INFORMATION SYSTEM RESOURCE MANAGEMENT AND
JOB ACCOUNTING IN A COMPLEX NETWORK ENVIRONMENT

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ABSTRACT

The use of job accounting to provide for more cost-effective system resource management is a traditional function within both large and small host processing environments. Chargeback and DP cost accounting have evolved based upon the business principles of management accounting and various methodologies currently exist to support a variety of specific management objectives. The application of such methodologies to network processing environments is still in the early stages of development. Network job accounting methodologies must rely equally upon statistical as well as traditional management accounting techniques, and additional tools and frameworks need to be developed and tested in order to provide effective resource management of complex integrated system environments. This consideration becomes especially important both as small PC-based workstation clusters or LANs access host networks, and large broad-band telecommunications and satellite data links impose new technical as well as financial complexities. Artificial Intelligence (AI) and Computer-Assisted Software Engineering (CASE) methodologies hold substantial promise for building expert systems and decision-enabling tools to support network optimization and resource usage management controls, but as yet AI and CASE methods have not been easily implemented. The SAS System has great potential to provide for the integration of statistics with traditional job accounting methodology as well as automated support to resource management and control in highly complex data communications networks.

1.0 MAINFRAME HOST JOB ACCOUNTING

The methodologies that have evolved to account for internal usage of DP system resources vary considerably in function as well as process. This is due to the fact that there are a wide variety of business objectives to be achieved by such system resource accounting, and is also due to the fact that a broad range of descriptors can be applied to the measurement of the resources that must be accounted for. This is true for even the least complex, host-based mainframe DP system environments, which require much simpler job accounting applications than networks, but nonetheless traditionaly impose complicated design constraints.

1.1 HOST JOB ACCOUNTING HISTORY

Ever since the early years of data processing, there have been fundamental disagreements over the level of system usage detail necessary to effectively manage DP resources. To a degree, the problem of "how much detail is really needed" is fairly similar to many other management information system applications. However in this case the problem is more complex due to the functional disparity between DP managers and accountants, both as job accounting system users and as sources of host job accounting schematic frameworks.

Although statistical analysts have only fairly recently become involved in technical advancement of job accounting standards, this disparity may be bridged somewhat by the introduction of statistical solutions to improve efficiency of resource data capture processing. Base SAS software procedures have already been used for pre-processing as well as analysis of job accounting data to provide sophisticated data verification and data reduction techniques, which hold promise for host as well as network job accounting.

The sharp division between the traditional technical requirements of DP accountants versus DP system performance analysts compelled IBM to develop the SMF as well as the RMF log record types to provide alternative levels of system resource measurement detail and precision. The SMF log records were provided by IBM to meet the functional needs of EDP auditors according to their job accounting functional requirements, and will continue to be their standard of choice for the foreseeable future.

The fundamental differences between DP accountants and technical specialists will undoubtedly always exist but the introduction of the RMF log records, as well as other precision software monitoring tools to support advances in CPE technology, gave both accountants and technical professionals tools to support management decision-making. This has also served to create new challenges to organizational executives, as they now must often analyze reports derived from two substantially different functional data sources -- which often measure the same resources according to widely varying, and often even contradictory, algorithms. In this regard, the increased precision that has been introduced by advances in CPE relative to job accounting has not only served to point out the discrepancies of the latter but have created an even greater need for statistical rigor as the assumptions behind both must be explained to organizational executives sufficiently that both functions benefit.

1.2 HOST JOB ACCOUNTING MEASURES

The term "job accounting" itself is an indication of the uneasy interface that has always existed between management accounting and DP management. In general, the complexity of accounting in host DP environments has confounded traditional methods that are used by financial analysts and controllers for most other operational areas of business. As a result, there have been a series of conventions adopted by DP management and accepted by EDP auditors to account for basic DP system operations.

The common denominator in DP host-based accounting is the "job", or batch-submission, which is the original operational Standard Unit of Work for DP management, as well as minimum level of DP accounting detail acceptable to EDP auditors. Although most host-based DP shops now have online "sessions" as well as batch job execution, and most conventional batch environments exist on many real and virtual systems managed by system software that necessarily gives higher priority to foreground rather than background processing -- and in spite of the fact that even batch resource usage accounting commonly requires detail down to the jobstep level in order to monitor execution of individual programs or software products, and to account for discription of individual output writers -- the term "job accounting" continues to be used to refer to the most basic level of resource usage measure needed to account for DP costs.

This most basic level of DP resource usage measurement can be found in the IBM System Management Facility (SMF) standard accounting "Type 30" record which logs both batch and online usage in MVS environments and similar basic job accounting log records exist for IBM's VM environment, as well as nearly every major vendor and operating system in use in the world today. Although arguments can conceivably be made for DP resource usage accounting as well as measurement based on IBM's SMF "Type 70" Resource Management Facility (RMF) records, the added cost of routine processing of the volume of raw data contained in the RMF records, or equivalent detail resource measurement logs for other operating systems, is not normally justified since EDP auditors commonly accept "Type 30" system resource measures as the standard and are usually uncomfortable with the complex detail of system usage measures contained in "Type 70" records.
The SMF "Type 30" records (actually 6, 26 and 30) -- or alternatively 4, 5, 20, 34 and 40) contain only summary usage data by job or session with account number and user identification, whereas RMF "Type 70" records (actually 70 through 79) are virtual "mini-logs" that detail activity and performance measures per device. RMF records can typically require 10 to 100 times greater storage than SMF records. More importantly, the SMF records normally contain only one, and generally no more than 5, variables to measure each type of system usage (CPU, DASD, tape, print, etc.), and they are measured in units commonly understood by EDP accountants (cpu second, EXCP, printline, etc.). However, the RMF records can contain up to 40 or more data elements providing alternative measures for each system usage variable, and are not easily interpreted without in-depth classification of the statistical assumptions inherent to the algorithms used by IBM to perform RMF data capture (which are unfortunately not always made available by IBM, and what is even more of a drawback is that they are subject to change without notice any time that IBM issues a new system software release -- and are also very vulnerable to unpredictable results anytime a new IBM or PCU device is linked to the host, which can lead to ongoing headaches in large-scale, complex host environments).

More often, the "Type 30" records are used for routine job accounting, whereas the "Type 70" records are used to support service level reporting and analysis. Notably, routine processing of job accounting data is normally performed on all system usage data on a daily basis, whereas the service level reporting and analysis is normally performed less frequently and samples rather than processes data for every system job and session.

1.3 FUNCTIONS OF HOST JOB ACCOUNTING

It has been widely noted that the evolution of DP host-based job accounting has been made more difficult by difference in functional responsibility of DP managers and DP capacity planners versus EDP auditors and DP financial analysts. There is not a lot of common ground with regard to either education or experience among these two groups, and the convolutions that have become accepted as standards for DP job accounting are viewed by each group as a very considerable accommodation of the other at a considerable lowering of their own normal standards of operating procedures. If it were not for demands of most organizational upper-level management, most job accounting systems would not be implemented to begin with, and, in fact, it has been observed by many that both the quality and detail of the job accounting system of any organization is most directly due to whether its senior executives demand some level of DP resource usage accounting to be developed to support their high-level organizational decision-making.

Fortunately, most organizational executives understand that DP job accounting has inherent limitations due to the complexities of attempting to integrate information that does not always have a common framework. However, it has been recently observed by many analysts that organizational executives have in recent years renewed interest and increased scrutiny of their DP job accounting systems, and the number of basic DP chargeback systems, as well as sophisticated host-system performance monitors and resource measurement tools, have greatly proliferated in number and functional capabilities.

This is at least in part due to heightened emphasis on organization-wide cost control to strengthen profitability in increasingly competitive market environments, but is more often due to increased awareness of technological alternatives available to the organizational decision-maker and increasing dissatisfaction with methods of DP resource usage measurement and costing which have been commonly regarded as crude in the past. Such "home-grown" DP job accounting methods have come to be commonly accepted by most DP resource managers well into the future, but it has already become common for organizations that are large, complex or in unusually competitive market sectors to begin evaluating more sophisticated alternatives for planning and monitoring costs related to the overall management of DP system environments.

Cost containment is, after all, the primary purpose of all job accounting systems -- normally DP budgeting, monitoring, billing and forecasting components are also included in the functions of a basic job accounting system, but the fact remains that the primary function of job accounting is "costing", not accounting at all. Although some job accounting systems of the "chargeback" variety are used for "charging" billing of external customers, most job accounting systems are only intended to be used for internal purposes, primarily tracking and monitoring DP system resources.

In some of the more recent forms of chargeback, historical job accounting data is used for purposes of pricing DP services and products, but in all cases job accounting involves the estimation of DP-associated indirect costs, which are accumulated and combined with direct costs of DP operations and compared against budgeted costs and reported as actual expenses. Due to the peculiar mixture of direct versus indirect expenses that characterize even the simplest mainframe-based DP shop, the resulting "actual expenses" may or may not be suitable for posting to organizational general accounting journals, depending on the quantity as well as quality of the cost estimation upon which the job accounting system is based (as well as the level of understanding of that estimation by the general accountants of the organization). Also depending on the quality and quantity of the cost estimation data, the job accounting system may attempt a "pricing" of the DP costs, which is essentially a "future cost" estimation or forecast that may include both base-line service level benchmarks and peak usage projections. Notably, the concept of what both DP management and accountants commonly regard as "estimation" varies most dramatically from the statistician's definition of the term.

2.0 BASICS OF HOST JOB ACCOUNTING

Although most DP job accounting systems have in the past been designed primarily by accountants and developed by application programmers, their ultimate usefulness an organization depends upon the proper balance of the expertise of both the financial and technical professionals in the specification of the methodologies that will be used to perform cost estimations. This is the most critical factor in the implementation of a DP job accounting system that is capable of providing reliable and relevant data to organizational decision-makers (and to customers, if the job accounting costs are "charged-out", or if the job accounting system uses a "charge-back" methodology that treats internal users of DP resources as customers of a computer center).

Since it has been commonly observed that management accountants most often stay with the same company (or at least the same industrial sector) for most of their professional careers, while most DP job accounting move from company to company and even industry to industry many times during their careers -- it is understandable that they normally have different perspectives on the costs of computer operations. The management accountants generally have in-depth understanding of their organization and its business sector, but usually have limited understanding of their organization's computer technology, while the expertise of the DP manager is usually just the opposite. While it might at first seem that these two groups would have complimentary skills, the reality is that they are most often in diametric opposition and rarely complement each other about anything.

2.1 APPROACHES TO COST ESTIMATION

Accountants are fond of referring to the cost estimation methodology of most DP managers as "Four-Wall Accounting" -- that is, accounting of only direct and tangible internal DP costs that can be immediately seen and consumed. Management accountants accuse DP managers of "leaving out the floor" -- that is, they often miss the indirect and intangible expenses such as administrative labor or facilities overhead, which are in fact actual expenses and greatly influenced by the size and efficiency of the computer operation. DP managers usually try to get around the whole issue by claiming that such
"Ceiling" and "floor" costs are not "real" expenses anyway, and usually try to impose a methodology based on direct project-related or system-processing cost.

Normally the result is a highly dislocated and complex set of cost pools that often over-lap as well as leave a lot of gaps between direct and indirect costs. Because of the ongoing struggle between the management accountants and technical management regarding which cost estimation methodologies to use, organizational executives normally experience a lot of frustration, as well as displeasure, as they try to interpret expense-related data originating from the simplest host-based job accounting systems. Partially because of traditional confusion due to associating DP job accounting with "real" accounting data, the costs that are reported by these systems have often been improperly regarded as actual in the past, rather than simply as estimates for purposes of financial analysis and budgetary control.

2.2 JOB ACCOUNTING METHODOLOGY

The basic host mainframe-based job accounting system has only 5 simple steps: 1) Define the service boundaries of the system resources to be accounted for; 2) Identify the user of the system resources, as well as identity of all other users or customers that benefit from that resource usage; 3) Quantify total costs of pooled system resources; 4) Measure the system resource consumption by user and by service boundary; 5) Estimate partitioned cost and (optionally) adjust by proration of undistributed cost or further partition by categories of incomplete or shared service boundaries. Although specific procedures for the implementation of this methodology vary considerably by individual application, these 5 steps comprise an algorithm common to all job accounting systems.

The first step in the design of a job accounting system is to define the DP service boundaries for each computer resource -- this includes all hardware as well as software and labor resources. This can be as simple as "Total Processor, Storage, and I/O" summaries. It may also be complex enough to identify every hardware device by type, software by type as well as individual programs and products, and programmers or technical support labor by job description. Once these resource types are defined, they remain to define the service boundaries for these resources -- that is, whether the resource is shared (or fully distributed), used by one functional area, or shared among a specific group of functional areas. Again, this can be as simple as defining all resources as shared and distributing all costs outside of the computer department, either equally or weighted by some arbitrary measure (a classic "Four-Wall" job accounting approach highly favored by DP managers) -- or else a very complex framework must be developed which may include full or partial assignment of costs for individual production systems (or even jobs) or individual projects (or even programmers). The former approach is sufficient for chargeback, but the latter approach is necessary for chargeout billing of system resources, either internally or outside the organization.

The second step, identification of the users of system resources, may seem at first a straightforward process since the SMF log record is keyed by jobname and userID of the job or session, and an almost unlimited number of accounting codes can be passed from the jobcard or session logon (the same is the case with most other vendor's operating system logs). However, unless there are only a few service boundaries, the accounting code standards needed to collect all information needed to "roll up" to all service boundary divisions can be prohibitive. On the other hand if sufficiently all-inclusive accounting code standards aren't in place (and enforced by security lock-outs at the time of initial request for the system resource), the only option to direct assignment by service boundary is external table lookups, which can be a headache to maintain and difficult to audit as well as potential major resource users themselves. The problems can be compounded and result in either a high level of "job work-not-captured" (the job accounting equivalent of lost revenues), or errors in assigning costs to the wrong user, or both.

The third and fourth steps are in fact straightforward, and involve the routine and relatively simple process of totalling direct and indirect costs with raw resource usage. The final step is in fact the least straightforward, as this is the "clean up" phase and can be either a manual or automated process where the accumulated error of the previous steps is either reconciled or written-off depending on the pragmatics of actual cost (and time) to account for the error, and realities of the perceived significance of the error by those who will view the job accounting reports.

The core of all job accounting methodologies are the embedded rules by which the rates derived by partitioning resource pool costs are multiplied against the raw usage to derive the chargeout rates. There are still many complexities involved in the algorithms used if it is necessary to weight or factor the estimated costs to account for multiprogramming, virtual storage, priority processing, shift differentials, or multiple processors (to name just a few) -- and to be truly equitable, these variables must be factored in. The only alternative is to distribute the accumulated differentials as overhead, which invariably results in dissatisfaction by the resource users if they perceive that the overhead costs are allocated on top of the direct costs.

Often job accounting systems try to hide this overhead within the rate structure for direct costs, which can lead to even greater dissatisfaction from the resource users if the ratio of overhead to direct charges is not within the range of what they expected. Normally, DP management and financial controls set an arbitrary limit on the overhead-to-direct cost ratio, based on a trade-off decision that considers both potential dissatisfaction of their customers and the prohibitive cost to develop, process, and maintain algorithms to support variable rate differentials. Unless there is a legal requirement such as an external contract or government regulation, this overhead cost is not normally justifiable if subject to the same Return-On-Investment analysis that an external investment usually involves. In effect, this is an "internal cost sharing plan" that can be aided by market research statistics and methods that apply to judge external market potentials -- since, practically speaking, the ultimate goal of DP is to sell its computer services to internal users and organization management.

The first two steps (identification of resources and resource users) and the final step (reconciliation) are the traditional weaknesses of all job accounting systems, regardless of approach. Notably, these are also areas where there is the greatest potential benefit from statistical analysis, both in terms of qualitative discrimination of discrete functional boundaries as well as more reliable and efficient resolution of identification and estimation errors. However, even the two traditionally stronger steps of job accounting (rate and weight multipliers against raw resource measures) are more and more often using complex statistical analysis to analyze resource pools and estimate costs using alternative algorithms to account for indirect costs.

2.3 JOB ACCOUNTING FRAMEWORKS

There are a variety of frameworks within which job accounting data can be evaluated. These frameworks relate to basic assumptions behind both the overall methodology that is selected, as well as the relative degree to which the data is regarded by organizational decision-makers as "hard" or "soft" (which is at least partially related to whether it is generated primarily for internal or external purposes).

In order to understand these frameworks, it is important to distinguish several key concepts as they have come into common usage with regard to job accounting, as well as their sources. Due to the many underlying complexities of function that characterize job accounting systems, there are a large number of key terms used related to these systems that differ somewhat from their most common context. Among the more important distinctions that should be made in any discussion of job accounting are: 1) "Cost Center" vs "Profit Center"; 2) "Cost" vs "Expense"; 3) "Resource Allocation" vs "Cost Allocation"; 4) "Costing" vs "Pricing"; 5) "Chargeback" vs "Cost Accounting".

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Most job accounting systems partition service boundaries into "cost centers", which are in effect the "accounts" to which resource usage is "charged". These "cost centers" for chargeback purposes are normally not as rigorous as accounts and sub-account partitions in traditional cost accounting systems, such as are normally used to determine costs to produce marketable goods. The latter may define "profit centers" as separate accounts or subaccounts if there is a revenue-related product or service that can be partitioned from the primary revenue generating activity of the organization. However, chargeback systems may sometimes partition "profit centers" as DP-internal service boundaries that do not generate revenue but are instead "credited" with estimated cost "reductions" (where the benefit is often more to the service provider than the user, and the resulting confound to the overall cost pool estimates can be catastrophic).

As previously indicated, the "cost" in a job accounting system is really an estimation, and accounting generally doesn't recognize estimates as having any value (with the notable exception of their standard methodologies for putting a value on residual inventories). To accountants, a "cost" is original amount actually paid, regardless of value or the losses associated with it. This makes things all the more confusing since, as pointed out earlier, DP managers view a cost as something lost, consumed, or used up. Accountants also get confused if DP managers interchangeably use the terms "cost" and "expense", since to accountants an "expense" is a partitioned net consumption offset by a corresponding revenue -- which implies a much more complicated algorithm and procedure -- yet this may be valid if the selected job accounting service boundaries are based on "profit centers" rather than "cost centers" (and if the service boundary is a valid "profit center").

Most job accounting systems use "resource allocation" methods to assign routine and recurring charges (such as equipment maintenance, technical support labor, space rental, etc.), which are normally batch updated from a static file and merged with accumulated estimated costs. These are actual indirect costs that may be distributed to all or a select group of cost centers, but are normally recovered by a flat charge. This method is a simple linear algorithm well suited to conventional data processing, and it is usually preferred over using the "cost allocation" of job accounting systems because of the volatility to the resource cost pools used to determine rates. Normally the former is used to "automate" allocation of routine actual indirect costs that are substantial in amount and unavailable to resource cost pools for the particular iteration of the rate-setting process.

The difference between "costing" and "pricing" is largely a matter of the intended functional use of the job accounting data, both in terms of whether it is for internal or external use, and whether the primary purpose is cost containment or planning. Traditional chargeback systems are used for internal purposes only and rely on routine resource allocation by simple rate multipliers per unit-of-work algorithms. This normally involves simple costing on a nonprofit basis with the primary intention of encouraging better rationing of resources by setting performance objectives which are directly linked to a "Actual-vs-Budget" exercise that is normally taken very seriously by executive decision-makers.

At the other end of the job accounting spectrum are "transfer pricing" systems, which can use job accounting data for both internal and external billing purposes, and are capable of all the functions of basic chargeback systems, with the additional capacity of performing "what-if" forecasting and "future-cost" analysis with the ability to handle both internal and external variable-rate billing as well as pricing of marketable products and services based upon accumulated historical cost estimation data. Obviously, this is a wide-open area for statistical methodologies that are not previously interfaced to job accounting systems, and they are not hindered by the underlying constraint of chargeback systems to "look like" a general accounting system even though that is not their actual function. Also, such "pricing" methodologies are a more accessible common ground between job accounting and more rigorous estimation applications involving CPE data. Another interesting characteristic of these pricing systems is they normally use advanced statistical procedures to track covariance of service boundary-level cost estimations to actual revenues of profit centers, and analysis of variances within cost center partitions to help identify duplication or waste to provide intelligent decision-making support to cost containment and planning.

Notably, there is a conspicuous absence of the standard measures of error and precision tolerance appearing on any conventional job accounting system reports as the statistician would normally provide along with any respectable estimate. However, these values are more commonly reported with service level measurements which are increasingly in demand by organizational decision-makers who want to tie the job accounting data to functional performance. It is not yet clear whether the standards set by service level reporting will carry over to cost estimations involved in host-based job accounting, but it is almost certain that executive decision-makers will be asking for reliability and even validity indicators with their job accounting cost estimates as they become increasingly aware of the importance of improved data precision to their cost containment and profitability.

3.0 NETWORK JOB ACCOUNTING

The methodologies used for network job accounting traditionally differ from host mainframe methodologies both in terms of complexity and dependency upon more statistical rather than strictly accounting methods. This is because of the lack of comprehensive measurement tools for networks as opposed to host mainframe tools during the early years of job accounting technology development. Due to this absence of practical raw measurement tools, network job accounting has been the origin of sophisticated statistical tools both for estimation of raw usage measures as well as forecasting algorithms which have greatly added to the methodological depth of modern CPE. Although host mainframe-based job accounting frameworks will probably always be the structure within which network cost estimations must be evaluated, there is significant benefit that host job accounting can achieve by accommodating some of CPE's statistical solutions. In the meantime, the primary problem of network job accounting is its reconciliation with the evaluation frameworks of network job accounting.

3.1 HARDWARE VS SOFTWARE MONITORS

In the absence of a comparable measurement tool to SMF, early network job accounting systems largely relied upon hardware-based network measurement tools. Hardware monitors measure number of bytes (or other logical unit of work) that is moved through the network. The advantages of hardware monitors are that they give accurate data about network loading and performance of the network device(s), but their disadvantage is that they do not give any detail as to application-specific identity (such as user or system), which is critical to establish relevance to job accounting applications -- and also that they may have an associated overhead that can have a staggering effect on overall network response. The advantage of software monitors is that they are more compatible with the host mainframe-based job accounting frameworks, but their disadvantage is that they cannot directly handle a substantial portion of the network usage overhead, which automatically distributes the cost of inefficient nodes or system support strata to all users of the network, and thereby negates the primary purpose of job accounting to identify bottlenecks and encourage improved resource utilization. The most effective network job accounting systems have taken a hybrid approach that leans heavily toward the software monitor approach, but nonetheless make heavy usage of hardware monitors in order to measure total system usage and overhead of the network, so that the indirect support costs can be more reliably estimated and added into the resource cost pools as direct charges.
3.2 NETWORK USAGE MEASUREMENT

The primary problem of online network job accounting is that logical units of work such as transaction counts and physical interface units have no significant relationship to actual consumption of network resources -- however, software monitors do not have sufficient corresponding physical work units to estimate the costs of the logical units of work. If a software monitor is the only source of network data, substantial statistical analysis may still be required in order to provide the full complement of logical and physical measures for all application and system support functions. These measures must account for the same CPU and storage usage as host mainframe-based job accounting, but must also account for all network front-end preprocessing, communications infrastructure, and distributed network technical support as well.

3.3 NETWORK CAP ENGINEERING

Network job accounting has traditionally involved more technical-oriented methods than mainframe-based job accounting, which is more heavily financial in nature. Therefore, it is understandable that network job accounting relies heavily upon Software Performance Engineering (SPE), which is a traditional methodology using professional engineering techniques. SPE methodology was drawn upon for the advancement of CPE technology, and promises to have an ultimate influence on mainframe-based job accounting. SPE has been integrated with several other established software engineering methodologies using expert system and automated decision support technology as the basis for Computer-Assisted Software Engineering (CASE). These methodologies are substantially statistical in nature, and have been implemented using SAS base procedures. These methodologies generally prove to be highly compatible, and can be readily integrated into hybrid network job accounting applications.

4.0 A PRACTICAL EXAMPLE

The American Airlines SABRE Computer Services (SCS) information networks are widely recognized as the largest integrated data communications network in the world. The SABRE network provides reservations, flight operations scheduling support for over 40 international airlines, and the SABRE commercial systems network supports business data communications, microfiche, and storage), as well as an inhouse front-end control facility for maintaining over 40 resource identities and both service boundary and resource type tables -- complete with over 40 ISPF online entry panels -- were coded in SAS entirely inhouse by only 2 programmers and 1 user. Only base SAS software and SAS/PSI full-screen entry software were used to develop and test the inhouse macros used to build the initial implementation of the new SABRE job accounting system.

The new SAS-based SABRE network job accounting systems are designed to handle both basic internal chargeback billing as well as transfer-pricing for both internal and external chargeout. The transfer-pricing system is under ongoing development, and is currently being interfaced to all other SCS management accounting and inhouse CPE systems. Development scheduled for the upcoming year includes upgrade of the SAS databases to autoupdate using concurrent multiple-user input as well as multi-streamed real-time integrated resource usage database update using SAS/DFM SAS/IMSDL/6/SAS/SHARE, and SAS/DB2™ and development of intelligent front-end data capture and data reduction to support variable rate structures and both historical and forecast cost estimation using SAS/IML<sup>™</sup> with Al and CASE techniques.

REFERENCES


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The author obtained undergraduate degrees from Arkansas State University and University of the State of New York, and a doctorate in service delivery network systems from Walden Advanced Studies Institute. Before working at American Airlines, he worked as a contractor on network system applications code in SAS language for EPA, FDA, PH, HCFA, USAF and NASA.