*An objective of a corporate-wide data processing service is to distribute its costs equitably among its users.*

*Aimed toward more realistically meeting this objective is an accounting system—general ledger, budget, and data processing resource utilization system—based on a cost-center configuration.*

*Discussed are techniques for accurately measuring data processing resource utilization in a multiprogramming environment and coordinating cost center expenses with the general ledger and the budget.*

# Accounting control of data processing

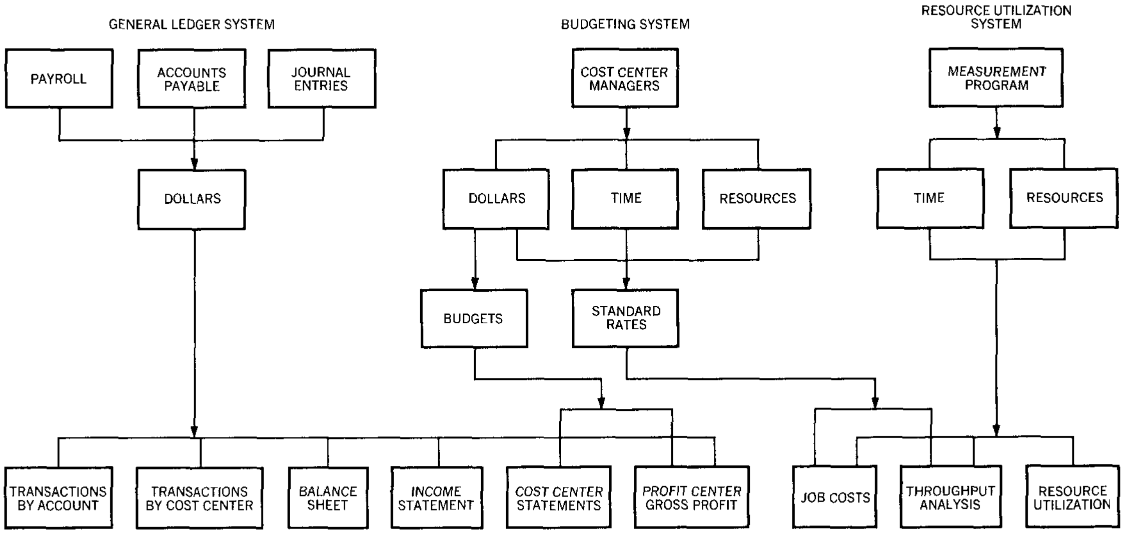
**by R. C. Rettus and R. A. Smith**

Emerging requirements for providing better control of all corporate activities have focused attention on improving cost control of data processing operations. Data processing departments have grown in their scope of applications; consequently, these operations comprise an increasing share of the corporate expenses. Thus equitably distributing the costs of data processing among user departments has become a necessity. This requirement has motivated a study of methods for integrating the measurement of data processing resource utilization into the corporate accounting system. The restructured system to accommodate all phases of accounting control, including data processing, is the subject of this paper.

The special problem of data processing accounting is that of analyzing and charging for jobs processed. For sequential job processing, charges have been previously based on a fixed rate and the elapsed time. Multiprogramming has further complicated the elapsed-time method of measuring system utilization in billing the user. In the past, a widely used method of charging users for data processing services was to pro-rate the total data processing expense among the users. This method, by which all users absorb the full cost of data processing, is commonly known as *full-absorption costing.*[1,2]

In a multiprogramming environment, however, elapsed time for any given job is affected by the interference of other jobs being

Figure 1 The integrated accounting system




processed concurrently. Therefore, the elapsed time for each job typically exceeds the time it would have required in a nonmultiprogramming environment. Elapsed time is, in general, a poor basis of data processing job accounting because jobs usually use less than all available resources. The objective toward which the data processing accounting method discussed in this paper is aimed is to charge each user in a multiprogramming environment the amount he would have paid in a nonmultiprogramming environment and to eliminate fluctuations in job costs caused by variations in system utilization.

The accounting method presented here, termed the *resource utilization system*, measures the system resources and personnel used for each job and measures the times for each of these factors in determining and controlling their costs to departments and to the corporation. The data processing resource utilization system is integrated with the whole corporate accounting system, which also includes the general ledger and budget. This integration is presented in Figure 1. The basic technique for relating these three accounting procedures involves a cost-center corporate configuration, standard rates for system components, and resource utilization measurement. Inputs, processing, and output requirements of the component accounting systems are discussed.

## Corporate accounting subsystems

All companies have a *general ledger system*—either manual or automated—that furnishes an income statement and balance sheet. The cost of data processing equipment was relatively small when it was being used primarily to perform these accounting functions and when the manager in charge of data processing usually reported within the accounting structure. All associated costs were therefore charged to the accounting department, and were included on the income statement as part of general and administrative expenses. Accompanying the development of broader computer capabilities, other departments, such as sales and production, began automating functions they had previously performed manually.

Data processing has now evolved into a service department that provides services for the entire company. It follows, therefore, that the using departments should be charged for this transfer of work. One of the objectives of this paper is to discuss a cost-center oriented accounting system whereby the objective of charging departments for data processing can be accomplished equitably.

*Cost centers*, which are defined more rigorously later in this paper, are points where the dollars, time, and resources of the corporate budgeting system are expended and recovered. One of the primary functions of a corporate *budgeting system* is to provide standards against which actual performance can be measured. The budgeting system described here provides such standards for each cost center. The budgeting system can also be used to develop standard rates for measuring resource utilization and determining the cost to perform the data processing service. The budgeted time that each resource is available to perform chargeable work is known. Also the budgeted dollar value of the resource is known. Therefore, the budgeted unit cost of each resource—defined here as the *standard rate*—can be determined. The purpose of the standard rate is to eliminate price and usage fluctuations from the cost of jobs and to provide an accurate cost of each job on which user billing can be based.

Companies whose data processing costs are a large part of their total expenses wish to know and account for the utilization of their computing center. This is particularly important to a company whose data processing costs are charged on the basis of the amount of service provided to several different users. In such a situation, an accurate measure of the cost of work processed should be determined because this provides the basis for billing the users.

Techniques for measuring analyst and programmer productivity are not subjects of this paper since they have analogies throughout the business world.[3] Further, accounting for resources of a computer system by jobs is relatively simple in a nonmultiprogramming environment (running only one job at a time on a central processor). Computing centers that operate in a multiprogramming environment find that a *resource utilization system* is essential. Such a system is directed toward determining the cost of each job that is run in that environment so that the charge for each job is not affected by other jobs being processed concurrently. Equally important is the measurement of the overall throughput of the system. The company that is not doing multiprogramming may also be able to use much of the information presented here, and later be able to make a smooth transition into a multiprogramming environment.

These three subsystems are presented as an integrated accounting system. The component subsystems—general ledger, budgeting, and resource utilization—can be used independently. That is, a company can install the resource utilization system without developing standard rates if it is concerned only with measuring resource utilization and does not want to assign costs to individual jobs or measure overall systems throughput. Similarly, standard rates can be developed for use by the resource utilization system without adopting the budgeting system. Further, the general ledger system can be installed without the budgeting system, provided management does not need to measure variances from the budget.

The methods presented in this paper should be thought of as a guide to the development of the integrated accounting system, which may require modifications to fit the particular company that is seeking to achieve better control of its data processing activity.

## Cost center identification

A *cost center* is defined as a group of resources for accounting control of the particular operation performed. Cost centers differ from departments in that a *department* is defined as a grouping of resources for reporting and managerial control purposes. Cost centers can exist independently of departments, within departments, or can coincide with an existing departmental organization. The first requirement for merging the computer resource utilization system into the integrated accounting system is to identify the data processing cost centers.

We now give a method for identifying data processing cost centers in a typical company. Assume that we have a data processing department that is presently divided into the following three separate reporting areas: operations, systems, and programming. Each area has a manager who reports to the data processing manager. The company presently has a three-digit departmental identification number and desires to renumber their departments as cost centers. The six-hundred series of numbers is allocated for use by the data processing center. For example, in analyzing the accounting requirements for data processing we determine that the following cost centers are required:

1. Operations
   - Model 65
   - Model 50
2. Systems
3. Programming
   - Maintenance
   - Development

**functions and groups**

In addition, assume that there are several supporting activities within operations that must be segregated because they cannot be identified with the Model 65 and Model 50 cost centers. Assume further that these activities are to be separate cost centers. Also, there is a requirement for segregating data processing management, the data processing secretarial pool, and the technical library as separate cost centers. The overall data processing department is defined as a cost function, which is divided into cost groups. *Cost groups* consist of one or more cost centers, and they comprise all cost centers performing a similar activity. In the example data processing function, the cost groups are operations, systems, programming, and data processing support.

The results of this analysis of the example data processing function are presented in Table 1. Cost centers are the only functional areas that can accumulate charges and, therefore, are the only entities identified by three digits. The data processing function and the four cost groups do not accumulate charges but receive combined financial statements of their component cost centers, e.g., the programming cost group (67X) receives a combined statement for cost centers 671 and 672. The systems cost group (65X) is also designated as a cost center because it is the only entity within the group. The numbers assigned allow for expansion as more cost centers or cost groups are added.

**corporate chart of accounts**

Accumulated cost center expenses are numerically classified into a *corporate chart of accounts*, which is a general ledger coding structure that includes both the balance sheet and income statement accounts. The structure and classification of accounts today are well standardized in formats supported by the Securities and Exchange Commission and the American Institute of Certified Public Accountants. Because it is so basic, the subject is extensively treated in most accounting texts and handbooks, an example of which is referenced.[4] The data processing cost center is integrated to the general corporate chart of accounts via the six-hundred series, which has been previously discussed.

Table 1 Data processing cost centers

| Cost center number | Cost center description | Level |
|---|---|---|
| 6XX | Data processing | Function |
| 60X | Data processing support | Cost group |
| 601 | Management | Cost center |
| 602 | Secretarial pool | Cost center |
| 603 | Technical library | Cost center |
| 62X | Operations | Cost group |
| 621 | Systems programming | Cost center |
| 622 | Tape/disk libraries | Cost center |
| 623 | Control desk | Cost center |
| 624 | Model 65 | Cost center |
| 625 | Model 50 | Cost center |
| 65X | Systems | Group/center |
| 67X | Programming | Cost group |
| 671 | Maintenance | Cost center |
| 672 | Development | Cost center |

## Standard rate

After segregating data processing resources into cost centers, one can determine what the costs are and provide a standard rate for each resource. *Standard Rates* (SR) are factors based on expected resource utilization and expected resource cost. The use of standard rates for data processing resources provides consistent cost and utilization data on which to base pricing decisions. Any cost or utilization fluctuations are reported as variances from the budgeted cost or utilization so that the specific area of variance can be acted upon.

The standard rates for the data processing resources are developed at the same time the budget is developed. However, they can be developed independently of, or in the absence of a corporate budget. The standard-rate development consists of the following three procedures: resource identification, derivation of the available time for each resource, and budgeting the cost of each resource. The determination of standard rates is discussed here by using a specific data processing configuration as an example.

**resource identification**

In this explanation, a computer system is discussed, although the same general method applies to such other resources as programming and systems analysis. We define the following four general categories of computer system resources: main storage, CPU cycles, channels, and Input/Output (I/O) devices with their associated control units.

- *Main storage* is the amount of addressable storage available measured in thousands (K) of bytes.
- *CPU cycles* are a measure of the operational time available, for the central processor.
- *Channels* consist of three categories—byte multiplexor, selector, and block multiplexor.
- *Input/Output devices* are grouped by like units called component groups.

The following central processor and devices are assumed in our example:

- A 2065 CPU with 512K bytes of main storage
- One Model 2314 direct access storage device with eight drives, yielding 4,000 available tracks each—for a total of 32,000 tracks
- Four Model 2420-5 tape drives
- Four Model 2420-7 tape drives
- One Model 2540 card read/punch
- Two Model 1403 printers
- Twenty Model 2260 display consoles

A special characteristic of main storage and Direct Access Storage Devices (DASD) is that they are not allocated to jobs by individual devices in the same way that other component groups are allocated because they can be used by two or more jobs concurrently. Therefore, the measurement unit for main storage is "K bytes," and direct access storage devices are measured by tracks. For all other devices the measurement unit is the number of devices. Also, not all main storage and DASD are available to perform productive work because of system requirements. Therefore, the measurement unit for main storage is the total bytes minus the number of bytes used by the nucleus or supervisor. For DASD, the measurement unit is the net available tracks. In Table 2, the ten component groups in our example with their measurement units are identified.

**budgeted time**

Next, determine the time each component group is available to do productive work. The standard rate is the same for the entire year unless some event occurs during the year that necessitates a change. Thus, one can define Total Time (TT) for each component group as follows:

TT = (Total available hours per year per component
× (Measurement unit)

Nonproductive conditions are then identified. A component is considered as nonproductive during the following times:

- *Preventive Maintenance* (PM), time regularly scheduled

Table 2 I/O component group measurement factors

| *Group Number* | *Description* | *Measurement Unit* |
|---|---|---|
| 0 | Main storage | K Bytes (net) |
| 1 | CPU | Number |
| 2 | Byte multiplexor channel | Number |
| 3 | Selector channels | Number |
| 4 | Direct-access storage devices | Tracks (net) |
| 5 | Tape drive, Model 2420–5 | Number |
| 6 | Tape drive, Model 2420–7 | Number |
| 7 | Card Read/Punch | Number |
| 8 | Printers | Number |
| 9 | Visual displays | Number |

- *Down Time* (DT) due to failure of hardware or system software
- *Idle Time* (IT) during which a component is not used by a job
- *Rerun Time* (RR) during which a component is performing non-billable work
- *Multiprogramming degredation* (MP), time during which a component is waiting and ready for work, but it is not being utilized because another job is impacting it. (The CPU and channels cannot be nonproductive as a result of multiprogramming degredation because they are never allocated to a specific job. There is no MP in a nonmultiprogramming environment.)

Companies are not limited to the categories in this example; Initial Program Load (IPL) could be a category for another company.

Budgeting PM, DT, IT, and RR is relatively easy. MP is derived empirically using the resource utilization system discussed later in this paper in connection with developing cost information. Productive Time (PT) can now be derived for each component according to the following formula:

$$\text{PT} = \text{TT} - (\text{PM} + \text{DT} + \text{IT} + \text{RR} + \text{MP})$$

**budget cost**

The budget cost of each component group consists of direct cost of the component group, allocated indirect costs in the cost center, and allocated overhead costs in the operations cost group and the data processing function.

*Direct costs* are those costs that can be specifically identified with the component group. They include such specific costs as equipment rent or lease expenses of devices and their control units, maintenance contracts, and depreciation of purchased equipment. Other costs might include printer forms, rent or depreciation of tapes and disk packs, and telecommunications charges.

*Indirect costs* are costs charged to a productive cost center that cannot be identified specifically with a component group. A productive cost center is one that charges users for its service. The allocation of indirect costs to component groups is based on the major manufacturer's monthly rental value of all equipment in the component group or some other equitable method. An allocation based on direct costs of the component groups is equitable only if all equipment is rented. Examples of indirect costs are rental (depreciation, lease, etc.) of devices that are not available to perform useful work. The console typewriter, main storage allocated to the nucleus (supervisor), and unavailable DASD tracks also generate indirect costs.

*Overhead costs* consist of all costs residing in the nonproductive centers in the operations cost group. Referring to Table 1, overhead costs might be the following:

621 – Systems programming
622 – Tape/disk libraries
623 – Control desk

Additionally, overhead costs consist of all costs residing in the nonproductive cost groups such as data processing support (60X). Although operations do not receive all these costs, they must be allocated among the three productive cost groups – operations, systems, and programming – based on an appropriate method such as budgeted costs or budgeted revenue.

The basis for combining and allocating overhead costs to productive cost centers is the major manufacturer's total rental value of all components residing in each of these centers. Because overhead costs are allocated to component groups in the same manner as indirect costs, they can be combined and allocated together.

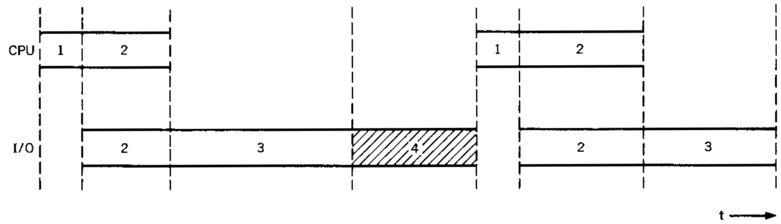
**standard rate**

The standard rate (SR) for the component group is determined by dividing the annual Budget Cost (BC) of each component group by the annual productive time (PT) for the component group as follows:

$$SR = \frac{BC}{PT}$$

The standard rate for each component is determined by dividing the standard rate for each component group by the measurement unit for the component group. In this sense, a track on a DASD and 2K of main storage are devices because these are the smallest units that can be allocated a job.

Figure 2 Wait-ready status




## Resource utilization measurement

The measurement of multiprogramming degradation for components of a computer system is considered to be nonproductive because it detracts from the time the component is available to perform productive work on a job. The underlying assumption on which the theory of multiprogramming is based is that in this environment the degradation suffered on certain components is offset by increased utilization of other components, primarily the Central Processing Unit (CPU). Therefore, the objectives of multiprogramming are to increase overall system utilization—throughput—and thereby decrease the cost of each job. The achieving of these two objectives requires the accurate measurement of resources used by jobs.

**wait-ready status**

The possible conditions regarding a job at any moment are the following:

- CPU alone is executing
- CPU and I/O devices are executing concurrently (overlapped)
- I/O devices alone are working on the job
- The job is in the wait-ready status when it is ready to continue executing, but it is waiting to obtain the CPU, which is working on another job

The *wait-ready period* is the time during which main storage and I/O devices allocated to the job are not able to be used. The execution time of the job is, therefore, degraded by the multiprogramming environment in which it operates. These four conditions are depicted in Figure 2.

If one measures the total time a job is in the Wait-Ready status (WR), he determines the multiprogramming degradation (MP) experienced by main storage and I/O devices allocated to the job because:

$$WR \equiv MP$$

And, because the total elapsed time of the job is known, one can measure resource utilization by subtracting the wait-ready time (MP) from elapsed time (ET), thereby obtaining productive time (PT):

$$PT = ET - MP$$

Techniques, however, are not commercially available to measure the amount of time each job is in the wait-ready status. Thus it is the user's responsibility to program and maintain the operating system modification necessary to measure this status.

**theoretical resource utilization**

Since users cannot readily make his modification, we present an alternative method for obtaining the approximate MP by calculating the theoretical stand-alone time of a job. This method attempts to find the theoretical amount of time systems resources are used by each job, based on the speeds of devices used and the amount of processed data. If the theoretical resource utilization (TRU time) and the elapsed time (ET) of a job are known, one can derive multiprogramming degradation (MP) applicable to main storage and I/O devices allocated to the job as follows:

$$MP = ET - TRU \text{ Time}$$

The information necessary to determine TRU time is provided by the Systems Management Facility of OS/360 and OS/370 (SMF), the Job Accounting Interface option of DOS/360, or any other comparable programming system.

We now discuss the theory underlying the measurement of resource utilization and also give further specialized considerations in the Appendix. Given that today's data processing environment provides modern language structures, double buffering, and sufficient channels on the system to take advantage of these facilities, one can assume that for most jobs the CPU and I/O times can be overlapped, and that any I/O time can be overlapped with any other I/O time. On this basis, one can define TRU time for main storage and I/O devices used for any job as the greater of the theoretical time required to process the longest data set, or CPU time.

To determine the theoretical time required to process the longest data set, one must compute the theoretical time required to process each data set. The theoretical measurement of utilization of the various components is the following:

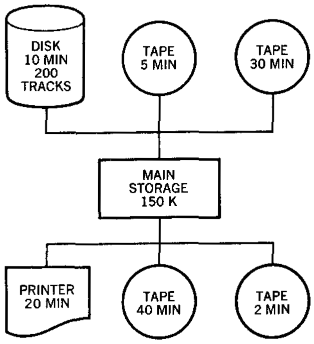
- Main storage and device utilization = job TRU time
- CPU utilization is the actual time (AT) the CPU is executing the job. AT is supplied by any of the programming systems previously described.
- Channel utilization is based on the number of Execute Channel Program (EXCP) commands processed by the channel, the

Table 3 Standard job costs

| *Component group* | *Utilization (minutes)* | *Number of components* | *Standard rate for group* | *Total cost* |
|---|---|---|---|---|
| Tape | 40* | 4 | $ .30 | $ 48.00 |
| Disk | 40* | 200** | .01 | 80.00 |
| Printer | 40* | 1 | .20 | 8.00 |
| Main storage | 40* | 150*** | .01 | 60.00 |
| CPU | 10 | 1 | 2.90 | 29.00 |
| MPX channel | 2 | 1 | .40 | .80 |
| SEL channel | 5 | 1 | .50 | 2.50 |
| | | | Job Total | $228.30 |

* Productive time
** Tracks
***K Bytes

Figure 3 Hypothetical job times




CPU TIME = 10 MINUTES
MULTIPLEXOR CHANNEL TIME = 2 MINUTES
SELECTOR CHANNEL TIME = 5 MINUTES
ELAPSED TIME (ET) = 60 MINUTES
PRODUCTIVE TIME (PT) = 40 MINUTES

Physical Record Length (PRL) of the records transferred across the channel, and, the Transfer Rate (TR) of the device the channel is servicing. The computation is:

Theoretical channel utilization = EXCPS × PRL × TR

The EXCPs, PRL, and the address of the device and channel are supplied by the previously described programming systems. The TR is supplied externally.

**standard job cost**

By using either method of determining the component utilization formula just described, and applying the standard rates described in the previous section, one can determine the standard cost of each job. Figure 3 shows the utilization of all components required by a hypothetical job. The following standard rates for components are assumed for this example:

| | |
|---|---|
| Tape | $0.30/device minute |
| Disk | 0.01/track minute |
| Printer | 0.20/printer minute |
| Main storage | 0.01/1K byte minute |
| CPU | 2.90/CPU minute |
| Multiplexor channel | 0.40/transmission minute |
| Selector channel | 0.50/transmission minute |

The standard cost of the example job is computed as shown in Table 3.

**component utilization**

To record component utilization for this hypothetical job, it is convenient to record the times for system components in various measurement categories in a table such as Table 4. The credits to idle time (IT) are entered because each component was debited with a device/day at the start of processing. Although Table 4 indicates minutes, smaller time measures may be used.

Table 4 Record of system component utilization

| Component group | Time-measurement categories (minutes) PT | MP | PM | DT | RR | IT |
|---|---|---|---|---|---|---|
| Tape | 160 | 80 | | | | (240) |
| Disk | 8,000 | 4,000 | | | | (12,000) |
| Printer | 40 | 20 | | | | (60) |
| Main storage | 6,000 | 3,000 | | | | (9,000) |
| CPU | 10 | | | | | (10) |
| MPX channel | 2 | | | | | (2) |
| SEL channel | 5 | | | | | (5) |

Component utilization information is accumulated for each job processed by the system. At the conclusion of the measurement cycle, resource utilization and system throughput are then reported.

## Integrated accounting system

The previous section discussed the measurement of resource utilization based on the concept of productive time. The input requirements, processing, and expected outputs of the systems are now presented for the three systems that constitute the integrated accounting system depicted in Figure 1: (1) general ledger; (2) budgeting; and (3) resource utilization.

**general ledger system**

*Input.* There are the following three primary areas that furnish financial inputs to the general ledger system: (1) payroll; (2) accounts payable, which records all payments which will be made to suppliers of services; and (3) journal entries, which record all other transactions. These transactions are coded in accordance with the corporate chart of accounts. In the case of payroll, if the application has been automated, individuals are normally coded to cost centers and distributed directly by the payroll program. If these three applications are already automated but the company wishes to change to a five-digit chart of accounts, the existing programs should be altered to accept a five-digit code. During processing, all inputs are verified so that only valid accounts are accepted. Entries for these applications are done at least once a month.

*Output.* The following reports are recommended to be produced by the general ledger system.

- *Transactions by account.* Each transaction, with a description and source is listed for each account so that the accounting department can verify the validity of all transactions and account balances.

Figure 4 Example format for summarizing cost center expenditures

```
                    CORPORATE INFORMATION PROCESSING CENTER
                                 COST ANALYSIS

                                                      THIS MONTH          YEAR TO DATE
                                                  HOURS       COST      HOURS       COST

01-659   CORPORATE GENERAL ACCOUNTING

 00459   APPROPRIATION REPORT
          SYSTEM 360 M-30
          UNIT RECORD
          CARD PUNCHING

 30111   MOVING & LIVING EXP.
          SYSTEM 360 M-50
          SYSTEM 360 M-30
          UNIT RECORD
          CARD PUNCHING

 40047   SPECIAL REFERENCES
          SYSTEM 370 M-155
          SYSTEM 360 M-30
          PROGRAMMING
          SYSTEMS
          CARD PUNCHING

 40073   ACCOUNTS PAYABLE
          SYSTEM 370 M-155
          SYSTEM 370 A&T
          SYSTEM 360 M-30
          PROGRAMMING
          SYSTEMS
          UNIT RECORD
          CARD PUNCHING
          OTHER CARD PUNCHING

 40077   AUTHORIZED SIGNATURES
          SYSTEM 360 M-50
          UNIT RECORD
          CARD PUNCHING
```

- *Transactions by account within cost centers.* Each cost center manager receives a report that enables him to examine the details supporting each account balance.
- *Balance sheet and income statement.* These reports are listed by detailed account and in summary for each month and the year-to-date.
- *Cost center statement.* Each cost center manager receives a cost center statement in detail and in summary, showing the current month and year-to-date balances by account. Such a report in summary form is depicted in Figure 4. Managers of cost groups and functions receive the total of cost centers for each group or function under their control. If a budgeting system is used, actual figures are compared to budgeted figures. Any variances are reported.
- *Profit center gross profit.* Each production cost center and sales unit receives a report showing actual sales of their service, cost of those sales, and gross profit. This report is also prepared for functions and groups. If a budgeting system is used, budget and variances also are shown.

**budgeting system**

*Input.* Cost center managers supply the budgeting information. Detailed expenses by account by month are necessary. Revenue budgets are prepared by the sales department with the assistance of the productive cost center managers. Other income and expenses are supplied by accounting. Time and resource inputs used for developing standard rates are the responsibility of each productive cost center manager.

*Output.* The budgeting system provides monthly budgets with an annual recap reported by cost center group, cost function, and total company. Revenue and gross profit budgets are also provided. If standard rates are developed, all component groups within system are analyzed to show total cost and expected utilization by category: PT, MP, RR, DT, PM, and IT.

**resource utilization system**

*Input.* The first input required is actual utilization data, which is supplied by any one of the programming measurement systems discussed. Utilization data consists of the following:

- Job Identification
- Beginning and end time of each job
- Devices used, by
  - Type
  - Physical record length
  - Number of READS or WRITES (EXCPS)
  - Address
- Access method (DASD)
- CPU cycles used
- Main storage allocated

Also, other data are needed such as are contained in the equipment file or the program resident table that identifies each component group by physical device address and component group number. The program resident table further contains standard unit rates and expected utilization by category (PT, MP, PM, DT, RR, and IT). Input regarding down time (DT) and preventive maintenance (PM) is furnished daily. A method of identifying reruns, presumably built into the job identification number is also required.

At least two processing programs are required. The primary functions of the daily processing program are to:

1. Read utilization data for each job
2. Compute job TRU time
3. Compute component utilization
4. Write job cost
5. Add component utilization to utilization table
6. Format and write utilization reports
7. Write utilization data

The monthly processing program reads, sorts, and combines job costs and utilization data, and writes the monthly reports.

Figure 5  Suggested format for a utilization report

```
                        U T I L I Z A T I O N  B Y  D E P A R T M E N T  &  F U N C T I O N                  10/31/71

                                 STAND                  PARA    BILL    NON-BILL LOST    TOT-BILL                MOD     UNIT     CARD
                                 ALONE    PROD   A & T  LLEL   RE-RUN   RE-RUN   SMF     S/360  %      1460      30     RECORD   PUNCH

 01 FINANCE STAFF-PMF
629 DIR OF FIN MNGMT DEVL
647 RENEGOTIATION ACCOUNTING
653 INCOME & EXPENSE ACCOUNTING
654 BALANCE SHEET ACCOUNTING
655 CONSOLIDATION ACCOUNTING
656 ACCOUNTING SYSTEMS & STANDARDS

TOTAL FUNCTION HOURS

TOTAL FUNCTION COST
```

Figure 6  Suggested format for an operating system utilization report

```
M-55-5                                 M V T  U T I L I Z A T I O N  R E P O R T                 DATE  OCTOBER, 1971

  TYPE OF OPERATION           CLOCK        CPU METER      %-METER              1ST SHIFT  2ND SHIFT   3RD SHIFT  NON-SCHED
                               TIME          TIME         OF CLOCK                                               WORK DAYS
SCHEDULED ATTENDANCE 21 W/D   483.00
ACTUAL ATTENDANCE
PREVENTIVE FE MAINT.
AWAITING FE MAINT.
UNSCHEDULED FE MAINT.
ENGINEERING CHANGES
SYSTEM PROGRAMMING MAINT.
SYSTEM OPERATIONS MAINT.
  AVAILABLE FOR PRODUCTION
EMULATION
USER STAND ALONE NON OS
NO WORK AVAILABLE
  USE IN MVT MODE

                                     CPU       % OF                         ***CPU ELAPSED TIME BY SHIFT ***************
                                   ELAPSED    TOTAL      CPU   %-CPU USED 1ST SHIFT    2ND SHIFT   3RD SHIFT NON-SCHED
                                             PROC HRS    USED  OF ELAPSED                                    WORK DAYS

PRODUCTION
  INSTALLED
  UNINSTALLED
  OUTSIDE DIVISION
         TOTAL
ASSEMBLY & TEST
  INSTALLED
  UNINSTALLED
  OUTSIDE DIVISION
         TOTAL
PARALLEL OR PRODUCTION TEST
  INSTALLED
  UNINSTALLED
  OUTSIDE DIVISION
         TOTAL
RE-RUN
  INSTALLED
  UNINSTALLED
  OUTSIDE DIVISION
         TOTAL
ADJUSTMENT FOR LOST SMF
  INSTALLED
  UNINSTALLED
  OUTSIDE DIVISION
         TOTAL
TOTAL MVT APPLICATION HOURS
TOTAL SYSIN HOURS
TOTAL SYSOUT HOURS

TOTAL MVT PROCESSING  HOURS

AVG. NO. CONCURRENT JOBS
AVG. CORE USED
AVG. CORE AVAILABLE  MVT
AVG. % CORE USED UNDER MVT
CPU TIME USED
% CPU USED OF MVT METER

OFF HOURS FE (NO OPERATOR)
```

*Output.* The basic reports produced by the system are (1) resource utilization, (2) throughput analysis, and (3) job costs. Other reports can also be generated such as summary utilization and operating system analysis reports. A suggested format for the summary utilization report is illustrated by Figure 5 and a suggested format for operating system analysis appears in Figure 6.

The resource utilization report, produced daily and monthly, provides for each component group the actual and budgeted hours as a percentage of total available hours. Percentage variation is given for PT, MP, RR, DT, PM, and IT.

The throughput analysis report provides the following information by component group and total for the system:

- Number of devices
- Standard rate
- Budgeted dollars (PT extended based on budgeted utilization)
- Actual dollars (PT extended based on actual utilization)
- Variance
- Actual hours of PT, MP, RR, DT, PM, and IT

The job cost report gives the standard cost by job within function within user of:

- CPU
- Main storage
- Channels
- DASD
- Tape
- Printer
- Card read/punch
- Teleprocessing devices
- Other devices
- Total

## Concluding remarks

The measurement of the use of data processing resources is necessary to allocate the cost of these resources to users. This is becoming more important because the cost of data processing is making up an increasingly larger percentage of each user's budget. Traditional measurements of the cost of data processing resources, such as the full absorption method, are unsuitable because users are not charged according to their actual resource utilization, and because data processing departments are not held accountable for fluctuations caused by efficiencies and inefficiencies of their operations.

Systems and programming resources are measured by any of the common manpower measurement systems used throughout industry. The measurement of computer systems resources, however, is more difficult, particularly if the computer is used in a multiprogramming mode. A system that measures resource utilization is required to furnish actual usage data to a program that calculates the cost of components used by a job. In addition, data processing cost centers are identified and budgeted utilization and cost data are supplied so that a standard rate for components can be calculated. Jobs are costed at a standard rate to isolate cost and usage fluctuations from job cost data.

Two methods determine component utilization. Measuring wait-ready time experienced by a job is the more accurate method, but the user may not be able to make the operating system modification necessary to measure it. An alternate approach is to compute theoretical resource utilization using algorithms based on the speed of devices and the amount of data being processed.

The resource utilization system described in this paper provides not only job cost data, but also systems throughput and component utilization information. It is presented with general ledger and budgeting systems to assist the company that desires to install an integrated accounting system, or simply to aid one in understanding how the utilization system interfaces with a general corporate accounting system. The systems presented in this paper pertain to the historical aspects of computer system utilization. An additional use of the cost data developed is a predictive one. New and revised applications can now be evaluated because standard costs of the proposed applications can be developed.

## Appendix

In developing theoretical resource utilization, other factors such as on-line jobs, spooling, and consecutively processed data sets regarding job type and resource identification may be considered.

**on-line jobs**

By definition, on-line jobs require the availability of all resources while the job is resident in the computer. The on-line job bears the cost of all allocated resources (I/O devices and main storage) for the elapsed time the job is resident.

**spooling**

The spooling, or writing of report files after the job creating the files has terminated, presents another special situation. If the costs of the spooling program are identified and allocated to the programs creating the records on a per-record basis, then this results in a full absorption cost system that is subject to price fluctuations. Therefore, the development of a standard rate for spooling operations is recommended since spooling is considered a resource of the total system.

**consecutively processed data sets**

In the measurement of TRU time, the assumption that all I/O is overlapped with all other I/O is not true when two or more data sets are processed consecutively because one or more data sets are completely processed before one or more subsequent data sets are processed. It follows that consecutively processed data sets are identified and I/O transfer time is calculated as if those data sets were one. Thus they are added together and treated as one data set before being compared with other data sets.

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