IGPSS

A General Purpose Simulation

Language for the Interdata

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B. A. North Texas State University, Denton, Texas, 1970

A MASTER'S REPORT

submitted in partial fulfullment of the

requirements of the degree

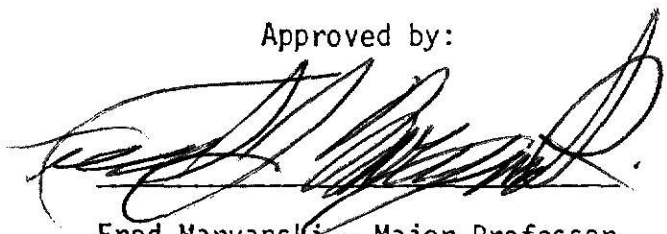
MASTER OF SCIENCE

Department of Computer Science

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1977

Approved by:



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INTRODUCTION

The purpose of this project is to develop a simulation language which is portable to different kinds of hardware systems. The language developed is called IGPSS and resembles IBM's General Purpose Simulation System. The program is written in Fortran since Fortran is available on most systems and is fairly well standardized. Although developed for use primarily on the Interdata 8/32, IGPSS is also implemented on the IBM/370.

This report will provide a description of the IGPSS internal organization and its user requirements. The user is assumed to have a knowledge of simulation.

The parser for IGPSS remains to be written, so the current input required for IGPSS is the anticipated output from the parser. The special requirements for this input are discussed in the section entitled "Coding IGPSS."

General Structure

There are three methods of building a simulation model. The event scheduling approach emphasizes a detailed description of the steps that occur when an individual event takes place. Each type of event has a distinct set of steps associated with it. The activity scanning approach emphasizes a review of all activities in a simulation to determine which can be begun or terminated each time an event occurs. The process interactive approach emphasizes the progress of an entity through a system from its arrival event to its departure event. (1)

IGPSS is a simulation language based on GPSS. It uses the process interactive approach to organizing behavior in a simulation. In IGPSS active objects called transactions act on a system of passive objects which include facilities and storages. For example, a job requiring service is a transaction, whereas a single server is a facility and a group of servers is a storage unit. The transaction passes through the system, encountering a facility or storage, depending on whether the simulation is a single or multiserver representation.

The program maintains a record of when each transaction in the system is due to move. The transactions move through the system on a first-come, first-served basis within a priority class. The program moves a transaction through the system until a blocking condition arises. When a transaction is moved as far as it can go, the program moves any other transaction due to move at the same time. If all movements are completed, the program advances the clock to the time of the next most imminent event and repeats the movement process.

A system to be simulated in IGPSS can be described as a block diagram in which the blocks represent activities and the lines joining the blocks indicate the sequence in which the events are to occur. If a choice of

activities can occur depending on a condition, more than one line leaves a block ans the condition for the choice is stated at the block. The sequence of events in real time is reflected in the movement of transactions from block to block in simulated time.

Transactions are created at one or more GENERATE blocks and are removed from the simulation at TERMINATE blocks. There can be many transactions moving simultaneously through the system. Each transaction is always positioned at a block and most blocks can hold many transactions simultaneously. The movement of a transaction from one block to another occurs instantaneously at a specific time or when some change of system condition occurs. A block number is given to each block, and the movement of transactions is usually from one block to the block with the next highest location. The TRANSFER block allows a transaction to move to a block other than the next sequential block.

A block type called ADVANCE is used to represent a time delay. IGPSS computes an action time for each transaction as it enters an ADVANCE block, and the transaction remains at that block for the calculated period of simulated time before it attempts to proceed to the next block. Queues may be established to gather statistics on delays transactions may encounter in the system.

The first example in Appendix G is a simulation of jobs as they progress through an office. Jobs arrive at the office at the rate of one every 10 to 20 minutes. Normally they go to clerk A, who takes 7 to 13 minues and then go to clerk B, who takes 3 to 7 minutes. However, if clerk B is busy at the time the job is brought to the office, the entire job is given to clerk C, who takes 10 to 30 minutes. Assuming that each clerk handles one job at a time, the simulation runs until 1000 jobs have been completed. The example shows the model run on GPSS followed by the

same model run on IGPSS.

In the GPSS program, the GENERATE block creates jobs every 10 to 20 minutes. The TEST block determines if clerk B is busy. If so, the job is sent to clerk C. The QUEUE block indicates entering into clerk A's stack of jobs to be processed. The stack is maintained in a FIFO arrangement. The SEIZE block indicates clerk A has begun processing the job; thus, the job leaves clerk A's stack of work in the DEPART block. The ADVANCE block indicated clerk A's processing time. The job leaves clerk A in the RELEASE block and enters clerk B's stack of work in the next QUEUE block. The job is processed by clerk B in the same manner as with clerk A. It then leaves the office in the TERMINATE block.

The output produced by both GPSS and IGPSS contains a section labeled 'BLOCK COUNTS'. This section indicates the total number of jobs that are currently in each block and the total number that has passed through each block. The facilities section shows how many jobs were processed by each clerk, the average processing time of each job, and the utilization for each clerk. The queues section indicates the maximum contents in each clerk's stack of jobs waiting to be processed was one. Most of the jobs had a zero waiting time, and the waiting time for those jobs that had to wait was 1.588 minutes for clerk A and 2.8 minutes for clerk C. No jobs had to wait for clerk B for processing.

The second example in Appendix G is a simulation of a grocery store checkout line. Thirty-two percent of the customers will use the express checkout line and the other sixty-eight percent will use one of the two regular checkouts. Customers arrive uniformly from two to fourteen minutes apart. Checkout time at the express counter requires 2 minutes and the regular lines require from 2 to 14 minutes. Queues are maintained to gather statistics on the waiting lines which form at each checkout

counter. The simulation is run for 100 customers. The example shows the model run on GPSS followed by the same model run on IGPSS.

In the GPSS program, the STORAGE block defines 2 regular checkout lines. The GENERATE block creates a customer uniformly every 2 to 14 minutes. The TRANSFER block sends 32% of the customers to EXPRS, the rest to REGCK. The express customer is first entered into the line at the QUEUE block, is serviced at the counter in the SEIZE block, thus leaving the line in the DEPART block. The ADVANCE block indicates a two-minute checkout time. The customer then leaves the counter in the RELEASE block and is recorded as leaving the store at the TERMINATE block. The customer is serviced at a regular checkout counter in a similar manner. The START block indicates the simulation will halt when the 100th customer enters the terminate block.

The output of the second example is similar to that of the first example. The additional section entitled STORAGES shows the statistics on the two regular checkout counters.

IGPSS Entities

IGPSS is built around a set of simple entities which are divided into four classes: dynamic, equipment, statistical, and operational.

Dynamic Entities. The dynamic entities are called transactions. Transactions are the items being simulated, such as customers in a grocery store. They are created and destroyed during a simulation run. Associated with each transaction are ten parameters which can be assigned values by the user to represent characteristics of the transaction. For example, a transaction representing a customer in a grocery store might have a parameter indicating the number of grocers at checkout time. This

number could be used in the simulation to determine how long the checkout process would take.

Equipment Entities. The second type of entity, the equipment entity, can be acted on by transactions. Facilities and storages are equipment entities. A facility can handle only one transaction at a time and represents a potential bottleneck in the system. A facility could be used to represent a grocery store checkout counter. A record of which transaction is using each facility within the system is maintained. If a transaction attempts to use a facility that is already in use, that transaction is delayed until the facility is available. IGPSS also maintains a record of the total number of time units for which each facility was in use. At the end of the simulation, this figure is used to compute the utilization of each facility. A count is also maintained of the total number of times each facility was used and the average time duration of each use.

Storages are used to represent parallel processing equipment which can handle more than one transaction at a time. A storage entity could be used to represent a parking lot. The user defines the capacity of each storage that he uses and IGPSS maintains a record of the number of storage units that are occupied at any given point in time. If a transaction attempts to occupy more space than is available in a given storage, the transaction is delayed until sufficient space becomes available. IGPSS maintains a record of the total number of transactions that enter each storage. The average number of clock units each transaction remained in each storage is reported at the simulation's end.

Statistical Entities. Queues are the third type of entity. In any system, transactions may be delayed by the unavailability of an equipment entity. Transactions that are delayed in their attempt to obtain a facility or a storage constitute such a queue. Queues are used to gather statistics on system behavior. Each queue maintains a list of transactions delayed at one or more points in the system, and keeps a record of average number of transactions delayed and the length of these delays. A grocery store checkout line could be represented by a queue. The user must specify selected points in the model where queue statistics are desired. IGPSS will then gather all queue statistics; a count of total number of transactions that enter the queue and also a count of the transactions that were delayed in each queue, the average time the transactions were delayed in each queue, and the maximum number of transactions in the queue at any time.

Operational Entities. The operational entities are called blocks. Like the blocks of a flowchart, they provide the logic flow of a system, instructing the transactions where to go and what to do next.

Transactions move from block to block in the simulation model in a manner similar to the way the items they represent would progress in the real system. Each movement of a transaction is considered as an event that is due to occur at some particular point in time. The program maintains a record of the times at which these events are due to occur in their correct time sequence (first come, first served, except when different priorities exist). In those cases where the action called for cannot be performed at the time originally scheduled (such as attempting to seize a facility which is already in use), processing the transaction ceases. When the blocking condition changes, the transaction is again

moved into its proper processing sequence; that is, transactions with the earliest event time are serviced first.

IGPSS maintains a clock that records the instance of real time that has been reached in the simulation. It is referred to as the clock time. All times are represented as integer numbers. The unit of system represented by a unit of clock time is implied by the user. The time unit chosen should be the smallest time difference between event occurrences and this same unit must be maintained consistently throughout the model.

PROGRAM STRUCTURE

An IGPSS program consists of a set of block definition cards, entity definition cards, and control cards.

Each defined block is entered on a separate 'block definition card'. Each block is assigned a sequential number as the program is read. The block type is entered in the card followed by the subfields specifying the block arguments. The meaning associated with each subfield (A-E) is a function of the particular block type and will be discussed later.

The entity definition cards define storage capacities or functions. The basic format is the same as the block definition card. The function definition card is followed by cards specifying the X and Y coordinate values for the function.

The control cards tell IGPSS the length of the run desired and when the end of the input deck is reached.

STANDARD NUMERICAL ATTRIBUTES

Quantities such as function (FN) and clock time (C1) are generally termed standard numerical attributes (SNA). They represent properties or states of the simulation model and are provided to give the user dynamic

access to the results of the simulation. For example, whenever a reference is made to Q12, the contents of queue 12 are obtained. By making such a reference, a transfer can be made by a transaction if, for example, more than 20 transactions are currently in a certain queue. Thus, a user may simulate a system whose logic depends dynamically on any standard numerical attributes.

All standard numerical attributes consist of a one- or two-letter mnemonic followed by a number. The mnemonic indicates the type of attribute desired and the number indicates the specific attribute desired.

A list of all SNA's available in IGPSS is shown in Appendix C. Standard numerical attributes may be used as arguments of almost any block types.

EQUIPMENT ORIENTED BLOCK TYPES

As discussed earlier, a facility can handle only one transaction at a time and storages can handle multiple transactions. This section discusses the various block types used to deal with these equipment entities.

Two block types, SEIZE and RELEASE, are provided so that transactions may make use of a facility. When a transaction enters a SEIZE block it is recorded as using the facility. The facility then remains in use until the seizing transaction enters a RELEASE block. Upon entering the SEIZE block, the usage count of the facility is incremented. The facility to be seized is specified in field A of the block definition card. When the seizing transaction enters a RELEASE block with the same facility specified in field A, the facility is returned to the available state, and the in-use time for the facility is incremented by the number of clock

units that the transaction remained in possession of that facility. A transaction may seize any number of facilities.

Two block types, ENTER and LEAVE, provide for usage of storages. The STORAGE definition card is used to define the capacity of a storage. Field A specifies the maximum storage capacity and the location field specifies the storage number. Each ENTER and LEAVE block specifies a storage number in field A and the number of units to be occupied or returned in field B. When a transaction encounters an ENTER block, the record of the number of units occupying the storage is incremented by field B. If field B is blank it is assumed to be one. If there is not enough space available for a particular transaction, it will be refused entry until sufficient storage becomes available. If there is room for a subsequent transaction, that transaction will be admitted before the rejected one. When a transaction encounters a LEAVE block, the number specified in field B is returned to the available storage. A transaction need not remove the same number of units that it added; in fact, the transaction entering a LEAVE block need not have entered the storage previously. The contents of the storage cannot be allowed to be made negative, however.

TRANSACTION-ORIENTED BLOCK TYPES

IGPSS provides five block types which modify transaction attributes.

Advance

The first of these, the ADVANCE block, provides for the explicit specification of a time delay. This block requests a computation of the number of clock units which a transaction is to spend in the block. This time may have any integer value, including zero. If the computed time is

zero, the simulator continues processing the entering transaction and immediately attempts to move it to the next block in its path. To specify the delay time at an ADVANCE block, the user states the mean in field B. If the modifier is omitted, a constant time delay is produced.

Two types of ADVANCE block modifiers exist: a spread and a function. A spread modifier is used when the delay times are equiprobable within a given range. For example, a spread of 5, used with a mean of 10, produces action times in the range of 10 ± 5. The delay time then becomes one of eleven possible integers since clock time only assumes integer values. All values are computed with equal probability. If delay times in a system follow a more complex distribution pattern than the simple uniform distribution produced by the spread modifier, a function modifier must be used. A value for the specified function is computed and multiplied by the mean. If the result is noninteger, the decimal portion is truncated and the resulting integer is the computed delay time.

Generate

The second transaction oriented block type is the GENERATE block. This block is used to create transactions for entry into the system. Field A is the mean time between generations. This mean can be modified by specifying either a spread or a function modifier in field B, as in the ADVANCE block. Each transaction contains ten parameters which are set equal to zero when the transaction is created. Field C is an offset interval. If specified it is used without modification as the time interval preceding the creation of the first transaction by that block. Field D is a limit count on the number of transactions that can be created by the GENERATE block. If this field is omitted, the block will continue to create transactions indefinitely. Field E is the priority of the

transactions to be created by this block. Newly created transactions have a priority of zero unless another value is specified in this field.

Terminate

The TERMINATE block removes transactions from the system. It represents the completion of a path of flow, such as the customer leaving the grocery store. Field A of the TERMINATE block specifies whether or not this block contributes to the total termination count and, if so, how many units it will contribute. The termination count is specified on the START card which will be discussed later. If the field is not specified it is interpreted to be 0, and transactions entering the block do not decrement the termination count. There must be at least one TERMINATE block with a value of 1 or more in field A of every model to terminate the simulation. If this does not happen, the model runs indefinitely.

Assign

Each transaction has 10 parameters associated with it. Contents of parameters are signed integers ranging from $-(2^{31})$ to $(2^{31}-1)$. At the time of creation of a transaction, these parameters are initialized to zero. The ASSIGN block is the principal means of entering values into the parameter fields of a transaction. The value of field A specifies which parameter is to be modified. Field B specifies the integer value the parameter is to become.

Priority

The PRIORITY block is used to set the priority of a transaction to a specified value. Field A specifies the priority the transaction will assume.

FLOW MODIFICATION

In IGPSS, the flow of transactions through blocks is generally sequential. That is, it is assumed that a transaction goes from its current block to the next sequentially numbered block. However, in an actual system, the flow may be diverted.

Transfer

The TRANSFER block is generally used to direct the transaction to a nonsequential next block. This may be done in a variety of ways. The choice is specified by means of a mnemonic selection mode specified in field A of the block. If the selection mode at the TRANSFER block is blank, every transaction that enters the block will be sent to the block specified in field B. If the selection mode is a fraction, a random choice between the blocks specified in fields B and C is made. The probability of selecting the next block in field C is given by the fraction. For example, if a selection mode of .370 were specified in field A, 37% of the transactions would proceed to the next block specified in field C and 63% would proceed to the next block specified in field B.

Test

The TEST block also provides a possible modification of the sequential block flow. The TEST block specifies a condition specified in the form of an algebraic comparison between two arguments. If the desired relation is satisfied, the transaction proceeds to the next sequential block. If not satisfied, the transaction proceeds to the block specified in field C. The arguments are specified in fields A and B. The following six mnemonic relations may be specified:

L Less than. If the first argument is greater than or equal to the second argument, the relation is not satisfied.

LE Less than or equal to. The relation is satisifed unless the first argument is greater than the second.

E Equal to. The relation is satisfied only if the two arguments are equal.

NE Not equal. The relation is satisfied unless the two system variables are equal.

G Greater than. If the first argument is less than or equal to the second argument, the relation is not satisfied.

GE Greater than or equal to. The relation is satisfied unless the first argument is less than the second argument.

COMPUTATIONAL AND REFERENCE ENTITIES

Very often, the complex logical and mathematical interrelations which exist among items within a model may be best expressed in terms of a mathematical function.

Functions

A FUNCTION returns a numerical value that is computed by a rule defined by the user. IGPSS provides for two types of functions: continuous and discrete. A unique relationship is defined between the independent and dependent variables. The independent variable can be any of the standard numerical attributes and is specified in field A. Field B contains the number of pairs of points desired, preceded by an

indication of whether a discrete or continuous function is desired. The X and Y values are entered in cards immediately following the FUNCTION block card. These values are entered by specifying X_1, Y_1, X_2, Y_2, ..., X_n, Y_n, until the desired number of pairs is given.

Random Number Generation

There are eight random number seeds in IGPSS. The user may specify any one of these seeds (RN1-RN8). In cases where reference to a random number is implied (such as TRANSFER .5, a1b1, b1b1), RN1 is used.

STATISTICAL BLOCK TYPES

The IGPSS user will primarily be interested in observing the values of numerical attributes which characterize a system in order to determine how the system is performing in simulated operation. Some statistics are gathered automatically by the program, but others which might be of interest can be gathered by inserting various queues into the system.

Queues are measured by inserting QUEUE and DEPART blocks into the model. A QUEUE block may be placed before any block that might cause a delay. The transactions increment the contents of a queue when they enter a QUEUE block and decrement the contents of that queue when they succeed in entering a DEPART block.

Queue Block

The QUEUE block is analogous to the ENTER block and signals the program that statistics should be gathered for a queue at the specified point in the model. The number of the queue the transaction is to enter is specified in field A. The length of time for which the queue specified has been at its present content is then computed. The product of that interval and the present contents of the queue are added to a sum that

represents the total unit occupancy (cumulative time integral) of the queue. At the end of the simulation run, this sum is divided by the length of the run to form the average contents of the queue. The number of units to be added to the queue is specified at field B in the same manner as in the ENTER block and LEAVE block. If field B is left blank it is assumed to be 1. When a transaction enters the block, the number of units specified in field B is added to the current contents of the queue. IGPSS then compares the new contents with the previous maximum length. If the new contents is larger, the new queue length is recorded as the maximum. The count of the total number of units that have passed through the queue is also incremented by the amount in field B. This total is used to compute the weighted average time per transaction in the queue.

Depart

The DEPART block is analogous to the LEAVE block. Field A specifies the queue number and field B, the number of units to leave the queue. When a transaction enters a DEPART block, the number of units specified in field B is subtracted from the contents of the queue. IGPSS also computes the length of time which transactions remained in the queue. If the time interval is 0, the specified number of units is added to a count which records the total number of units to pass through the queue with no delay.

CONTROL CARDS

Start Card

This card indicates to the simulator that all input data has been received and that the run may now proceed. Field A specifies the number of terminations to be executed before printing the final summary statistics. This quantity is called the run termination count and when it has been

decremented to 0 or less, the run will terminate. The count is decremented by the amount specified in field A of a TERMINATE block each time a transaction enters that block.

End Block

This card specifies the end of the input deck.

PROGRAM OUTPUT

Program output occurs when an error condition arises or upon normal completion of a run.

The output produced upon normal completion is as follows:

1) Clock time - This is the actual clock time at the end of the simulation run.

2) Block counts - The entry and wait counts of all defined blocks is printed out. This printout includes block number, the number of transactions currently waiting at that block and the total number of transactions which have entered that block in the course of the simulation.

3) Facility statistics - The statistics which are gathered for each facility referred to in the simulation are listed. These statistics include utilization (the fraction of time that each facility was seized), the total number of entries, the average number of time units that a transaction held each facility, and the number of the transaction seizing the facility at the clock instance the run ended.

4) Storage statistics - A listing is provided of the statistics gathered for each storage that was referenced during a run. These include the capacity of each storage as defined by the user, the average contents of each storage, the average utilization (average contents divided by maximum capacity), the total number of entries, the average length of

time transactions remained in each storage, the current contents at the end of the run, and the maximum occupancy recorded for each storage during the run.

5) Queue statistics - The statistics gathered for each queue referenced in the simulation. These statistics include the maximum contents of each queue, the average contents, the total number of entries, the number of transactions which entered each queue but were not delayed, the average time per transaction, the average time per transaction for those transactions which were delayed (excluding zero delay entries), and the current contents of each queue at the time of the simulation run termination.

INTERNAL ORGANIZATION

Transactions in IGPSS are maintained in chains. There are two such chains and a transaction may be in either one at a given time. The current event chain (CEC) contains those transactions whose scheduled event time is less than or equal to the current value of the clock. The future events chain (FEC) contains those transactions whose scheduled event times are greater than the current clock time; that is, transactions whose event time is in the future.

Current Events Chain

The current events chain is organized in descending order of priority. Each transaction in the CEC is either in the active status or in a delay status. The scan status indicator specifies the status condition. If the transaction is in the active status IGPSS attempts to move it to its next block. If the transaction has been blocked for some reason it is put into delay status. Transactions in this status are

skipped by the overall scan. When the blocking situation is changed, the transaction is returned to the active status.

Future Events Chain

The future events chain transactions are strictly in ascending block departure time order. There are no distinctions made by priority in this chain.

DATA STRUCTURES

The data structures in IGPSS are implemented through the use of arrays in a common block. A maximum of 200 transactions are allowed at any one time. Each transaction word contains a pointer to the next block to be executed, a scan status indicator, the priority of the transaction, the time of the last status change, the current block, and 10 parameters which are initially zero. A maximum of 120 blocks are permitted. Each block word contains the block type, field A, B, C, D, and E if applicable, and a current and total block entry count. Thirty-five facilities can be used. Each facility word contains the number of the transaction seizing the facility, the cumulative time usage, the clock time of the last status change, an indicator as to whether a delay chain exists, and an entry count. Each storage word of the 35 possible storages contains the current contents, the available contents, the cumulative time usage, the clock time of the last status change, the entry count, the maximum contents, and a field indicating the existence of a delay chain. Each of the 70 queue words contains the clock time of the last status change, the entry count, the zero delay entries, the cumulative time usage, the current and the maximum contents. Twenty functions are allowed with a maximum of twenty-five X and Y values. Each function word also indicates

the number of X and Y values present, whether it is continuous or discrete, and the SNA associated with function. Also contained in the common block are the future and current events chains. Each chain may contain fifty transactions at any one time. Each entry in the chains contains pointers to the previous and next entry in the chain, the priority of the transaction and the transaction number. The future events chain entries also contain the block departure time. A pointer is maintained to the first and last entry in each chain. A pointer also exists which indicates the next available array location into which a new entry is to be placed when a transaction is added to a chain. The common block also contains the clock time and the status change flags. Eight random number seeds are available and are located in the common area.

INTERNAL FLOW

The main routine initializes all necessary common block data then calls the input routine. The input routine reads all the simulation input data. If a generate block type is read, the GENERATE routine is called and a transaction is entered into the future events chain. If a START block type is encountered, the start count is initialized. If a FUNCTION definition is encountered, the function initialize routine is called and the function X, Y cards are read and the function common block is initialized. If a STORAGE definition is read, the appropriate storage available area is initialized. When an END block is read, the input routine returns control to the main program. If all input is read before an END block is encountered, the program encounters an end of file error and execution is halted. The main routine then calls the SCAN routine which controls the overall transaction scanning. A check is first

made to determine if the start count is greater than zero. If not, an error is written and the program is stopped.

The overall scan is divided into three phases: clock updating, current event chain scan, and transaction move. The overall scan begins by increasing the clock time to the block departure time of the first transaction in the future events chain. Next the first transaction is moved from the future events chain to the current events chain. Succeeeding future events chain transactions are moved to the current events chain as long as their block departure time equals the new clock time. Transactions are inserted into the current events chain maintaining the priority ordering. New transactions are added behind existing ones with the same priority. When all transactions have been moved, the status change flag is turned off and the current events chain scan begins The first current events chain transaction is obtained. If the scan status indicator (SSI) is on, the transaction is not processed since it is waiting on an unavailable entity. The next current events chain transaction is then obtained. When all transactions are processed the clock time is again updated to the block departure time of the first future events chain transaction and the process is repeated. When a current events chain transaction is obtained whose SSI is not on, IGPSS attempts to move the transaction through the next block. The block number is obtained from the transaction word and the appropriate block type routine is called. If the transaction did not succeed in entering the next block, the status change flag is tested. If on, a facility or storage was released which had a transaction waiting on it. IGPSS then returns to the first of the current events chain and repeats processing of the entire chain. If the status change flag is not on, the next transaction in the CEC is obtained for processing. If the transaction did move through the current block, a test

is made to determine if the block terminated the transaction or if it entered a positive time advance block. If the test is true, IGPSS then checks the status change flag and proceeds as above. If the test is false, an attempt is made to move the transaction through the next block by calling the appropriate block routine. Thus each CEC transaction is in turn moved through as many blocks as possible. Then movement is stopped; control passes to the next CEC transaction. If a transaction frees a facility or storage which has waiting transactions, control returns to the first of the CEC after the freeing transactions movement is stopped.

The flow of the routines which process each individual block type is illustrated by the flowcharts in Appendix F.

CODING IGPSS

The parser of IGPSS remains to be written. Currently IGPSS uses as its input the anticipated output from the parser. A coding sheet to simplify data entry is provided in Appendix A. The NUM field, columns 1-3, is an integer variable which contains the storage or function number. The remaining eight fields correspond to the fields 1-8 of the block word. They are all real numbers. The block type entered in columns 4-5 is shown in Appendix B. The SNA for field A is entered in columns 6-7. A table of SNA's is shown in Appendix C. Field A is contained in columns 8-17. The SNA for field B is placed in 18-19. Fields B, C, D, and E are placed in columns 20-29, 30-39, 40-49, 50-59, respectively. If the SNA's for fields A and B are constants, the SNA field may be left blank.

RUNNING IGPSS

To run IGPSS on the Interdata 8/32 the user must sign on, load IGPSS, select the logical units desired for input and output, then start the program. Following is an example of some possible methods of running IGPSS.

To use card input and the terminal as output:

```
SIGNON yourname,5,GRAF
V USR6
LO IGPSS
AS 5,CR:
AS 6,.ME
ST
SIGNOFF
```

To use terminal as input and printer as output:

```
SIGNON yourname,5,GRAF
V USR6
LO IGPSS
AS 5,.ME
AS 6,pr:
ST
SIGNOFF
```

The terminal will return:

```
STOP
*
```

when execution is completed. If another run is desired the program must be reloaded and the units reassigned.

RESTRICTIONS

IGPSS is a subset of GPSS. The available block types in IGPSS are identical to those described in the GPSS Introductory User's Guide (3) with the following exceptions. The number of parameters set in field F of the GENERATE block in GPSS is set to 10 in IGPSS. The function modifier in field C of the ASSIGN block is not implemented. The TRANSFER block of IGPSS does not recognize the BOTH, ALL, or SIM options. Functions

are limited to 25 X,Y coordinates and the standard numerical attributes are limited to parameters, random numbers, storage contents, storage remainder, and queue length. The quantity limitations for all IGPSS entities are shown in Appendix D.

TESTING

IGPSS was first implemented on the IBM/370. A test case was first made to test correctness of the simplest overall scan using only a GENERATE, TERMINATE, START, and END blocks. All options of the GENERATE were then tested. Next a facility was added followed by simple advance block. The modifier of the ADVANCE block was then tested. Queues were added, followed by storages and functions. The transfer was then tested and the resulting simulation was compared to the same model using GPSS. The results were very similar and any variations were attributed to the difference in the random number generators. Next the TEST block, the ASSIGN, and the PRIORITY blocks were tested. When the program appeared to be working, several test cases were run to compare results between GPSS and IGPSS. All results were very similar.

In the meantime, IGPSS was compiled on the Interdata 8/32. Minor differences were discovered between compilers on the two machines. The Interdata would not allow comparison of integers and reals or the use of a real as a subscript.

When the program was successfully working on the 370, a test run was run on the Interdata. A problem existed in passing an argument to a subroutine. The implicit real statement apparently had no effect on changing the mode of the argument. When this problem was corrected, the models tested on the 370 produced identical results to those run on the Interdata.

The run times for all test models are less than a minute. There is no means of determining CPU time on the 8/32 so no direct time comparisons could be made. The compile time on the Interdata, however, was over fifteen minutes while it was less than one minute on the 370. No apparent reason was found for this long a compile time required on the Interdata.

CONCLUSION

IGPSS is currently implemented on the IBM/370 and the Interdata 8/32. Minor compiler differences were encounterd between the two hardware configurations during development. Simulation results from the test models were identical on both systems.

Some IGPSS standard numerical attributes such as variable and function can contain subfields which are also standard numerical attributes. This would require a recursive call to the routine which determines the SNA. Since recursion is not possible in Fortran, the variable block type was not implemented and the standard numerical attributes available with functions are limited. The variable block type is very useful in GPSS and could possibly be added as a future project through the use of an assembler subroutine. The SNA's for use with functions could be changed fairly easily if the need for additional SNA's arises.

Input to IGPSS is somewhat clumsy, but this was anticipated since the parser remains to be written. The parser will allow the user to enter his data in a format similar to that used for GPSS. This format is more free form than that necessary for IGPSS. The parser will also accept variable names for entities and labels and resolve them to the absolute numbers required by the IGPSS program.

Most of the restrictions on internal limitations shown in Appendix D could be increased with little difficulty. The dimensions of the arrays in common would have to be increased and some minor program changes might have to be made, depending on the entity that is to be increased. The limitations set for IGPSS are the same as the 64K version of GPSS.

REFERENCES

1. Fishman, George S. *Concepts and Methods in Discrete Event Digital Simulation.* New York: John Wiley & Sons, 1973.

2. Geoffrey, Gordon. *Systen Simulation.* Englewood Cliffs, New Jersey: Prentice-Hall, 1969.

3. IBM, GPSS/360 Introductory User's Manual. IBM Corp., Form No. H20-0304.

4. IBM, GPSS/360 User's Manual. IBM Corp., Form No. GH20-0326.

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

THIS IS AS RECEIVED FROM CUSTOMER.

IGPSS CODING SHEET

Num	Block Type	SNA A	A	SNA B	B	C	D	E
1 - 3	4 - 5	6 - 7	8 - 17	18 - 19	20 - 29	30 - 39	40 - 49	50 - 59

IGPSS BLOCK TYPES

BLOCK TYPE	A	B	C	D	E
1 - Generate	mean	(spread)	(offset)	(count)	(priority)
2 - seize	facility no.				
3 - release	facility no.				
4 - storage	capacity				
5 - enter	storage	(units)			
6 - leave	storage	(units)			
7 - advance	mean	(spread)			
8 - terminate	(units)				
9 - assign	parameter	source			
10 - priority	priority				
11 - transfer	selection mode	next block a	next block b		
12 - test	arg1	arg1	next block b		
13 - function	ind. variable	no points			
14 - variable	not implemented				
15 - queue	queue no.	(units)			
16 - depart	queue no.	(units)			
17 - start	units				
18 - end					

STANDARD NUMERICAL ATTRIBUTES (SNA)

1	Pj	parameters
2	PR	priority
3	Kj	constant
4	RN(x)	1 x 8 random numbers
5	C1	clock time
6	FNj	function
7	Vj	variable
8	Sj	contents of storage
9	Rj	remaining storage
10	SRj	utilization of storage
11	SAj	average of storage
12	SMj	maximum of storage
13	SCj	number of entries
14	STj	average time in storage
15	Fj	status of facility
16	FRj	utilization of facility
17	FCj	number of entries in facility
18	FTj	average time in facility
19	Qj	queue length
20	QAj	average length of queue
21	QMj	maximum length of queue
22	QCj	number of entries in queue
23	QZj	number of zero entries in queue
24	QTj	average time with zero entries in queue
25	QXj	average time with no zero entries in queue

QUANTITY LIMITATIONS ON IGPSS ENTITIES

Internal Limitations

Parameters	10
Transactions	200
Block	120
Facilities	35
Storage	35
Queues	70
Functions	20
Variables	not implemented

Currents Events Chain (CEC)

CEC1	previous # in chain
CEC2	next # in chain
CEC3	priority
CEC4	tran #

Future Events Chain (FEC)

FEC1	previous # in chain
FEC2	next # in chain
FEC3	block departure time (BDT)
FEC4	priority
FEC5	tran #

DATA STRUCTURES

Facility word

F1	tran # seizing
F2	cumulative time usage
F3	clock time of last status change
F4	delay chain
F5	entry count

Storage word

S1	current contents
S2	available
S3	cumulative time usage
S4	last clock status change
S5	entry count
S6	maximum contents
S7	delay chain

Queue word

Q1	time of last status change
Q2	entry count
Q3	zero-delay entries
Q4	cumulative time
Q5	current contents
Q6	maximum contents

Transaction word

T1	next block for transaction
T2	scan status indicator
T3	priority
T4	time of last status change
T5	current block
T6 - T 15	parameters

Block word

B1	block type
B2	sna for field A
B3	field A
B4	sna for field B
B5	field B
B6	field C
B7	field D
B8	field E
B9	current block count
B10	total block count

Function word

Func1-Func25	x values
Func26-Func50	y values
Func51	number of points
Func52	continuous(C) or discrete(D)
Func53	sna for field C
Func54	field C

```
C*************************************************************************
C                                                                        *
C                                  MAIN                                  *
C                                                                        *
C       THE MAIN ROUTINE INITIALIZES ALL NECESSARY COMMON BLOCK          *
C       VARIABLES, CALLS THE INPUT RCUTINE, CALL THE SCAN ROUTINE        *
C       AND CALLS THE OUTPUT ROUTINE ROUTINE.                            *
C                                                                        *
C*************************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANC,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLCCKN,STARTC,RN(8),TRANA,FUNC(20,54)
      DO 1 I=1,8
    1 RN(I) = 13672563
      DO 10 I = 1,35
      DO 20 J = 1,5
      FACIL(I,J) = 0
   20 QUEUE(I,J) = 0
      STOR(I,1) = 0
      STOR(I,2) = -1
      DO 30 J = 3,7
   30 STOR(I,J) = 0
   10 QUEUE(I,6) = 0
      DO 35 I=36,70
      DO 35 J=1,6
   35 QUEUE(I,J)=0
      C1 = 0
      MOVE = 0
      STATUS = 0
      DO 40 I=1,199
   40 TRAN(I,1) = I+1
      TRAN(200,1) = 0
      TRANA = 1
      DO 50 I = 1,49
      CEC(I,2) = I + 1
```

```
   50 FEC(I,2) = I + 1
      CECA = 1
      FECA = 1
      FECF = 0
      FECL = 0
      CECF = 0
      CEC(50,2) = 0
      CECL = 0
      FEC(50,2) = 0
      STARTC = 0
      DO 60 I = 1,120
      BLOCK(I,9) = 0
      BLOCK(I,10) = 0
   60 BLOCK(I,1) = 0
      CALL INPUT
      CALL SCAN
      CALL OUTPUT
      STOP
      END
      SUBROUTINE ADVANC(CECT,ID)
C*************************************************************
C                                                            *
C                          ADVANCE                           *
C                                                            *
C       SUBROUITNE ADVANCE DETERMINES THE BDT OF THE TRANSACTION  *
C       IF THE CALCULATED TIME IS GREATER THAN C1 IT, IS PLACED IN  *
C       THE FEC. IF TIME IS = C1, MOVE IS SET TO ZERO INDICATING  *
C       THE TRANSACTION HAS MOVED THROUGH THE BLOCK.          *
C                                                            *
C*************************************************************
```

```
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER CECT
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
C     UPDATE BLOCK COUNTS
      ILST = TRAN(TRANO,5)
      TRAN(TRANO,5) = BLOCKN
      BLOCK(BLOCKN,9) = BLOCK(BLOCKN,9) + 1
      BLOCK(ILST,9) = BLOCK(ILST,9) - 1
      BLOCK(BLOCKN,10) = BLOCK(BLOCKN,10) + 1
      TRAN(TRANO,1) = TRAN(TRANO,1) + 1
C     DETERMINE FIELD A
      SNAC = BLOCK(BLOCKN,2)
      SNAN = BLOCK(BLOCKN,3)
      CALL SNA(SNAC,SNAN,A)
      IF(BLOCK(BLOCKN,5).EQ.0.0) GO TO 200
C     DETERMINE FIELD B
      SNAC = BLOCK(BLOCKN,4)
      SNAN = BLOCK(BLOCKN,5)
      CALL SNA(SNAC,SNAN,B)
      IF(BLOCK(BLOCKN,4).EQ.6.0) GO TO 100
      CALL RANDU(I,IY,YFL)
      IR = 2*B*YFL+A-B+C1+.5
      GO TO 300
C     FIELD B MODIFIER IS FUNCTION
  100 IR      = A * B + C1
      GO TO 300
  200 IR = A + C1
  300 IF(IR.EQ.C1) GO TO 700
C     PLACE IN FEC IF POSITIVE ADVANCE BLOCK
      IF(FECF.NE.0) GO TO 350
      FECT = FEC(FECA,2)
      FEC(FECA,1) = 0
      FEC(FECA,2) = 0
      FEC(FECA,3) = IR
```

```
      FEC(FECA,4) = CEC(CECT,3)
      FEC(FECA,5) = CEC(CECT,4)
      FECF =FECA
      FECL = FECA
      FECA = FECT
      GO TO 600
  350 FECT = FECF
  400 IF(FEC(FECT,3).GT.IR) GO TO 500
      FECT = FEC(FECT,2)
      IF(FECT.NE.0) GO TO 400
C     ADD TO END OF FEC
      FECT = FEC(FECA,2)
      FEC(FECA,1) = FECL
      FEC(FECA,2) = 0
      FEC(FECA,3) = IR
      FEC(FECA,4) = CEC(CECT,3)
      FEC(FECA,5) = CEC(CECT,4)
      FEC(FECL,2) = FECA
      FECL = FECA
      FECA = FECT
      GO TO 600
C     ADD INTO FEC
  500 FECAT = FEC(FECA,2)
      FEC(FECA,2) = FECT
      FEC(FECA,1) = FEC(FECT,1)
      FEC(FECA,3) = IR
      FEC(FECA,4) = CEC(CECT,3)
      FEC(FECA,5) = CEC(CECT,4)
      IF(FECT        .EQ.FECF) FECF = FECA
      OLDPRE = FEC(FECT,1)
      IF(OLDPRE.NE.0) FEC(OLDPRE,2) = FECA
      FEC(FECT,1) = FECA
      FECA = FECAT
C     UNLINK FROM CEC
  600 OLD1 = CEC(CECT,1)
      OLD2 = CEC(CECT,2)
      IF(OLD1.NE.0) CEC(OLD1,2) = OLD2
      IF(OLD2.NE.0) CEC(OLD2,1) = OLD1
```

```
      CEC(CECT,2) = CECA
      CECA = CECT
      IF(CECT.EQ.CECF) CECF = OLD2
      IF(CECT.EQ.CECL) CECL = OLD1
      IF(CECL.NE.0) GO TO 650
      CECT = 0
      ID = 1
      RETURN
  650 ID = 1
      CECT = OLD2
      RETURN
  700 MOVE = 1
      RETURN
      END
      SUBROUTINE ASSIGN
C*****************************************************************
C                                ASSIGN                          *
C                                                                *
C       SUBROUTINE PLACES THE RESULT DETERMINED FROM FIELD B IN THE *
C       PARAMETER SPECIFIED IN FIELD A.                          *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
      MOVE = 1
C     DETERMINE SNA
      SNAC = BLOCK(BLOCKN,4)
      SNAN = BLOCK(BLOCKN,5)
      CALL SNA(SNAC,SNAN,RESULT)
C     MOVE VALUE TO PARAMETER
      IPARM = BLOCK(BLOCKN,3) + 5
      TRAN(TRANC,IPARM) = RESULT
```

```
C       UPDATE BLOCK COUNTS
        ILST = TRAN(TRANO,5)
        TRAN(TRANO,5) = BLOCKN
        BLOCK(BLOCKN,9) = BLOCK(BLOCKN,9) + 1
        BLOCK(ILST,9) = BLOCK(ILST,9) - 1
        BLOCK(BLOCKN,10) = BLOCK(BLOCKN,10) + 1
        TRAN(TRANO,1) = TRAN(TRANO,1) + 1
        RETURN
        END
        SUBROUTINE DEPART
C*************************************************************************
C                                                                        *
C                                  DEPART                                *
C                                                                        *
C         SUBROUTINE DEPART REMOVES THE NO OF UNITS SPECIFIED IN         *
C         FIELD B FROM THE QUEUE SPECIFIED IN FIELD A.                   *
C                                                                        *
C*************************************************************************
        IMPLICIT INTEGER(C,F,Q,S,O)
         REAL FUNC
        INTEGER TYPE,TRANO,BLOCKN,BLOCKT
        COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
       1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
       2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
C       DETERMINE Q
        SNAC = BLOCK(BLOCKN,2)
        SNAN = BLOCK(BLOCKN,3)
        CALL SNA(SNAC,SNAN,RES)
        Q = RES
C ARE YOU TRYING TO REMOVE MORE UNITS FROM QUEUE THEN IN QUEUE
C       DETERMINE NO TO RELEASE
        SNAC = BLOCK(BLOCKN,4)
        SNAN = BLOCK(BLOCKN,5)
        CALL SNA(SNAC,SNAN,RESULT)
        IR = RESULT
        IF(IR.EQ.0) IR = 1
        IF(IR.GT.QUEUE(Q,5)) GO TO 1000
```

```
C CALCULATE NEW CUMULATIVE TIME
C CALCULATE NEW CURRENT IN QUEUE
      QUEUE(Q,4) = QUEUE(Q,4) + (C1 - QUEUE(Q,1)) * QUEUE(Q,5)
      QUEUE(Q,5) = QUEUE(Q,5) - IR
      QUEUE(Q,1) = C1
C CALCULATE ZERO TIME ENTRIES
      NIME = TRAN(TRANO,4)
      IF(C1.EQ.NIME) QUEUE(Q,3) = QUEUE(Q,3) + IR
      MOVE = 1
C     UPDATE BLOCK COUNTS
      ILST = TRAN(TRANO,5)
      TRAN(TRANO,5) = BLOCKN
      BLOCK(BLOCKN,9) = BLOCK(BLOCKN,9) + 1
      BLOCK(ILST,9) = BLOCK(ILST,9) - 1
      BLOCK(BLOCKN,10) = BLOCK(BLOCKN,10) + 1
      TRAN(TRANO,1) = TRAN(TRANO,1) + 1
 2000 RETURN
 1000 WRITE(6,1001)
 1001 FORMAT('0TRYING TO REMOVE MORE UNITS FROM QUEUE THEN EXIST')
      STOP
      END
      SUBROUTINE ENTER
C*****************************************************************
C                                                                *
C                            ENTER                               *
C                                                                *
C       SUBROUTINE ENTER ATTEMPTS TO OBTAIN THE NO OF STORAGE UNITS *
C       SPECIFIED IN FIELD B FFOM THE STORAGE SPECIFIED IN FIELD A. *
C       IF THE UNITS ARE OBTAINED, THE TRANSACTION PRCEEDS THRCUGH *
C       THE BLOCK, OTHERWISE THE TRANSACTION IS BLOCKED.          *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
```

```
C       DETERMINE STORAGE
   10   SNAC = BLOCK(BLOCKN,2)
        SNAN = BLOCK(BLOCKN,3)
        CALL SNA(SNAC,SNAN,RES)
        SNO = RES
C       HAS STORAGE BEEN DEFINED
        IF(STOR(SNO,2).NE.-1) GO TO 100
        WRITE(6,50) SNO
   50   FORMAT('0STORAGE NO.',I3,' HAS NOT BEEN DEFINED')
        STOP
  100   SNAC = BLOCK(BLOCKN,4)
C       DETERMINE NO TO ENTER
C CAN YOU GET DESIRED NO OF STORAGE UNITS
        SNAN = BLOCK(BLOCKN,5)
        CALL SNA(SNAC,SNAN,RESULT)
        IR = RESULT
        IF(IR.EQ.0) IR = 1
        IF(STOR(SNO,2).GE.IR) GO TO 1000
C SET UP DELAY CHAIN
        STOR(SNO,7) = 1
        GO TO 2000
C CALCULATE NEW CUMULATIVE TIME
 1000   STOR(SNO,3) = STOR(SNO,3) + (C1 - STOR(SNO,4))* STOR(SNO,1)
        STOR(SNO,4) = C1
        STOR(SNO,2) = STOR(SNO,2) - IR
        STOR(SNO,1) = STOR(SNO,1) + IR
        STOR(SNO,5) = STOR(SNO,5) + IR
        IF(STOR(SNO,1).GT.STOR(SNO,6)) STOR(SNO,6) = STOR(SNO,1)
C XACT WAS MOVED THRU BLOCK
C       UPDATE BLOCK COUNTS
        ILST = TRAN(TRANO,5)
        TRAN(TRANO,5) = BLOCKN
        BLOCK(BLOCKN,9) = BLOCK(BLOCKN,9) + 1
        BLOCK(ILST,9) = BLOCK(ILST,9) - 1
        BLOCK(BLOCKN,10) = BLOCK(BLOCKN,10) + 1
        TRAN(TRANO,2) = 1
```

```
      MOVE = 1
      TRAN(TRANC,1) = TRAN(TRANO,1) + 1
 2000 RETURN
      END
      SUBROUTINE FUNCT(RESULT,IN)
C*****************************************************************
C                                                                *
C                          FUNCT                                 *
C                                                                *
C       SUBROUTINE FUNCT DETERMINES THE VALUE OF THE FUNCTION    *
C       SPECIFIED AS AN SNA.                                     *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANC,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
C     DETERMINE FUNCTION X VALUE
      SNAC = FUNC(IN,53)
      SNAN = FUNC(IN,54)
C     CALL SNA(SNAC,SNAN,A)
C     PARAMETER
      IF(SNAC.EQ.1) A = TRAN(TRANO,SNAN+5)
C     RANDOM NO.
      IF(SNAC.EQ.4) CALL RANDU(SNAN,IY,A)
C     STORAGE CONTENTS
      IF(SNAC.EQ.8) A = STOR(SNAN,1)
C     STORAGE REMAINDER
      IF(SNAC.EQ.9) A = STOR(SNAN,2)
C     QUEUE LENGTH
      IF(SNAC.EQ.19) A = QUEUE(SNAN,5)
      IF(FUNC(IN,52).EQ.1.0) GO TO 1000
C     DISCRETE FUNCTION
      IF(A.GT.FUNC(IN,1)) GO TO 100
      RESULT = FUNC(IN,26)
      RETURN
```

```
  100 N = FUNC(IN,51)
      DO 200 I=2,N
      IF(A.GT.FUNC(IN,I)) GO TO 200
      RESULT = FUNC(IN,I+25)
      RETURN
  200 CONTINUE
      RESULT = FUNC(IN,N+25)
      RETURN
C      CONTINUOUS FUNCTION
 1000 IF(A.GT.FUNC(IN,1)) GO TO 1100
      RESULT = FUNC(IN,26)
      RETURN
 1100 N = FUNC(IN,51)
      DO 1200 I=2,N
      SLOPE = (FUNC(IN,I-25) - FUNC(IN,I+24))/
     U     (FUNC(IN,I) - FUNC(IN,I-1))
      IF(A.GT.FUNC(IN,I)) GO TO 1200
      RESULT = SLOPE * (A-FUNC(IN,I-1))-FUNC(IN,I-24)
      RETURN
 1200 CONTINUE
      RESULT = FUNC(IN,N+25)
      RETURN
      END
      SUBROUTINE FUNCTI(NUM,IN)
C*****************************************************************
C                                                                *
C                          FUNCTI                                *
C                                                                *
C       SUBROUTINE FUNCTI READS AND STORES THE X , Y VALUES FOR THE
C       SPECIFIED FUNCTION.                                      *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
```

```
      IXY = BLOCK(IN,5)
      FUNC(NUM,51) = BLOCK(IN,5)
      FUNC(NUM,52) = BLOCK(IN,4)
      FUNC(NUM,53) = BLOCK(IN,2)
      FUNC(NUM,54) = BLOCK(IN,3)
      READ(5,100) (FUNC(NUM,I),FUNC(NUM,I+25),I=1,IXY)
  100 FORMAT(8F10.5)
      RETURN
      END
      SUBROUTINE GENERA(ID,IN)
C*****************************************************************
C                                                                *
C                          GENERA                                *
C                                                                *
C     SUBROUTINE GENERA CREATES A TRANSACTION, DETERMINES A      *
C     BDT, AND ENTERS THE TRANSACTION INTO THE FEC.              *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
      MOVE = 1
      IF(BLOCK(IN,7).LE.0.0.AND.ID.EQ.2)   GO TO 1000
C     CREATE TRANSACTION
C     UPDATE BLOCK COUNTS
      BLOCK(IN,9) = BLOCK(IN,9) + 1
      BLOCK(IN,10) = BLOCK(IN,10) + 1
      OLDT = TRANO
      TRANO = TRANA
      TRANA = TRAN(TRANO,1)
      TRAN(TRANO,1) = IN
      TRAN(TRANO,2) = 1
      IF(BLOCK(IN,8).EQ.0.0) BLOCK(IN,8) = 1
      TRAN(TRANO,3) = BLOCK(IN,8)
      DO 100 I=6,15
```

```
  200 IR      = A * B + C1
      GO TO 400
  300 IR      = A + C1
  400 IF(BLOCK(IN,6).EQ.0.0) GO TO 450
      IR      = IR      + BLOCK(IN,6)
      BLOCK(IN,6) = 0
C     PLACE IN FEC
  450 IF(FECF.NE.0) GO TO 500
      FECTA = FEC(FECA,2)
      FEC(FECA,1) = 0
      FEC(FECA,2) = 0
      FEC(FECA,3) = IR
      FEC(FECA,4) = TRAN(TRANO,3)
      FEC(FECA,5) = TRANO
      FECF=FECA
      FECL=FECA
      FECA = FECTA
      GO TO 800
  500 FECT = FECF
  600 IF(FEC(FECT,3).GT.IR) GO TO 700
      FECT = FEC(FECT,2)
      IF(FECT.NE.0) GO TO 600
  700 TRAN(TRANO,I)= 0
C     DETERMINE FIELD A
      SNAC = BLOCK(IN,2)
      SNAN = BLOCK(IN,3)
      CALL SNA(SNAC,SNAN,A)
      IF(BLOCK(IN,5).EQ.0.0) GO TO 300
C     DETERMINE FIELD B
      SNAC = BLOCK(IN,4)
      SNAN = BLOCK(IN,5)
      CALL SNA(SNAC,SNAN,B)
      IF(BLOCK(IN,4).EQ.6.0) GO TO 200
      CALL RANDU(1,IY,YFL)
      IR = 2*B*YFL+A-B+C1+.5
      GO TO 400
C     FIELD B MODIFIER IS FUNCTION
```

```
C       ADD TO END OF FEC
        FECT = FEC(FECA,2)
        FEC(FECA,1) = FECL
        FEC(FECA,2) = 0
        FEC(FECA,3) = IR
        FEC(FECA,4) = TRAN(TRANO,3)
        FEC(FECA,5) = TRANO
        FEC(FECL,2) = FECA
        FECL = FECA
        FECA = FECT
        GO TO 800
C       ADD INTO FEC
  700   FECAT = FEC(FECA,2)
        FEC(FECA,1) = FEC(FECT,1)
        FEC(FECA,2) = FECT
        FEC(FECA,3) = IR
        FEC(FECA,4) = TRAN(TRANO,3)
        FEC(FECA,5) = TRANO
        OLDPRE=FEC(FECT,1)
        IF(OLDPRE.NE.0) FEC(OLDPRE,2) = FECA
        FEC(FECT,1) = FECA
        IF(FECT        .EQ.FECF)  FECF = FECA
        FECA = FECAT
  800   IF(ID.EQ.2)    GO TO 900
        IF(BLOCK(IN,7).EQ.0.0) BLOCK(IN,7) = 99999999
        RETURN
  900   BLOCK(IN,7) = BLOCK(IN,7) -1
        TRANO = OLDT
 1000   TRAN(TRANO,1) = TRAN(TRANO,1) + 1
        TRAN(TRANO,5) = IN
        RETURN
        END
```

```
      SUBROUTINE INPUT
C*****************************************************************************
C                                                                             *
C                                   INPUT                                     *
C                                                                             *
C        SUBROUTINE INPUT READS IN THE IGPSS INPUT.                           *
C                                                                             *
C*****************************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
C     READ IN ALL GPSS STATEMENTS
      WRITE(6,50)
   50 FORMAT('1',9X,'BLOCK TYPE   A',19X,'B',19X,
     1'C',10X,'D',10X,'E')
      I = 1
   10 READ(5,100) (NUM,(BLOCK(I,J),J=1,8))
  100 FORMAT(I3,F2.0,F2.0,F10.0,F2.0,4F10.0)
      WRITE(6,150)(NUM,(BLOCK(I,J),J=1,8))
  150 FORMAT(' ',I5,8F10.3)
      TYPE = BLOCK(I,1)
      IF(TYPE.EQ.18) RETURN
      IF(TYPE.EQ.1) CALL GENERA(1,I)
      IF(TYPE.EQ.17)STARTC = BLOCK(I,3)
      IF(TYPE.EQ.13) CALL FUNCTI(NUM,I)
      IF(TYPE.EQ.4) STOR(NUM,2) = BLOCK(I,3)
      IF(TYPE.EQ.17.OR.TYPE.EQ.13.OR.TYPE.EQ.4) GO TO 10
      I = I + 1
      GO TO 10
      END
```

```
      SUBROUTINE LEAVE
C*****************************************************************
C                                                                *
C                              LEAVE                             *
C                                                                *
C       SUBRCUTINE LEAVE RELEASES THE NO OF UNITS SPECIFIED IN FIELD  *
C       B FROM THE STORAGE SPECIFIED IN FIELD A.                 *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
C     DETERMINE STORAGE
      SNAC = BLOCK(BLOCKN,2)
      SNAN = BLOCK(BLOCKN,3)
      CALL SNA(SNAC,SNAN,RES)
      SNO = RES
C ARE YOU TRYING TO RELEASE MORE STORAGE THAN IN USE
C     DETERMINE NO TO RELEASE
      SNAC = BLOCK(BLOCKN,4)
      SNAN = BLOCK(BLOCKN,5)
      CALL SNA(SNAC,SNAN,RESULT)
      IR = RESULT
      IF(IR.EQ.0) IR = 1
      IF(IR.GT.STOR(SNO,1)) GO TO 1000
C CALCULATE NEW CUMULATIVE TIME
      STOR(SNO,3) = STOR(SNO,3) + (C1 - STOR(SNO,4)) * STOR(SNO,1)
C DETERMINE NEW CURRENT AND REMAINING STORAGE UNITS
      STOR(SNO,2) = STOR(SNO,2) + IR
      STOR(SNO,1) = STOR(SNO,1) - IR
```

```
      STOR(SNO,4) = C1
C DID A DELAY CHAIN EXIST
      IF(STOR(SNO,7).EQ.0) GO TO 2000
      STOR(SNO,7) = 0
C SET STATUS CHANGE FLAG
      STATUS = 1
      GO TO 2000
 1000 WRITE(6,1001)
 1001 FORMAT('0TRANSACTION TRYING TO RELEASE MORE STORAGE THEN IN USE')
      STOP
 2000 MOVE = 1
C     UPDATE BLOCK COUNTS
      ILST = TRAN(TRANC,5)
      TRAN(TRANO,5) = BLOCKN
      BLOCK(BLOCKN,9) = BLOCK(BLOCKN,9) + 1
      BLOCK(ILST,9) = BLOCK(ILST,9) - 1
      BLOCK(BLOCKN,10) = BLOCK(BLOCKN,10) + 1
      TRAN(TRANC,1) = TRAN(TRANO,1) + 1
      RETURN
      END
      SUBROUTINE OUTPUT
C*************************************************************************
C                                                                        *
C                                  OUTPUT                                *
C                                                                        *
C       SUBROUTINE OUTPUT PRINTS THE SIMULATION STATISTICS.              *
C                                                                        *
C*************************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
```

```
C       OUTPUT BLOCK COUNTS
        XC1 = C1
        WRITE(6,10) C1
   10   FORMAT('1CLOCK',I10)
        WRITE(6,20)
   20   FORMAT(' BLOCK COUNTS')
   25   WRITE(6,30)
   30   FORMAT(' BLOCK CURRENT   TOTAL ')
        DO 50 I = 1,120
        IF(BLOCK(I,1).EQ.18.0) GO TO 155
        I2 = BLOCK(I,9)
        I3 = BLOCK(I,10)
        WRITE(6,70) I,I2,I3
   70   FORMAT(' ',I5,I7,I8)
   50   CONTINUE
  155   DO 156 I=1,35
        IF(FACIL(I,5).NE.0) GO TO 160
  156   CONTINUE
        GO TO 205
  160   WRITE(6,170)
  170   FORMAT('0FACILITY    AVERAGE',10X,'NUMBER',7X,'AVERAGE',7X,
       1'SEIZING')
        WRITE(6,180)
  180   FORMAT(' ',12X,'UTILIZATION',6X,'ENTRIES',6X,'TIME/TRAN',5X,
       1'TRAN NO.')
        DO 200 I = 1,35
        IF(FACIL(I,5).EQ.0) GO TO 200
        XF2 = FACIL(I,2)
        XF5 = FACIL(I,5)
        UTIL = XF2/XC1
        AVG = XF2/XF5
        WRITE(6,190) I,UTIL,FACIL(I,5),AVG,FACIL(I,1)
  190   FORMAT(I5,F12.3,I16,F16.3,I12)
  200   CONTINUE
C       STORAGE OUTPUT
  205   CONTINUE
```

```
      DO 206 I=1,35
      IF(STOR(I,5).NE.0) GO TO 207
  206 CONTINUE
      GO TO 255
  207 WRITE(6,210)
  210 FORMAT('0',23X,'AVERAGE     AVERAGE',19X,'AVERAGE',
     16X,'CURRENT     MAXIMUM')
      WRITE(6,220)
  220 FORMAT(' STORAGE    CAPACITY    CONTENTS    UTILIZATION',
     14X,'ENTRIES    TIME/TRAN    CONTENTS    CONTENTS')
      DO 240 I=1,35
      IF(STOR(I,5).EQ.0) GO TO 240
      XS3 = STOR(I,3)
      XS5 = STOR(I,5)
      XCAP = STOR(I,1) + STOR(I,2)
      CAP = XCAP
      AVGCON = XS3/XC1
      UTIL = XS3/(XC1*XCAP)
      AVGTM = XS3/XS5
      WRITE(6,230) I,CAP,AVGCON,UTIL,STOR(I,5),AVGTM,STOR(I,1),STOR(I,6)
  230 FORMAT(I4,I13,F12.3,F12.3,I14,F13.3,I10,I12)
  240 CONTINUE
C     QUEUE OUTPUT
  255 CONTINUE
      DO 256 I=1,70
      IF(QUEUE(I,2).NE.0) GO TO 257
  256 CONTINUE
      GO TO 300
  257 WRITE(6,250)
  250 FORMAT('0',9X,'MAXIMUM',5X,'AVERAGE',4X,'TOTAL',8X,'ZERO',7X,
     1'PERCENT',5X,'AVERAGE',6X,'$ AVERAGE     CURRENT')
      WRITE(6,260)
  260 FORMAT(' QUEUE    CONTENTS    ENTRIES    ENTRIES    ENTRIES',5X,
     1 '  ZEROS      TIME/TRAN    TIME/TRAN',5X,'CONTENTS')
      DO 280 I = 1,70
      IF(QUEUE(I,2).EQ.0) GO TO 280
```

```
      XQ3 = QUEUE(I,3)
      XQ2=QUEUE(I,2)
      XQ4 = QUEUE(I,4)
      AVGCON = XQ4/XC1
      AVGTM = XQ4/XQ2
      AVGZTM = 0.0
      IF(XQ2.NE.XQ3) AVGZTM = XQ4/(XQ2-XQ3)
      PCTZ = XQ3/XQ2*100.
      WRITE(6,270) I,QUEUE(I,6),AVGCON,QUEUE(I,2),QUEUE(I,3),PCTZ,
     1AVGTM,AVGZTM,QUEUE(I,5)
  270 FORMAT(I4,I10,F14.3,I10,I11,F15.3,F11.3,F14.3,I10)
  280 CONTINUE
      WRITE(6,290)
  290 FORMAT('0$ AVERAGE TIME/TRAN EXCLUDES ZERO DELAY ENTRIES')
  300 RETURN
      END
      SUBROUTINE PRIORI(CECP)
C*****************************************************************
C                                                                *
C                          PRIORI                                *
C                                                                *
C     SUBROUTINE PRIORI DETERMINES IF THE PRIORITY IN FIELD A IS *
C     DIFFERENT FROM THAT OF THE TRANSACTION. IF SO, THE TRANSACTION*
C     IS DELETED FROM THE CEC AND READDED AT THE PROPER LOCATION. *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      INTEGER CECP
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
      MOVE = 1
```

```
C       UPDATE BLOCK COUNTS
        ILST = TRAN(TRANO,5)
        TRAN(TRANC,5) = BLOCKN
        BLOCK(BLOCKN,9) = BLOCK(BLOCKN,9) + 1
        BLOCK(ILST,9) = BLOCK(ILST,9) - 1
        BLOCK(BLOCKN,10) = BLOCK(BLOCKN,10) + 1
        TRAN(TRANC,1) = TRAN(TRANO,1) + 1
         RESULT = BLOCK(BLOCKN,3)
        IF(RESULT.EQ.TRAN(TRANC,3)) RETURN
        CEC(CECP,3) = RESULT
        TRAN(TRANC,3) = RESULT
C       MOVE TRAN LAST IN NEW PRIORITY CLASS IN CEC
        CECT = CECF
        IR = RESULT
        IF(CECF.EQ.CECL) RETURN
C       UNLINK FROM OLD LOCATION
        OLD1 = CEC(CECP,1)
        OLD2 = CEC(CECP,2)
        IF(OLD1.EQ.0) CECF = CEC(CECP,2)
        IF(OLD2.EQ.0) CECL=CEC(CECP,1)
        IF(OLD1.NE.0) CEC(OLD1,2) = OLD2
        IF(OLD2.NE.0) CEC(OLD2,1) = OLD1
        CECT = CECF
   50   IF(CEC(CECT,3).GE.IR) GO TO 100
        OLD1 = CEC(CECT,1)
        CEC(CECP,1) = CEC(CECT,1)
        CEC(CECP,2) = CECT
        CEC(CECT,1) = CECP
        IF(OLD1.NE.0) CEC(OLD1,2) = CECP
        IF(OLD1.EQ.0) CECF = CECP
        STATUS = 1
        RETURN
  100   IF(CEC(CECT,2).EQ.0) GO TO 150
        CECT = CEC(CECT,2)
        GO TO 50
  150   OLD2 = CEC(CECT,2)
```

```
      CEC(CECP,1) = CECT
      CEC(CECP,2) = CEC(CECT,2)
      CEC(CECT,2) = CECP
      IF(OLD2.NE.0) CEC(CECT,1) = CECP
      IF(OLD2.EQ.0) CECL = CECP
C     SET STATUS CHANGE FLAG ON
      STATUS = 1
      RETURN
      END
      SUBROUTINE QUEUES
C*****************************************************************
C                                                                *
C                            QUEUES                              *
C                                                                *
C       SUBROUTINE QUEUES ENTERS THE NO OF UNITS SPECIFIED IN FIELD  *
C       B INTO THE QUEUE SPECIFIED IN FIELD A.                   *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
C     DETERMINE Q
      SNAC = BLOCK(BLOCKN,2)
      SNAN = BLOCK(BLOCKN,3)
      CALL SNA(SNAC,SNAN,RES)
      Q = RES
C CALCULATE NEW CUMULATIVE TIME
      QUEUE(Q,4) = QUEUE(Q,4) + (C1 - QUEUE(Q,1)) * QUEUE(Q,5)
C     DETERMINE NO TO QUEUE
      SNAC = BLOCK(BLOCKN,4)
      SNAN = BLOCK(BLOCKN,5)
      CALL SNA(SNAC,SNAN,RESULT)
      IF(RESULT.EQ.0.0) RESULT = 1.0
      QUEUE(Q,5) = QUEUE(Q,5) + RESULT
      TRAN(TRANO,4)  = C1
```

```
C INCREMENT ENTRY COUNT
      IF(QUEUE(Q,5).GT.QUEUE(Q,6)) QUEUE(Q,6) = QUEUE(Q,5)
C IS NEW CURRENT  > OLD MAX
      QUEUE(Q,2) = QUEUE(Q,2) + 1
      QUEUE(Q,1) = C1
      MOVE = 1
      TRAN(TRANO,1) = TRAN(TRANO,1) + 1
C     UPDATE BLOCK COUNTS
      ILST = TRAN(TRANO,5)
      TRAN(TRANO,5) = BLOCKN
      BLOCK(BLOCKN,9) = BLOCK(BLOCKN,9) + 1
      BLOCK(ILST,9) = BLOCK(ILST,9) - 1
      BLOCK(BLOCKN,10) = BLOCK(BLOCKN,10) + 1
      RETURN
      END
      SUBROUTINE RANDU(IN,IY,YFL)
C*****************************************************************
C                                                                *
C                            RANDU                               *
C                                                                *
C       SUBROUTINE RANDU CALCULATES A RANDOM NUMBER USING THE    *
C       SPECIFIED RANDOM NUMBER SEED.                            *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
       INTEGER TYPE,TRANO,BLOCKN,BLOCKT
       COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
      1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
      2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
       IX = RN(IN)
       IY = IX * 1220703125
       IF(IY) 1,2,2
    1  IY = IY + 2147483647 + 1
    2  YFL = IY
       YFL = YFL * 0.4656613E-9
       RN(IN) = IY
```

```
      RETURN
      END
      SUBROUTINE RELEAS
C*****************************************************************
C                                                                *
C                            RELEAS                              *
C                                                                *
C       SUBROUTINE RELEAS RELEASES THE FACILITY SPECIFIED IN FIELD A. *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
C     DETERMINE FACILITY
      SNAC = BLOCK(BLOCKN,2)
      SNAN = BLOCK(BLOCKN,3)
      CALL SNA(SNAC,SNAN,RES)
      FAC = RES
C TRAN# SAME AS SEIZING TRAN
      IF(FACIL(FAC,1).NE.TRANO)GO TO 1000
C CALCULATE NEW CUMULATIVE TIME
      FACIL(FAC,2) = FACIL(FAC,2) + C1 - FACIL(FAC,3)
C SET FACILITY NOT IN USE
      FACIL(FAC,1) = 0
      FACIL(FAC,3) = C1
      IF(FACIL(FAC,4).EQ.0) GO TO 100
C ELIMINATE DELAY CHAIN
      FACIL(FAC,4) = 0
C SET STATUS CHANGE FLAG IF OTHER TRANS WAITING TO SEIZE FACILITY
      STATUS = 1
  100 MOVE = 1
C     UPDATE BLOCK COUNTS
```

```
      ILST = TRAN(TRANO,5)
      TRAN(TRANO,5) = BLOCKN
      BLOCK(BLOCKN,9) = BLOCK(BLOCKN,9) + 1
      BLOCK(ILST,9) = BLOCK(ILST,9) - 1
      BLOCK(BLOCKN,10) = BLOCK(BLOCKN,10) + 1
      TRAN(TRANO,1) = TRAN(TRANO,1) + 1
      RETURN
 1000 WRITE(6,1001)
 1001 FORMAT('OFACILITY RELEASE BY A TRANSACTION NOT SEIZING IT')
      STOP
      END
      SUBROUTINE SCAN
C*****************************************************************
C                                                                *
C                            SCAN                                *
C                                                                *
C       SUBROUTINE SCAN CONTROLS THE OVERALL IGPSS SCAN.  IF MOVE *
C       EQUALS 1 THE TRANSACTION ENTERED THE NEXT BLOCK.  IF STATUS*
C       EQUALS 1 , A STATUS CHANGE OCCURED AND THE OVERALL SCAN  *
C       RETURNS TO THE FIRST OF THE CEC.                         *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
      CD = 0
      IF(STARTC.NE.0) GO TO 10
      WRITE(6,101)
  101 FORMAT('ONO START CARD, EXECUTION TERMINATED')
      STOP
C     INCREASE CLOCK TO BDT OF FIRST TRAN IN FEC
   10 C1 = FEC(FECF,3)
      CECT = CECF
```

```
C       IS CURRENT EVENT CHAIN NULL
        IF(CECT.NE.0) GO TO 100
C       SET UP CEC LINKAGE
        CECF = CECA
        CECL = CECA
        OLDNXT = CEC(CECA,2)
        CEC(CECF,1) = 0
        CEC(CECF,2) = 0
        GO TO 200
   50   IF(CEC(CECT,2).EQ.0) GO TO 75
        CECT = CEC(CECT,2)
        GO TO 100
C        WAS TRAN ADDED AT END OF CHAIN
   75   OLDNXT = CEC(CECA,2)
        OLD2 = CEC(CECT,2)
        CEC(CECA,1) = CECT
        CEC(CECA,2) = CEC(CECT,2)
        CEC(CECT,2) = CECA
        IF(OLD2.NE.0) CEC(CECT,1) = CECA
        IF(OLD2.EQ.0) CECL =CECA
        GO TO 200
C       INSERT TRAN INPROPER PRIORITY IN CEC
  100   IF(CEC(CECT,3).GE.FEC(FECF,4)) GO TO 50
        OLDNXT = CEC(CECA,2)
C       SET UP LINKAGE OF NEW TRAN
        OLD1 = CEC(CECT,1)
        CEC(CECA,1) = CEC(CECT,1)
        CEC(CECA,2) = CECT
        CEC(CECT,1) = CECA
        IF(OLD1.NE.0) CEC(OLD1,2) = CECA
        IF(OLD1.EQ.0) CECF = CECA
C       MOVE UP AVAILABLE PTR
  200   CEC(CECA,3) = FEC(FECF,4)
        CEC(CECA,4) = FEC(FECF,5)
        CECA = OLDNXT
C       UNLINK FROM FEC
        FECT = FEC(FECF,2)
        FEC(FECF,2) = FECA
```

```
      FECA = FECF
      FECF = FECT
      IF(FECF.NE.0) FEC(FECF,1) = 0
      IF(FECF.EQ.0) FECL = 0
      CECT = CECF
C     IS BDT OF NEXT TRAN EQUAL CLOCK
      IF(FECF.EQ.0) GO TO 300
      IF(FEC(FECF,3).EQ.C1) GO TO 100
C     SET STATUS CHANGE OFF
  300 STATUS = 0
C     GET FIRST CEC TRAN
      CECT = CECF
  310 TRANO = CEC(CECT,4)
C     SSI ON
C     IF(TRAN(TRANO,2).EQ.1) GO TO 400
      GO TO 400
  320 CECT = CEC(CECT,2)
C     LAST CEC TRAN
      IF(CECT.EQ.0) GO TO 10
      GO TO 310
C     MOVE TRAN  -  DETERMINE BLOCK TYPE
  400 BLOCKN = TRAN(TRANO,1)
      BLOCKT = BLOCK(BLOCKN,1)
      IF(BLOCKT.EQ.1) CALL GENERA(2,BLOCKN)
      IF(BLOCKT.EQ.2) CALL SEIZE
      IF(BLOCKT.EQ.3) CALL RELEAS
      IF(BLOCKT.EQ.5) CALL ENTER
      IF(BLOCKT.EQ.6) CALL LEAVE
      IF(BLOCKT.EQ.7) CALL ADVANC(CECT,CD)
      IF(BLOCKT.EQ.8) CALL TERMIN(CECT,CD)
      IF(BLOCKT.EQ.9) CALL ASSIGN
      IF(BLOCKT.EQ.10) CALL PRIORI(CECT)
      IF(BLOCKT.EQ.11) CALL TRANSF
      IF(BLOCKT.EQ.12) CALL TEST
      IF(BLOCKT.EQ.15) CALL QUEUES
      IF(BLOCKT.EQ.16) CALL DEPART
```

```
C       DID TRAN ENTER NEXT BLOCK
        IF(MOVE.NE.1) GO TO 500
        MOVE = 0
C       TERMINATE BLOCK
        IF(BLOCKT.NE.8) GO TO 450
        IF(STARTC.LE.0) RETURN
        GO TO 500
C       ADVANCE BLOCK
  450   IF(BLOCKT.NE.7) GO TO 400
C       IS STATUS CHANGE ON
  500   IF(STATUS.EQ.1) GO TO 300
C       IS END OF CEC REACHED
        IF(CD.NE.1) CECT = CEC(CECT,2)
        IF(CECT.EQ.0    ) GO TO 10
        CD = 0
        GO TO 310
        END
        SUBROUTINE SEIZE
C*****************************************************************
C                                                                *
C                            SEIZE                               *
C                                                                *
C       SUBROUTINE SEIZE ATTEMPTS TO SEIZE THE FACILITY SPECIFIED *
C       IN FIELD A.  IF THE FACILITY IS CURRENTLY IN USE THE      *
C       TRANSACTION IS BLOCKED.                                  *
C                                                                *
C*****************************************************************
        IMPLICIT INTEGER(C,F,Q,S,D)
         REAL FUNC
        INTEGER TYPE,TRANC,BLOCKN,BLOCKT
        COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
       1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
       2STATUS,MOVE,C1,TRAND,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
C       DETERMINE FACILITY
    10  SNAC = BLOCK(BLOCKN,2)
        SNAN = BLOCK(BLOCKN,3)
        CALL SNA(SNAC,SNAN,RES)
        FAC = RES
```

```
C       IS FACILITY IN USE
        IF(FACIL(FAC,1).EQ.0) GO TO 1000
C SET UP DELAY CHAIN
        FACIL(FAC,4) = 1
        GO TO 2000
C       NOT IN USE
C PLACE TRAN # IN F1
 1000 FACIL(FAC,1) = TRANO
        TRAN(TRANO,2) = 1
C PLACE CLOCK TIME IN F3
        FACIL(FAC,3) = C1
C INCREMENT ENTRY COUNT
        FACIL(FAC,5) = FACIL(FAC,5) + 1
        TRAN(TRANO,1) = TRAN(TRANO,1) + 1
        MOVE = 1
C       UPDATE BLOCK COUNTS
        ILST = TRAN(TRANO,5)
        TRAN(TRANO,5) = BLOCKN
        BLOCK(BLOCKN,9) = BLOCK(BLOCKN,9) + 1
        BLOCK(ILST,9) = BLOCK(ILST,9) - 1
        BLOCK(BLOCKN,10) = BLOCK(BLOCKN,10) + 1
        TRAN(TRANO,2) = 1
 2000 RETURN
        END
        SUBROUTINE SNA(SNAC,SNAN,RESULT)
C*****************************************************************
C                                                                *
C                          SNA                                   *
C                                                                *
C     SUBROUTINE DETERMINES THE VALUE OF THE SNA.                *
C                                                                *
C*****************************************************************
        IMPLICIT INTEGER(C,F,Q,S,O)
         REAL FUNC
        INTEGER SNAC,SNAN
        INTEGER TYPE,TRANO,BLOCKN,BLOCKT
```

THIS BOOK CONTAINS NUMEROUS PAGES WITH THE ORIGINAL PRINTING ON THE PAGE BEING CROOKED.

THIS IS THE BEST IMAGE AVAILABLE.

```
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
C     PARAMETER
      IF(SNAC.NE.1) GO TO 50
      RESULT = TRAN(TRANO,SNAN+5)
      RETURN
C     RANDOM NUMBER
   50 IF(SNAC.NE.4)   GO TO 100
      I = SNAN
      CALL RANDU(I,IY,YFL)
      RESULT = YFL
      RETURN
  100 IF(SNAC.NE.3.AND.SNAC.NE.0) GO TO 200
      RESULT = SNAN
      RETURN
C     PRIORITY
  200 IF(SNAC.NE.2)  GO TO 300
      RESULT = TRAN(TRANO,3)
      RETURN
C     CLOCK
  300 IF(SNAC.NE.5)  GO TO 400
      RESULT = C1
      RETURN
C     FUNCTION
  400 IF(SNAC.NE.6)  GO TO 500
      CALL FUNCT(RESULT,SNAN)
      RETURN
C     VARIABLE
  500 IF(SNAC.NE.7) GO TO 600
C     CALL VARIAB(RESULT,SNAN)
      RETURN
C     CONTENTS OF STORAGE
  600 IF(SNAC.NE.8) GO TO 700
      RESULT = STOR(SNAN,1)
      RETURN
```

```
C     REMAINING STORAGE
  700 IF(SNAC.NE.9) GO TO 800
      RESULT = STOR(SNAN,2)
      RETURN
C     UTILIZATION OF STORAGE
  800 IF(SNAC.NE.10) GO TO 900
      RESULT = STOR(SNAN,3)/(C1*(STOR(SNAN,1)+STOR(SNAN,2)))
      RETURN
C     AVERAGE OF STORAGE
  900 IF(SNAC.NE.11) GO TO 1000
      RESULT = STOR(SNAN,3)/C1
      RETURN
C     MAXIMUM OF STORAGE
 1000 IF(SNAC.NE.12) GO TO 1100
      RESULT = STOR(SNAN,6)
      RETURN
C     NO OF ENTRIES IN STORAGE
 1100 IF(SNAC.NE.13) GO TO 1200
      RESULT = STOR(SNAN,5)
      RETURN
C     AVERAGE TIME IN STORAGE
 1200 IF(SNAC.NE.14) GO TO 1300
      RESULT = STOR(SNAN,3)/STOR(SNAN,5)
      RETURN
C     STATUS OF FACILITY
 1300 IF(SNAC.NE.15)GO TO 1400
      RESULT = 1
      IF(FACIL(SNAN,1).EQ.0) RESULT = 0
      RETURN
C     FACILITY UTILIZATION
 1400 IF(SNAC.NE.16) GO TO 1500
      RESULT = FACIL(SNAN,2)/C1
      RETURN
C     NO OF ENTRIES IN FACILITY
```

```
 1500 IF(SNAC.NE.17) GO TO 1600
      RESULT = FACIL(SNAN,5)
      RETURN
C     AVERAGE TIME IN FACILITY
 1600 IF(SNAC.NE.18) GO TO 1700
      RESULT = FACIL(SNAN,2)/FACIL(SNAN,5)
      RETURN
C      QUEUE LENGTH
 1700 IF(SNAC.NE.19)GO TO 1800
      RESULT = QUEUE(SNAN,5)
      RETURN
C     AVE QUEUE LENGTH
 1800 IF(SNAC.NE.20) GO TO 1900
      RESULT = QUEUE(SNAN,4)/C1
      RETURN
C     MAXIMUM QUEUE LENGTH
 1900 IF(SNAC.NE.21) GO TO 2000
      RESULT = QUEUE(SNAN,6)
      RETURN
C     NO OF ENTRIES IN QUEUE
 2000 IF(SNAC.NE.22) GO TO 2100
      RESULT = QUEUE(SNAN,2)
      RETURN
C     NO OF ZERO ENTRIES IN QUEUE
 2100 IF(SNAC.NE.23) GO TO 2200
      RESULT = QUEUE(SNAN,3)
      RETURN
C     AVERAGE QUEUE TIME WITH ZERO
 2200 IF(SNAC.NE.24) GO TO 2300
      RESULT = QUEUE(SNAN,4)/QUEUE(SNAN,2)
      RETURN
C     AVERAGE QUEUE TIME WITH NO ZEROS
 2300 IF(SNAC.NE.25) GO TO 2400
      RESULT = QUEUE(SNAN,4)/(QUEUE(SNAN,2)-QUEUE(SNAN,3))
      RETURN
```

```
C      ERROR
 2400 WRITE(6,2500) SNAC
 2500 FORMAT('0INVALID SNA ',I4)
      STOP
      END
      SUBROUTINE TERMIN(CECT,ID)
C*****************************************************************
C                                                                *
C                          TERMIN                                *
C                                                                *
C        SUBROUTINE TERMIN REMOVES A TRANSACTION FROM THE CEC AND *
C        DECREMENTS THE START COUNT.                             *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER CECT
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
C      UPDATE BLOCK COUNTS
      ILST = TRAN(TRANO,5)
      BLOCK(ILST,9) = BLOCK(ILST,9) - 1
      BLOCK(BLOCKN,10) = BLOCK(BLOCKN,10) + 1
      MOVE = 1
C      UNLINK BLOCK FROM CEC
      OLD1 = CEC(CECT,1)
      OLD2 = CEC(CECT,2)
      IF(OLD1.NE.0) CEC(OLD1,2) = OLD2
      IF(OLD2.NE.0) CEC(OLD2,1) = OLD1
      CEC(CECT,2) = CECA
      CECA = CECT
      IF(CECT.EQ.CECF) CECF = OLD2
      IF(CECT.EQ.CECL) CECL = OLD1
      IF(CECL.NE.0) GO TO 100
      CECT = 0
      ID = 1
```

```
      GO TO 200
  100 ID = 1
      CECT = OLD2
C     DECREMENT START COUNT
  200 SNAC = BLOCK(BLOCKN,2)
      SNAN = BLOCK(BLOCKN,3)
      CALL SNA(SNAC,SNAN,RESULT)
      STARTC = STARTC - RESULT
C     REMOVE TRANSACTION
      TRAN(TRANC,1) = TRANA
      TRANA = TRANO
      RETURN
      END
      SUBROUTINE TEST
C*************************************************************
C                                                            *
C                          TEST                              *
C                                                            *
C       SUBROUTINE TEST TESTS THE VALUE IN FIELD A AGAINST THE *
C       VALUE IN FIELD B.  IF THE CONDITION IS MET THE TRANSACTION *
C       NEXT BLOCK IS CHANGED TO THE BLOCK SPECIFIED IN FIELD C *
C       OTHERWISE IT IS INCREMENTED BY ONE.                  *
C                                                            *
C*************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
       REAL FUNC
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MCVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
      TRAN(TRANO,1) = TRAN(TRANO,1) + 1
      MOVE = 1
      ILST = TRAN(TRANO,5)
      TRAN(TRANC,5) = BLOCKN
      BLOCK(BLOCKN,9) = BLOCK(BLOCKN,9) + 1
      BLOCK(ILST,9) = BLOCK(ILST,9) - 1
      BLOCK(BLOCKN,10) = BLOCK(BLOCKN,10) + 1
```

```
C       DETERMINE FIELD A
        SNAC = BLOCK(BLOCKN,2)
        SNAN = BLOCK(BLOCKN,3)
        CALL SNA(SNAC,SNAN,A)
C       DETERMINE FIELD B
        SNAC = BLOCK(BLOCKN,4)
        SNAN = BLOCK(BLOCKN,5)
        CALL SNA(SNAC,SNAN,B)
        IF(BLOCK(BLOCKN,8).NE.1.0) GO TO 100
C       TEST L
        IF (A.GE.B) TRAN(TRANO,1) = BLOCK(BLOCKN,6)
        RETURN
  100   IF(BLOCK(BLOCKN,8).NE.2.0) GO TO 200
C       TEST LE
        IF(A.GT.B) TRAN(TRANC,1) = BLOCK(BLOCKN,6)
        RETURN
  200   IF(BLOCK(BLOCKN,8).NE.3.0) GO TO 300
C       TEST E
        IF(A.NE.B) TRAN(TRANC,1) = BLOCK(BLOCKN,6)
        RETURN
  300   IF(BLOCK(BLOCKN,8).NE.4.0) GO TO 400
C       TEST NE
        IF(A.EQ.B) TRAN(TRANC,1) = BLOCK(BLOCKN,6)
        RETURN
  400   IF(BLOCK(BLOCKN,8).NE.5.0) GO TO 500
C       TEST G
        IF(A.LE.B) TRAN(TRANC,1)= BLOCK(BLOCKN,6)
        RETURN
  500   IF(BLOCK(BLOCKN,8).NE.6.0) GO TO 600
C       TEST GE
        IF(A.LT.B) TRAN(TRANC,1) = BLOCK(BLOCKN,6)
        RETURN
C       ERROR
  600   WRITE(6,700) BLOCK(BLOCKN,8)
  700   FORMAT('0INVALID TEST RELATION',I3)
        STOP
        END
```

```
      SUBROUTINE TRANSF
C*****************************************************************
C                                                                *
C                            TRANSF                              *
C                                                                *
C       SUBROUTINE TRANSF - IF FIELD A OF THE TRANSFER BLOCK IS  *
C       BLANK THE NEXT BLOCK FIELD OF THE TRANSACTION IS SET     *
C       TO FIELD B OF THE TRANSFER BLOCK.  OTHERWISE, A RANDOM   *
C       NUMBER IS GENERATED.  IF THE GENERATED NUMBER IS LT THE  *
C       SELECTION FACTOR IN FIELD A THE NEXT BLOCK IS SET TO FIELD*
C       C, ELSE TO FIELD B.                                      *
C                                                                *
C*****************************************************************
      IMPLICIT INTEGER(C,F,Q,S,O)
      COMMON /A/ TRAN(200,15),BLOCK(120,10),FACIL(35,5),STOR(35,7),
     1QUEUE(70,6),FEC(50,5),FECF,FECL,FECA,CEC(50,4),CECF,CECL,CECA,
     2STATUS,MOVE,C1,TRANO,BLOCKN,STARTC,RN(8),TRANA,FUNC(20,54)
      INTEGER TYPE,TRANO,BLOCKN,BLOCKT
       REAL FUNC
      MOVE = 1
C     UPDATE BLOCK COUNTS
      ILST = TRAN(TRANO,5)
      TRAN(TRANO,5) = BLOCKN
      BLOCK(BLOCKN,9) = BLOCK(BLOCKN,9) + 1
      BLOCK(ILST,9) = BLOCK(ILST,9) - 1
      BLOCK(BLOCKN,10) = BLOCK(BLOCKN,10) + 1
      IF(BLOCK(BLOCKN,3).NE.0.0) GO TO 100
      TRAN(TRANO,1) = BLOCK(BLOCKN,5)
      RETURN
  100 CALL RANDU(1,IY,YFL)
C     SNAN = BLOCK(BLOCKN,3)
C     SNAC = BLOCK(BLOCKN,2)
C     CALL SNA(SNAC,SNAN,RESULT)
```

```
      RESULT = BLOCK(BLOCKN,3)
      IF(YFL  .LE.RESULT) GO TO 200
      TRAN(TRANC,1) = BLOCK(BLOCKN,5)
      RETURN
  200 TRAN(TRANC,1) = BLOCK(BLOCKN,6)
      RETURN
      END
```

```
LOCN.
NUMBER   *LOC    OPERATION  A,B,C,D,E,F,G,H,I        COMMENTS                                          NUMBER
                SIMULATE                                                                                  1
1                GENERATE   15,5          JOBS ARRIVE EVERY 10 TO 20 MINUTES                            2
2                TEST E     F2,0,CLKC     IS CLERK B BUSY                                               3
3                QUEUE      ACLK          ENTER LINE FOR CLERK A                                        4
4                SEIZE      ACLK          CLERK A BEGINS PROCESSING                                     5
5                DEPART     ACLK          LEAVE LINE FOR CLERK A                                        6
6                ADVANCE    10,3          CLERK TAKES 7 TO 13 MIN TO PROCESS JOB                        7
7                RELEASE    ACLK          CLERK A COMPLETES JOB                                         8
8                QUEUE      BCLK          ENTER LINE FOR CLERK B                                        9
9                SEIZE      BCLK          CLERK B BEGINS PROCESSING                                    10
10               DEPART     BCLK          LEAVE LINE FOR CLERK B                                       11
11               ADVANCE    5,2           CLERK B PROCESSES JOBS IN 3 TO 7 MIN                         12
12               RELEASE    BCLK          CLERK B COMPLETES JOB                                        13
13               TERMINATE  1             JOB LEAVES OFFICE                                            14
14       CLKC    QUEUE      CCLK          ENTER LINE FOR CLERK C                                       15
15               SEIZE      CCLK          CLERK C BEGINS PROCESSING                                    16
16               DEPART     CCLK          LEAVE LINE FOR CLERK C                                       17
17               ADVANCE    20,10         CLERK C  TAKES 10 TO 30 MIN TO PROCESS                       18
18               RELEASE    CCLK          CLERK C COMPLETES JOB                                        19
19               TERMINATE  1             JOB LEAVES OFFICE                                            20
                 START      1000          RUN SIMULATION FOR 1000 JOBS                                 21
                 END                                                                                    22
```

```
                 SIMULATE
1                GENERATE   15,5
2                TEST E     F2,0,14
3                QUEUE      1
4                SEIZE      1
5                DEPART     1
6                ADVANCE    10,3
7                RELEASE    1
8                QUEUE      2
9                SEIZE      2
10               DEPART     2
11               ADVANCE    5,2
12               RELEASE    2
13               TERMINATE  1
14               QUEUE      3
15               SEIZE      3
16               DEPART     3
17               ADVANCE    20,10
18               RELEASE    3
19               TERMINATE  1
                 START      1000
```

BLOCK COUNTS

BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL
1	0	1000	11	0	698									
2	0	1000	12	0	698									
3	0	698	13	0	698									
4	0	698	14	0	302									
5	0	698	15	0	302									
6	0	698	16	0	302									
7	0	698	17	0	302									
8	0	698	18	0	302									
9	0	698	19	0	302									
10	0	698												

****
*   *
* FACILITIES *
*   *
****

FACILITY	NUMBER ENTRIES	AVERAGE TIME/TRAN	-AVERAGE TOTAL TIME	UTILIZATION DURING- AVAIL. TIME	UNAVAIL. TIME	CURRENT STATUS	PERCENT AVAILABILITY	TRANSACTION NUMBER SEIZING	PREEMPTING
ACLK	698	10.024	.469				100.0		
BCLK	698	5.017	.235				100.0		
CCLK	302	19.553	.405				100.0		

****
*   *
* QUEUES *
*   *
****

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/TRANS	$AVERAGE TIME/TRANS	TABLE NUMBER	CURRENT CONTENTS
ACLK	1	.008	698	627	89.8	.180	1.774		
BCLK	1	.000	698	698	100.0	.000	.000		
CCLK	1	.003	302	287	95.0	.182	3.666		

$AVERAGE TIME/TRANS = AVERAGE TIME/TRANS EXCLUDING ZERO ENTRIES

END

***** TOTAL RUN TIME (INCLUDING ASSEMBLY) = .05 MINUTES *****

	BLOCK TYPE	A		B		C	D	E
0	1.000	0.0	15.000	0.0	5.000	0.0	0.0	0.0
0	12.000	15.000	2.000	0.0	0.0	14.000	0.0	3.000
0	15.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
0	2.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
C	16.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
0	7.000	0.0	10.000	0.0	3.000	0.0	0.0	0.0
0	3.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
0	15.000	0.0	2.000	0.0	0.0	0.0	0.0	0.0
0	2.000	0.0	2.000	0.0	0.0	0.0	0.0	0.0
C	16.000	0.0	2.000	0.0	0.0	0.0	0.0	0.0
0	7.000	0.0	5.000	0.0	2.000	0.0	0.0	0.0
0	3.000	0.0	2.000	0.0	0.0	0.0	0.0	0.0
C	8.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
0	15.000	0.0	3.000	0.0	0.0	0.0	0.0	0.0
0	2.000	0.0	3.000	0.0	0.0	0.0	0.0	0.0
0	16.000	0.0	3.000	0.0	0.0	0.0	0.0	0.0
C	7.000	0.0	20.000	0.0	10.000	0.0	0.0	0.0
0	3.000	0.0	3.000	0.0	0.0	0.0	0.0	0.0
0	8.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
0	17.000	0.0	1000.000	0.0	0.0	0.0	0.0	0.0
0	18.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CLOCK 15061

BLOCK COUNTS

BLOCK	CURRENT	TOTAL
1	1	1002
2	0	1001
3	0	677
4	0	677
5	0	677
6	0	677
7	0	677
8	0	677
9	0	677
10	0	677
11	0	677
12	0	677
13	0	677
14	0	324
15	0	324
16	0	324
17	1	324
18	0	323
19	0	323

FACILITY	AVERAGE UTILIZATION	NUMBER ENTRIES	AVERAGE TIME/TRAN	SEIZING TRAN NO.
1	0.454	677	10.097	0
2	0.226	677	5.019	0
3	0.451	324	20.551	4

QUEUE	MAXIMUM CONTENTS	AVERAGE ENTRIES	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/TRAN	$ AVERAGE TIME/TRAN	CURRENT CONTENTS
1	1	0.004	677	643	94.978	0.080	1.588	0
2	1	0.0	677	677	100.000	0.0	0.0	0
3	1	0.005	324	299	92.284	0.216	2.800	0

$ AVERAGE TIME/TRAN EXCLUDES ZERO DELAY ENTRIES

```
BLOCK                                                                    STATEMENT
NUMBER   *LOC    OPERATION  A,B,C,D,E,F,G,H,I        COMMENTS             NUMBER
                  SIMULATE                                                   1
         REGCK    STORAGE    2            TWO REGULAR CHECKOUT COUNTERS      2
1                 GENERATE   3,2          CUSTOMERS ARRIVE FROM 1 TO 5 MINUTES APART  3
2                 TRANSFER   .32,REG,EXPRS                                   4
3        EXPRS    QUEUE      EXPRS        ENTER EXPRESS QUEUE                5
4                 SEIZE      EXPRS        ENTER EXPRESS CHECKOUT             6
5                 DEPART     EXPRS        LEAVE EXPRESS QUEUE                7
6                 ADVANCE    2            TWO MINUTES REQUIRED FOR EXPRESS CHECKOUT  8
7                 RELEASE    EXPRS        LEAVE EXPRESS CHECKOUT             9
8                 TRANSFER   ,TERM                                           10
9        REG      QUEUE      REGCK        ENTER REGULAR QUEUE               11
10                ENTER      REGCK        ENTER REGULAR CHECKOUT            12
11                DEPART     REGCK        DEPART REGULAR QUEUE              13
12                ADVANCE    8,6          2 TO 14 MIN REQUIRED IN REGULAR CHECKOUT  14
13                LEAVE      REGCK        LEAVE REGULAR CHECKOUT            15
14       TERM     TERMINATE  1            CUSTOMER LEAVES STORE             16
                  START      100          RUN 100 CUSTOMERS                 17
                  END                                                       18
```

```
                  SIMULATE
1                 STORAGE    2
1                 GENERATE   3,2
2                 TRANSFER   .320,9,3
3                 QUEUE      1
4                 SEIZE      1
5                 DEPART     1
6                 ADVANCE    2
7                 RELEASE    1
8                 TRANSFER   ,14
9                 QUEUE      2
10                ENTER      1
11                DEPART     2
12                ADVANCE    8,6
13                LEAVE      1
14                TERMINATE  1
                  START      100
```

RELATIVE CLOCK 286 ABSOLUTE CLOCK 296

BLOCK COUNTS

BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL	BLOCK	CURRENT	TOTAL
1	0	103	11	0	60									
2	0	103	12	2	60									
3	0	42	13	0	58									
4	0	42	14	0	100									
5	0	42												
6	0	42												
7	0	42												
8	0	42												
9	1	61												
10	0	60												

FACILITIES

FACILITY	NUMBER ENTRIES	AVERAGE TIME/TRAN	AVERAGE TOTAL TIME	UTILIZATION DURING AVAIL. TIME	UTILIZATION DURING UNAVAIL. TIME	CURRENT STATUS	PERCENT AVAILABILITY	TRANSACTION NUMBER SEIZING	TRANSACTION NUMBER PREEMPTING
EXPRS	42	2.000	.293				100.0		

STORAGES

STORAGE	CAPACITY	AVERAGE CONTENTS	ENTRIES	AVERAGE TIME/UNIT	AVERAGE TOTAL TIME	UTILIZATION DURING AVAIL. TIME	UTILIZATION DURING UNAVAIL. TIME	CURRENT STATUS	PERCENT AVAILABILITY	CURRENT CONTENTS	MAXIMUM CONTENTS
RECCK	2	1.703	60	8.117	.851				100.0	2	2

QUEUES

QUEUE	MAXIMUM CONTENTS	AVERAGE CONTENTS	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/TRANS	$AVERAGE TIME/TRANS	TABLE NUMBER	CURRENT CONTENTS
EXPRS	1	.306	42	40	95.2	.047	1.000		
RECCK	6	1.601	61	17	27.8	7.508	10.409		1

$AVERAGE TIME/TRANS = AVERAGE TIME/TRANS EXCLUDING ZERO ENTRIES

END

***** TOTAL RUN TIME (INCLUDING ASSEMBLY) = .02 MINUTES *****

	BLOCK TYPE	A		B		C	D	E
1	4.000	0.0	2.000	0.0	0.0	0.0	0.0	0.0
0	1.000	0.0	3.000	0.0	2.000	0.0	0.0	0.0
0	11.000	0.0	0.320	0.0	9.000	3.000	0.0	0.0
0	15.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
0	2.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
0	16.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
0	7.000	0.0	2.000	0.0	0.0	0.0	0.0	0.0
0	3.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
0	11.000	0.0	0.0	0.0	14.000	0.0	0.0	0.0
0	15.000	0.0	2.000	0.0	0.0	0.0	0.0	0.0
0	5.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
0	16.000	0.0	2.000	0.0	0.0	0.0	0.0	0.0
0	7.000	0.0	8.000	0.0	6.000	0.0	0.0	0.0
0	6.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
0	8.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
0	17.000	0.0	100.000	0.0	0.0	0.0	0.0	0.0
0	18.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CLOCK 278

BLOCK COUNTS

BLOCK	CURRENT	TOTAL
1	1	102
2	0	101
3	0	37
4	0	37
5	0	37
6	0	37
7	0	37
8	0	37
9	0	64
10	0	64
11	0	64
12	1	64
13	0	63
14	0	100

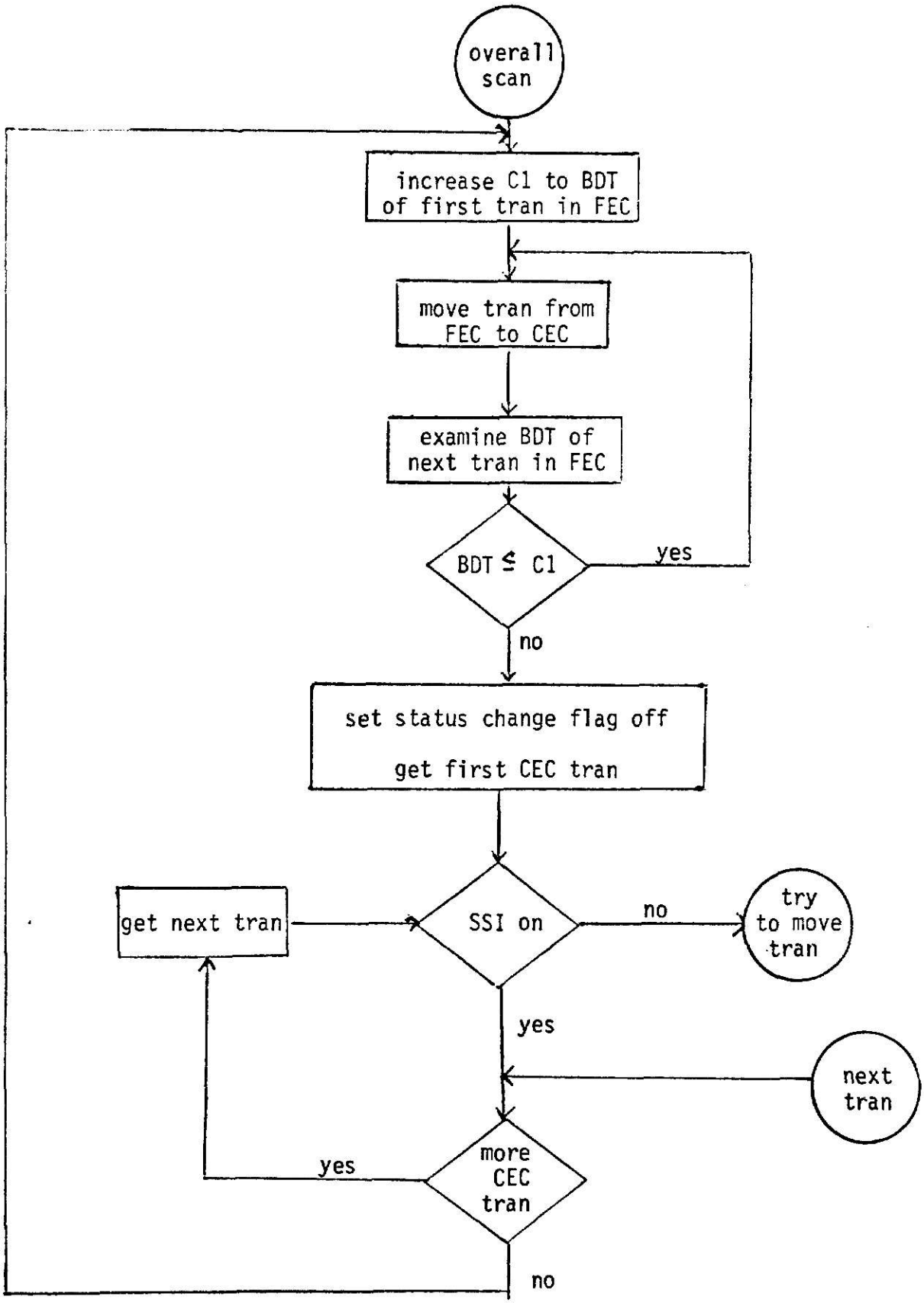
FACILITY	AVERAGE UTILIZATION	NUMBER ENTRIES	AVERAGE TIME/TRAN	SEIZING TRAN NO.
1	0.266	37	2.000	0

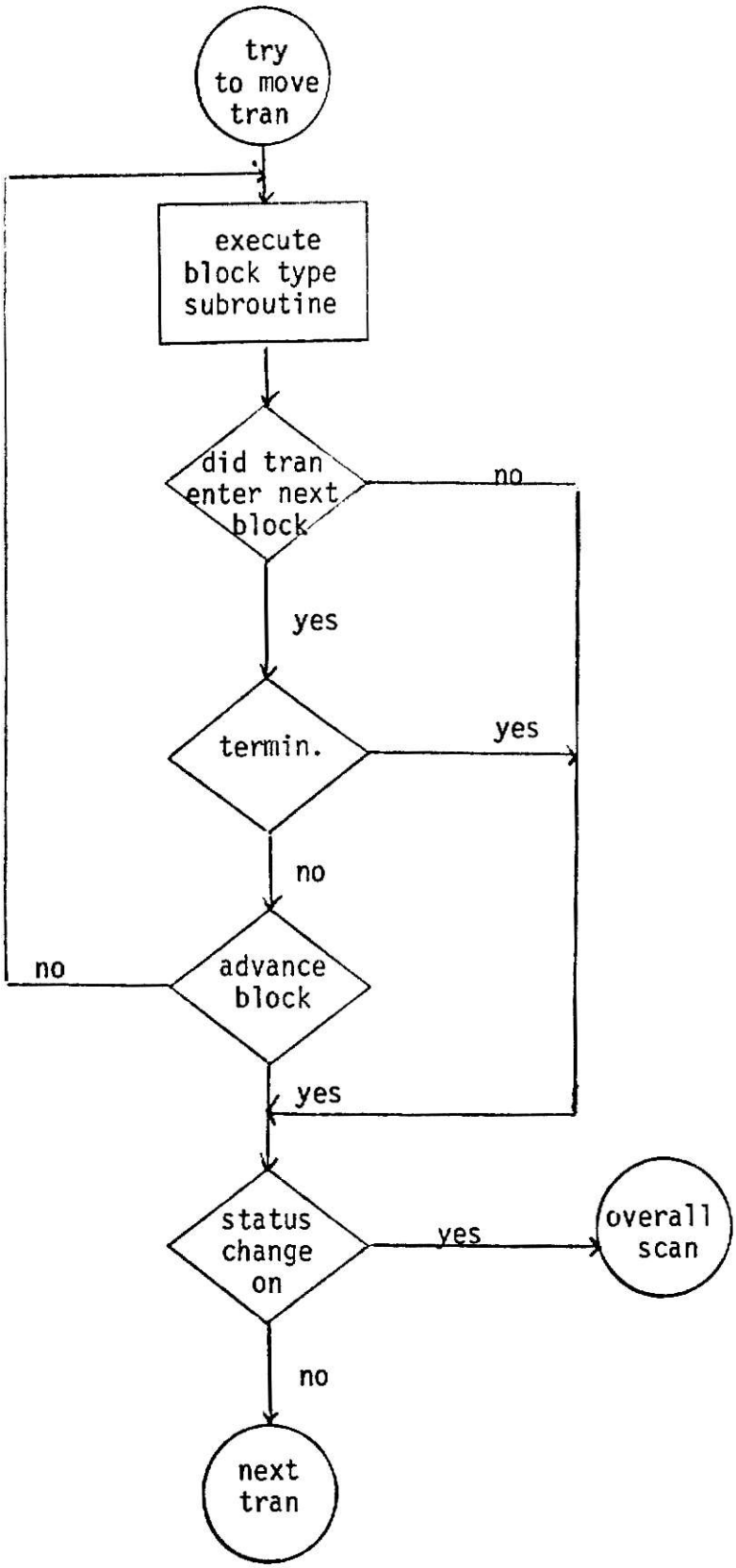
STORAGE	CAPACITY	AVERAGE CONTENTS	AVERAGE UTILIZATION	ENTRIES	AVERAGE TIME/TRAN	CURRENT CONTENTS	MAXIMUM CONTENTS
1	2	1.719	0.860	64	7.469	1	2

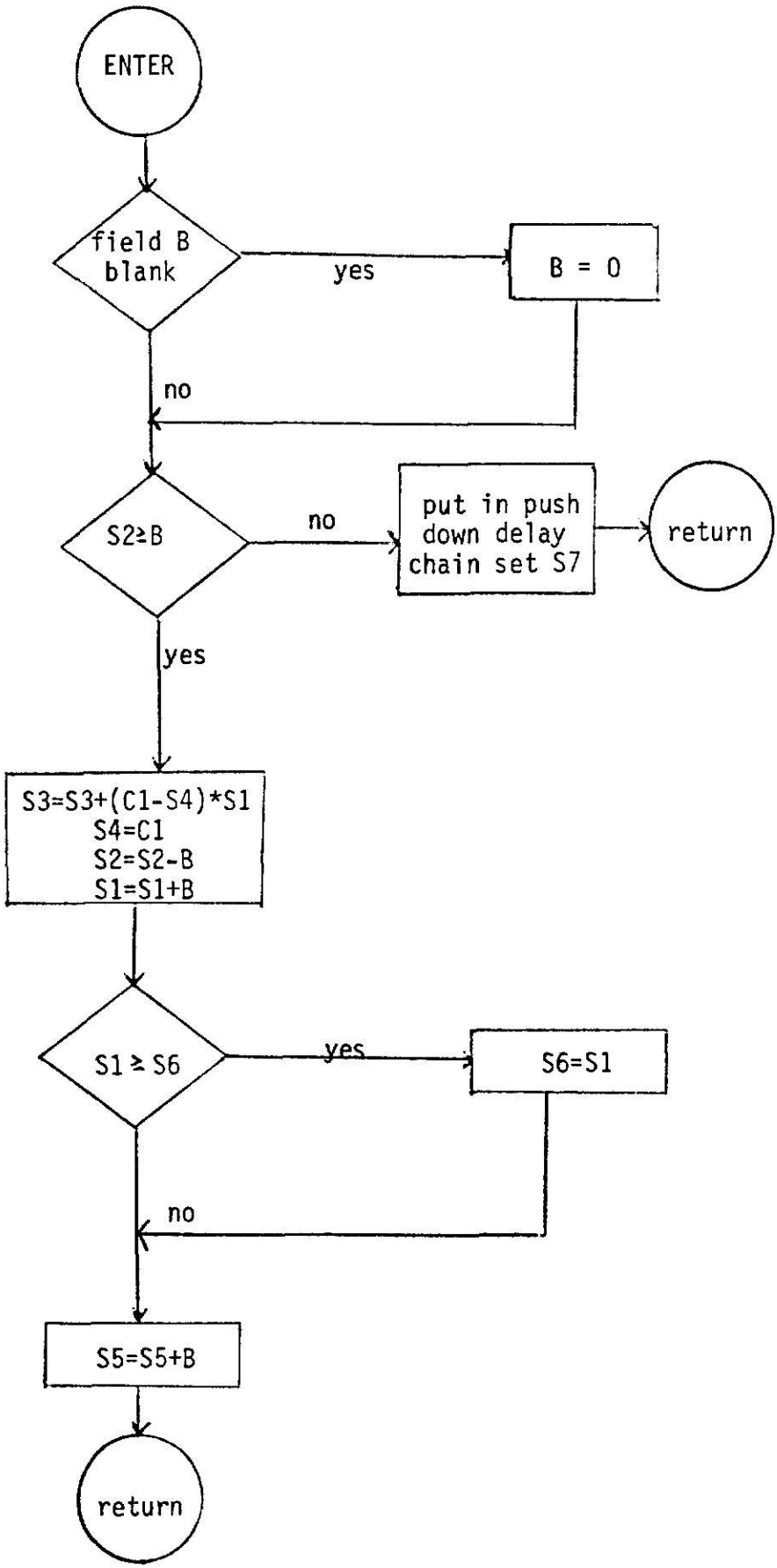
QUEUE	MAXIMUM CONTENTS	AVERAGE ENTRIES	TOTAL ENTRIES	ZERO ENTRIES	PERCENT ZEROS	AVERAGE TIME/TRAN	$ AVERAGE TIME/TRAN	CURRENT CONTENTS
1	1	0.007	37	35	94.595	0.054	1.000	0
2	4	0.791	64	29	45.313	3.438	6.286	0

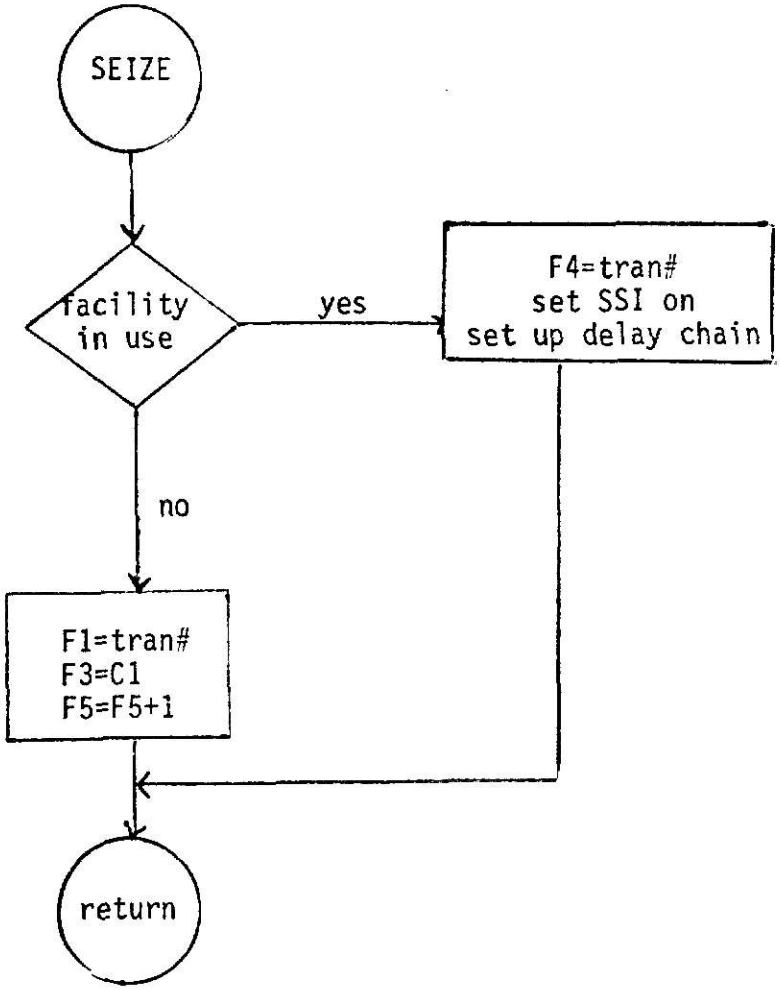
$ AVERAGE TIME/TRAN EXCLUDES ZERO DELAY ENTRIES

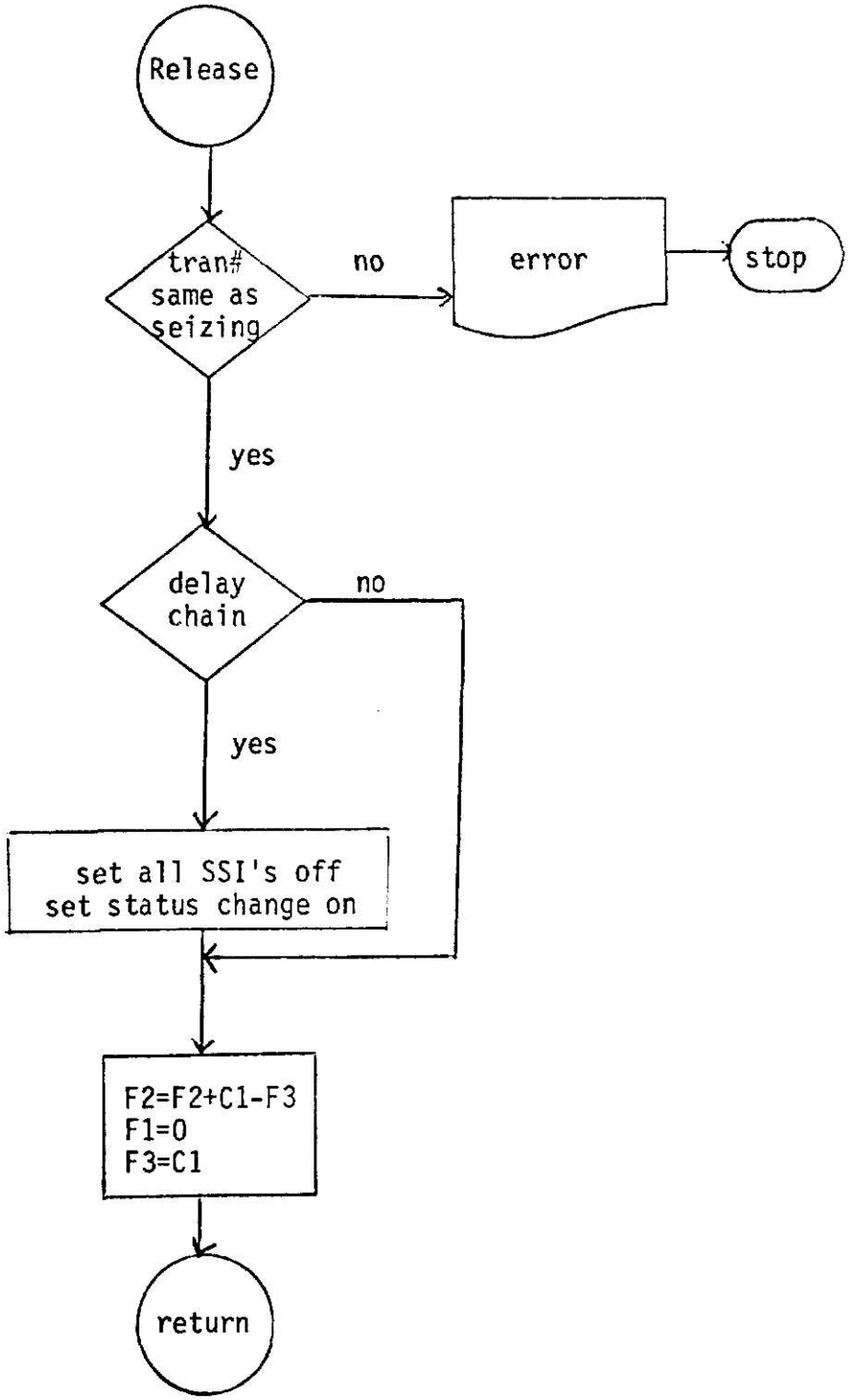
BLOCK TYPE FLOWCHARTS

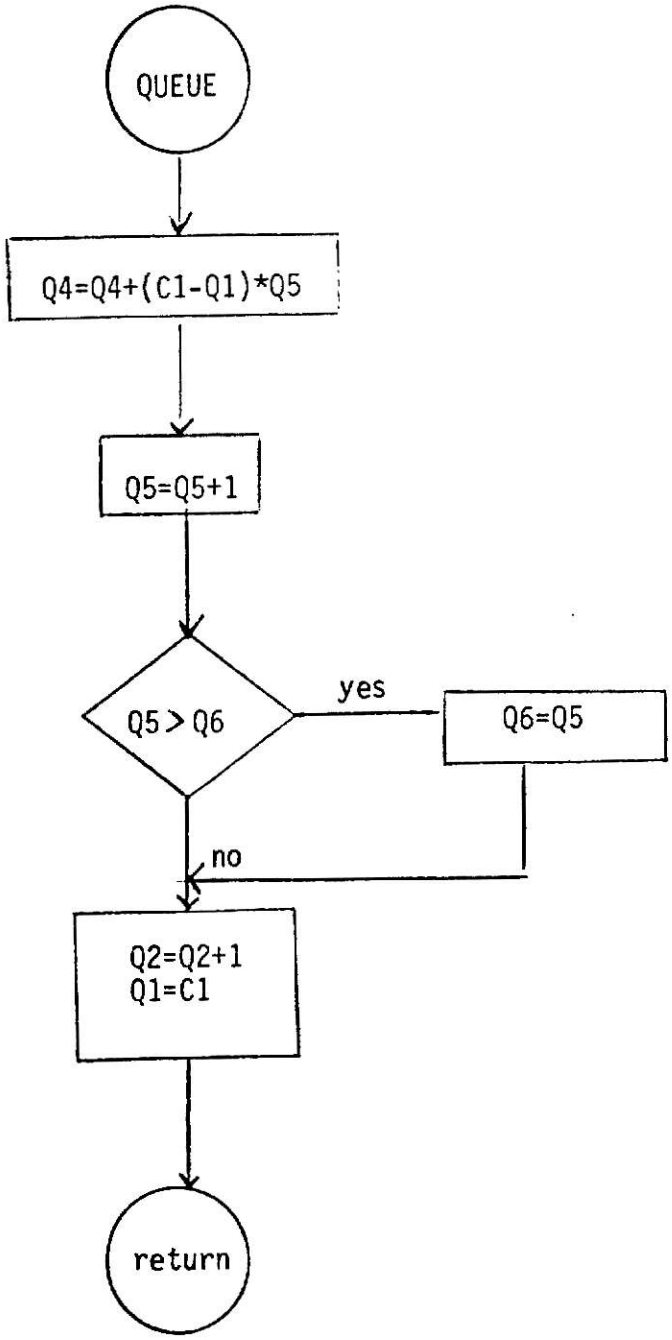


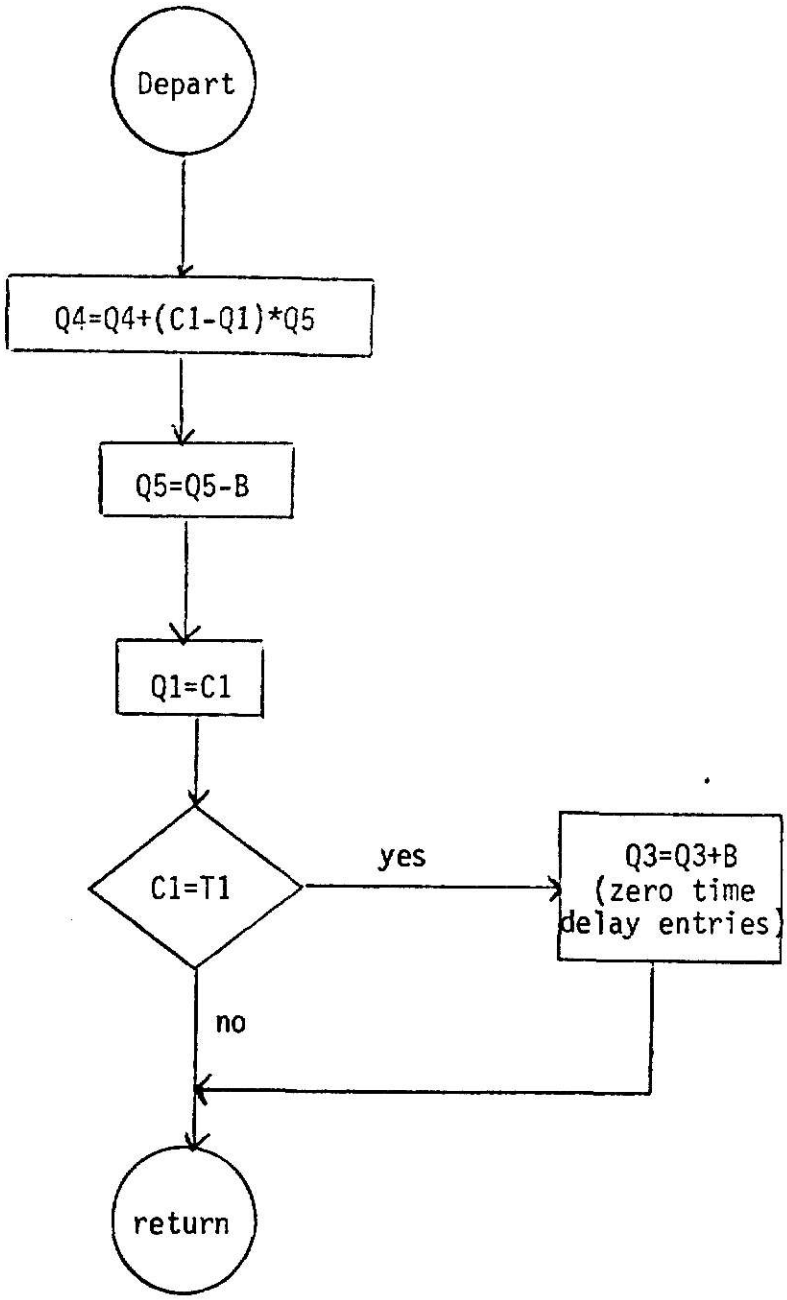

try to move tran
execute block type subroutine
did tran enter next block
no
yes
termin.
yes
no
advance block
no
yes
status change on
yes
overall scan
no
next tran

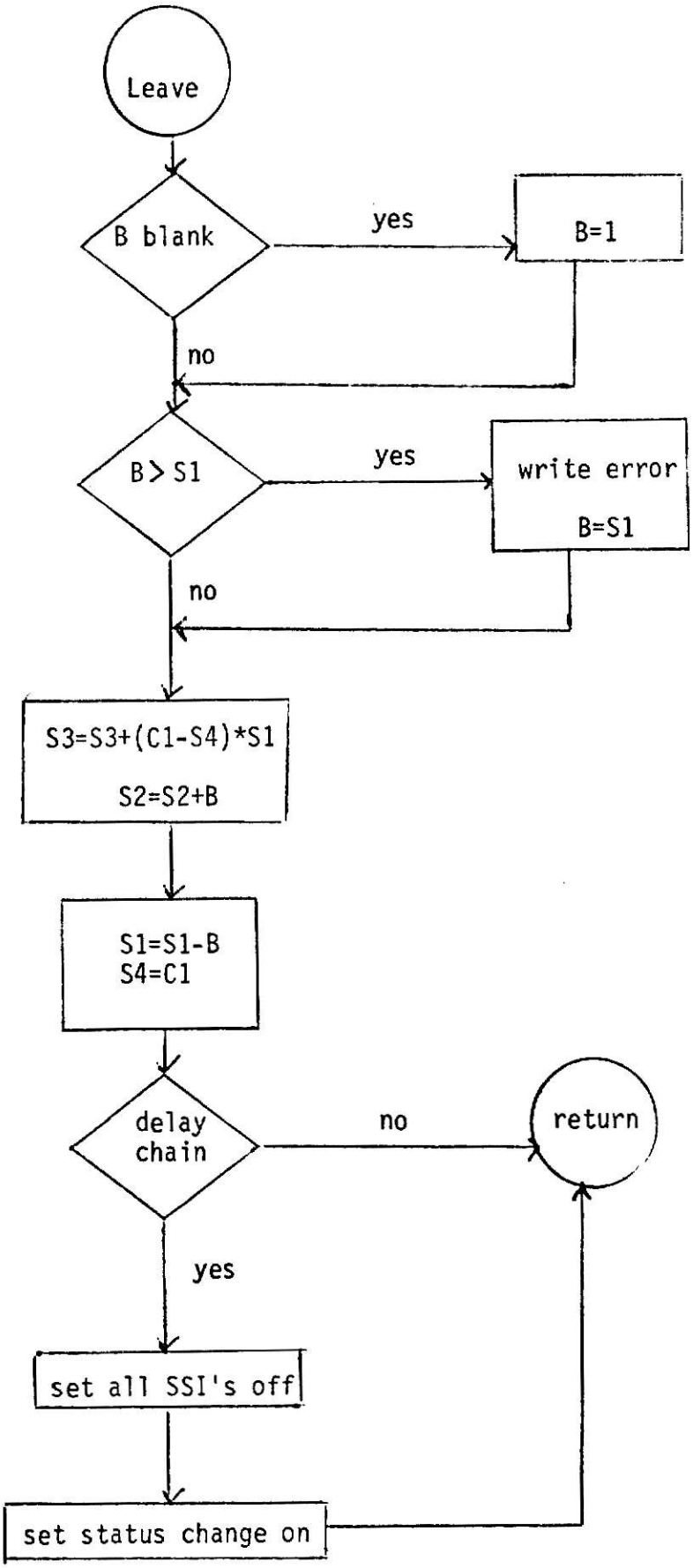

ENTER
field B blank
yes
B = 0
no
S2≥B
no
put in push down delay chain set S7
return
yes
S3=S3+(C1-S4)*S1
S4=C1
S2=S2-B
S1=S1+B
S1 ≥ S6
yes
S6=S1
no
S5=S5+B
return

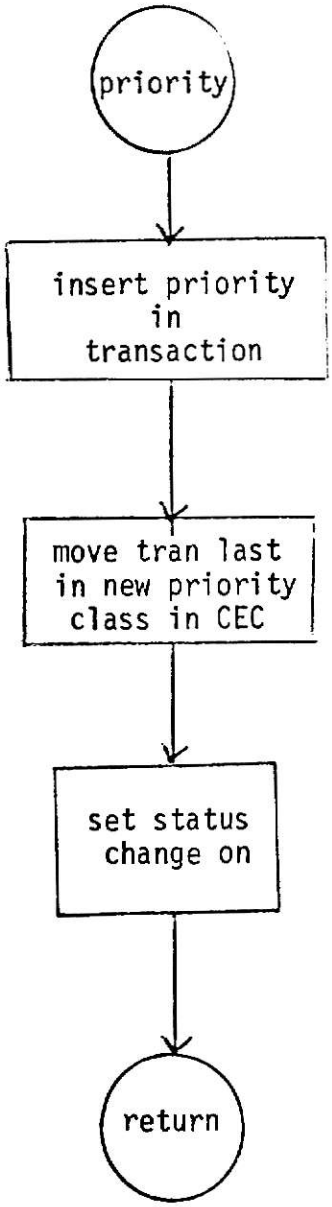

SEIZE
facility in use
yes
F4=tran#
set SSI on
set up delay chain
no
F1=tran#
F3=C1
F5=F5+1
return

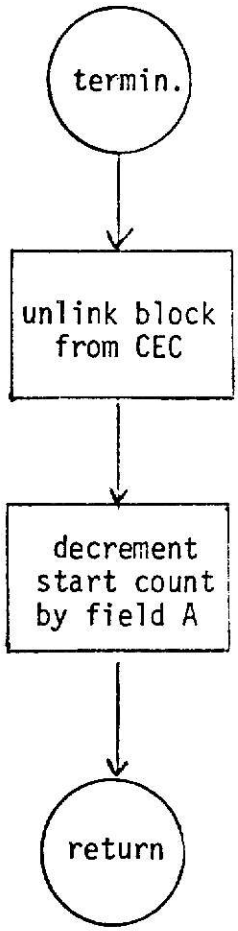

Release
tran#
same as
seizing
no
error
stop
yes
delay
chain
no
yes
set all SSI's off
set status change on
F2=F2+C1-F3
F1=0
F3=C1
return

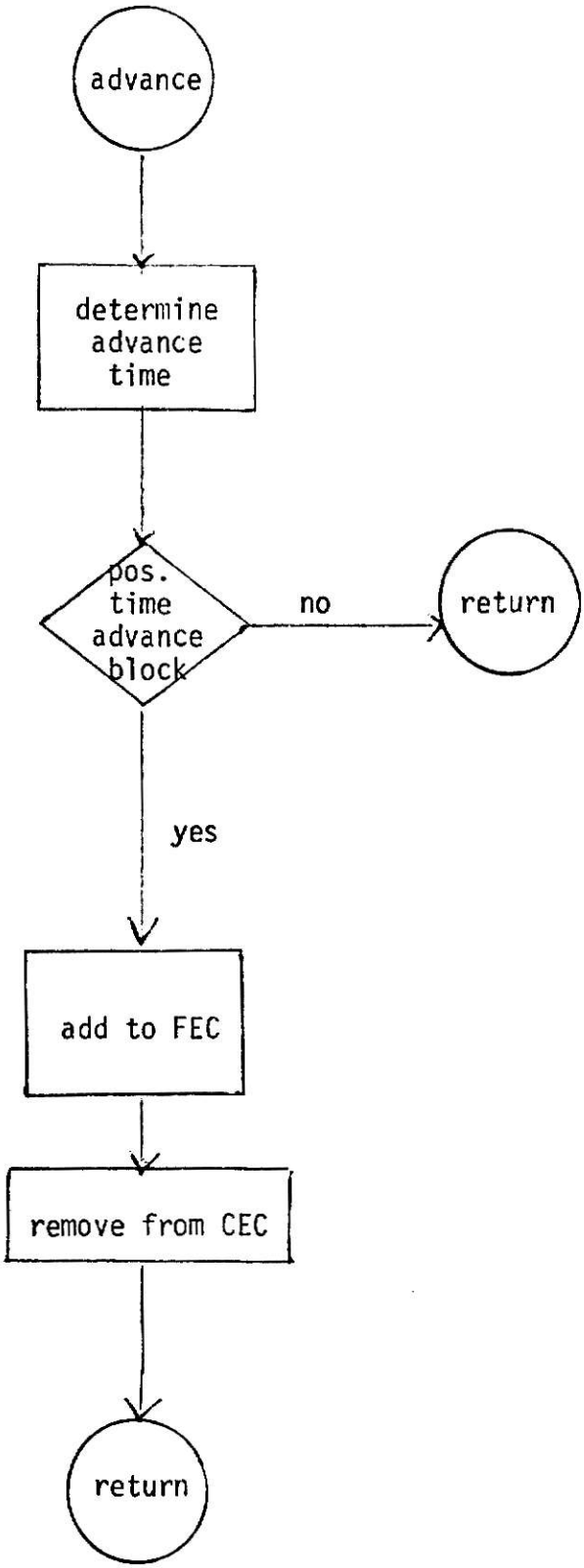

QUEUE
Q4=Q4+(C1-Q1)*Q5
Q5=Q5+1
Q5 > Q6
yes
Q6=Q5
no
Q2=Q2+1
Q1=C1
return

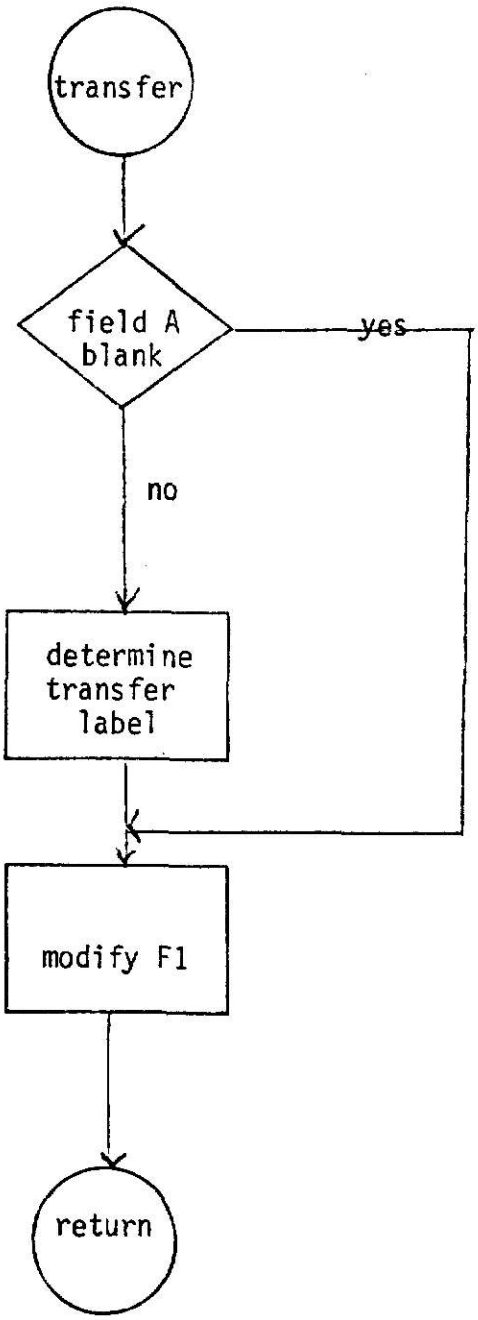

Depart
Q4=Q4+(C1-Q1)*Q5
Q5=Q5-B
Q1=C1
C1=T1
yes
Q3=Q3+B
(zero time
delay entries)
no
return

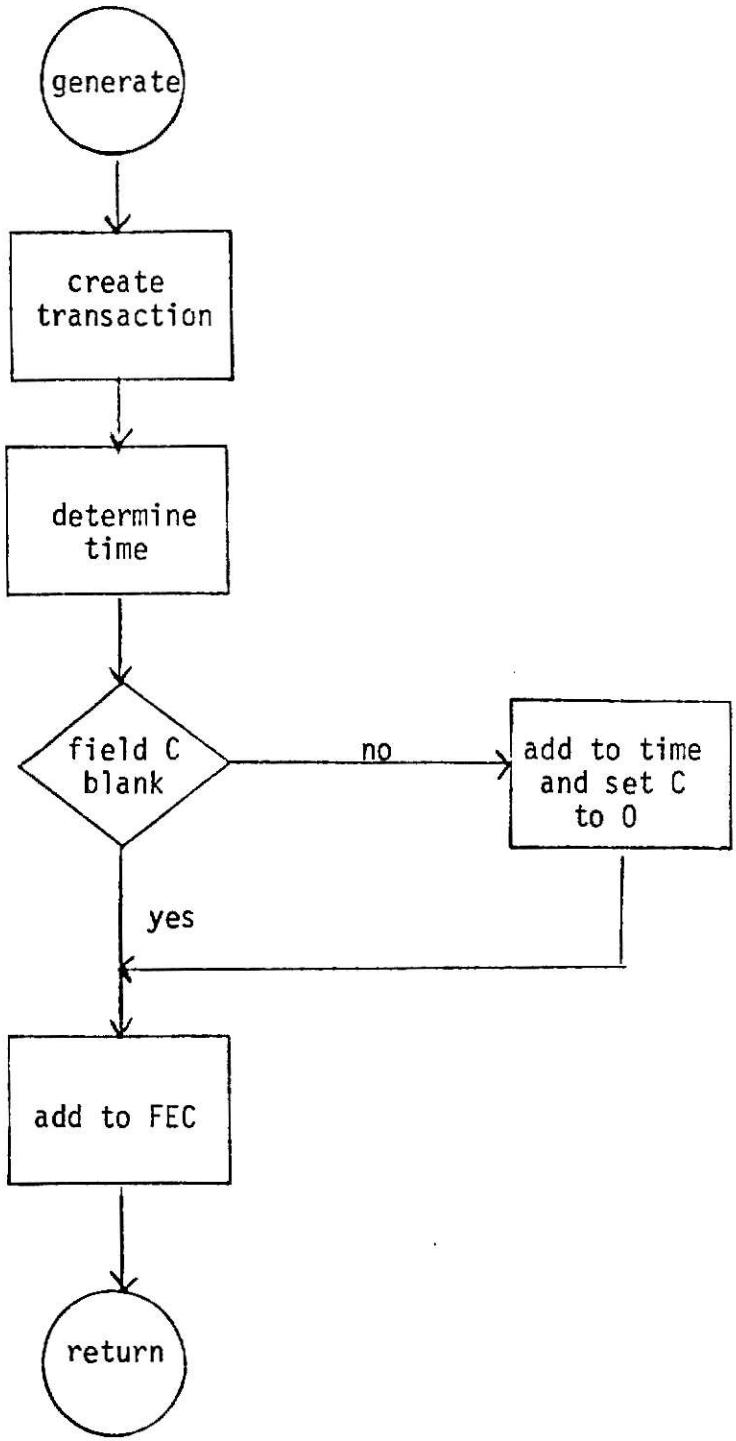

Leave
B blank
yes
B=1
no
B > S1
yes
write error
B=S1
no
S3=S3+(C1-S4)*S1
S2=S2+B
S1=S1-B
S4=C1
delay chain
no
return
yes
set all SSI's off
set status change on


priority
insert priority in transaction
move tran last in new priority class in CEC
set status change on
return


termin.
unlink block from CEC
decrement start count by field A
return


advance
determine advance time
pos. time advance block
no
return
yes
add to FEC
remove from CEC
return


transfer
field A blank
yes
no
determine transfer label
modify F1
return


generate
create transaction
determine time
field C blank
no
add to time and set C to 0
yes
add to FEC
return

IGPSS

A General Purpose Simulation

Language for the Interdata

by

Martha Hoflich

B. A. North Texas State University, Denton, Texas, 1970

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfullment of the

requirements of the degree

MASTER OF SCIENCE

Department of Computer Science

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1977

The purpose of this project is to provide a simulation language that is portable to different hardware configurations. It is designed primarily for use on the Interdata 8/32.

IGPSS is written in Fortran. It is based on GPSS and is used like GPSS with the following restrictions:

1. The input to IGPSS will be the anticipated output from the parser which remains to be written. The purpose of this project is to produce a program which will simulate a model given a set of strictly formatted input. A parser to be written as a future project will allow for more flexible input which more closely resembles the input required for GPSS.

2. The language statements available for use in IGPSS are a subset of those described in the GPSS/360 Introductory User's Guide (3).

3. Limits on number of parameters, facilities, etc. in IGPSS will be the same as the 64K version of GPSS.

The testing objective is to provide the same results using IGPSS as the same model would produce with GPSS. Documentation will consist of instructions for the use of IGPSS and any differences between it and GPSS.