ON-LINE SYSTEM SIMULATION

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SUMMARY

The objectives and description of a simulation model in the evaluation of On-Line Systems are discussed. In addition, the design and implementation of the model is considered. Finally, simulation results obtained from the model are presented.

INTRODUCTION

This paper discusses a discrete stochastic SIMSCRIPT simulation model developed by NCR to be used as a tool in the evaluation of On-Line Systems. The On-Line System (Figure 1) consists of remote terminals, line concentrators, communication multiplexors and a central computer system. The remote terminals communicate with a communication multiplexor via the line concentrators. The communication multiplexor contains its own local processor. This local processor is connected via an intercoupler to a central processor. Other similar local processor configurations may also be connected to the central processor system. The simulation model, however, consists of a single local processor configuration connected to a central processing system.

OBJECTIVES AND GENERAL DESCRIPTION

The simulation model was developed to evaluate the performance of both the software and hardware for proposed On-Line Systems. The model was designed so that a variety of systems configurations and user applications could be simulated without recoding major portions of the model. Such model flexibility was accomplished by modularizing and parameterizing the design of the simulation model.

The parameters which can be varied easily include the following:

- Application parameters: e.g., number of different transactions, transaction logic, user program times, etc.
- Hardware parameters: e.g., line speeds, scanning times, cycle stealing rates, etc.
- Configuration parameters: e.g., number of remote terminals assigned to each line concentrator, number of line concentrators connected to the communication multiplexor, etc.
- Software parameters: e.g., interrupt service times, verify times, etc.
- Traffic parameters: e.g., customer arrival rate, distribution of different transaction types, load distribution for different branches, etc.
- Number and types of different simulation reports.

The simulation process generates customers (transactions) with a specified Poisson arrival rate and assigns them to a remote terminal according to load distribution tables. The transactions then follow the sequence of events from remote terminals to multiplexor to central computer and back to the terminal depending on the type of transaction created. The model computes variable transmission times depending on the number of characters transmitted and accounts for variable interrupt service, verify, disc operation, and user times.

MODEL DESIGN

The model was designed to simulate a general On-Line System, although it was first applied in an on-line retail environment. Therefore, the following model design details are described with respect to a retail application.

The retail environment may be envisioned as a typical supermarket (Figure 2). The simulation model is concerned with the arrival of customers at the checkout counters and the procedures involved in servicing the customers. The cashier uses a remote terminal to record and control (credit authorization, department and class validation, etc.) customer sales. The terminal sends all pertinent sales information to a computer system where inventory control, sales statistics, etc., are maintained on a real-time basis.

Each retail transaction was segmented into a sequential string of basic messages. The transaction type depends upon the media of exchange (cash, charge), the number of items purchased, and whether or not a discount will be given. An example of a retail transaction would be a charge, two or more items, no discount transaction (Figure 3). The number of input and output characters shown in Figure 3 are used in the computation of the transmission times (between a remote terminal and a communication multiplexor) for each step in the transaction flow.

Each step in the transaction flow is represented by a basic message type. Each message type consists of a sequential string of basic hardware functions. An example of a message type is the sequence of hardware and software functions necessary to verify an account number. A graph with respect to time of the hardware and software functions is shown in Figure 4. The SIMSCRIPT flow chart of the same message is shown in Figure 5.

Hardware Functions

The model executes the message and function strings in an interpretive fashion, i.e., each element of the string is analyzed sequentially to determine the transaction flow and/or hardware function. This processing technique is the key in achieving the desired flexibility and is schematically shown in Figure 6.

The message strings are comprised of the following hardware functions:

A — Line concentrator turn on

The 'line concentrator turn on' function controls the requests for the line usage of all remote terminals and initiates the message processing.

B — Terminal-to-multiplexor transmission and vice versa

The model accounts for cycle stealing during terminal-to-multiplexor transmissions.

C — Local processor usage

Requests for local processor usage are processed according to a priority scheme; application processing is generally interruptable.

D — Local disc usage

The 'local disc usage' function controls and services the disc requests. The disc serves only one transaction at a time.

E — Local processor-to-central computer transmission and vice versa

Again, the model accounts for cycle stealing during processor-to-central computer transmission.

F — End of message function

The 'end of message' function releases the line concentrator and initiates the scanning mechanism which detects line requests from remote terminals that are assigned to the released concentrator.

Depending upon the type of transaction, each basic message consists of a specific mix of the hardware functions noted in steps B through E.

The initiation and completion of a hardware function may necessitate a request for executive software service. The executive service is performed by software functions which are independent of the message routines and their hardware functions. The executive software controls and initiates future hardware functions of the active system messages.

A simplified representation of the hardware functions B, C and D are shown in Figures 7, 8 and 9, respectively to illustrate some stages of the transaction process.

MODEL IMPLEMENTATION

The implementation of the model from its inception was accomplished in less than four months. The use of generalized NCR-developed SIMSCRIPT routines made this short implementation time possible. Some examples of these routines include the following:

- A debugging-validation package was inserted in the model allowing the user to check the internal model logic without performing extensive hand calculations. This validation aid is extremely valuable for a complex model for which there are no comparable analytical results obtainable.
- A generalized queuing routine was inserted in the model to allow the programmer to perform any standard queuing operation on all sets within the model by a single CALL statement.
- Finally, standardized data gathering and reporting routines were included in the model to provide a variety of simulation reports for the various interested parties. Furthermore, additional reporting requests can be included in the model with minimal programming effort.

SIMULATION RESULTS

The simulation model produces the following types of reports which the user can request at any desired time during the simulation:

- The systems performance characteristics are summarized in the system utilization report (Figure 10).
- System configuration and traffic data are illustrated in Figure 11.
- A number of different queuing and timing reports are produced by the simulation model. An example of a timing report is given in Figure 12.

CONCLUSION

The on-line system model designed by NCR proves that a specified hardware configuration and its software could be simulated for a specific application by use of a generalized model. Thus, it is possible to use the described model to simulate many different On-Line Systems. At the same time, the model can be used for both system design and system analysis of hardware and software.

THE SIMULATED SYSTEM

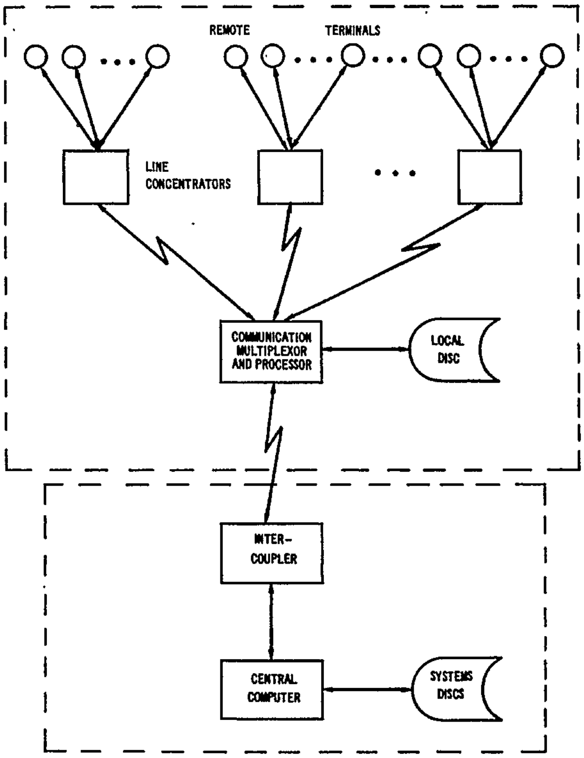

Fig. 1

RETAIL ENVIRONMENT

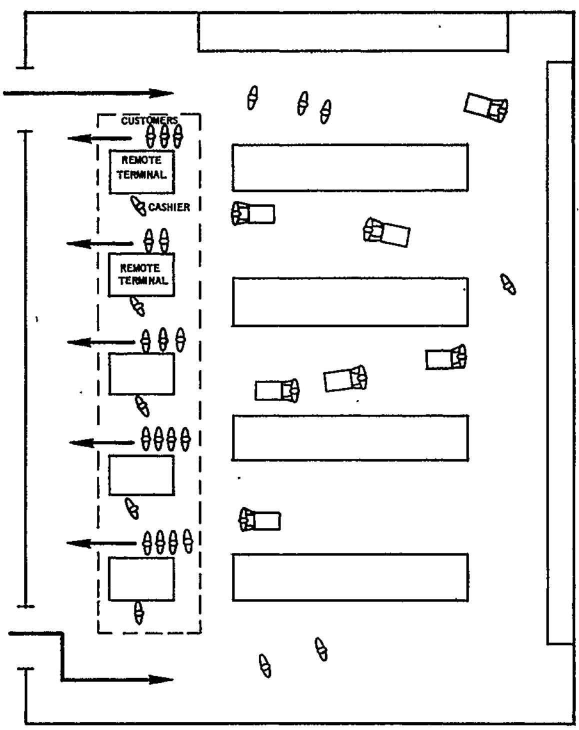

Fig. 2

TRANSACTION FLOW

EXAMPLE: CHARGE, 2 OR MORE ITEMS, NO DISCOUNT

STEP	MESSAGE NAME	AVERAGE INPUT CHARACTER	AVERAGE OUTPUT CHARACTER	MESSAGE TYPE
1	QUALIFICATION – Type of transaction – Charge Credit – No discount – Clerk number	13	4	3
2	REQUEST	6	24	3
3	MERCHANDISE – Department No. – Class No. – SKU No.	16	4	4
4	REQUEST	6	21	3
5	PRICE			
	– Select Single Price	12	5	
	– Select Quantity Quantity Price	13	30	
6	TOTAL	8	21	3
7	REQUEST B	6	13	3
8	REQUEST C	6	19	3
9	ACCOUNT NO.	14		2
10	REQUEST 1	6	4	3
11	REQUEST 2	6	11	3
12	REQUEST 3	6	30	5

Fig. 3

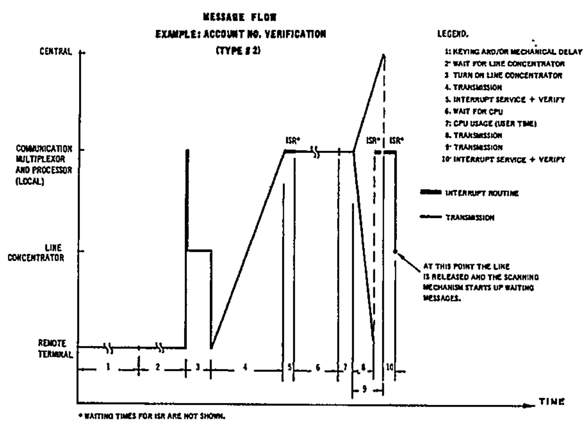

Fig. 4

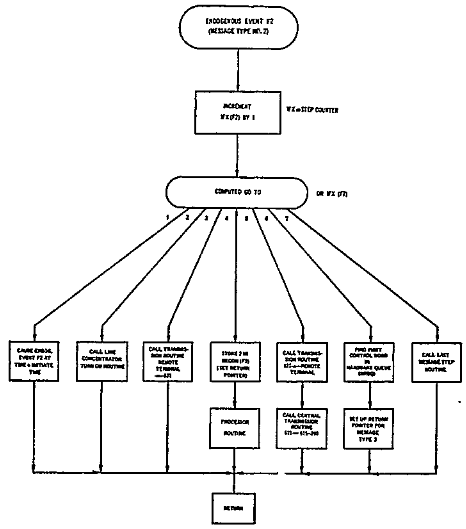

Fig. 5

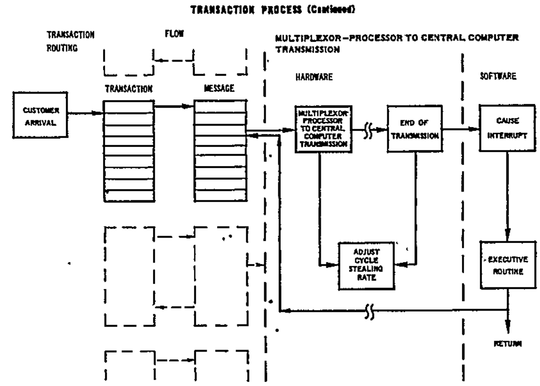

Fig. 6

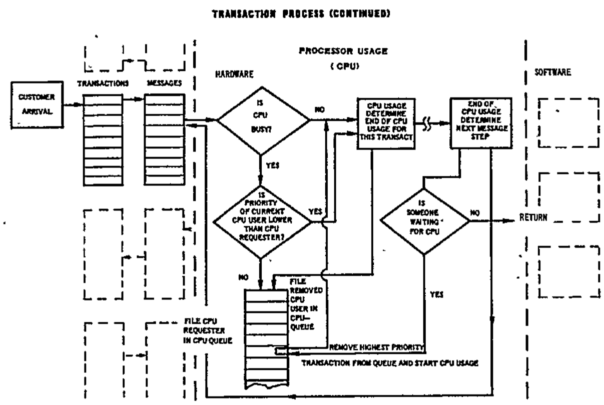

Fig. 7

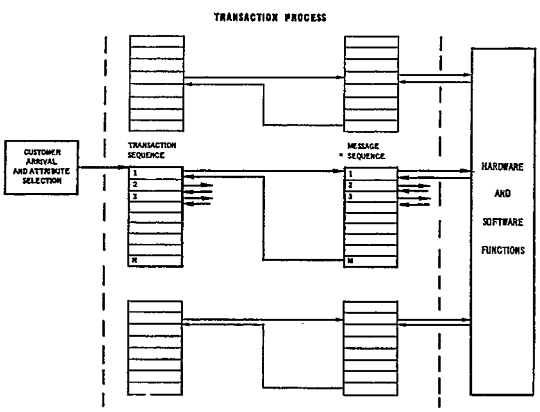

Fig. 8

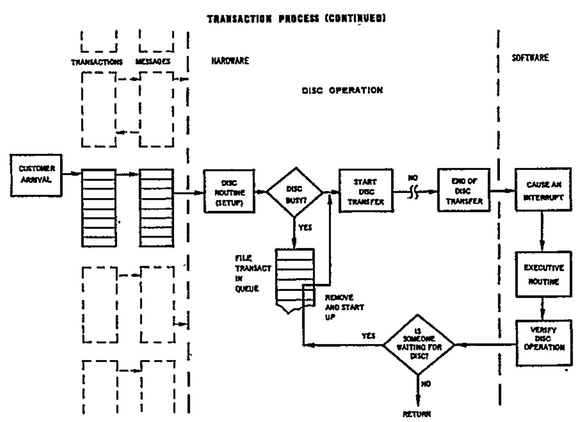

Fig. 9

SYSTEM UTILIZATION FROM 60.00000 SEC. TO 120.000000 SEC. RETAIL SYSTEM B1

PAGE 1

TOTAL ACCUMULATED CPU TIME 18.270650 SEC.

AVERAGE CYCLE STEALING RATE 0.092074

ARRIVAL RATE FOR TRANSACTIONS

SPECIFIED 2.269 T/SEC.
ACTUAL 2.250 T/SEC.

AVERAGE WAITING TIMES

FOR CUSTOMERS AT POES 0.115044 SEC.
FOR SEGMENTS AT LINE CONCENTRATORS 0.025602 SEC.

TOTAL ACCUMULATED SOFTWARE TIME 11.399517 SEC

TOTAL ACCUMULATED DISC SERVICE TIME 41.060722 SEC

CHANNEL UTILIZATION 12.212154 SEC

Fig. 10

REMOTE CONFIGURATION REPORT AT 120.000000 SEC RETAIL SYSTEM B1

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BRANCH NAME	LINE CONCENTRATOR	POES NUMBER	POES ASSIGNMENT	TRANSACTIONS ARRIVED	TRANSACTIONS ON-HAND	TRANSACTIONS PROCESSED	SEGMENTS ARRIVED	SEGMENTS PROCESSED	UTILIZATION TIME	TRANSFER TIME
CITY 1	1	14	FROM 1 TO 14	19	2	12	106	106	29.792241	26.857903
CITY 1	2	14	FROM 15 TO 28	17	5	15	133	132	37.228012	33.547452
CITY 2	3	14	FROM 29 TO 42	10	2	5	54	53	14.976359	13.423321
CITY 2	4	14	FROM 43 TO 56	12	10	17	136	136	38.248836	34.460579
CITY 3	5	14	FROM 57 TO 70	10	7	10	122	122	33.941176	30.530543
CITY 4	6	14	FROM 71 TO 84	10	12	13	156	155	43.234165	38.765843
CITY 5	7	14	FROM 85 TO 98	12	4	8	103	102	26.898042	23.742866
CITY 6	8	14	FROM 99 TO 112	14	5	11	144	143	37.308559	32.987523
CITY 6	9	7	FROM 113 TO 119	4	0	3	35	35	9.267147	8.144701
CITY 7	10	14	FROM 120 TO 133	17	5	10	167	166	44.141746	39.168211
CITY 8	11	14	FROM 134 TO 147	10	9	9	156	155	40.625233	36.082695
TOTALS AND AVERAGE TIMES				135	61	113	1312	1305	32.332865	28.882876

Fig. 11

RUN NO... RETAIL SYSTEM B1

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TABLE 3 ----------TRANSACTION 2 (CASH, 2 OR MORE ITEMS, NO DISCOUNT) SERVICE TIME

ENTRIES IN TABLE	MEAN VALUE	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	REPORTING TIME
26	48.169486	15.429392	29.004923	78.755524	120.0000 0

LOWER CLASS LIMIT	UPPER CLASS LIMIT	OBSERVED FREQUENCY	PER CENT OF TOTAL	CUMULATIVE PER CENT	REMAINING PER CENT
-99999.999999	14.999999	0	0.000	0.000	100.000
15.000000	18.999999	0	0.000	0.000	100.000
19.000000	22.999999	0	0.000	0.000	100.000
23.000000	26.999999	0	0.000	0.000	100.000
27.000000	30.999999	7	26.923	26.923	73.077
31.000000	34.999999	0	0.000	26.923	73.077
35.000000	38.999999	3	11.538	38.462	61.538
39.000000	42.999999	1	3.846	42.308	57.692
43.000000	46.999999	0	0.000	42.308	57.692
47.000000	50.999999	4	15.385	57.692	42.308
51.000000	54.999999	2	7.692	65.385	34.615
55.000000	58.999999	3	11.538	76.923	23.077
59.000000	62.999999	2	7.692	84.615	15.385
63.000000	66.999999	0	0.000	84.615	15.385
67.000000	70.999999	1	3.846	88.462	11.538
71.000000	74.999999	1	3.846	92.308	7.692
75.000000	999999.999999	2	7.692	100.000	0.000

Fig. 12