Identification

Overview of Accounting
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Purpose

Section BO.2 provides an overview of the techniques used
to implement resource-usage metering and accounting for
the Multics system.

Introduction

If Multics is to become a utility system capable of meeting
the computation needs of business as well as universities,
service bureaus as well as inhouse operations, it must
possess an extensive resource-management facility which
includes capabilities for measuring resource usage, charging
for resources expended, regulating the use of resources,
and evaluating the demands made on the resources available.
Such a facility must be precise enough to satisfy the
strictest auditor; must be clearly and flexibly designed
so that different installations' needs and policies may
be accomodated; must be tamperproof, as far as possible;
and must be reliable in the event of hardware trouble.

Requiring precision in the accounting system dictates
that resource consumption will be measured by the modules
directly concerned with the use of each resource, in
units which reflect the kind of resource being metered.
These meter readings are associated with the process
which caused the consumption of the resource.

However, accounting is not usually concerned with which
process used a resource, but rather with which account
should be charged for this use. Furthermore, accounting
is done in terms of a single accounting unit (which may
be dollars or "credits" - the choice is left to the in-
stallation), each of which has some value in terms of
the metering units.

Therefore, raw resource usage must be converted into
a cost in accounting units, and the information concerning
the identity of the process which consumed a resource
must be mapped into an account number. To do this, each
process is required to call on accounting procedures
responsible for reading meters, converting values into
costs, and recording the charges. Prices for resource
usage are determined by calls to the system pricing routines;
these express installation changing policy.

The recording is done in the Account Data Segment, which
is used by all processes charging to an account. Normally,
one account (and one account segment) is established
for each possible combination of person and project.
However, it is possible for several users to share one
account, or for a user to set up several accounts to
distinguish various phases of his work. The accounting
procedure is responsible for charging the proper account,
and for taking special action when the amount charged
to an account passes administratively-defined thresholds.

The Account Data Segments are found in a special directory,
the Account Directory, where each account has an account
data segment. These segments contain history and control
information regarding system use, and pointers to "pool
files", which may contain a balance of unallocated resources
in accounting units. A user may make withdrawals from
or deposits into these pool files, subject to controls
specified in the account data segment and the account
pool files.

Pool files have superior pool files, and so on up to
a single final file which represents the total allocation
of system resource allotments. The tree structure of
these files mirrors the administrative structure of re-
sponsibility for and control of use of system resources.

All of the system resource-usage metering will be multiple-
entry, so that, at any time, all of the use of the system
can be accounted for. It is intended that all system
resources be metered completely, either to a user's or
to a system overhead account.

Overview

Multics accounting can be divided into four layers, as
shown in Table 1. Naturally, the boundaries of the layers
are imprecise, and some modules have functions in more
than one layer; however, the division should serve as
an aid to explanation.

The first layer: hard-core metering

The procedures which perform the metering of resource
consumption constitute the most elementary layer of the
accounting system. These procedures and their associated
data bases are part of the hard-core Multics supervisor.

Included in the first layer are the procedures for metering

    1. processor usage

2.   secondary storage usage

3.   file-system I - O traffic.

All of these procedures are called upon to record resource
usage at times when page-not-in-core faults are not permitted.
Therefore, a wired-down system-wide data base, the Active
Meter Table, is provided for use as a "scratchpad" to
hold the metering information until it can be updated
to paged storage.   This data base and the procedures
to manage it are also part of the first layer.

Section BO.3 describes the procedures in this layer.

The second layer: further metering and meter collection

The distinction between the first and second layers of
accounting occurs because second - layer procedures are
part of the flexible supervisor: their data bases and
procedure segments are paged, and they may be replaced
on a per/process basis without bringing the system down.
The second layer is, like the first, concerned with metering
resource consumption; it includes procedures for

1.   metering the usage of peripheral I - O devices

2.   metering system use for transmission to and from
     I - O devices

3.   updating resource - consumption figures from the
     Active Meter Table to the corresponding Account
     Data Segment.

Sections BO.3.04, BO.3.05, and section BO.4 describe the
procedures and data bases for this layer of accounting.

The third layer: pricing and operating policy

The procedures in the third layer of the accounting system
are responsible for expressing the administrative policy
concerning the use and control of system resources.
In this ring, there are procedures for

1.   converting the incremental resource usage recorded
     in the Account Data Segment into a cost in whatever
     units accounting uses, and maintaining each
     account's balance.

2.   associating a process with an account, and controlling
     who may use an account.

3. determining when a user has used up all of an account's resources and what to do about it.

4. Making available to the user information on the status of an account.

5. Transferring funds between superior pool files and accounts associated with them.

6. Interface with the system Transactor.

At this level, the concept of a tree-structured system of pool files, mirroring the administrative responsibility for resource-usage control, is introduced; the data base required to support this is the Account Directory and the files which reside in it.

The procedures in the third layer are determined in the sense that certain entries will be called by the lower levels; what the programs do, however, is a function of the needs of a particular installation. Section BO.5 describes the procedures which will be used on the initial Multics.

The Fourth Layer billing and administration

The fourth layer of the accounting system is primarily concerned with the needs of the administrator. It is here that the system - resource usage costs can be integrated with the accounting system used to run the computer center. "Overhead" enters at this point, as do whatever procedures are provided for billing, for manipulation of the entries in the account hierarchy by administrators, for auditing, and for history recording. The number and kind of procedures available at this level is determined by the needs of the individual installation: Section BO.6 describes the programs which will be supplied with the initial Multics system, including

1. The Biller, a system process which sends bills for resource usage at predetermined intervals.

2. The Auditor, a system process which checks all usage records at random intervals to see that no discrepancies exist.

3. The Accounting salvager, a process which can reconcile discrepancies and inconsistencies in accounting records which may have been caused by system crashes.

4. The resource-budgeting system, and in particular
the Allocate command, which is used by system
and group administrators to distribute accounting
units among pool files and account data segments.

BO. Section	AREA	OPERATIONS	DATA BASES	FLEXIBILITY	ENTRIES
3	Usage Meters mtering	Metering Raw Resorce use when page faults forbidden. Management of AMT.	Active Meter Table (AMT)	Very rigidly specified; many modules call these entries	Meter_core,meter_cpu meter_length,meter_ss_io start_cpu_meter,stop_cpu_meter start_sgt_meter,stop_sgt_meter meter_move
4	Meter Reading and collecting	Metering when page faults allowed. Transfer of Meters to paged Storage.	Account Data Segment (ADS)	Rigidly specified; many calls from other modules	Update_accounting meter_gen_io,signon_dev signoff_dev,lock_pages file_scan
5	Pricing and Operating Rules	Price computation and Balance Maintenance. Out-of-funds. Transactor calls.	ADS, Prices, Pool Files, Transactor.	Type of calls fixed, content depending on installation's needs. Pricing policy here.	Price, getprice, signon,signoff,transfer, out-of-funds, status, Transaction
6	Billing and Accounting	Billing Hierarchy manipulations History and Statistics External Accounting Budgeting	ADS, Pool Files. Logs. Etc.	Free; Programs here tailored to installation's taste. General Financial Policy Here.	Biller Auditor Allocate Etc.

TABLE 1.   AREAS OF RESOURCE MANAGEMENT