FINANCIAL SIMULATION MODEL FOR THE COMPUTER BUSINESS

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Abstract

This paper describes a model used for financial simulation of computer systems, their component cabinets, and the Univac Data Processing Division of Sperry Rand Corporation. The analyses derived from the model are part of the company's short-range (2-year period) and long-range (6-year period) planning procedures. This model, which runs on UNIVAC® 1108 computer, provides the means through which both short- and long-range effects of certain types of decisions can be traced in greater detail and speed than by previous procedures. The model has been utilized for long-range revenue forecasting, for measuring effects of alternative marketing programs, and for estimating manpower requirements.

INTRODUCTION

The computer industry is in the forefront of the current technological explosion. Technological obsolescence of a system precedes physical depreciation by years. Despite rapid obsolescence, the industry has a tradition of rental to its customers as the means of supplying the bulk of this expensive capital equipment. Put these two things together--accelerated obsolescence and retention of ownership by the manufacturer--and you have the ingredients for a succession of painful decisions.

Fortunately, the computer itself can be used as a tool to alleviate somewhat the difficulties of the decision process in this dynamic industry. Through the use of models of the business, the consequences of alternative courses of action and different sets of assumptions can be explored prior to substantial financial commitment.

With the growing importance of leasing contracts for capital equipment, in general, the manufacturers of other types of technically advanced articles may also benefit from models of this type. Their basic economic problems in leasing such things as electron microscopes, microprobes, numerically controlled tools, video tape handlers, gas turbines, and deep sea submersibles are the same as those faced by computer manufacturers. In time the manufacturers of communications satellites, super tankers, ice-breaker tankers, and nuclear power generators may encounter similar economic problems. It is the hope of the authors that in dealing with the practical problems of manufacturing, selling, and leasing electronic computers, this paper will make a small contribution toward solving problems of efficient resource management under conditions imposed by our accelerating technology.

DESCRIPTION OF THE PROBLEM

The Univac Division of Sperry Rand Corporation is one of the major manufacturers of electronic computers. Its product line includes a wide variety of computer systems. Each system consists of a number of components and can be upgraded with additional equipment throughout its useful life on the customer's premises. Subsystems (a specified group of functionally related components) and peripheral cabinets can be used as parts of more than one computer system. The table below illustrates a relationship that is typical for computer systems and their component subsystems.

Subsystem \ System	UNIVAC 1108	UNIVAC 418	UNIVAC 9400
1. UNISERVO VI-C Master, 7 Channel	X	X	X
2. 1004-II-06 Processor	X	X	
3. Single Station Display	X	X	

Thus, the UNIVAC 1108 system can include UNISERVO VI-C, Master, 7 Channel; a 100r-II-06 processor; and a single station display; while the system component UNISERVO VI-C, Master, 7 Channel is used in configurations of UNIVAC 1108, 418, and 9400. The advantage of simulation at the component level of detail is that the financial implications of a decision can be evaluated for each of the components, for a specified group of components (a subsystem), for a computer system, and for the Division.

For administrative control, the inventory of components is divided into revenue producing and non-revenue producing items. Revenue producing items are those that are:

(1) On rental to customers and on maintenance contract

(2) Sold with continuing contract for maintenance

Non-revenue producing items are those that are:

(1) Shipped but awaiting completion of installation

(2) Used internally by the Univac Division for its own management control and production purposes

(3) Idle, including units that are being transferred or reconditioned.

The inventory status of the components is very volatile. There is normally a constant flow from a non-revenue producing status to the revenue producing status as a result of shipment, installation, and acceptance. A computer system or any of its components can also become idle as a result of transfer or replacement by a higher performance system or component.

Each rental customer has an automatic option to purchase any equipment that he is renting. When such an option is exercised, the sale is called a conversion sale. At the time of a conversion sale the customer is granted a portion of past rental payments as credit toward the purchase. The amount of his credit is written into the rental contract and depends upon the length of time the customer has rented the equipment. When a conversion sale occurs, the system's status changes from "rental" to "sold".
A newly shipped computer system normally does not contribute immediately to revenue. Most systems require a short period ot time for installation and check-out. Until such time as installation is completed and revenue is initiated, the system is in "awaiting billing" status. Throughout the simulation it is necessary to keep track of the inventory status of each system, as the status determines the revenue.

A certain percentage of the systems are sold initially to the customer.* The remainder of the newly shipped systems are rented. In the model the allocation between sales and rental is controlled by the specified sales/rental ratio. This is a very important ratio as it affects both the cash flow and the timing of profits. An initial sale eliminates the possibility of future rental revenue, while rented equipment does not generate high initial cash flow. It is usually desirable to achieve a balance between sales and rentals. The simulation model must be designed so that the effects of varying this ratio can be studied period by period and on an overall basis.

In addition to the initial sales, conversion sales, and rented systems, some systems are transferred to other divisions of the Sperry Rand Corporation. It is necessary for the model to provide for stipulated revenue and cost formulae related to these intracompany transactions.

There are costs associated with each source of revenue. The cost of an initial sale is the manufacturing cost of the unit plus the installation cost. The cost of a conversion sale is the book value (initial capitalized cost less accumulated depreciation). The costs associated with revenue from rented equipment are depreciation, installation cost write-off, and property taxes. The aggregate monthly depreciation cost for a given type of computer is a function of the distribution of ages of individual system components. This age, however, is a function of the initial schedule for manufacturing, shipping, and installing the systems, modified by conversion sales and system additions. The depreciation cost calculation is fairly complex.

MODEL FORMULATION

Handling the varying needs of a worldwide population of computer customers results in a very broad and complex product line. For example, the Univac Division currently has more than 20 computer systems for which future shipments are planned. There are over 2,000 components which make up these active systems. In addition, many of these components are available with a variety of special features. It was not practical to cover all components and features individually and in detail. For economy of effort certain combinations of similar components were made.

*In the jargon of the computer industry such an initial sale is termed an "outright sale".

This consolidation and selection required two steps:

(1) Identification of similar components, consisting of those that were closely related to each other from a functional and production standpoint and with about the same unit revenue and cost

(2) Selection of high-revenue/high-impact components

After the aggregation and after considering only the high value components, 200 major components (approximately 10 percent of the original number) were selected. They accounted for more than 90 percent of revenue and cost of revenue. This reduction of input volume made the model formulation job simpler and its output more manageable. The principal model inputs and outputs are shown in Figure 1.

We will describe the following three major aspects of this model in detail:

(1) Principal inputs

(2) Simulation Logic

(3) Principal outputs

Principal Inputs. The requirements for the model's principal inputs were developed along with the simulation logic and the principal output specifications. The details of the inputs shown in the diagram follow.

The current electronic data processing equipment inventory. Univac's inventory of EDP equipment includes all equipment that is potentially revenue producing. Most of these system components are assigned to customers under rental contracts; however, a substantial amount is used for company activities. The revenue and cost projections of the model start with this current inventory of rental equipment. This information is available at serial number (individual cabinet) level of detail in various formats. A special program was written to process the detailed inventory information into the form required for model input. The processing included collecting similar components, selecting high-revenue components, and formatting.

Shipment forecast by system. A customer has great latitude in choosing a computer configuration. There is a minimum requirement for obtaining a workable system. But, beyond that, the selection depends entirely on the customer's specific requirements. Out of thousands of systems in service it is possible for no two to be identical. In order to develop a reliable shipping forecast, each computer system family was subdivided into small, medium, and large systems. Average configurations for each of these subdivisions were prepared. Operations Research, working in close cooperation with Marketing, used automated techniques to prepare forecasts for each system, using the three average configurations. In addition, forecasts for sets of expansion equipment for field upgrading were developed. The principal forecasts were point forecasts. However, as an experiment, estimates of shipment variability were developed from past data. The forecasts were then treated as random variables with specified mean and distribution function during these experimental simulation runs. Further work is contemplated in this area of realistic randomization.

Rental/sales ratios. Rental/sales ratios were estimated by the Marketing Department for each of the configurations of each system. The model permits these ratios to vary by time period.

Average delay between shipment and the initiation of revenue. The average billing delay depends on the type of system. For large systems, the delay could be more than one month, while for small systems it could be a fraction of a month. The model provides for both. An analysis of the time interval between shipment and commencement of revenue was of special interest for financial analysis.

Sales, rental and maintenance revenue by component. Aggregate revenue figures were developed by applying the standard prices to the components in the various revenue categories. The unit prices were applied with proper allowance for installation time, turnaround time, and items destined for internal use.

Manufacturing, installation and maintenance cost for each component. Aggregate cost figures in these areas are estimates developed by the Controller using unit cost data from the various operating departments.

Miscellaneous inputs. There were a number of additional control parameters necessary to drive the model through time. The Marketing Department furnished several of these as functions of time, including the following:

(1) Conversion sales proportion of each time period

(2) Average age of equipment involved in conversion sales

(3) Idle systems going back on rent

(4) Proportion of rented and sold systems on maintenance contract

The average age of each system component in the inventory was derived from accounting records, using the applicable depreciation formula. Manpower and floorspace standards were obtained from the operating departments. Miscellaneous expenses not covered elsewhere came from the Controller.

Simulation Logic. Calculations were performed at a system component level of detail covering 24 units of time. The number of system components sold and those on rent were calculated as shown in Figure 2. This figure demonstrates the dynamics of equipment inventory status.

Revenue calculations. Shipment schedules for each system were prepared primarily as point forecasts.* From the system schedule, the component shipment schedules were generated. As shown in Figure 2, all new system component shipments, as well as system components made available by reduction in idle equipment, pass through the "awaiting billing" status. After retaining this status for a period equivalent to average billing delay, the components begin producing revenue. Idle components include those components that are being transferred from one customer to another but are in the process of being reconditioned. These components, as well as any decrease of components in company use, enter the "awaiting billing" status after they are shipped to a new customer.

The total system components that have passed through "awaiting billing" status and hence are available for customer use are distributed according to the rental/sales ratio.

At the beginning of each time period, there are a certain number of components that are on rent. During this time period, a certain number of components:

(1) Go off rental agreement (out flow)

(2) Are converted into sales from rental (out flow)

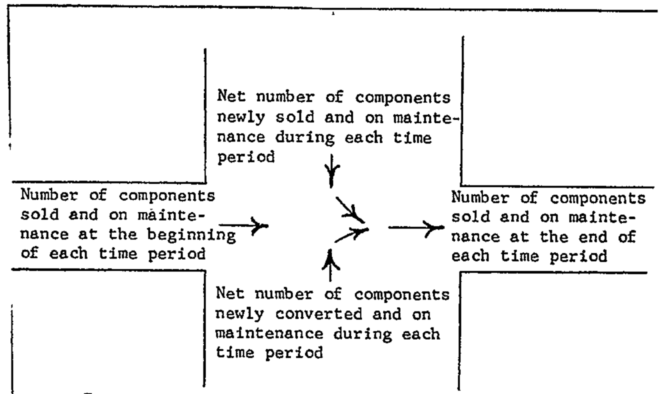
(3) Are placed on rental (in flow)

A forecast is made for the number of systems that go off rental and that are converted (sold). To calculate the number of components, it is necessary to know the configuration of each system. In the cast of the rental systems, the average configuration of those systems on rent at the beginning of each time is utilized. In the case of conversion sales, the average configuration a specified number of time units earlier (depending upon the estimated conversion sales age) is utilized. The result of the outflows and inflows is the total number of system components that are on rent at the end of each time period.

Maintenance contract and maintenance revenues are treated separately from rental contracts. To simulate revenue from this source, it is necessary to include components that are sold to customers but are still covered by maintenance contracts.

The components that are sold and on maintenance can be determined as shown in the following diagram.

*Some test runs have been made by Monte Carlo techniques, using a pseudo-random number generator to determine shipments within a prescribed range.



Components - Sold and on Maintenance

From the number of components on rent, sold, and on maintenance, the rental and maintenance revenue can be estimated. Revenue from conversion sales is treated as a function of conversion sales age. This average age is used to estimate the configuration of the system that is converted. This age also determines the rental credit to be granted to the customer.

Cost of revenue calculations. Calculations of a few important cost items can be explained at this point.

(1) Cost of sales (except taxes) in the ith time unit for the sales of the kth system

$$= A_{ik} = s_{ik}\left[\sum_{j=1}^{m_k} B_{ijk}\left(C_{jk} + D_{jk}\right)\right]$$

m_k - Number of different components in the kth system

s_{ik} - Number of kth systems sold in the ith time unit

B_{ijk} - Average number of jth component in system k sold in ith time unit

C_{jk} - Standard manufacturing cost of jth component of kth system

D_{jk} - Installation cost of jth component of kth system

(2) Cost of conversion sales in ith time unit for kth system

$$= E_{ik} = c_{ik}\left[\sum_{j=1}^{m_k} \bullet\, G_{i-p,jk}\left(H_{jkp} + L_{jkp}\right)\right]$$

c_{ik} - Number of conversion sales of kth system in ith time unit

$G_{i-p,jk}$ - Average number of jth component in system k on rent p time units preceding current time unit i.

H_{jkp} - Remaining book value of standard manufacturing cost of jth component of kth system at age p

L_{jkp} - Remaining book value of installation cost, jth component, kth system at age p

(3) Cost of rent in ith time unit for the kth system

$$= M_{ik} = r_{ik}\left[\sum_{j=1}^{m_k} Q_{ijk}\left(R_{ijk} + S_{ijk}\right)\right]$$

r_{ik} - Number of kth systems on rental in ith time unit

Q_{ijk} - Average number of jth component in system k on rent in ith time unit

R_{ijk} - The periodic depreciation write-off (based on computed average age) for the ith time unit, jth component of the kth system

S_{ijk} - The periodic installation cost write-off for the ith time unit, jth component of kth system

In order to obtain standard cost depreciation, first, the average age of each of the components in the equipment inventory file was determined. Using the average age and the applicable method of depreciation, the depreciation cost projections were obtained for these system components. Depreciation cost projections for newly shipped components are based upon the applicable formula at time shipment. Appropriate reductions are made in depreciation cost projections to allow for conversion sales. The detailed equations used for depreciation cost projections are beyond the scope of this paper.

Installation cost amortization projections were also derived from the average age of units on rental, modified by the effect of new shipments.

Expense calculations. Expenses of Marketing and Field Engineering Departments are developed utilizing manpower and floor space standards. These expenses along with expense budgets of other operating departments permit derivation of a net profit and loss statement for the division.

Programming technique. For the purpose of translating mathematical formulation into computer program logic, FORTRAN IV language was chosen because of familiarity with the language on the part of Operations Research Analysts and conservation of computer time. FORTRAN IV was adequate because queueing problems were minimal.

In addition to generation of profit/loss statements, graphs were produced on a high-speed printer. Because of the number of variables involved, the total operation utilized more than 65,000 words of memory. Use of the very large UNIVAC 1108 drum memory and standard mapping procedures permitted very efficient runs (3 to 5 minutes) despite the mass of data being processed. The output of each subroutine was checked manually for one computer system in order to make sure that the program logic conformed to the mathematical formulation.

Principal Outputs. The final result of a model is a set of simulated net profit/loss statements for the Univac Data Processing Division covering a period of two to six years. In addition, gross profit statements are prepared for each system and system component. Intermediate results include shipping schedule, equipment status summaries, revenue schedules by source, and major resource requirements. Charts plotted by high-speed printer can be prepared for any of these items of interest.

The model running on a UNIVAC 1108 system generates, prints, and plots output summaries for about 20 systems and 200 system components in about three minutes.

CONCLUSIONS

This simulation model has given Univac Division management a tool which permits prompt measurement of the probable effect of different decisions. These alternative courses of action may be in the fields of marketing, manufacturing, field engineering and pricing. Comparisons of the computer generated results with those desired serves as a useful feedback mechanism through which management personnel can move by iterative steps toward a desired goal.

It is also possible to make sensitivity analyses; that is, to evaluate the financial effects of changes in one variable while holding others constant. This capability is especially important in the business-social-economic sphere, because such controlled experiments cannot be run in real life.

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THE AUTHORS

Mr. H. B. Horton is a graduate of the University of Texas, BBA ('37) and MBA ('38). Pre-World war II positions included teaching statistics and accounting at the University, and serving as economist with the National Resources Planning Board. During World War II, he served as a Navy Aerologist, Pacific Theatre.

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Mr. Horton has published papers in the fields of statistics and computers, and is a member of the American Statistical Association, Institute of Mathematical Statistics, American Meteorological Society, and American Ordnance Association.

After receiving his Bachelor of Science Degree in Mechanical Engineering in 1958 from the University of Poona, India, Dr. M. N. Bartakke earned his Master of Science Degree in 1960 and his Doctorate in 1963 in Industrial Engineering and Operations Research from the University of California at Berkeley.

He is presently working as Senior Operations Research Analyst in the area of Business Simulation for Univac, a division of Sperry Rand Corporation, and has also worked for the Matson Navigation Company, San Francisco, in the areas of containerization and fleet planning until 1967.

In addition to publishing papers in the fields of simulation and manufacturing processes, Dr. Bartakke is a member of Alpha Phi Mu Honor Society, Senior Member of AIIE and Associate Member of ORSA and TIMS.

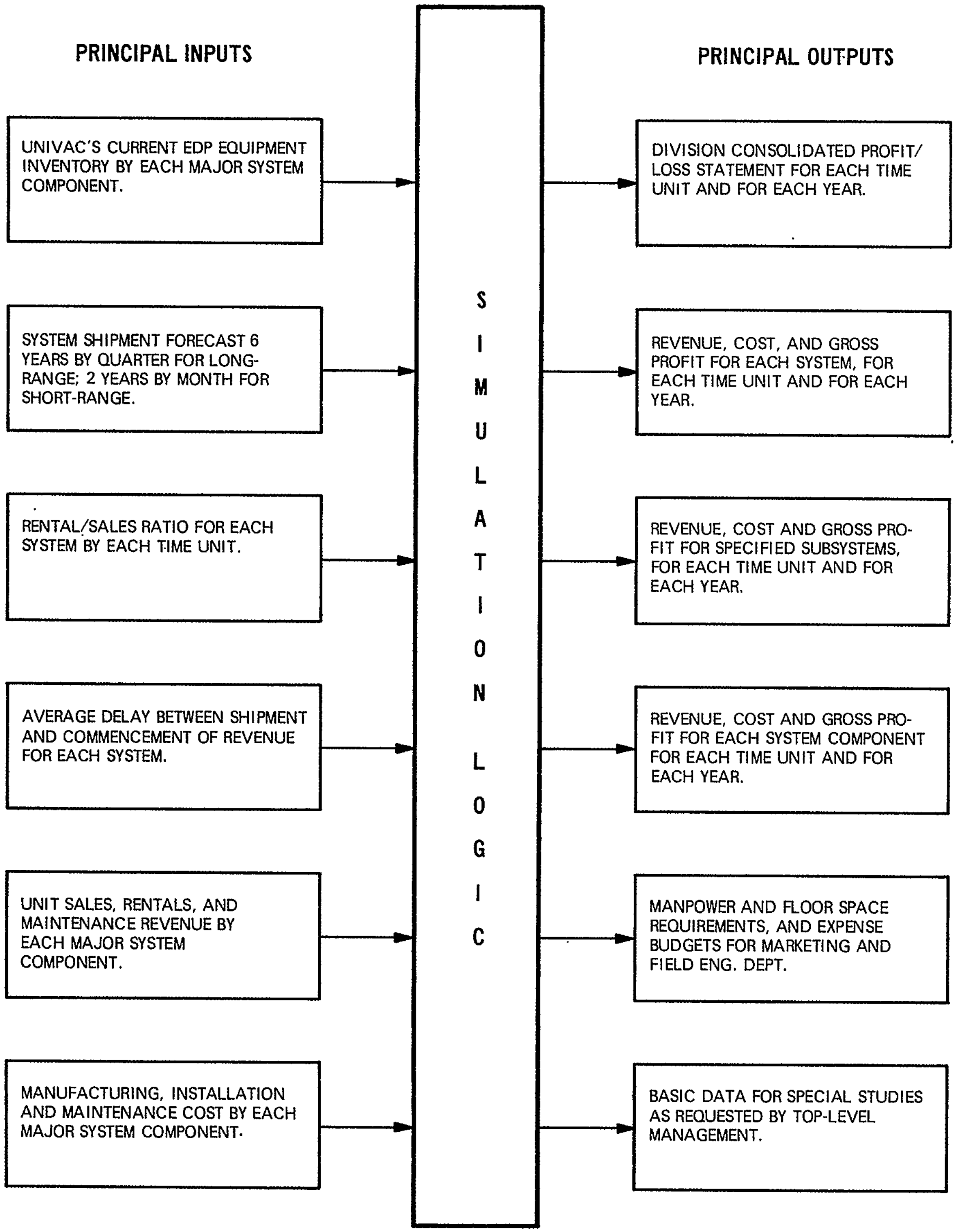

Figure 1. Univac DPD Financial Simulation Model

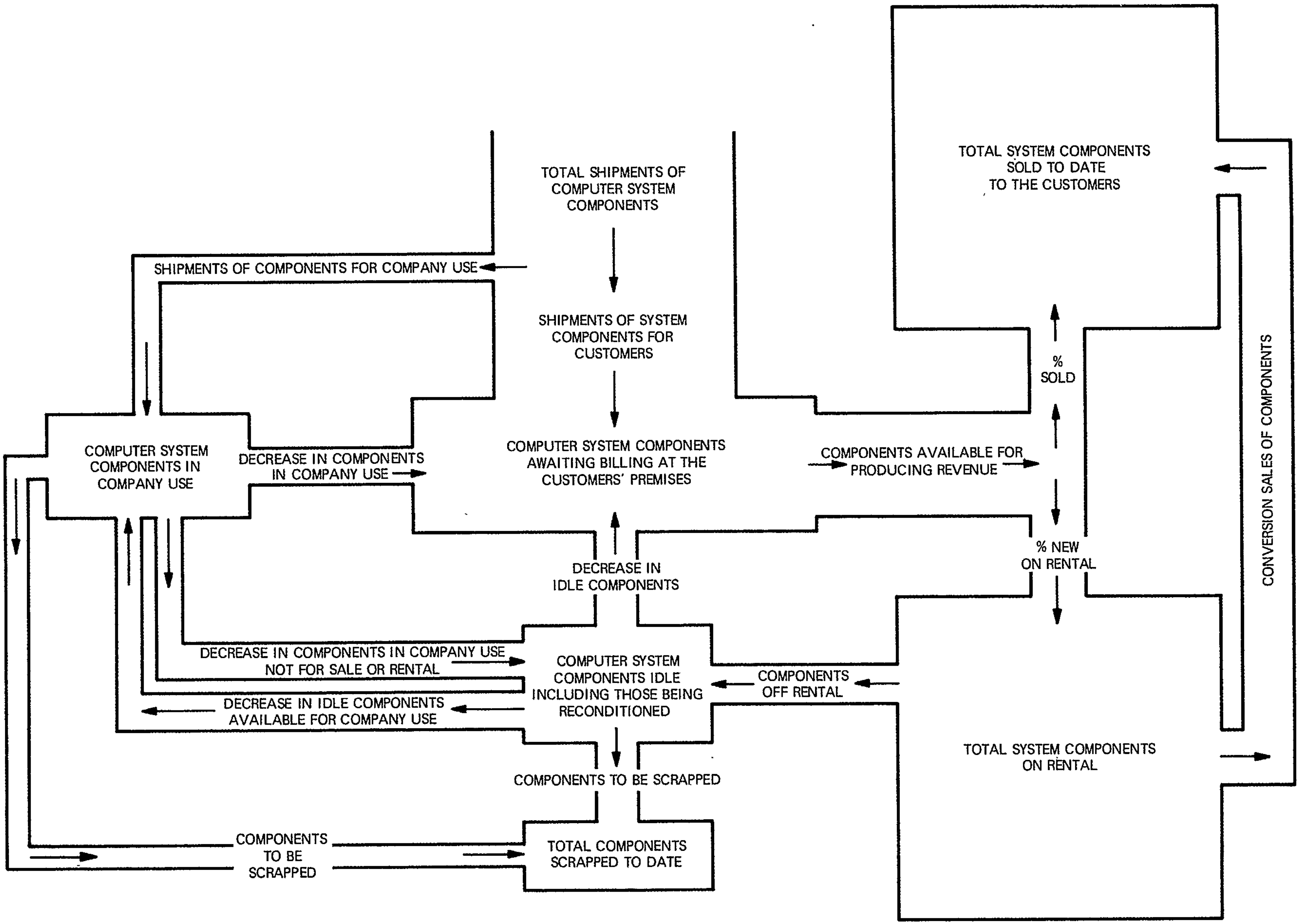

Figure 2. Flow of Computer System Components