer essentially at the same time. Figure 1 illustrates how this concept works. Many different users are connected to the same system by way of telephone lines. A black box interfaces between the user and the computer to communicate with the user and in the process of doing so cues up the incoming computing request. The computer main frame then gives each user in cue a small slice of computing time. Unbelievably, this slice of time is normally between one-tenth and three-tenths of a second. During this small time-slice the work of a particular user is computed. The results of the computations are fed back to the interface. If the individual user's computer job is not finished in the small time slice, the status of this job is also rolled back out to the black box and held in cue until this user gets another turn. The computer then goes to the next user in cue and serves his computing requirements. While the individual user is waiting for his next access to the computer, the interface normally keeps the user's terminal busy in returning the answers that were developed during the preceding time slice. As a result, one large computer can normally keep from one dozen to several hundred users' terminals busy by merely giving each of them a very small time slice of computing power every 15 or 20 seconds.

A second important aspect of timesharing machines concerns "live" or "on-line" storage associated with the system. This is also shown on Fig. 1. This massive amount of file storage permits the user to store his programs or his data for future use or for use of other users. With proper linkage between the storage area, the computer and the interface, the capability of retrieving any such stored information on instant notice is possible. The storage area can be almost visualized as a huge file cabinet. Every file in this cabinet is given a name. To retrieve the contents of the file, all that is necessary is to tell the computer the name of the file. Likewise, information may be added to the files from time-to-time, deleted from the file, or new files set up. The power of the timesharing computer is thus enhanced by the combined use of a large amount of storage directly accessible to a computer. These files may be protected so that only the one user may access them or, on the other extreme, they may be shared (accessed) by many users.

The third important aspect of timesharing is the ease and simplicity involved in accessing the computer and in working with the files associated with the computer.

APPLICATIONS SUITABLE FOR TIMESHARING

Not all types of computer programs can best be solved by timesharing computers. The best applications will have the following criteria:

1. Limited input and output (due to relative slowness of terminals)
2. Small to medium computer core requirements
3. Small to medium job run lengths
4. Small to medium file storage requirements
5. Need for rapid response (rapid obtainment of answers)
6. Need for being able to talk to the computer (user-computer interaction).

From analysis of the above requirements, one can see that applications that generally fall in the engineering or scientific field are far more suitable than the applications which fall in the bookkeeping or accounting department fields.

Over the years most computer users, even in the scientific or engineering fields, have be-

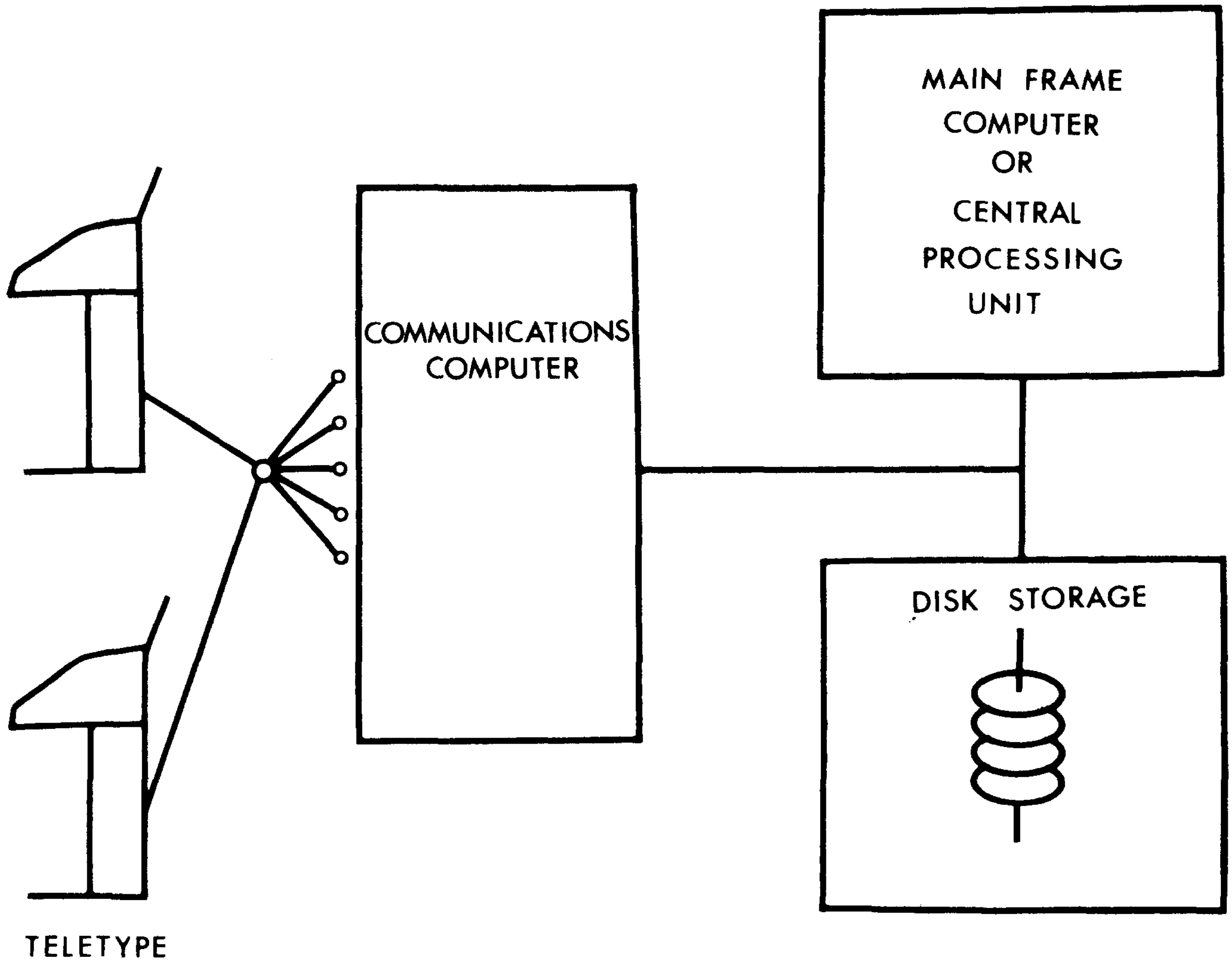

FIGURE 1

Schematic of Timesharing System

come accustomed to voluminous program output. In reflecting on this, most users have become accustomed to this because the frequency of access to the computer is sufficiently limited such that the philosophy is taken that all potentially usable answers will be printed; those which are not needed will be ignored; and hopefully, the answers needed will be included somewhere in the printout.

Since one of the features of timesharing is the user's ability to communicate directly with the computer on instant notice, it really is not necessary for the user to always obtain more printed output than he needs. Instead, the programs for timesharing computers may be developed so that very limited output is first shown the user and the opportunity given to ask for additional information. Thus, many jobs initially thought of as being inappropriate for timesharing because of the conventional way of getting many pages of answers can be redesigned to be more satisfying to the user.

From the authors' experiences, a list of suitable applications as far as the practicing petroleum engineer is concerned, is as follows:

1. Reserve estimates
   a. Decline curves, volumetric estimates, watercut curve extrapolations
2. Reserve evaluations
3. Material balance calculations with or without aquifer influence
4. Solution gas-drive performance calculations
5. P.I. decline calculations
6. Layered waterflood performance analysis
7. Optimization shut-in of water producers
8. Reservoir performance
   a. Gas well simulation
   b. Pinnacle reef simulation
   c. Two-dimensional, three-phase reservoir simulation
   d. Water and gas coning models
9. Bottom-hole pressure analysis
10. Gas well open flow potential calculations
11. Wellbore hydraulics
12. Core analysis (sorting and averaging)
13. PVT data simulation
14. Relative permeability correlations
15. Electric log analysis
16. Pumping unit design
17. Optimum casing design
18. Gathering system design
19. Pipeline design
20. Transient fluid flow in pipelines
21. Well drilling optimization.

Applications which may or may not be suitable for timesharing depending on the size of the job include:

1. Preparation of tank tables
2. Run ticket calculations
3. Rates from gas charts
4. Monthly production reports
5. Well allocation
6. Production ledgers
7. Well tests
8. Waterflood reports.

APPLICATIONS NOT WELL SUITED FOR TIMESHARING

The applications that, by and large, should be avoided on conventional timesharing equipment have the following characteristics:

1. Voluminous amounts of input and/or output data
2. Extremely large amounts of core storage required
3. Massive amounts of file storage required
4. Runs which require many hours of computing.

The above applications requirements describe those that the typical accounting department will be familiar with or very large and unusual scientific applications wherein massive amounts of computer memory and unusually long-running jobs are involved.

FRUSTRATIONS OF TIMESHARING

The perspective of timesharing would be incomplete without some word about the difficulties the user will encounter. There are always some minor frustrations in learning how to use the system but these are temporary in duration. After the user gets through this transition or learning stage, he rapidly becomes accustomed to getting his answers instantly. He expects the same accessibility from the timesharing system as from his slide rule.

It must be noted, however, that computers and the associated communications network are very complex electro-mechanical devices and are not without their frailties. The timesharing terminal brings the engineer face-to-face with the fact that these computing devices do break down on occasion.

Trouble encountered using timesharing systems can come from three sources:

1. The terminal may not be functioning properly.
2. There may be faulty transmission linkage between the terminal and the computer.
3. The communications computer, the main-frame computer or the disk storage units may be experiencing difficulty.

Considering the complex combination of the terminal devices, the communications linkage and the computers, it is surprising that they work as consistently as they do. Generally speaking, it has been the authors' experience that the computers are available about 80-90 per cent of the time for which they are scheduled to be operational. The duration of the downtime will range from five minutes to one-half day.

Paradoxically this expectation of immediate results leads to considerable frustration when the performance is in the 80-90 per cent range and the attendant delay for the downtime may be only of a relatively short duration.

Even considering the short transition period of learning to use the timesharing system and the frustrations of computer downtimes, the general immediate availability of timesharing computers make them worthwhile tools in the applications for which this particular type of computing procedure is suited.

ECONOMICS OF TIMESHARING

There are five cost considerations involved with timesharing computers. These are:

1. Cost of the terminal facility
2. Cost of linkage from terminal to computer site
3. Computer usage cost
4. Cost of program and data file storage
5. Cost of developing and maintaining computer software (programs).

Most timesharing users rent their terminals from the local telephone company. Usually this is the so-called Model 33 teletype with a paper tape punch and read unit attached. The Model 33 looks and acts like an electric typewriter. It is available on the same basis as regular telephone service for a cost of about $75.00 per month. No long-term contracts are involved. The service can be discontinued as one can discontinue his normal telephone service. The telephone company will probably recommend, and it will normally be necessary, that an additional telephone line be obtained to serve the teletype unit. The cost for this is the standard rate for a business telephone of some $18.50 per month.

The cost of service between the user's terminal and the computer is normally included in the cost of the computing service and therefore is not an incremental cost to the user. In other words, the owners of the independent timesharing computing systems will provide a local telephone number to call to access their computer in most cities throughout the United States. The cost of the communications lines are generally rolled into the charges for computer usage. In the event the user is located in a place where local telephone service to the computer is not available, he will be expected to pay for the cost of calling long distance to reach the computer facility. The cost of long distance calls is not as expensive as one might think when compared to the other costs of computing. For example, a typical long distance cost may be $1.00 per three minutes which is only $20.00 per hour.

The third cost area to the user involves the cost of the computer service itself. Many timesharing companies base their charges on a formula which is a function of the time the user is connected to the system and the number of seconds that he uses the main frame of the computer. Typical costs in this area range between $10.00 and $15.00 per hour that the user is connected to the system. In addition to this cost, the user may also be charged for the number of seconds that the computer was doing his work. These costs may range from a few cents per second to as high as $.60 per second. Some independent timesharing companies simply charge a flat rate per hour of connect time regardless of the amount of computer time used. For example, rather than charging $10.00 per connect hour plus $.30 per second, a computer supplier may instead charge a flat $15.00 per connect hour and absorb the computer main frame cost in the hourly charge.

With regard to the cost of storing programs and data files at the computer site, the typical approach is to charge the user on the basis of both the amount and duration of storage. The cost of storage is usually stated as so many characters of data storage per dollar per month. Typical costs range from $1.00 per month to store 1280 characters of data to $350 per month to store one million characters of data. This can be envisioned as costing $1.00 per month to store the data which will typically be put on from 30 to 100 punched cards. Stated another way, it will cost from $20 to $60 per month to store what would normally be put in a full box containing 2000 punched cards. As one can see from these costs, only those programs and data should be kept in storage that will be used with some frequency.

The remaining cost area to the user concerning timesharing computers (or any other computer), concerns the cost of the programs needed to make use of the computer. The plain fact is—a computer is worthless to a practicing engineer in its bare state without the addition of computer programs to handle the specific application in which the user is interested. The timesharing companies supply computer software such as compilers, sorters, and editors which will permit the user to develop his own applications or manipulate his data files; however, very few (if any) computing companies have successfully offered the user quality programs suited to the user's needs. This is not unusual since computing companies serve very broad types of industry and cannot be expected to have a specialist in all of the industries they serve, at least to the extent of developing meaningful application models. As a result the timesharing user will need to develop his own programs or alternatively use or buy programs developed by reservoir engineering-oriented software firms.

COST OF SOFTWARE DEVELOPMENT

The cost to develop a program for solving a particular engineering application is a function of the application itself, the computer on which the development is undertaken, and the experience and efficiency of the developer. Before the advent of timesharing computers, development costs were normally very high, largely because of the significant manpower involved in program development. Timesharing development goes faster because instantaneous response from the timesharing computer no longer requires the developer do so much desk checking and calculating to get to the same end-point. The development is also more efficient since the developer can stay on the job and not be frequently interrupted with other things while he is waiting on his output from the computer. However, in spite of this, the minimum program development cost will typically be in the one to five-thousand dollar range. Programs of some substance will be in the $10,000 to $15,000 range whereas the more difficult and sophisticated applications such as reservoir simulators will be in the $25,000 and over range. The above development cost estimates include the computing cost and the engineering or programmer cost. Not included, however, and a very real cost that is often overlooked, is the cost of maintaining the program once it is developed. Part of this maintenance cost is the storage of the program at the computer site. This may range from $5.00 to $10.00 per program per month to as high as $100 or more per program per month. But, the biggest maintenance costs are finding program bugs which arise with usage, modifying the programs to cure them, and continually updating the programs to keep them abreast of current technology. A fair estimate of this facet of maintenance cost is two per cent of the program's purchase or development cost per month. For example, a $10,000 program may cost $200 per month to maintain.

TYPICAL COMPUTING COSTS

Once a computer program has been developed and placed in operation, usage costs are normally quite modest. From personal experience, the cost to compute oil and gas reserves for a lease, time-schedule them for twenty years, determine net cash flow, present worth, and rate of return, will typically cost from $1.00 to $4.00. The cost to perform a solution gas-drive performance calculation may cost $3.00; an analysis of a bottom-hole pressure test for $3.00; completely simulate the performance of a gas well from discovery to depletion using a grid-type simulator for less than $50.00; develop a full set of PVT data for oil, gas, and water for twenty pressure points using correlation techniques for $15.00; calculate a risk analysis on a wildcat prospect wherein 800 reserve samples are computed, reserve and economic distribution made, probability of success, and chance of avoiding gambler's ruin determined from $10.00.

VALUE TO THE USER OF TIMESHARING

In some cases in examining the economics of using timesharing, the user is faced with comparing the cost of using timesharing versus not using a computer at all. However, generally, at least in theory, the user has the prospect of using some other type of computing and accordingly the value of timesharing is primarily in obtaining an answer sooner than he otherwise would. In the authors' opinion, the value of computer accessibility is based on two interactions. One is the present worth deferment value of the project being studied; i.e., for each day that a profitable project is delayed, a loss in P.W. value occurs. The second is the reduction or loss of project value through less than optimum operations if computer turnaround time is sufficiently long to prevent or reduce computer usage. A formula that we have devised in an attempt to place a quantitative value on computer accessibility is as follows:

$$V_t = V_{pw}\left[(1-f_{pw})P_o + (1-P_o)f_o\right] \quad \text{(1)}$$

where,

V_t = Value of computer accessibility ($/Month)

f_o = Fractional benefit realized by full computer usage

f_{pw} = Present worth factor = $1/e^{rtn}$, where r = discount rate, t = computer turnaround time, and n = number of computer turnarounds needed.

P_o = Portion of studies which are optimized

V_{pw} = Present worth value of projects being studied, $

The most difficult number in the above study to estimate is P_o, the portion of studies which are optimized. The logic of determining this number, however, would seem to say that if instantaneous access to the computer is possible, all studies would be optimized or P_o would be one. On the other extreme, if access to the computer is so limited that one would have to wait as long as 30 days to obtain an answer, it would seem reasonable that no more than one per cent of the studies would be optimized. In between the two extremes stated above, the authors suggest the following formula for P_o:

$$P_o = \frac{1}{e^{tD}} \quad \text{(2)}$$

where,

t = Turnaround time in days

D = ln(100/1)/30

The term f_o in equation (1) is equal to:

$$\frac{\begin{pmatrix}\text{Project Value if}\\ \text{Computer Used}\end{pmatrix} - \begin{pmatrix}\text{Project Value if}\\ \text{Computer Not Used}\end{pmatrix}}{\text{Project Value if Computer Not Used}}$$

In other words, if use of the computer would result in a 10 per cent increase in the value of the project, f_o would be .1. The authors' experience has been that values up to as high as .3 are not unusual in reservoir engineering and waterflood applications. The following example will illustrate the value of computer accessibility as can be obtained through timesharing.

In this example, consider the case where the operation of a line-drive waterflood has progressed to the stage where shutin of high water producers must be considered. Premature shutin may reduce reserves and, on the other hand, tardy shutin causes handling of excess water and extended flood life. By simulating waterflood performance on the computer, the present worth value of the project could be optimized. Typical results of such a simulation study may show that the value of the remaining reserves for one of the patterns can be increased from $200,000 to $250,000 by optimum shutin. Using a 10 per cent interest rate and equation (1) yields a value for timesharing accessibility (as a function of how fast answers could be obtained from a batch-type computer) displayed in the following table:

TABLE 1

Batch Computer Turnaround Time (Hours)	$Value of Timesharing Accessibility @ 10% Discount Assuming 3 Runs to Optimize
24	$ 7,256
48	13,460
72	18,763
168 (1 week)	33,319
720 (1 mo.)	49,549

Table 1 and Figure 2 illustrate, in this case, that the longer the turnaround time for a computer run, the less likelihood there will be of computing optimum procedures in the operation of a flood. Stated another way, the more trouble it is to get computerized output of a particular problem, the less likely it will be that there will be sufficient analysis of the problem to allow the engineer to design the best method of operation. If the incremental present worth, due to optimization, is considerable, then the value of being able to make an immediate analysis may also be correspondingly quite high.

SUMMARY

Timesharing computer systems provide an additional important tool for the working engineer. They are well suited for the engineering problems normally encountered in daily practice. Because of their ability to provide on-line access in problem solving, they provide the engineer with the opportunity to work difficult problems through to conclusion while the various ramifications of a particular application are fresh on his mind. The value of this immediate

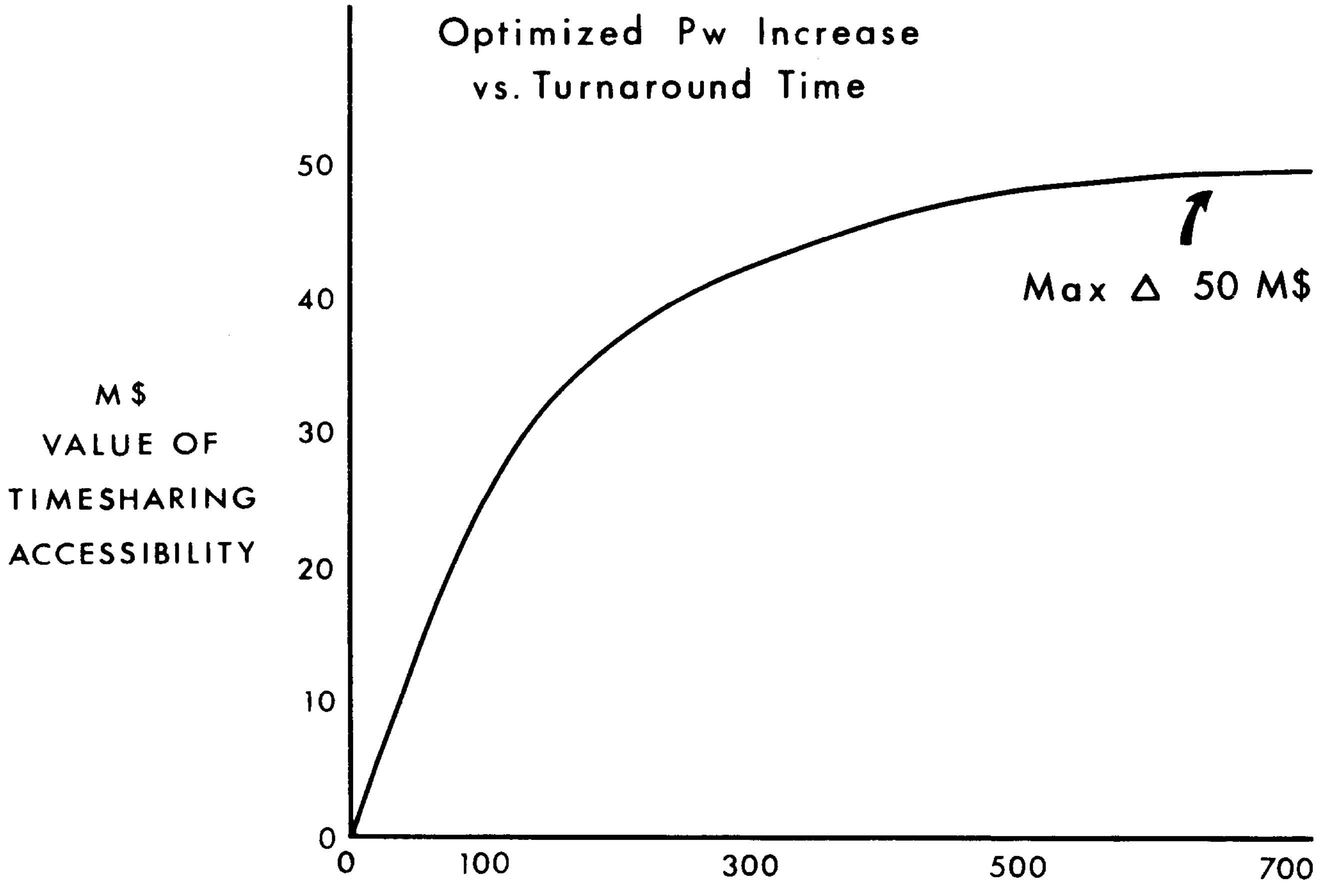

FIGURE 2

Hours Turnaround Time For Batch Computing

accessibility can be quite substantial when it means the difference between making a thorough analysis of a particular problem or on the other hand, making an analysis which may or may not be sufficiently complete to arrive at an optimum design. Because of the different requirements for timesharing applications as opposed to batch processing applications, the timesharing systems are an adjunct to, but not a replacement for, batch processors. With the advent of timesharing systems, it has become possible to network non-unique sophisticated applications for petroleum engineering analyses. The result of this software network means that the user no longer is required to put up the heavy initial outlay for the development of programs nor the continual outlay for storage and maintenance of those programs on an individual basis. It is possible to lease this software on a use-basis at less cost than to develop and maintain this same software on one's individual system. In addition, the networking also provides the user with instant support in the use of the software. For complex programs, software support is a must. It is the authors' experience that the timesharing method of computing enables both a higher quality and a greater quantity of engineering for the same amount of manpower. The economic benefits to be obtained by this more efficient application of engineering talent will pay out many times the costs associated with adding timesharing computers to the engineer's list of working tools.