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Feasibility Study for a Remote Terminal Central Computing Facility Serving School and College Institutions.  
Volume I, Functional Requirements.

International Business Machines Corp., White Plains, N.Y.

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The economic and technical feasibility of providing a remote terminal central computing facility to serve a group of 25-75 secondary schools and colleges was investigated. The general functions of a central facility for an educational cluster were defined to include training in computer techniques, the solution of student development problems in mathematics and the sciences, and basic administrative tasks. An analysis of task requirements in terms of demand estimates was followed by the selection of equipment and systems structure for four model regions differing in number of schools and average enrollment. The delineated systems were then validated by sampling actual requirements of a geographic area approximating one of the model regions and fitting derived demand requirements to system capacities. The Computer System Simulator program developed by IBM was also employed to evaluate the system's workload capacities and determine probable response times. Both simulation techniques indicated the system configurations would be entirely feasible and within given cost ranges. A recommendation was made for further study and pilot implementation. Details of cost estimates and simulation procedures are included in appendices. (SS)

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**IBM**

**Feasibility Study for  
a Remote Terminal Central Computing Facility  
Serving School and College Institutions  
Volume I: Functional Requirements**

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## FOREWORD

This study was prepared over a four-month period by an IBM study team selected from throughout the company. The team was composed of IBM personnel from the following organizations: Instructional Systems Department, IBM Data Processing Division; GEM Regional Headquarters of the same division; IBM Systems Development Division; Instruction Systems Development Department, IBM Corporate Staff; and Schools Development Center, IBM Data Processing Division Headquarters. In addition, numerous consultants from within the various divisions and departments of the IBM Corporation served from time to time.

The findings of this study represent the best technical judgments of the members of the IBM study team, and do not represent any official statement of policy of the IBM Corporation. Furthermore, the discussions of data processing equipment and programming systems are in response to the specific objectives of the USOE Study Contract, and in no way should be considered product commitments or specific development plans of the IBM Corporation.

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## INTRODUCTION

On April 20, 1967, the U.S. Office of Education awarded the International Business Machines Corporation a contract to conduct a feasibility study for a remote terminal central computing system to serve secondary schools and colleges.

The contract was awarded to IBM on the basis of its proposal responding to a formal advertised request for proposal dated December 30, 1966, and a letter of solicitation from the Office of Education, received January 9, 1967. Work began on May 1, 1967 and was concluded on September 7, 1967.

The primary purpose of the study was to determine the economic and technical feasibility of providing modern data processing services to large numbers of students in order that such students may become familiar with modern data processing techniques. As a secondary purpose, the procurement specified that "routine" administrative functions normally accomplished by data processing equipment should be supported by the same system.

The statement of work further required that the Remote Terminal Centralized Computing System should be capable of providing the following services:

1. Problem Solving. Compute solutions to student problems in mathematics, science, and other academic subject areas.
2. Data Processing Training. Train students in the use of standard high-level programming languages, such as FORTRAN, COBOL, and PL/I.
3. Administrative Data Processing. Perform student scheduling functions, maintain school records, prepare reports, and so forth.

The statement of work also required that "computing support to the students will include complete diagnostics in source language and a job turn-around time of less than five minutes. For administrative data processing tasks, the system will provide only standard programs which are common to all users, and can tolerate longer turn-around times."

Additional factors that were to be considered during the study were presented at the bidder's conference on January 19, 1967 in Washington, D.C. A summary of these additional factors follows:

- The study will determine the economic parameters of supplying computer services to small- and medium-size educational institutions through remote terminals from a large central computing center. Cost acceptability is a major factor in establishing feasibility of a computing system designed for the school and college population.

- No computer-assisted instruction should be contemplated for this system unless it is concerned with the teaching of standard high-level programming language, and then only to the extent that it is economic to do so.

- The 50 educational institutions should be considered to be secondary schools, junior colleges, and four-year colleges, varying in size from 500 to 5000 students. These institutions would be located within a 100-mile radius. (Subsequent to the award of the contract, USOE required that no four-year higher educational institution should be included as users of the system.

- Equipment specifications need not relate to items concurrently available, and may include items to be first delivered within from 18 to 24 months.

The scope of work was specified in the request for proposal as follows:

1. Collect data on present educational usage.
2. Estimate input and output and computational requirements necessary to adequately furnish the services required.
3. Carry out two preliminary designs as described below:
  - a. Keyboard-type student consoles operated on a time-shared basis.
  - b. Moderately high-speed readers and printers operating on a multiprogrammed basis. This system is to provide for a high-priority program to run until such time as it must wait for peripheral equipment operations, at which time the next-highest priority program would run until it must wait, and so on. At such time as the peripheral operations are completed on a suspended program, it would run again.
  - c. For both systems the following specifications were required:
    - (1) Communications system parameters, including the buffer sizes
    - (2) Fast memory speed and size
    - (3) Auxiliary memory size, access, and transfer rates
    - (4) Central processor parameters and utilization
    - (5) Average turnaround times for various usages
    - (6) Approximate cost of the facilities reflected in the preliminary designs
    - (7) A recommended or appropriate billing system which would be compatible with such a facility

The configuration for the remote terminal computing system involves equipment installed at the computer center and equipment installed at

schools, junior colleges, and administrative centers. Computer center equipment comprises a central processing unit with main storage and secondary storage facilities. Secondary storage consists of high-speed, random access disk devices; low/medium speed, random access cell devices; and low speed, sequential access tape devices. Input/output facilities consist of online printer, card read, card punch, and document reader units.

The computer center communicates with the remote sites through a communication control unit that uses leased or rented communication facilities.

Remote site equipment includes administrative terminals and instructional terminals.

Administrative terminals consist of a keyboard and attached typewriter printer, card reader, and card punch units. Instructional terminals are low-cost typewriter terminals.

Users of the administrative terminal include both teachers and administrators and students in data processing training programs. Teachers and administrators use the system to access certain files for a wide variety of administrative tasks. Data processing students use the capabilities of the terminal to enter punched card programs and to obtain printed program runs. The terminal is also used for an instructional terminal.

Users of the instructional terminal are teachers and pairs of students who use the terminal for 20-minute problem-solving sessions in science and mathematics. Through the use of a special problem-solving language, users operate the terminal in a conversational mode for a quick interchange of questions and answers.

Excess data processing training workloads and problem-solving workloads are handled by overnight batch processing. Overnight batch processing involves two methods. In the first method, student programs and problems are keypunched using the administrative terminal's card punch in an offline mode. Cards are then read and sent via the terminal to the computer center for processing overnight; results are transmitted from the computer to the terminal printer by the following morning. Cards

may also be sent to the computer center via a carrier, who may also pick up printed results from the previous overnight processing cycle. The combination of processing options provides reasonable access to the computing center for both administrative users and students at a reasonable cost.

Administrative terminal users have direct access to central student, staff, curriculum, property, and fiscal information files for queries and a wide variety of reports as defined by the needs of the individual schools and administrative centers.

System configuration will vary with the composition of school regions. Enrollment figures, distance between the locations, and number of locations served have an impact on equipment characteristics and number of terminals required. These factors, in turn, affect system costs.

Three model regions (A, B, C) and a case study region defined by IBM, and a USOE region, were analyzed; equipment was selected on the basis of the individual needs of the regions. Costs were then projected, and the system configuration was simulated for all five regions. Simulation results on the percentage of equipment utilization for the five regions confirmed the technical feasibility of the system configurations.

Cost projections confirmed the economic feasibility objectives established early in the study.

The measure of "economic feasibility" was calculated as follows:

1. Estimate total system cost (excluding initial development expense).\*
2. Deduct costs applicable to administrative use as follows:
  - a. Business services: 50¢/elementary student, \$1.50/secondary student
  - b. Pupil administrative services: 60¢ for 37.5% of elementary students, \$4.00 per secondary student
3. The remainder represents costs for instructional use. Such costs should not exceed one to two percent of the school district's total operating costs, based on a national average operating cost of \$532 per student.

\*"Operating costs" are defined to include computing equipment and maintenance expense on a rental equivalent basis, communication facilities, and manpower and supplies to directly support the system. They exclude capital and overhead expenses for facilities in which to house the central computer, assigned general and administrative costs, startup costs, and initial development expense. They also exclude costs for instructional materials.

Table 1 correlates the five regions studied with equipment requirements, costs, and simulation results.

Table 1

## SUMMARY

Region Statistics	A	B	C	USOE	Case Study
Total Enrollment K-12	160,000	320,000	480,000	400,000	404,642
Total Enrollment 9-14	42,000	84,000	126,000	104,000	93,383
Total Locations	27	54	81	54	61
Total Annual Problem Solving Sessions	273,060	546,120	819,180	674,400	-
Total Annual DP Problem Sessions	42,400	84,800	127,200	104,400	-
Total Problems	315,460	630,920	946,380	778,800	507,000
Total No. Instructional Terminals	58	116	174	156	147
Total No. Administrative Terminals	29	58	87	58	69
Total Region Operating Expense	\$86,184,000	\$172,368,000	\$258,552,000	\$214,928,000	\$247,018,400
Total Annual System Costs	\$791,900	\$1,202,600	\$1,677,000	\$1,455,600	\$1,246,069
Ratio System Cost to Operating Expense	0.86%	0.70%	0.65%	0.68%	0.50%
Administrative Costs Assigned	\$307,000	\$614,000	\$921,000	\$688,100	\$704,811
Instructional Costs Assigned (9-14 students only)	\$484,900	\$588,600	\$756,000	\$767,500	\$541,258
Ratio Instructional Cost to Operating Expense (9-14 students only)	2.2%	1.3%	1.1%	1.4%	1.0%

## PART 1: CONDUCT OF STUDY

This part outlines the approach to the study in terms of the individual tasks performed, summarizes the results of each task, and presents the conclusions and recommendations.

### TASK DEFINITION

To define a system that meets all instructional and administrative objectives and the overall system requirements, seven study task areas were established:

- Task 1. Establish general system requirements.
- Task 2. Identify and quantify the user population for the instructional task.
- Task 3. Identify and quantify the user population for the administrative task.
- Task 4. Perform a functional analysis of the instructional and administrative tasks to be performed.
- Task 5. Design a computing system to accomplish the instructional and administrative tasks, including selection of equipment types, manpower requirements, and administrative file structures.
- Task 6. Develop preliminary system specifications and estimate system costs.
- Task 7. Validate the preliminary system specifications.

### SUMMARY OF RESULTS

#### Task 1--General System Requirements

These four general system requirements represent the first level of precision in defining the system:

Acceptability. The introduction of the system into the schools and colleges should cause an absolute minimum of disruption to current plans and programs in the instructional and administrative areas.

Responsiveness to Changes. A very large, diverse, and changing user population as typified by school and college students requires a system that can readily adapt to its changing needs.

Economic Practicality. The costs of the total system must be consistent with current and planned educational expenditures for innovative programs.

Operational Readiness and Efficiency. The system must be maintained in a high degree of operational readiness, commensurate with cost

objectives. The system should handle the workload projected over the next five years with the highest possible efficiency.

#### Task 2--Instructional Users

Instructional users include both students and teachers in the areas of problem solving and DP training.

Problem Solving. Student users need computing services for problem-solving support, including computation, algorithm development, and simulation for physical experience and social science games in the following ways:

- "Conversational" access to the computer during normal school hours
- Courier service for transporting lower-priority student jobs to the central computer for overnight batch processing with the processed output transmitted back to the school via a school terminal

Teachers, curriculum specialists, and related members of the instructional staff need the same type of remote terminal services to support in-service teacher training, aid in preparation of lesson materials, and assist in classroom demonstrations.

For maximum student access and ease of communications with the computer for problem solving, the system should provide the facilities necessary to support a specialized problem-solving language that has the following characteristics:

- Rapid response to all entries
- Freedom from spacing restrictions on input
- Brief and self-explanatory error messages
- Easy correction of keystroke errors before transmission
- Easy data entry procedure
- Access to a common library of frequently used programs and functions
- Ability to save work-in-progress (at a subsequent session a student can begin where he left off previously)
- Protection against accidental destruction of saved files
- Simple terminal commands
- Easy recovery from any inadvertent error in terminal operation

DP Training. For data processing vocational training support, programs in card form should be entered into the computer via a card reader attached to a school administrative terminal or via courier service for at least overnight

processing of programs. Conventional high-level language processors are available for the control computer. DP vocational training does not require the use of a remote terminal in an immediate interactive mode.

For DP familiarization training, little or no access to the system is required; computer demonstrations will satisfy the needs for this type of training.

### Task 3--Administrative Users

Administrative users of the system include members of the boards of education, school administration, educational staff, clerical and service staff, and others. These users are grouped into five areas: the public users, the administrative center, the school office, the school staff, the student, and the parent. These users require access to large volumes of data. Generalized data management facilities are needed to allow individual users to input data and prepare reports according to their own specifications. Security locks are also needed to preserve the integrity of the data against unauthorized usage.

### Task 4--Functional Task Analysis

Problem Solving. Conversational versus remote batch entry of the problem algorithm from the terminal were considered, with a review of the equipment and costs required for each. The conversational mode is the proposed method both from the standpoint of performance and cost.

DP Training. Choices involved the means by which student programs would be compiled and executed. Both remote terminal batch entry and central site entry of "jobs" were selected to accomplish this task.

Administrative. System functions to support administrative requirements are defined as a terminal-oriented school information system. Administrative tasks cannot be performed on a conventional application-by-application basis. All data wherever collected and wherever needed should be used as elements in a single integrated system. Such information should be collected close to the source only once; the system should accept such data in whatever form it is most conveniently available.

The requirements of a generalized system were reviewed, and a design preference was given to the Generalized Education Management System

under development as part of the Oregon Total Information System.

### Task 5--Definition of Computing System Equipment

The instructional and administrative terminals, the computer, and the shared use of communications lines by multiple terminals were defined in terms of equipment specifications. Administrative file structures for student, staff, fiscal, property, and curriculum files were also defined. Manpower requirements and preliminary cost estimates completed the effort on this task.

### Task 6--Preliminary System Specification

General system specifications were written to meet the total requirements for instructional and administrative tasks and their projected workloads. The central processing unit, main storage, auxiliary storage, input/output controls and channels, communications control unit, programming systems, and remote terminals were defined, and detailed cost estimates were prepared for the USOE region, three IBM-defined regions, and an actual case study region. (The preliminary system specification is contained in Volume II.)

### Task 7--System Validation

Validation techniques incorporated two elements: First, a real geographic region was selected in which to gather data; with the collected data a theoretical systems implementation for the area was postulated. The Washington, D. C. metropolitan area was selected as the closest to the headquarters of the study team. This area includes a great variety of characteristics, including two states and the District of Columbia, a mix of large and small school districts, and homogeneous and heterogeneous student populations.

A second element of the validation was to simulate the selected system for the four model regions and the case study region. The method employed used the Computer System Simulator available within the IBM Corporation. The simulator modeled the teleprocessing and multi-programming environment of the proposed system, and by closely adhering to the step-by-step performance expected, the study team tested and evaluated the workload capabilities of the proposed system. Response times that would compare to real life were then determined.

After comparing intermediate simulation results with the performance of a live problem-solving system, the study team validated the system design.

## CONCLUSIONS

1. A remote terminal centralized computer system serving a very large number of users simultaneously is entirely feasible, considering the total performance and price objectives. In addition, such a system serves extremely important educational needs that cannot be met otherwise. These needs must be met to adequately cope with the problems of the students as the nation approaches the 1970s.

2. The problem-solving capabilities of the system offer by far the greatest direct instructional benefit, and serve many more students than are served for DP training. The unique element in this conclusion was the identification of a requirement for a problem-solving language. This language is not a general purpose computer programming language, but a specialized mathematical notation system that can be implemented for use in a conversational mode on a remote typewriter terminal. Only with this specialized capability can the computer system be designed on an efficient and economic basis. Furthermore, this capability eliminates the major barrier to widespread use of computing in the schools; namely, that courses in programming are prerequisite to the problem-solving experience.

3. For administration, a worthwhile contribution can be made in behalf of the entire operation of the district or regional groupings of districts by implementing a total schools information system, using terminals that were justified primarily for problem solving. Thereupon, a truly excellent computing system also becomes available for data processing training, and administrative work. Through shared use, not only can most needs of the users be met in total, but the financial savings which can be effected make the entire operation financially feasible.

4. Both performance and cost considerations have led to the selection of computer-controlled typewriters in the schools and colleges, with the addition of card reader and punch features to support administrative and data processing training tasks. Satellite computers or moderate-speed card readers and printers in schools and colleges were considered carefully, and met the technical requirements for the system. However, to provide these facilities to all institutions in the region would exceed cost objectives. Therefore, they were not included in the system designs. The system design architecture does accommodate these components, however, if funds are available in a particular implementation.

## RECOMMENDATIONS

1. With respect to the grade levels to be served for instructional use, the desires of the USOE were observed in limiting these uses of the system to the high schools, with the most usage in grades 10 through 14. The study team concluded, that the problem-solving language has much applicability at lower levels, perhaps as low as grade 7.

2. With respect to the grade levels to be served by the administrative system, the study team concluded that it would be impossible to limit availability to high schools only, and that in fact an obligation exists to make advantageous use of the system in meeting the entire needs of the district, for all grades served without distinction. Thus, the administration needs for grades K through 14 should be met.

3. The study team recommends a follow-on detailed study and a pilot implementation of the system, in some one locality. This system should be subsidized at an appropriate level, and be implemented in a manner which will produce a generalized "package" that can subsequently be installed elsewhere. It is not necessary for each potential user of such a system to undertake a development program at each new location.

4. During the site visits, and later at a group presentation in Washington, D.C., many managers or directors of current data processing installations in schools "volunteered" their area as a pilot center. The interest is very great, and a large number of locations desire to be the first. The selection criteria for such a site are as follows:

- a. The area must include an appropriate mix of the types of schools, and of student populations, that would most likely be subject to all of the problems that will eventually occur. Here problems are desirable. It is much easier to deal with problem situations in the controlled environment of a pilot center than after the system is completely designed.
- b. The second site-selection criterion is the availability of money to pay for the cost of the development. Few school districts could finance such an effort without assistance. Even at the state level, funds are not available in sufficient amounts, for a long time, to adequately finance the required development effort.
- c. The third site-selection criterion is the availability of people to adequately staff the undertaking. Unique individuals are required for the system development

effect. They must be found and induced to work towards this goal, if a true implementation is ever to occur.

#### DEVIATIONS

1. The model regions projected assumed the presence of large junior colleges; those found in the case study area were also large. The needs for problem solving and data processing training were incorporated into the projected system for junior

colleges, but the assumption was made that administrative tasks would not be performed by the system for junior colleges.

2. Five-minute turnaround time is provided for problem solving only. For DP training, the system provides reasonable access to the terminals, and overnight batch processing to accomplish the workload projections used in the study.

3. In addition to the model region defined by USOE, three other regions (A, B, C) were defined.

## PART 2: SYSTEM DEFINITION

This part describes the considerations that led to a system definition for the problem solving, DP training, and administrative requirements. Each requirement is presented separately in terms of user requirements, workload, system requirements, and system definition.

### PROBLEM SOLVING

#### Student Requirements

All students in mathematics, physics, chemistry, biology, and related academic subjects must be provided reasonable access to computer facilities:

1. To support problem-solving and computational experiences
2. To become knowledgeable about the application of computing techniques to appropriate scholastic tasks

"Reasonable access" as used for academic subject support was determined to be:

- Scheduled availability of computer services to the students in the "problem-solving" sessions of 20 minutes duration.
- Additional availability of conventional computer facilities in off-hours. "Conventional" facilities are defined as batched job input with sequential processing.
- Student/computer communications should not necessarily require an extensive knowledge of a conventional computer programming language, such as FORTRAN, COBOL or PL/I. Student attention should be placed on the problem-solving task itself, not on the computer-necessitated detail.

#### Teacher Requirements

Teachers and other members of the instructional staff must be provided the same reasonable access as the students to computer facilities:

1. To support in-service training
2. To assist in the preparation of lessons, exercises, and test materials
3. To enhance classroom demonstration in problem solving
4. To develop curriculums

### WORKLOAD

Table 2 shows the courses taught in high school (grades 10-12) and junior college (grades 13-14) that are most likely to use the problem-solving capability in an initial implementation. An

estimate of the percentage of students in each grade who would be taking those courses and the approximate number of problem sessions of 20 minutes each for a student or student team in each course during the school year are shown. This annual workload is the projection after the first five years of use.

The estimate of the number of problem sessions per year is based on an appraisal of the gradual implementation of a new technique in the secondary school program, and on the economics of school budgeting for this technique. During the first five years, there will be an accelerating growth of interest in computer-based problem solving as teachers acquire the experience and as the materials for instruction using this new tool become available. After five years, new demands on the system should evolve with experience, and future systems design features should be evolved to satisfy these demands. Because of the varying percentages of students enrolled in courses, and the varying level of activity, the estimates of total system usage are about equal for grades 10 and 11. Senior students in grade 12 will be fewer in number, but much more active. For example, many students taking biology in 10th grade will be light users of the system, but the few students taking calculus in the 12th grade will be heavy users of the system.

### SYSTEM REQUIREMENTS

To satisfy the user requirements and workload for problem solving, the system must:

1. Allow students and teachers scheduled access during school hours to "instructional terminals" in the schools for problem-solving support. These terminals may communicate over common carrier facilities or private facilities with a modern high-speed computer.

(Problem-solving support refers primarily to support of mathematical and scientific subjects, including computation, algorithm development, and simulation for experimenting with physical phenomena and gaming in the social and management sciences.)

2. Provide overnight service for processing lower-priority tasks. These tasks could include independent study assignments, extra-curricular activities (i. e. computer club), and selected homework problems. This would be accomplished through conventional batched job entry at the computer center site, followed by sequential processing, and transmission of the processed output back to a school terminal on a scheduled basis.



Table 2

## PROBLEM SOLVING WORKLOAD

Grade	Course	Percent of Students in Grade (1)	Number of Problem Sessions/Year (2)
10	Geometry	40%	10
	Algebra I	20%	5
	Biology	80%	10
11	Elementary Functions	25%	20
	Algebra II	25%	10
	Chemistry	37%	10
12	Calculus	12%	30
	General Mathematics	12%	5
	Physics	25%	15
13, 14	Math A (Calculus)	10%	20
	Math B (Elementary Functions)	15%	15
	Math C (Basic Algebra, Trig)	25%	10
	Physical Science (Physics, Chemistry)	10%	15

<sup>1</sup>Based on data collected by the IBM study team and on the USOE Digest of Educational Statistics, 1966.

<sup>2</sup>Projected for the first five years of use based on estimates of curriculum consultants.

3. Support the students and teachers at the terminals by processing their tasks rapidly and efficiently in a conversational way. This support requires a problem-solving language implementation to ensure that the system will process the maximum number of jobs possible during the problem-solving session. This language must be sufficiently general so that the user can concentrate on the elements of problem definition and program formulation, rather than computer-oriented procedures.

#### SYSTEM DEFINITION

The preferred means of performing the problem-solving tasks is in conjunction with the remote terminal at the school. Normally, the student or groups of students will enter their own problems with an immediate response from the computer on a statement-by-statement basis. A teacher may also use the terminal for demonstration purposes

in the classroom. The same immediate response will be provided. (Consideration was given to conversational versus remote batch entry for problem solving. Results of the comparison are in Appendix A.)

#### Conversational Mode

Each input statement is interpreted by the problem-solving language processor. Each statement is keyed in and diagnosed for syntax. If a syntactical error is found, an immediate diagnostic message is given to the student before the next statement is entered. In this manner, the student is aware of improper program formats before execution time.

The student enters data for execution, and results are immediately printed at the student terminal. If the student desires other iterations of the problem with different data, he keys in the new data, and immediately executes the problem again. The student continually observes the results of each problem

execution. Advantages of the conversational mode for problem solving are as follows:

Immediacy of Response. Experience of secondary schools now using time-sharing systems indicates that the level of student interest in computer problem-solving is roughly inversely proportional to the response time in getting answers. It is questionable that the rapid interchange of problems and solutions can be duplicated by any batch system, even one having quick turnaround time. It is the quality of give and take that students appreciate.

Useful Work Accomplished. A student can do more useful work in a 20-minute period of conversational interaction with a computer because he can correct his errors immediately, change his data for testing his conclusions, and rerun his jobs immediately. (In batch mode, two or more compilations and executions are often required before the student has a program that runs correctly; additional runs are required if any data are changed.)

Directness of Approach. The conversational system does not require the user to learn an elaborate set of computer-oriented conventions to solve problems. It eliminates the need for key-punching or other offline preparation of problems. It enables the student to use the computer easily and quickly with a minimum of training.

Cost. The conversational system uses low-cost typewriter terminals without the card reader feature required for batch mode. In addition, the cost of the central processor required for conversational mode is also less.

The Pierce Report (Computers in Higher Education, February 1967) gives a good summary of the rationale for a conversational system for problem solving:

"On the basis of available data and experience we believe that the simple programming languages, convenient terminals and rapid access of time-sharing systems will lead to a faster growth rate and a more widespread use than with older batch-processing systems."

### Problem-Solving Language

Implementation of the problem-solving language on a computer should be efficient, permitting a student to enter a problem, correct any errors, enter data, get results, and experiment with the

problem using different data--all in one 20-minute session at the terminal. To accomplish this interaction, the system communicates with the student in a "conversational" way. The computer-based system accepts statements in the problem-solving language from the student and responds appropriately and immediately, on a statement-by-statement basis. If the student has made mistakes in logic or expression, the system tells him so, clearly and succinctly. The student is able to modify his problem statement immediately, and see the results of the modification at once. The problem-solving language should have the following characteristics:

1. Compatible Notation. Allows direct expression of problems in the notation and symbolism reflecting the problem; not a general purpose programming language.

2. Direct Expression. Allows direct expression of mathematical statements, describes functions, manipulates arithmetic and character-oriented data structures, and develops models of natural phenomena.

3. Ease of Learning. A knowledge of a standard high-level programming language, such as FORTRAN, COBOL, or PL/I, should not be a prerequisite of learning the language.

4. Ease of Use. None of the computing "house-keeping", such as definition of file sizes and formatting of input and output data records, should be required.

5. Algorithmic Representation. A facility for efficient development and representation of algorithms should be provided.

6. Computer Independence. The language and its notations should be useful to a user who has only a pencil and paper, as well as to the user who has access to the language as implemented on the computer.

7. General Applicability. The language should apply to the needs of all users through the introduction of selected language statements at appropriate curriculum points in the school career.

## DATA PROCESSING TRAINING

### Student Requirements

All students should have the opportunity to understand the use of computing systems in today's society. The same introductory course should form the basis for subsequent courses to train vocationally oriented students in business and scientific systems design and programming.

Students should have reasonable access to computer facilities to handle student-prepared programs that result from data processing

vocational training courses. "Reasonable access" as used for data processing training courses has been determined to be as follows:

1. Scheduled availability of remote terminals for transmission of program data after school hours, to allow the student to enter prepared problems into the central computer system for processing in a sequential mode.

2. Additional availability of conventional computer facilities in off-hours; for example, for use with night classes conducted primarily for adults.

3. Availability of programming language processors to support the demonstration requirements of computer concept courses. For those courses which concentrate on a specific programming language, the appropriate language processor must be available.

### Workload

Each of four courses that could be offered at both the secondary and junior college levels are shown in Table 3. The percentage of students in each grade has been projected separately for each level; however, the courses are identical. Topic outlines for the courses based on portions of a data processing curriculum developed for the Ontario Department of Education, Toronto, Canada, are contained in Appendix B.

### System Requirements

In the Computer Concepts course, there is little contact with a computer; most classes will visit various computer centers to acquaint the students with the appearance and general functions of data processing equipment. Since little attempt is made to instruct Computer Concepts students in machine operations or programming techniques, no machine time is required other than that used for simple demonstrations.

Once computer concepts have been taught, course material becomes more specific so that the student can specialize in complex machine operations, programming, systems analysis, or installation management. In these courses, the computer is used to a greater extent, especially in the programming classes. Here the student writes increasingly difficult programs, using increasingly higher-level programming languages as he gains proficiency. Naturally, the less-experienced students tend to use greater amounts of computer time for assemblies and testing than do more-experienced programmers. The solution to the system definition to meet this need must satisfy the following requirements:

1. The student must be able to prepare his program in a direct, machine-sensible form, and must be able to make changes and corrections as he progresses.

Table 3

DATA PROCESSING TRAINING WORKLOAD

Grade	Course	Percent of Students in Grade	Number of Problems Assigned Per Year
<b>Secondary Schools</b>			
10, 11, 12	Computer Concepts	15%	4
11, 12	Basic Programming	5%	6
12	Systems Design	1%	4
12	Business Systems Programming	1%	4
<b>Junior Colleges</b>			
13, 14	Computer Concepts	15%	4
13, 14	Basic Programming	10%	6
14	System Design	5%	4
14	Business Systems Programming	5%	4

2. The student must have access to the computer for both assembly and execution phases with no less than overnight turnaround times.

3. The compiler and operating system that control execution must provide maximum information to the student in the form of diagnostics to aid determination of nonperformance of the program.

### System Definition

A first choice of equipment design to meet the requirements is to have enough individual computers so that each student can spend all the time necessary at his own machine.

A second choice is to have at least one computer physically present, with each student spending some time at the machine personally, but allowing a professional operator to process the remainder of the work.

A third choice is to have a computer present, but to have all work processed by the professional operator.

A fourth choice provides a computer located at another installation but accessible to the student via remote terminals. These terminals must be capable of job entry and execution as if the terminal itself were a computer system.

A fifth choice is to use a computer at some other location, sending all programs via a courier service. (Figure 1 shows the five choices graphically.)

(The terminal in the fourth choice may appear to be only an updated courier service technique. Yet experience in using remote terminals in this manner belies this observation; to the student, the terminal is his computer.)

Only in the training period of the programmer is hands-on experience appropriate. With the use of high-level languages, hands-on experience is no longer necessary. As a result, the system definition is a combination of the fourth and fifth choices.

Each school has an administrative terminal with an associated printer and card reader/punch. By sharing this terminal for administration and DP training and adding courier service to the computing center, students have reasonable access to the computer and adequate turnaround time.

Two methods may be used to process student problems.

In the first method, the students use the key-punch in an offline mode to prepare punched card programs and data decks. These decks are read by the card reader and transmitted via the terminal to the computing center during the early after-school hours before the last clerk has left the school office. At the computing center, student data is processed immediately or deferred. In either case, the processed output, including the same listing and results, is transmitted via the communication network to the terminal printer on an overnight basis. By using this procedure,

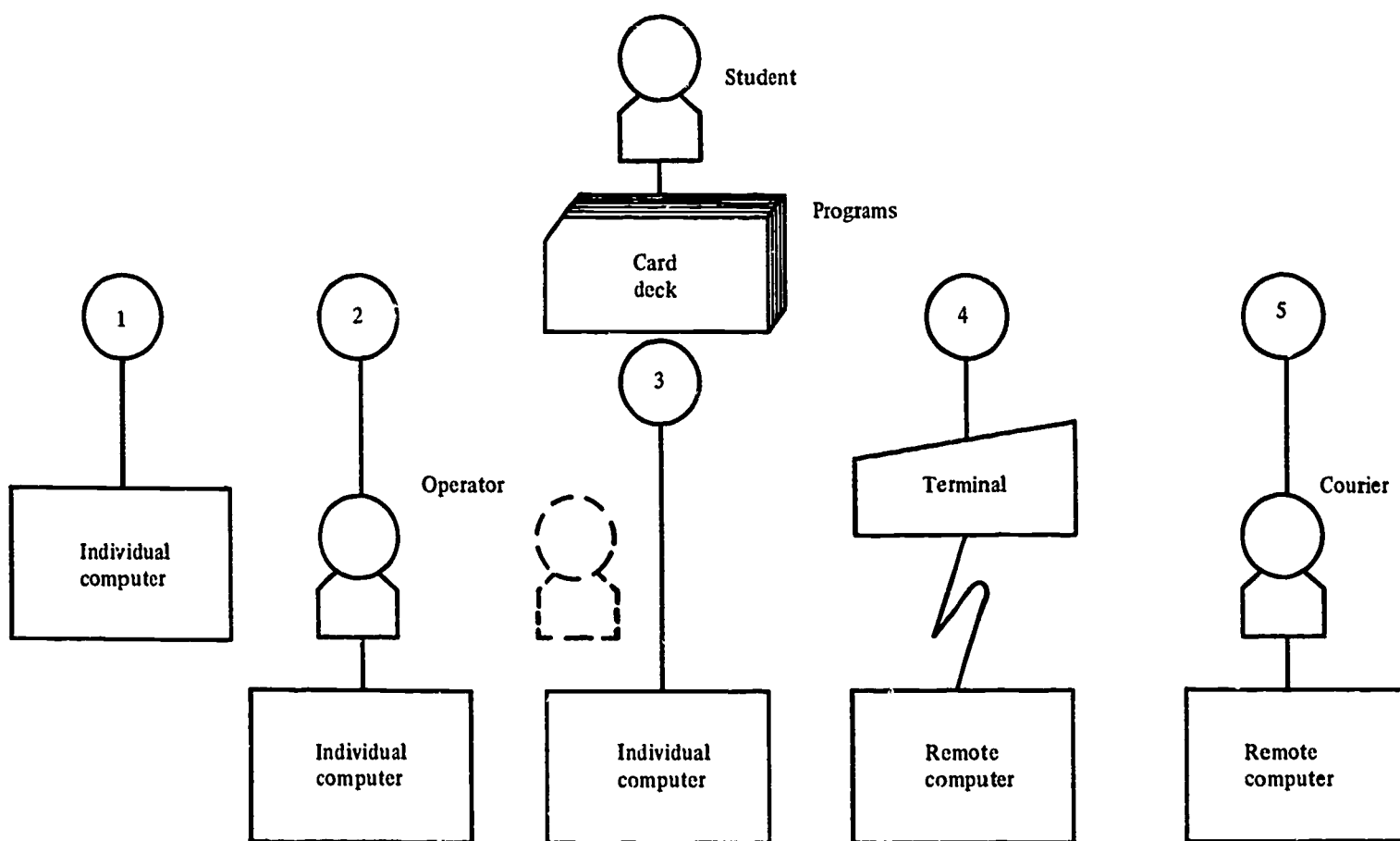


Figure 1. Methods for processing DP students' programs

programs completed in card form before the end of one school day are processed and returned before the start of the next school day.

For the second method, special forms designed to be marked in pencil and read by a special document-mark reader are used. The student marks the program and data characters on the sheet. The students' marked sheets are picked up by a courier at the end of the school day and taken to the computing center. At the computing center, the sheets are read by a document-mark reader and processed. Results are transmitted via the communications network to the school terminal printer before the start of the next school day. The marked forms are returned to the students by the courier on his scheduled pickup the next school day. The same courier technique may be used to handle cards punched on the offline keypunch connected to the administrative terminal. For larger or more advanced schools, additional keypunches may be needed to supplement the single keypunch associated with the school administrative terminal.

Figure 2 shows both methods described previously.

### Program Preparation and Execution

A program is defined by the student, coded, and converted to machine-sensible form offline. Keypunches prepare problem statements on punched cards for input. (Experience shows that a typical student problem will average 25 input cards, the number used for this assumption.)

The terminal for batch entry consists of a keyboard/printer and card reader. Cards are read by the terminal and transmitted to the central site. At the central site, the programs are first compiled and then executed. Diagnostics do not occur until the compilation phase has begun. If a major error is encountered, the compilation aborts, and diagnostic messages are transmitted to the terminal and printed out. The student must correct the input statement in error offline, and the entire program must be reentered at the terminal.

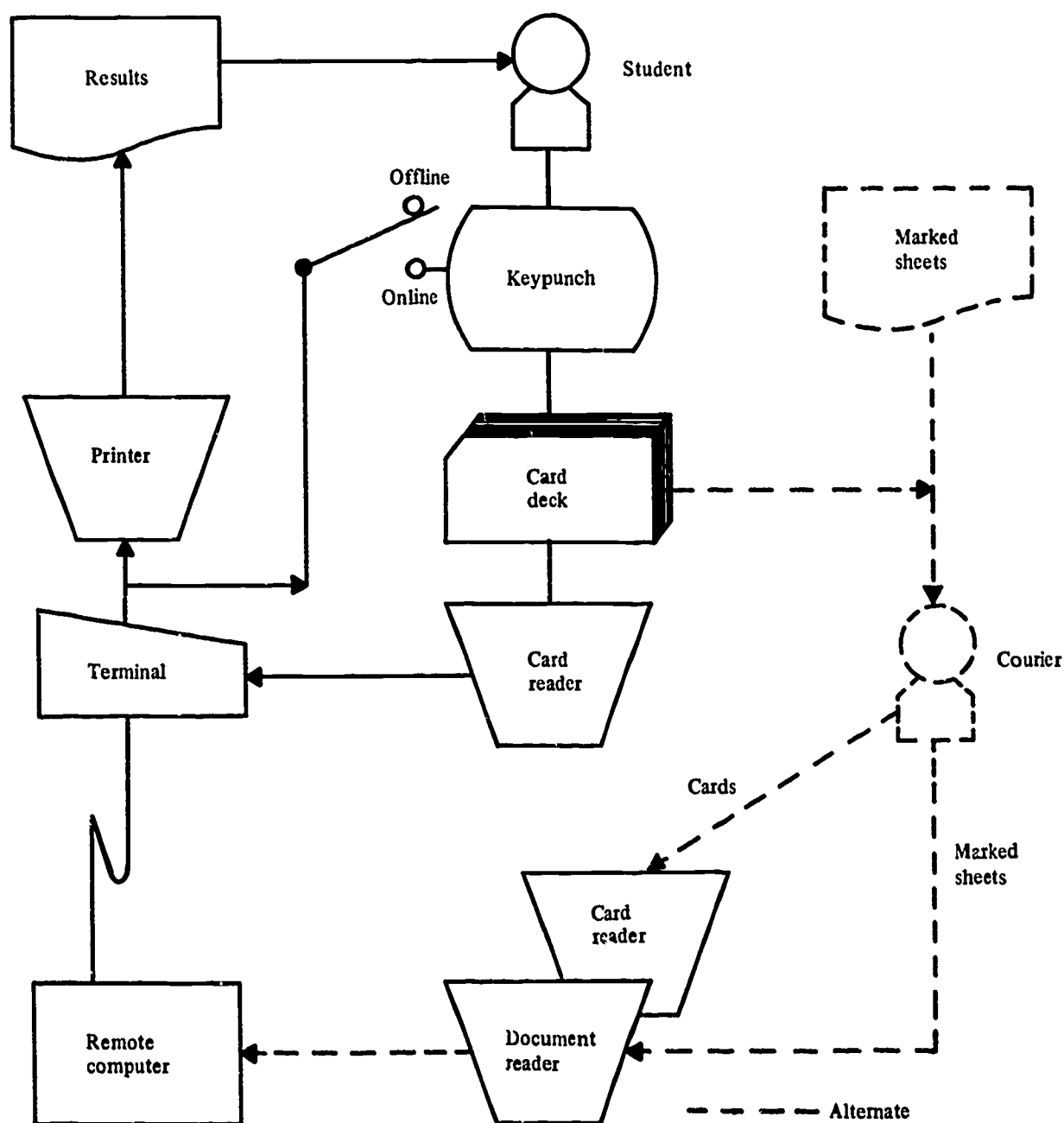


Figure 2. Selected method for processing DP students' programs

Experience with an efficient FORTRAN compiler specifically designed for student use was used for an analysis. With this compiler, a typical student problem requires approximately four seconds to compile and execute. The total terminal time is approximately four minutes per job. The output at the terminal consists of compilation diagnostics for any errors encountered and the results of the problem solution.

## Language

Several levels of language exist and are in common use. The general terms used to distinguish between the major categories are "low-level" and "high-level".

A low-level language is one in which the program steps planned by the programmer are converted one for one into the assembled machine operations. The programmer, in effect, codes the problem using machine-type instructions. The language processor simplifies the task by performing dictionary construction of symbols used, substituting the hardware codes for the symbolic but, generally speaking, supplying no logic other than that coded by the programmer.

Examples of low-level languages are: S. P. S., Autocoder, Assembler Language, etc. Most manufacturers of computer hardware supply such languages under various titles with the software routines necessary to process the original program and define the hardware required to object-code the programs.

A high-level language is one in which the program steps are planned and written in a language not read directly by the machine. During compilation, prewritten routines called for by the programmer are assembled to accomplish the programmed task. There is no one-for-one relationship between the code supplied by the programmer and that compiled for use by the machine. Since the code of the programmer is designed to express the intended problem solution independent of the machine requirements, it is theoretically possible to construct compilers for the same source language program to operate on a number of different types of computers. In actual practice, this has been realized to some extent, but there are still some discrepancies between high-level language compilers supplied for different computers. Nevertheless, the differences are so slight that for a person who understands more than one compiler system, the time to make changes can be very little compared to the time it would take to recode the same problem using a low-level language.

Examples of high-level languages are FORTRAN, COBOL, and PL/I. At a minimum, the system should handle those languages which are standard in the industry, such as FORTRAN and COBOL.

## Computer Simulator

For DP training it would be desirable to have a local computer for each school to use in a "hands-on" environment. However, local computers for all schools are impracticable from a standpoint of cost.

One way to provide a hands-on environment is through a simulated computer console typewriter. A simulation program can be prepared and stored in the common library. The simulation can give the hands-on feeling to the student, and permit him to trace the operation of his program within a simulated computer that registers type-outs at various critical points. If used with mural photographs of computer equipment, the feeling of being at a computer can be markedly heightened, since with the exception of the lights, there are no moving parts in the main frame of a computer.

## ADMINISTRATION

### Objectives

The computer system must respond to these general objectives for administrative users:

1. Help reduce clerical workloads of the teachers and members of the instructional staff, to allow greater concentration on student plans and programs.
2. Maintain extensive student records to assist teachers, counselors, curriculum specialists, and research staff in planning and evaluating programs for individual students.
3. Process high-priority administrative jobs during the hours of the normal school day, and process other jobs on an overnight basis.
4. Provide modern data management services to the school and central staff, including the following:
  - a. Assistance in the acquisition, validity checking, and filing of all data pertinent to effective school management
  - b. Rapid access for all information stored in the files
  - c. Production of routine and special management reports in a meaningful and timely way
5. Provide support to all generally accepted student-oriented data processing tasks, such as student scheduling, attendance accounting, grade reporting, and student registration.

6. Provide support to the school business operations, particularly:
- To provide complete and current budgetary and encumbrance information to administrative and operating divisions
  - To facilitate ordering and availability of supplies and equipment
  - To control growth of administrative and clerical costs to provide a greater share of funds for instructional use

### Workload

Key tasks to be accomplished by the system to meet administrative requirements are listed below:

Student Administration. Registration, scheduling, attendance, grade reports, testing, locker assignments, counseling and guidance, funds accounting, receipt of district funds.

School Administration. Employee absences, audio-visual circulating materials, supply requisitions, budget control, purchase requisitions, parent/teacher organizations.

Central School Administration. Business services, budget control, program cost accounting, revenue accounting, budget preparation and

projection, maintenance control, purchasing, audio visual selection-evaluation-scheduling, book order control, reporting to management, personnel control and payroll, planning and research, publications and information, curriculum development.

Figure 3 shows the data bank files used for instruction administration, business service, personnel, planning and research, publications and information, and curriculum development. Table 4 shows the Administrative workload.

### System Requirements

Based on the foregoing user requirements, the remote terminal system must contain the following capabilities to provide the school information system functions:

1. Large-volume storage for school information within a centralized computer system.
2. Remote terminals in the schools and administrative sites to provide communications with the central computer.
3. Generalized data management and formatting facilities within the computing system to allow the authorized user to input data and obtain reports according to his own specifications. The computing system must provide security locks to preserve the integrity of the data against unauthorized users.

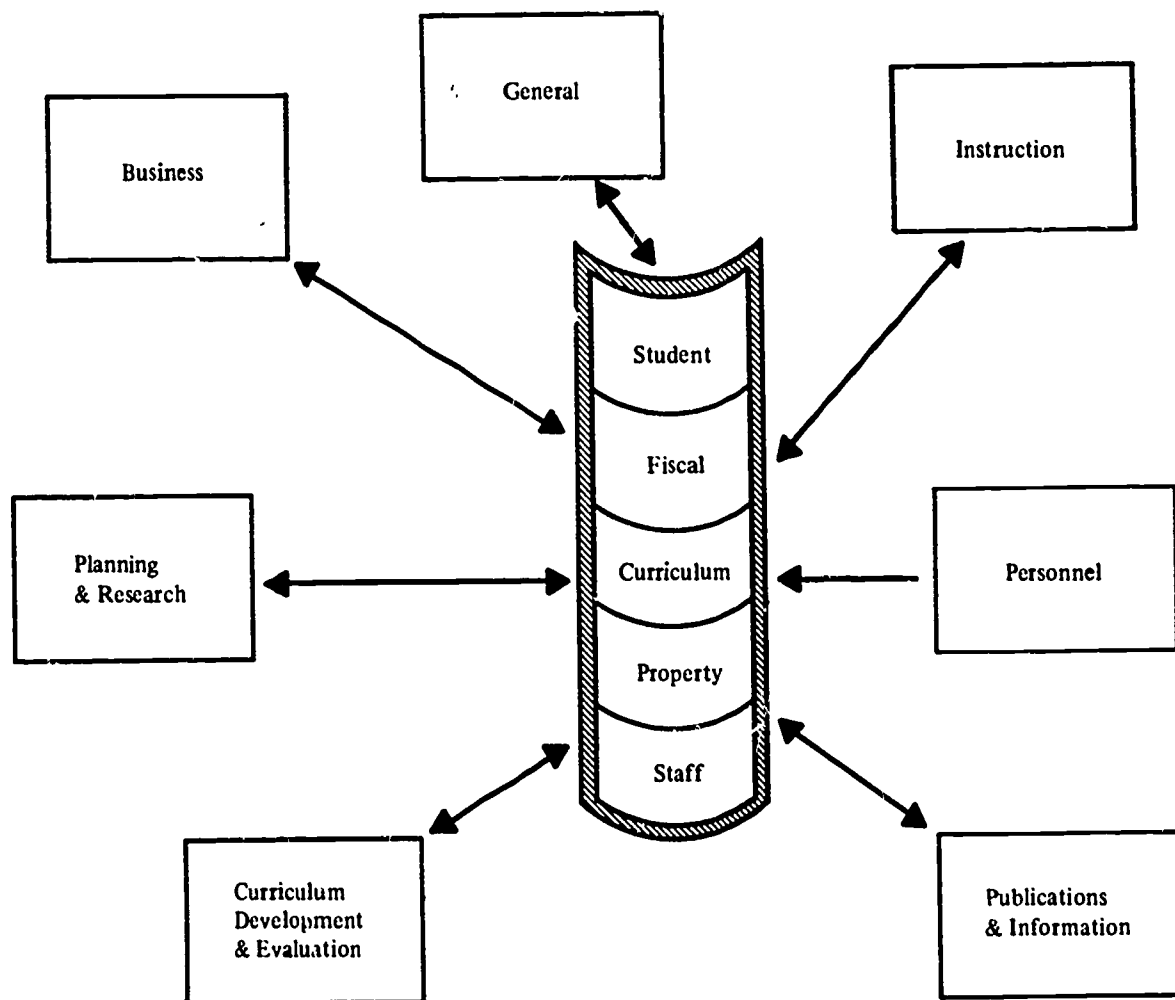


Figure 3. Administrative users of the integrated data bank

Table 4

## ADMINISTRATIVE WORKLOAD

Major Tasks & Master Files	Time Period	Master Files		Activity	
		Read	Write	Input	Output
Remote Entry Processing:	(volume per 1000 students)				
1. Attendance -Student File	Daily	200	200	200	200
2. Guidance -Student File	Daily	80	-	80	80
3. Registration -Student File	Daily	10	10	20	20
-Census File	-	10	10	-	-
-Class File	-	20	20	-	-
Major Batch Entry Tasks:	(volume per 1000 students)				
1. Student Processing -Attendance Student File	Monthly	1,000	1,000	-	1,000
-Report Cards Student File	Quarterly	1,000	1,000	200	2,000
-Student File Org. Student File	Annual	1,000	1,000	-	-
-Student Scheduling Student File	Annual	1,000	1,000	-	5,000
Course File	-	200	200	-	800
-Testing Student File	Weekly	-	-	1,000	2,000
-Census Central File	Annual	1,000	500	500	1,000
2. School Administration -Supplies Requisition Supply File	Weekly	-	50	50	50
Budget File	-	5	5	5	-
Requisition File	-	-	5	50	50
-Budget Budget File	Weekly	-	30	-	30
(volume per center)					
3. Central Administration -Enrollment Projection Census File	Semi-Annual	25,000	-	-	-
Student File	-	25,000	-	-	500
-Personnel Processing Applicant File	Monthly	-	120	60	180
Substitute File	-	600	600	600	600
Employee File	-	5,000	5,000	1,250	10,000
-Fiscal Operation Budget File	Monthly	-	6,000	2,500	3,500
Vendor File	-	2,000	1,000	2,000	2,000
Order File	-	500	500	500	1,000
Warrent File	-	350	350	350	1,050
Maintenance File	-	2,000	2,000	2,000	3,000
-Property Audio-Visual File	Monthly	-	1,000	1,000	200
Supply File	-	10,000	8,000	8,000	12,000



4. Terminals supporting procedures in the schools that provide for one-time collections of data to be stored in the central files and accessed by all authorized users.

5. Standard computer programming languages and library facilities within the central computer to support all routine administrative tasks, and generate periodic, exception, and on-request reports.

6. Sufficiently generalized to permit changes and differences in data, report formats, inquiries, etc., without reprogramming the entire system.

## System Definition

### School Information System

The recommended solution to the requirement of administrative data processing is a system comparable to the Generalized Educational Management System (GEMS), currently under development by Project OTIS, the Oregon Total Information System. This project is funded by the USOE, and is staffed in Eugene, Oregon.

The concept of GEMS was first implemented in the Advanced Medical Information System (AMIS) of the Veterans Administration Hospital in Washington, D.C. This system, with changes appropriate for use in the educational area, has evolved into the GEMS. Since GEMS was designed to meet administrative data processing requirements essentially identical to those required by the study and provides all of the generalized capabilities described in the previous subsection, GEMS is the preferred design choice for this system solution. However, it may be that other programming systems in development, of which the team is not aware, may provide a capability equivalent to GEMS. For this reason, the preliminary system specification describes only the functions to be performed by the system, and does not specify GEMS per se.

### Administrative Center Terminal

Four typewriter terminals of average size will be required for the administrative center, located as follows:

1. Purchasing has need for rapid access to a terminal for quick reference when on the phone, or when answering personal inquiries. As a result, one of the terminals should be located within the purchasing department itself. In addition to being used for purchasing-originated inquiries, considerable quantity of copy will be produced by incoming supply requisitions from schools, etc.

2. Personnel has need for rapid access to a terminal for inquiries concerning employees, etc., originating internally and externally. In addition, because of the workload, it is necessary that a terminal be available for steady use in the updating of personnel files.

3. Depending upon local physical arrangements, the supply warehouse, maintenance office, operations office, and the audio-visual delivery center may normally share a common terminal in a mutually convenient location. Workload is such that if a choice must be made, it would probably be best to have the terminal in the maintenance office area, with pickup of copy for the supply warehouse if not convenient to the area.

4. The terminal for the budget control functions and the hard-copy terminal for payroll functions could be located in the accounting department. If a choice must be made, the workload would suggest that it should be located nearest the budget control section office.

### School Terminal

For communication with the central computer site, a school administrative terminal with a printer and card reader/punch online will be required. After the school day ends and before the next school day begins, the terminal will be used for overnight batch processing as described under "Data Processing Training". It is also used for the problem-solving function.

### Data Files

The five models defined for the administrative data files are Student, Staff, Fiscal, Property, and Curriculum. Each model is incorporated within the total information system, which in turn is subdivided into subsystems, each with its own files of data records. The data in any subsystem file can be used in conjunction with any other file, without regard to the model created by the data in the files. Collectively, they form an integrated data bank, as shown in Figure 4.

Each of the models within the system has certain typical files. Table 4 represents the types of files that might be available within the total system.

Most of the files shown in Table 5 are essential elements in a total information system. Some must be present in an initial implementation; others can be phased in one by one during the early stages of the implementation. By far the most critical file is the student file; the entire system is centered on the educational process.

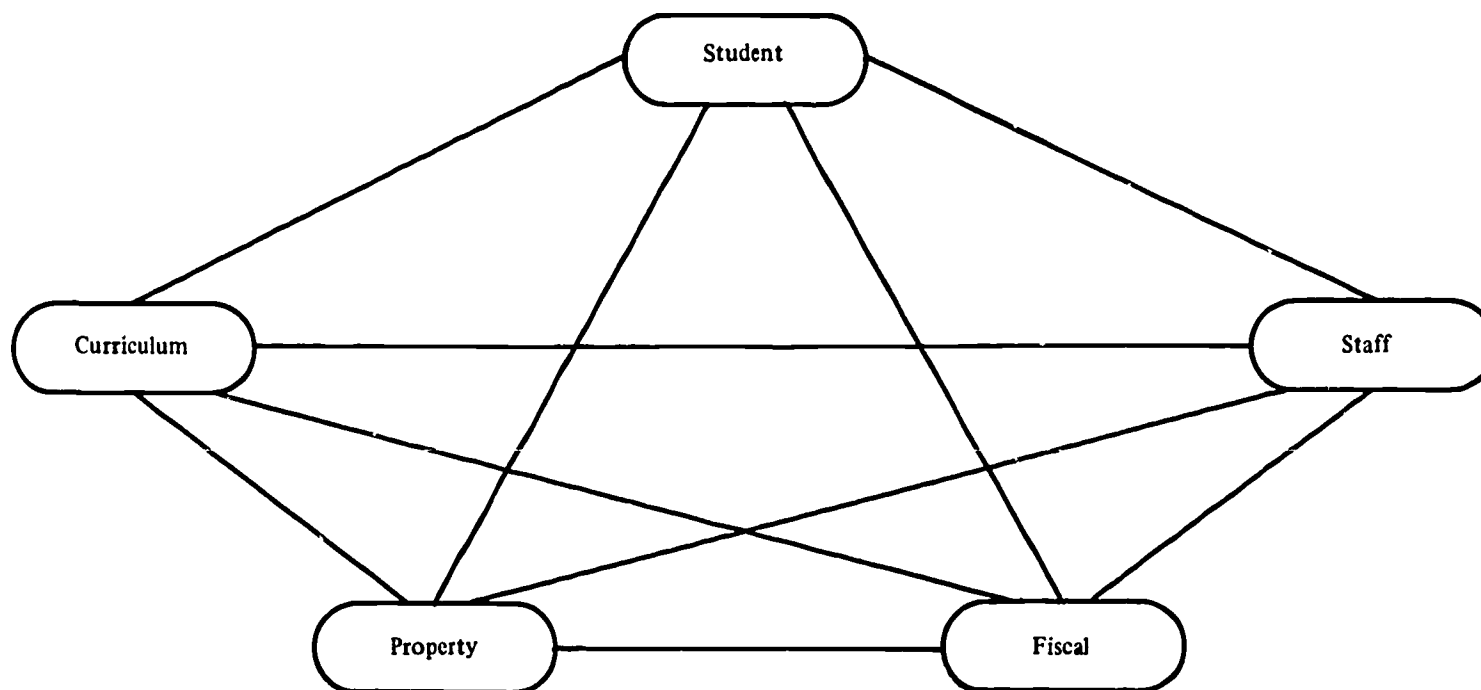


Figure 4. Integrated data bank

All files within the system are direct access because of the heavy emphasis upon real-time processing of data. Magnetic tape, however, may be used to record the status of the files at periodic intervals, for backup in the unlikely event of

destruction of the main files. Magnetic tape also can be used to store transactions in the input stream, and to store the processed output records, if a failure in any part of the system makes it necessary to restart at some point.

Table 5

ADMINISTRATIVE FILE STRUCTURES

System Model	Subsystem File	File Sequence
Student	Student Demographic Census	Student Name Within School Geographic coordinates Residence Address within area
Staff	Applicants Substitutes *Employees	Position applied for Position qualified for Alphabetic by Employee Name
Fiscal	Payroll Budget/General Ledger Vendor Purchase Orders Warrants Issued Bdgt. Appropriations Maintenance Jobs Construction Projects	Employee Number (Soc. Sec. Number) Account Code within Fund Alpha by Vendor Name Encumbrance Reference Number Warrant Number Appropriations Reference Number Job Number Project Number
Property**	Equipment Facilities Library Audio-Visual Materials Educational Supplies Maintenance Supplies Cafeteria Supplies	Inventory tag number Location and type Book Classification code Catalog Number Catalog Number Catalog Number Catalog Number
Curriculum	Courses Classes Test Item Bank Test Conversion Tables Test Scoring Keys CAI Units	Course Code Section Number Classification Code Test and part code Test and part code Unit Code

Notes:

\*Payroll data may be integrated into the Employee file where accounting control permits.

\*\*Supply files in the property model may be used for inventories in a warehouse, or for ordering for direct purchase without distinction.

Many indices would be established not listed above, to permit reference of files through many different reference keys.

Detailed file layouts are shown in Appendix C.

## PART 3: SYSTEM DESCRIPTION

This part describes the system configuration that meets the system defined in Part 2. System features, a currently feasible configuration, a future configuration, other computing center equipment, and manpower requirements are given in summary form. Volume II contains complete preliminary system specifications.

### FEATURES

Figure 5 shows the equipment types selected by the study team to configure the remote terminal centralized computer system. It is an economic and efficient multiapplication computing system, serving a very large, dispersed user population. The system is designed to bring the power of current computer technology to the total user community, with the increased effectiveness and economies resulting from a large-scale facility. In addition, the system has the capability for efficient and simultaneous handling of a wide range of instructional and administrative jobs. With the availability of remote terminal facilities at the schools and colleges, the central computer system can provide services to a larger number of students in a wide range of disciplines.

Specifically, the system meets the general system requirements previously defined: acceptability, responsiveness to changes, economic practicality, operational readiness and efficiency. Features that match those requirements are as follows:

#### Acceptability

In the instructional area, services provided by the computer facility supplement the established curriculum. In the administrative area, transitional functions and data handling techniques of the system are reasonably compatible with the current administrative systems and procedures.

No net additional school personnel should be required at the individual school or college sites to operate or maintain the school-based equipment.

The remote terminals are capable of simple low-cost installation in the school buildings without any modification of existing plant, and occupy very little floor space.

#### Responsiveness to Changes

The system accommodates reasonable variations in workload because of changes in user population,

course selections, curriculum materials, and administrative demands, without substantial system change.

When extensive workload changes occur, the system accommodates these changes without major system redesign effort or major disruption in the system operation.

The system automatically collects basic data on system utilization to assist operations management in improving the system, optimizing design selection for future growth, and measuring the services rendered.

#### Economic Practicality

The total cost for the operational system to service a population of secondary and junior college students is absolutely minimal, consistent with the objectives of the users.

#### Operational Readiness and Efficiency

All computing equipment and programming system modules are provided from commercial product lines whenever possible. The equipment and programming systems meet industry conventions of reliability, maintainability, and operability.

Redundancy of equipment solely to improve the operational readiness is not required. Instead, arrangements may be made to obtain backup support on a service bureau basis for critical administrative jobs, in accordance with conventional computer operations.

Advanced but proven computer techniques and technology are used wherever possible to ensure the maximum system efficiency at the lowest possible cost. Techniques such as terminal "time-sharing" of the central processor, and data communications over common carrier facilities are a part of the design system. The system is capable of handling many tasks concurrently on a "multiprogrammed" basis to ensure that the system resources are utilized to the maximum possible extent.

### CURRENT CONFIGURATION

#### Main Storage

The programs required to service a large number of terminals in a time-sharing system are large and complex, and require large memories when compared to single-use programs. The operating system is an essential requirement to permit a single computer to service many users, both concurrently, as in the case of terminals, and

Central site

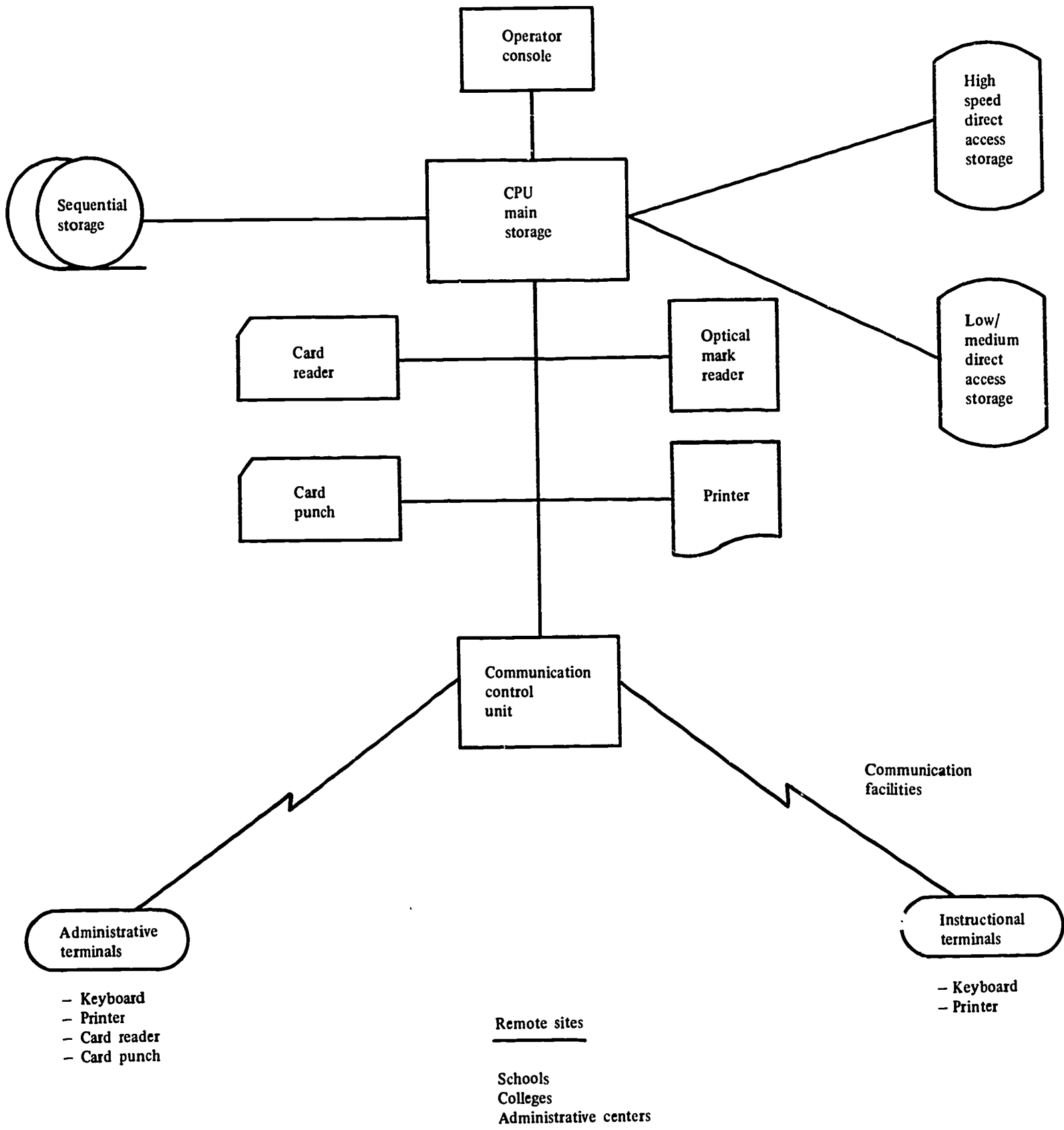


Figure 5. Equipment configuration

consecutively, as in the case of batch entry at the central computer site. Operating systems to perform these tasks are very large, and the probability is that they will get larger in the future, as they become more sophisticated in capabilities.

As a result of these factors, 256,000 characters of main storage is the minimum that should be provided in an initial implementation, with, perhaps, double that size eventually when the maximum volumes are being serviced.

### Secondary Storage

Two types of secondary storage are available: magnetic tape for sequential storage of data, and direct access storage for random storage and retrieval.

#### Magnetic Tape Storage

Magnetic tape is used for recording sequentially all input and output transactions, and for transcribing the contents of direct access storage periodically ("dumping") for backup use in case of a system failure, but it is not used directly online for any active task.

#### Direct Access Storage

Two types of direct access storage devices are used: disk and cell. Each type differs in the total amount of storage capability, and in the speed with which stored data can be made available to the computer.

Disk Storage. Larger types of these units have very large numbers of disks, permanently mounted. Smaller types use disks containing from six to eleven platters per disk pack; the packs may be physically removed by the operator and replaced with packs containing different data.

Cell Storage. Data is magnetically recorded on plastic cards, which can be rapidly selected from a cell, wrapped around a rapidly revolving cylinder, and read as from the surface of a drum. Once read, the card is returned to its cell. A large number of cells are mounted on a rotating array, permitting the selection of the desired cell. Cells are easily removable, permitting a selection of cells suitable to the tasks being performed. (Although cell storage devices are considerably slower than disk devices, they have larger total storage capacities,

and are cheaper per character stored than any other direct storage device.)

### Card and Printer Devices

The fastest high-speed punched card input and output, and high-speed printer output capabilities are used. Typical speeds available are approximately 1000 cards per minute for the card reader, and 300 cards per minute for the card punch. Printer speeds range up to 1400 lines per minute, but should not go much under 1100 lines per minute as a minimum capability, to produce the output needed for large-volume centrally printed jobs, such as report cards.

### Document Reader

The document reader reads 8-1/2x11 forms, on which a student marks with an ordinary pencil in spaces indicated on each form. Such marks, for example, are answers to test questions from standardized test booklets or teacher-made tests, or are used for batch entry of problems or programs done for homework where no terminal or keypunch is available. At least one such device, capable of reading such marks into the central computer, must be installed. As the volume of such work builds up, the requirement may build up to as many as four.

### Instructional Terminals

The instructional terminal is a keyboard/printer resembling an ordinary office typewriter. It satisfies all requirements and is usable for many purposes in the school. The instructional terminal provides the same typewriter functions as the administrative terminal. Since the terminal will be used only in a conversational mode, the terminal has no card reader/punch components. Its only means of input is through a keyboard.

The keyboard provides the extended character set necessary for problem-solving. Since it also functions as an ordinary automatic electric typewriter in an offline mode, it has the capability to handle a character set modification to conform to the conventional typewriter upper/lower character set.

Since it is a low-speed manual entry device, the instructional terminal does not have the heavy-duty construction required for the administrative terminal. Thus, the instructional terminal should have a somewhat lower cost as compared to an equivalent administrative terminal without the card/read punch.

The normal use of the instructional terminal involves classroom demonstration use by the teacher, and student use on a scheduled basis. This terminal has the associated data-set for attachment to communications lines physically connected to the unit, all of which are mounted on casters. This data set terminates in a long cord with a phone jack. With casters, the terminal is taken from its normal location, wheeled into a classroom, and connected into a local phone jack. After the classroom need has ended, the terminal is wheeled back to its normal location where it can be used by students.

In addition to classroom and/or student use, certain administrative uses can also be accommodated on the same terminal. This terminal is well suited for inquiry and type-out of low-volume responses. For example, when not otherwise in use, counselors could use the terminals for student record inquiry, updating, and production of student records needed for student interviews. At certain times of the year, such as the opening of school, they might be exclusively used in this manner, since they would not yet be needed for instructional use. At other times of the year, such as at report-card time, they could be used, for example, by teachers for sending grades, comments, etc., to the central computer for use in preparing report cards.

### Administrative Terminals

This terminal is a heavy-duty typewriter terminal that is connected to the central computer through common carrier facilities. The terminal contains a standard typewriter keyboard for data entry. A hard-copy typed output is available for all incoming or outgoing traffic. In addition to the typewriter component, an attached card reader accepts data in punched card format for transmission to the central computer, and an attached punch unit produces standard punched cards at the terminal under the control of the central computer. The terminal transmits and receives data at a rate comparable to the maximum typing speed of the typewriter (about 15 characters per second).

The typewriter portion of this terminal has multiple character set capabilities to support all administrative and instructional tasks. For problem solving or data processing training, sets with special characters satisfy the needs of the functions performed. For administrative uses, an all-capital-character set is available. The "home loop" or local use of the terminal as an automatic typewriter when using the card reader as the data

source is available. The character set is exchangeable by the operator upon demand. (This must be a very simple and noncritical operation.)

The card punch component of the terminal prints the punched cards with easily readable alphabetic/numeric characters across the top of the card. Since the punch will be used as an output of the terminal under computer control only at rare intervals, the punch provides normal keypunch services at other times. Since a keypunch is a necessary element to service both administrative and data processing training needs in the school, this device satisfies both the online card punch and offline punch requirements.

Since this terminal must support a heavy workload, all secondary schools, regardless of size, must have at least one administrative terminal with the card reader and card punch features. Manual keyboard entry cannot maintain the full-speed capabilities required of this terminal, nor can accuracy be guaranteed without visual verification before release of the data entered. Through use of a card reader, in fully-automatic mode or in conjunction with partial manual entry, an improved average input speed can be maintained, and accuracy is guaranteed where it is most critical. The additional throughput clearly justifies the added cost for the card reader and punch.

### FUTURE CONFIGURATIONS

#### Central Computer

Functional differences in the central computer system between the first implementation and a future one will be minimal. The major differences pertain to capacity relative to workload. For example, a first implementation would service only a portion of the total user population. Yet all the demands on the system, other than volume, would be about the same. For this reason, a medium-scaled computer may be required initially, with a planned conversion to compatible computers of larger memory, secondary storage, and higher internal speeds, but not increased function capabilities. Thus, the computer programs, with minor exceptions (mostly to increase system capabilities, such as the number of incoming communication lines) would be the same for the initial and future system.

As the system size expands in the number of communication lines to be serviced, the internal high-speed memory of the computer may increase from 256,000 positions to as much as 512,000. In addition, as the total load on the system increases,

the internal speed of the device will become more and more inadequate. At some point, usually about the time that more communication lines are required than can be physically attached, the computer itself will have to be upgraded to a higher model, with a faster internal speed. Before an actual implementation, it is difficult to estimate the exact point when an upgrade will be necessary. As a general axiom, however, the larger the computer, the lower the unit cost of performing a single operation. Thus, upgrading to a larger machine will in the end provide a greater economy per operation performed, even though the rental cost of the larger machine is greater.

Advancing technology will eventually require the replacement of the computer itself with a new generation computer. New technology will permit improvements in the price/performance ratios of new computers, and will perhaps bring improvements in the basic capabilities of the devices themselves.

#### Document Reader

At the present time, except for very sophisticated devices which require a constant high-volume load to justify, the only practical page reader within the school economic constraints reads the presence or absence of marks. Sophisticated devices are available, however, that can read both human-printed characters as well as machine-printed characters. Many type fonts can be read with these devices. With respect to handwriting, however, such devices usually limit the user to the numerics, and a few selected, printed, capital-letter alphabets.

#### Communications Control Unit

Future technology may make it possible to increase the number of terminals which can share the use of a single line. The limiting factor for simultaneous transmission in either direction is the data bit capability of the line itself, compared to the data bit generation rate of the terminal use. Newer devices may become available that increase the number of terminals that can be serviced on a single line by temporarily storing the data from the terminal if the line is momentarily in use, and transmitting it during the next instant that the line is free. Thus, time that would otherwise be wasted on the line can be placed into use, with little or no noticeable effect upon the user. As educational television systems are installed in school districts or larger areas, technology may permit use of unused channel capacity for the two-way transmission of data.

#### Instructional Terminal

It is not expected that there will be a significant change in the design of the instructional terminal. While a display terminal could be considered, the lack of hard-copy output is a serious disadvantage to the student. A faster-rate printer would not be a significant benefit because of the small volume of output. As cost savings are achieved in the future because of improved technology, the increased buying power would probably be used to increase the number of such terminals, not to enhance their capabilities.

#### Administrative Terminal

In the future, the workload of certain schools may require hard-copy output that will exceed the rate possible to obtain from a low- or medium-speed terminal. To meet this requirement, it will be necessary to have a line-printer (line-by-line) capability at the terminal to replace the character-by-character output of a typewriter-output device.

The line printer should be able to print a standard, full-width form of approximately 120 characters wide, at a rate of approximately 100 lines per minute to justify the additional projected expense. An additional item of cost results from the necessity to use a high-speed communications line for such a terminal, because of the increased character rate necessary to maintain this speed.

Some of the administrative load in the future could be met through use of a visual display terminal. Currently, although they have some valuable capabilities, their cost exceeds the economic objectives for initial implementation. In the future, however, as the price of such terminals is reduced, and wherever hard copy is not an absolute requirement, these terminals should come into increased use, and are highly recommended. Naturally, since the requirement for hard copy from an administrative terminal is expected to remain, the display terminal would have to be considered as a supplement to the typewriter or line-printer terminal, to meet increased workload.

The visual display terminal is a cathode-ray television-type device, with a manual keyboard, essentially identical to that of a typewriter. As data is keyed in, the characters keyed appear on the face of a screen. Thus, all data entered on the keyboard is visible to the operator and available for correction before transmission to the computer, when released by the operator as correct.

At the present time, there are display terminals which meet all the above requirements, except that of low cost. For a first implementation, considering the cost objectives of this study,



the display terminal cannot be recommended, even at an administrative center, where it can be best used. If adequate funds are available, however, this terminal can be well used in the administrative center. It is especially appropriate for use by the personnel department for examining and updating employee records, and for use in the control of school budgets.

There are many advantages to the display terminal. It can display a large amount of computer-generated text simultaneously, without the delays associated with the character-by-character production of a typewriter device or line-by-line printer. One of its most important features is its rapid edit capability. The operator corrects data by positioning a pointer under the data to be changed and then keying in the correct data. This action replaces the original data. The new data can then be quickly verified visually and released to the computer. The same ability applies to the initial entry of the data, or revision or deleting data.

The display terminal does not produce hard copy. For some administrative jobs, such as entering orders of supplies or obtaining budget balances, this would be a disadvantage, since a permanent record of the transaction should be maintained. For a guidance counselor, with a student seated before him in an interview, it would be an advantage. Significant portions of student record could be visible in a page-by-page fashion, easily accessed. Updates to the record could be made instantly by the counselor. Access to the computer files could be made rapidly and directly, with the user scanning large volumes of data in a browsing mode. For example, a student might be interested in examining college data for which his academic record would indicate a reasonable choice.

Data on each college could be displayed, one college at a time, with computer-generated annotations as to the student's probability of success, and what deficiencies, if any, would have to be overcome to improve chances of acceptance.

Over a period of years, technology improvements should not only bring down the cost of display terminals, but make them more flexible and adaptable. Current cabling requirements may be eliminated when a "stand-alone" display terminal is readily available on an economic basis. Some of the general objections with regard to eye-ease

in using such a terminal over prolonged periods, will undoubtedly be eliminated with improvements in phosphors, display regeneration, and the matrixing method of generating characters. When the price/performance breakthroughs do occur for display terminals, they should be readily accepted by the administrative centers and the school counseling staff.

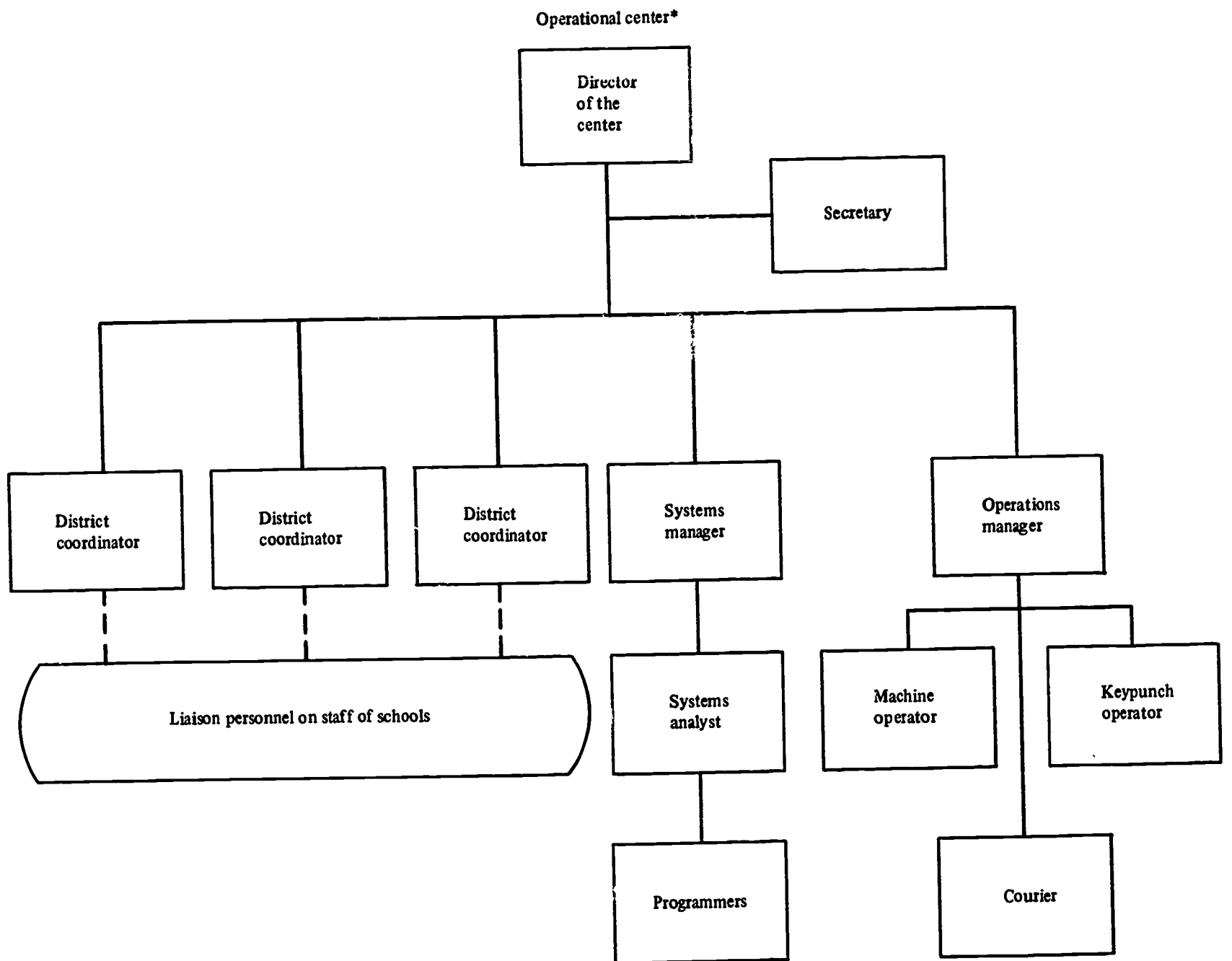
Send-only devices, such as touch-tone pads, have inherent problems of accurate verification. Such devices require blind keying, which is subject to human error, and must be caught quickly if ever to be fully satisfactory. While not as serious a problem, transmission errors because of noise in the phone circuits can occur, and must be detected. One possible means of immediate verification for such devices is voice-answerback under computer control. Because of the expense of this technology, however, it is not recommended for use in the proposed system at the present time.

#### OTHER COMPUTING CENTER EQUIPMENT

In addition to the central computer, and its attached devices, the usual array of auxiliary machines, such as keypunches and verifiers, sorters, interpreters, and perhaps collators, reproducers, etc., must be available. Extensive form-handling equipment to decollate carbon sets, burst the forms, and even insert report cards into envelopes, is also required. The computer center itself should be physically located to facilitate delivery and pickup, including perhaps a loading dock and adequate, close parking. Telephone facilities must also be planned and budgeted.

#### MANPOWER REQUIREMENTS

A computer center requires the usual complement of managerial and operational staff. Systems personnel are required to handle a continuing demand for doing new tasks, improving old ones, and maintaining present ones. In addition, there must be coordinators to act as liaison between the school and district users, and the center. Finally, there must be operators to run the machines and to do the clerical tasks required. Outside the computer center, there must be assignment of responsibilities for school staff personnel, to work with the coordinators. An example of a staff organizational chart for the center is shown in Figure 6.



\*No development staff for the initial implementation of the system is included.

Figure 6. Manpower requirements

## PART 4: SYSTEM VALIDATION

This part describes the procedure used to validate the system configuration developed by the IBM study team. The effort involved the selection of a case study area to collect pertinent information on enrollment, workloads, and other statistics. On the basis of this data, equipment was selected and costs were projected. The equipment was then simulated as a system to determine its ability to handle the projected workloads for the case study region, the USOE region, and three regions (A, B, C) defined by IBM.

### APPROACH

System validation involved two main areas:

1. A Case Study. An existing body of schools was selected to collect live data about the real world to evaluate school district sizes and machine costs.

2. A Simulation. The purpose of simulation was to simulate workload volumes and characteristics of the system to evaluate the technical feasibility of the system.

#### Case Study

##### Purpose

The case study was undertaken for five major reasons:

1. To produce realistic results, a simulation model requires input data that is representative of the live system being simulated. The model used for the initial phase of the feasibility study was theoretical and approximate. Real input data could be obtained only by selecting an existing body of schools, discovering their actual enrollments, and using these and other pertinent statistics in the simulation.

2. The experience in educational data processing today has been primarily in the administrative area. The instructional area is still largely speculative and experimental. No authoritative experience is available to determine how many terminals are required for problem solving in the schools. Only an intensive study of an actual school environment could establish the probable nature and extent of such needs.

3. The expense of a computer facility that can meet the needs of education today must be justifiable and feasible. The total cost of such a system could be estimated; however, to project approximate costs, it is necessary to know what

is now being spent by school districts in a given area. With this information, costs were put into perspective, and the economic feasibility ascertained.

4. In a terminal-oriented system, line costs are an important factor in determining the total system cost. These expenses can be calculated only if the terminal locations, and the distances from terminal locations to central computer, are known. Arbitrary distances, assigned in a given radius, are not truly meaningful. Only a case study of an existing school system could provide realistic data.

5. A case study and simulation aids in proving that the findings of a feasibility study can be borne out in at least one true instance. Simulation is the only method of validation short of actual implementation. For these reasons, a case study of the real world was decided upon.

##### Data Collected

Four categories of data were collected. A brief description of their relevance to the validation effort follows:

Enrollment Information. Four types of enrollment data were collected:

1. The first was the total for K through 12 enrollment in each school district included in the study. This data helped to determine the administrative costs per pupil.

2. The names of all senior high schools and their enrollments, by grade, were collected. This data helped to determine the number of administrative terminals required in each school, and the peak loads on the computer for daily priority tasks.

3. The math/science course enrollment, by school, was collected. This data helped to determine how many problem-solving users there would be in each school and, thus, the number of instructional terminals required. (Math and science were assumed to be the courses most likely to utilize problem-solving capabilities in the immediate future.)

4. The names of all junior colleges, and their enrollments by grade and by course, were collected. This data helped to determine the number of instructional terminals required.

Course Information. The content of the courses offered by each district helped to determine the level of the courses and, thus, the degree of problem solving which would be used in each.

Since both titles and course content vary widely among districts, a catalog with course descriptions was used to obtain a true definition of the courses.

The objective of this analysis was to fit each course under one of the USOE math/science categories, calculate the enrollments, calculate the number of problem sessions on the terminal in each course, and then, as the ultimate goal, determine the number of terminals required by each school.

Geographic Information. Maps of each school district included in the study were used for spotting school locations. From this information, distances were derived, and the line costs of terminals were calculated.

Budget Information. The present operating costs of each school district were used to calculate the percentage of the budget that would represent the centralized computer facility. (The USOE Financial Accounting Handbook was used to describe the categories of the budget included in these operating expenses.)

### Case Study Location

The case study area represented a reasonable cross section of the socio-economic population, as well as one that was near the study team location. The Washington, D.C. metropolitan area filled both qualifications.

The Central Atlantic Regional Education Lab (CAREL) located in Alexandria, Virginia, provided a great deal of assistance in determining which school districts in the D.C. metropolitan area should be included in the study. On the basis of approximate school enrollment figures and numbers of schools, the study area was selected to fit the USOE model as closely as possible. The six districts included in the study were:

- District of Columbia
- Montgomery County, Maryland
- Fairfax County, Virginia
- Falls Church, Virginia
- Alexandria, Virginia
- Arlington County, Virginia

### Results

The objective of the case study was to take the conclusions of the feasibility study, supply data from an existing school system, and test the results. The following charts and tables describe the case study area and the results in terms of critical load volumes, equipment selection, and cost estimates and analysis. The assumptions and characteristics of the system design previously discussed were used as the framework for the case

study. For example, the instructional use of the system is by senior high schools and junior colleges; and the administrative functions serve grades K-12, exclusively.

Enrollments and budgets for the school districts are based on 1966-67 figures. According to these figures, the average dollar amount spent per pupil in the total study area was \$602.00 in 1966-67.

Population Table. Table 6 lists the districts included in the study; junior colleges are listed separately under the counties in which they are located. The number of schools and campuses are given, the enrollments, and the number of administrative centers, with totals for all categories. The total problem-solving enrollment for the area (senior high's and junior colleges) is 93,383. Total enrollment for administrative area to be served (K-12) was 404,642.

A map of the senior high schools, district administrative centers, and junior colleges located in the case study is shown in Figure 7. The numerals in each figure are the number of terminals projected for that location. Circles represent senior high schools; circled triangles represent district administrative centers; rectangles represent junior/community colleges.

The starred figure is the "named" location for the computer center. This location was determined by giving each spot an x,y coordinate on the map and calculating the most logical position (least average miles per terminal from each location). These results were then adjusted according to line costs in the Washington, D.C. metropolitan area. It is a theoretical computer center, but it fixes the best "area" in which such a center should be located.

Workload Tables. Tables 7 and 8 give the instructional workloads based on course enrollment statistics collected in the math/science areas from each school included in the case study. Calculations were made by using the number of problems estimated per course category. For secondary schools, the number of problem-solving sessions was derived from the following formula: 80% of the students do their problems in paired sessions; the remaining 20% work individually. For junior colleges, the number of problem-solving sessions is based upon individual sessions at the terminal.

The tables also include the daily priority pupil-administrative report workloads. These are based on total enrollments in each school, and estimated daily volume in attendance, guidance, and registration. "Daily Transactions" refers only to those

Table 6  
POPULATION TABLE

District or Junior College	Sr. High Schools	District K-12 Enrollments			Adm. Centers	Junior Colleges	
		9/10-12	K-8/9	TOTAL		No. Campuses	Enrollment
District of Columbia	11	18,855	124,199	143,054	1		
Fairfax	17	30,195	71,224	101,419	1		
N. Va. Community Coll.						1	3,200
Falls Church	1	710	1,422	2,132	1		
Alexandria	3	4,768	11,433	16,211	1		
Arlington	3	6,114	20,031	26,145	1		
Montgomery	17	25,525	90,156	115,681	1		
Montgomery J. C.						2	4,016
TOTALS	52	86,167	318,475	404,642	6	3	7,216

transactions occurring after the first period of the day, and continuing through the last period. It is assumed that the bulk of these transactions will be performed during the first period (when problem solving is not in session) or after the regular school day. Since the critical period for administrative work is during the day, when the instructional traffic is heaviest, the daily workloads were considered most important. On the basis of these workloads, the number of terminals was ascertained. Table 8 shows the number of instructional terminals and administrative terminals. In school locations, problem solving takes priority over administrative work on both instructional and administrative terminals during the "problem solving" day. Only during the first period of school and after school hours will the administrative terminal be used exclusively for administrative functions.

In the district administrative centers only, the administrative terminals are dedicated, full time, to administration.

In the summary table, Table 7, the center terminal represents the number of administrative terminals in each district administrative center.

The data processing training workloads could not be determined in a realistic way, because none of the secondary schools presently incorporate a

comprehensive DP training program in their curriculum. For these reasons, no data processing training workloads are included in the tables. Since most of the workload in this area should be in the remote batch entry mode, terminal requirements will not be significantly affected.

**Cost Estimates.** The summary cost data is presented in Table 9, with detail cost data in Appendix E. These costs are based upon the same assumptions utilized to compute costs for the four model regions set forth in "System Costs", with the following exceptions:

1. **Equipment Selection.** Table 10 shows the characteristics of the equipment costed for the case study region.

2. **Communication Equipment.** Common carrier costs for the communications support are based upon the representative tariffs for full-time leased facilities in the Washington, D.C. area. These tariffs are described in Table 11. Airline mileage between the remote location and the central site in northwest Washington, D.C. was estimated from area maps.

3. **Personnel and Supplies.** Estimated annual costs for personnel and supplies are those as specified for model region B in "System Costs".

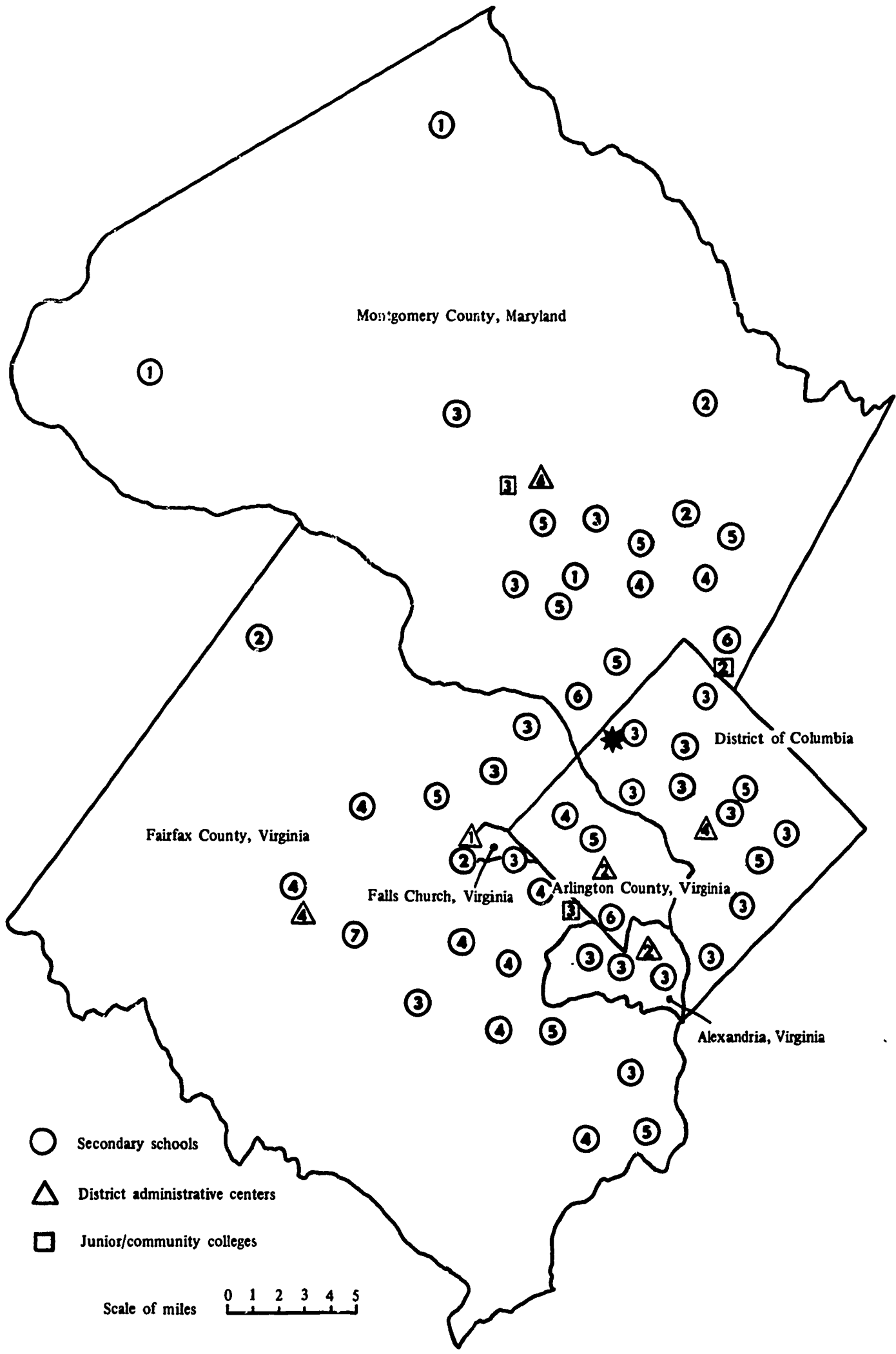


Figure 7. Case study area map

Table 7

## WORKLOAD SUMMARY

District or Junior College	No. Sr. High's or Cam- puses	Enrollments			No. Adm. Cen- ters	*No. Terminals			Terminal Totals
		9/10-12	K-8/9	Total (or 13-14)		IT	AT	CT	
District of Columbia	11	18,855	124,199	143,054	1	26	11	4	41
Fairfax	17	30,195	71,224	101,419	1	50	17	4	71
N. Va. Community C.	1	-	-	3,200	-	3	-	-	3
Falls Church	1	710	1,422	2,132	1	1	1	1	3
Alexandria	3	4,768	11,433	16,211	1	6	3	2	11
Arlington	3	6,114	20,031	26,145	1	12	3	2	17
Montgomery	17	25,525	90,156	115,681	1	44	17	4	65
Montgomery J. C.	2	-	-	4,016	-	5	-	-	5
<b>TOTALS</b>	<b>55</b>	<b>86,167</b>	<b>318,475</b>	<b>411,858</b>	<b>6</b>	<b>147</b>	<b>52</b>	<b>17</b>	<b>216</b>

\*IT = Instructional Terminal

AT = Administrative/Instructional Terminal

CT = Center Terminal (District Administrative Centers)

Table 8

## WORKLOAD

School	Enrollment	Annual Problem- Solving Sessions	Terminal*		Pupil Administrative Services Daily Transactions		
			IT	AT	Attendance (220/1000)	Guidance (20/1000)	Registration (28/1000)
<u>District of Columbia</u>							
Anacostia	1,569	7,467	2	1	346	32	44
Ballou	1,474	7,989	2	1	324	30	42
Cardozo	1,791	10,818	2	1	394	36	50
Coolidge	1,653	10,785	2	1	364	34	46
Dunbar	1,514	7,944	2	1	334	30	42
Eastern	2,576	15,006	4	1	566	52	72
McKinley	2,293	14,358	4	1	504	46	64
Roosevelt	1,518	9,030	2	1	334	30	42
Spingarn	1,675	9,114	2	1	368	34	46
Western	1,379	9,396	2	1	304	28	38
Wilson	1,413	10,359	2	1	310	28	40
<b>TOTALS</b>	<b>18,855</b>	<b>112,446</b>	<b>26</b>	<b>11</b>	<b>4,148</b>	<b>380</b>	<b>526</b>
<u>Fairfax County</u>							
Annandale	2,009	13,955	3	1	442	40	56
Edison	2,177	14,535	4	1	478	44	60
Fairfax	1,852	12,324	3	1	408	38	51
Falls Church	1,539	10,296	2	1	338	30	43
Fort Hunt	2,246	14,040	4	1	494	44	62
Groveton	1,324	8,892	2	1	292	26	37
Herndon	737	4,845	1	1	162	14	20
Jefferson	1,608	10,704	3	1	354	32	45
Langley	1,379	9,093	2	1	304	28	38
Lee	1,575	10,509	3	1	346	32	44
Madison	2,009	13,125	3	1	442	40	56
Marshall	2,281	15,691	4	1	502	46	63
McLean	1,401	9,495	2	1	308	28	39
Mt. Vernon	1,694	11,319	3	1	372	34	47
Stuart	1,899	13,020	3	1	418	38	53
W. Springfield	1,190	7,092	2	1	262	24	33
Woodson	3,275	22,185	6	1	720	66	91
<b>TOTALS</b>	<b>30,195</b>	<b>201,160</b>	<b>50</b>	<b>17</b>	<b>6,642</b>	<b>544</b>	<b>838</b>

\* IT = Instructional Terminal

AT = Administrative/Instructional Terminal



Table 8 (cont.)

School	Enrollment	Annual Problem-Solving Sessions	Terminal* Requirements		Pupil Administrative Services Daily Transactions		
			IT	AT	Attendance (220/1000)	Guidance (20/1000)	Registration (28/1000)
<u>Falls Church</u>							
George Mason	1,085	5,571	1	1	238	21	30
<b>TOTALS</b>	<b>1,085</b>	<b>5,571</b>	<b>1</b>	<b>1</b>	<b>238</b>	<b>21</b>	<b>30</b>
<u>Alexandria</u>							
T. C. Williams	1,789	9,804	2	1	394	36	50
F. Hammon	1,469	8,304	2	1	324	30	42
G. Washington	1,510	8,556	2	1	332	30	42
<b>TOTALS</b>	<b>4,768</b>	<b>23,328</b>	<b>6</b>	<b>3</b>	<b>1,050</b>	<b>96</b>	<b>134</b>
<u>Arlington</u>							
Wakefield	2,553	18,495	5	1	562	52	72
Washington-Lee	2,042	15,258	4	1	450	40	58
Yorktown	1,519	12,963	3	1	334	30	42
<b>TOTALS</b>	<b>6,114</b>	<b>45,419</b>	<b>12</b>	<b>3</b>	<b>1,346</b>	<b>122</b>	<b>172</b>
<u>Montgomery County</u>							
Bethesda - Chevy Chase	1,860	15,516	4	1	410	38	52
Walt Whitman	2,065	21,138	5	1	454	42	58
Gaithersburg	1,520	7,878	2	1	334	30	42
Poolesville	505	1,320	-	1	112	10	14
Damascus	865	2,382	-	1	190	18	24
Peary	1,792	10,125	2	1	394	36	50
Montgomery	2,008	16,224	4	1	442	40	56
Einstein	1,558	11,406	3	1	342	32	44
Springbrook	1,864	15,015	4	1	410	38	52
Northwood	1,770	13,296	3	1	390	36	50
Montgomery-Blair	2,340	18,399	5	1	514	46	66
W. Johnson	1,940	17,877	4	1	426	38	54
C. W. Woodward	1,058	2,754	-	1	232	22	30
Wheaton	2,147	15,336	4	1	472	24	60
Churchill	1,288	7,173	2	1	284	26	36
Kennedy	858	4,881	1	1	188	18	24
Sherwood	1,390	4,692	1	1	306	28	38
<b>TOTALS</b>	<b>26,828</b>	<b>185,412</b>	<b>44</b>	<b>17</b>	<b>5,900</b>	<b>522</b>	<b>750</b>

\* IT = Instructional Terminal

AT = Administrative/Instructional Terminal

Table 8 (cont.)

School	Enrollment	Annual Problem-Solving Sessions	Terminal* Requirements		Pupil Administrative Services Daily Transactions		
			IT	AT	Attendance (220/1000)	Guidance (20/1000)	Registration (28/1000)
<b>Junior Colleges</b>							
N. Virginia C. C.	3,200	12,435	3	-	-	-	-
Montgomery-Rockville	2,356	12,160	3	-	-	-	-
Montgomery-Tacoma Park	1,660	7,360	2	-	-	-	-
<b>TOTALS</b>	<b>7,216</b>	<b>31,955</b>	<b>8</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>
<b>Administrative Centers</b>							
D. C.			-	4	All Administrative Services		
Fairfax			-	4	All Administrative Services		
Falls Church			-	1	All Administrative Services		
Alexandria			-	2	All Administrative Services		
Arlington			-	2	All Administrative Services		
Montgomery			-	4	All Administrative Services		
<b>TOTALS</b>			<b>8</b>	<b>17</b>			

\* IT = Instructional Terminal

AT = Administrative/Instructional Terminal

Table 9

## SUMMARY ANNUAL COST ESTIMATES

Item	Case Study Region Cost
<b>RTCCS COSTS</b>	
-Equipment	
● Central Computer Site	\$ 525,003
● Remote Locations	469,066
-Personnel	222,000
-Supplies and Unit Record	30,000
<b>TOTAL</b>	<b>1,246,069</b>
<b>TOTAL REGION OPERATING EXPENSE</b>	<b>247,018,448</b>
<b>% RTCCS COSTS OF OPERATING EXPENSE</b>	<b>.50%</b>
<b>ADMINISTRATIVE COSTS ASSIGNED</b>	<b>704,811</b>
<b>INSTRUCTIONAL COSTS ASSIGNED</b>	<b>548,038</b>

Table 10

## EQUIPMENT SELECTION

Item	No.
<b>Central Site</b>	
-- CPU Main Storage (characters)	256,000
-- Direct Access Storage (characters)	
• High Speed	230,000,000
• Low/Medium Speed	400,000,000
-- Sequential Storage	
• (No. of Magnetic Tape Units)	2
-- Card Input/Output	
• (No. of Card-read-punch Units)	1
	Read 1,000 cpm
	Punch 300 cpm
-- Printer	
• (No. and speed in lines/min.)	1
	Print 1,100 lpm
-- Optical Mark Reader	3
-- Communication Control Unit	
• (No. of Control lines)	
Local Monitor Terminal	1
Secondary Schools	191
Junior Colleges	8
Administrative Center	17
	<u>217</u>
-- Communication Terminations	
• Common Carrier	2
• DP Mfg. Adapter	214
-- Average Monthly Usage (hours)	
• Summer (3 months)	176 hours
• School Year (9 months)	300 hours

Item	No.
<b>Secondary School</b>	
-- Number of Schools	52
-- Instructional Terminals	139
-- Administrative Terminals	52
	<u>191</u>
	TOTAL
-- Communication Network	
• Single Communication Lines	2
• Shared Communication Lines	65
	<u>67</u>
	TOTAL
-- Communication Terminations	
• Common Carrier	2
• DP Mfg. Adapter	189
<b>Junior College</b>	
-- Number of Schools	3
-- Instructional Terminals	8
-- Communication Network	
• Shared Communication Lines	3
-- Communication Terminations	
• DP Mfg. Adapter	8
<b>Administrative Center</b>	
-- Number of Centers	6
-- Printer/Keyboard Terminals	17
-- Communication Network	
• Shared Communication Lines	6
-- Communication Terminations	
• DP Mfg. Adapter	17

Table 11

## COMMON CARRIER CHARGES--CASE STUDY REGION

Item	Monthly Charges
<b>150 BPS LEASED LINE</b>	
● Channel Arrangement--Central Site	None
● Channel Arrangement--Remote Site	
District of Columbia	None
Maryland	8.25
Virginia	8.25
● Station Arrangement--Central Site	25.00
● Station Arrangement--Remote Site	
District of Columbia	25.00
Maryland	25.00
Virginia	25.00
● Line Costs/per mile	1.75
<b>VOICE-GRADE LINE (Share up to four subchannels with DP Mfg. shared-line adapters)</b>	
● Channel Terminal--Central Site	None
● Channel Terminal--Remote Site	
District of Columbia	None
Maryland	7.50 (First Channel)
Maryland	5.00 (Each Additional Channel)
Virginia	7.50 (First Channel only charged)
● Line Costs/per mile	3.00

Budget amounts reported in Appendix E for the school districts include annual operating expenses only. Capital outlay is excluded. The cost analysis which follows these budget figures uses the same criteria as described in "System Costs", to distribute the costs of instructional and administrative use. The estimated value of administrative data processing services was first computed. This value is based on the experience of typical school systems around the nation, as explained in detail in "System Costs". The instructional cost is the net cost remaining, and is distributed to secondary schools and junior colleges on the basis of their percentage of total workload. The cost per student is determined from secondary school and junior college enrollments.

Two types of communication line costs were calculated for each location, using the figures in Table 11. The lower of the two resulting amounts was used in each case.

### Simulation

The objective of the simulation task was to predict the performance of the selected equipment and programming system configurations. Since time did not permit the simulation of the total system activity, the simulation effort was directed towards modeling that period during which the critical time-dependent tasks must be processed. These critical tasks include the student remote terminal problem-solving session and major daily administrative tasks, which require remote terminal entry and priority processing during the normal school day.

To accomplish the simulation task, a detailed algorithmic model of each configuration was developed and programmed. This model was then used in two ways:

First, simulation runs were made with a preliminary systems design, using the workload and model regions. These runs provided detailed data on system performance characteristics that pointed the way to design improvements. These design improvements were then incorporated in the model, and further simulation runs were made. This process was repeated until a system was evolved which met all major system requirements.

Second, after a feasible system was developed to handle one model region and its workload, the same design/simulation process was repeated to develop additional systems to handle other model regions, both smaller and larger. This process was utilized to establish the major equipment and programming system specifications contained in Volume II.

Finally, the live data collected for the Washington, D.C. metropolitan area case study were utilized for simulating the equipment requirements for this region. The remote problem-solving language portion for the simulation was validated by successfully simulating an existing problem-solving language implemented on an IBM System/360 at the IBM Research Center in Yorktown Heights, New York. The parameters for the operating system were derived from the IBM Disk Operating System/360; these parameters included the estimated overhead times associated with each of the DOS/360 tasks. The model was validated to the point where all contention for, and utilization of, system resources was accurately simulated. This validation represents an unusual occurrence in the simulation of complex computing systems, wherein a live system provided a direct validation of the basic model.

Upon completion of the model validation, the model was adjusted to reflect the characteristics applicable to the school environment.

### System Operation

Figure 8 shows the system components which were simulated to obtain peak load performance on the problem-solving and administrative applications. Appendix F shows the exact simulator configurations by model region.

Students use both the Type 2741 and Type 1050 terminals for problem solving, which consists of student requests entered from the keyboard, followed by computer responses typed on the printer. Each student is assigned one or more 18,000-byte workspaces, which are stored in a library on disk. A time-sharing algorithm is used so that it appears that each terminal has exclusive use of the CPU, with average response times less than three seconds. The currently active workspaces are swapped back and forth between core and disk as required.

Problem solving is given first priority in order to achieve the fast response times required. When there are no active student workspaces available in core to be processed, administrative inquiries are handled until the next interrupt occurs. These inquiries are sent in from the 1050 keyboards or card readers, and responses are returned to the terminal printers or card punches. The average response time for high-priority inquiries is less than two minutes, and low-priority inquiries are queued for overnight processing if they cannot be handled during the day.

Appendix F contains a description of the problem-solving and administrative models used in the simulator, plus logical flowcharts.

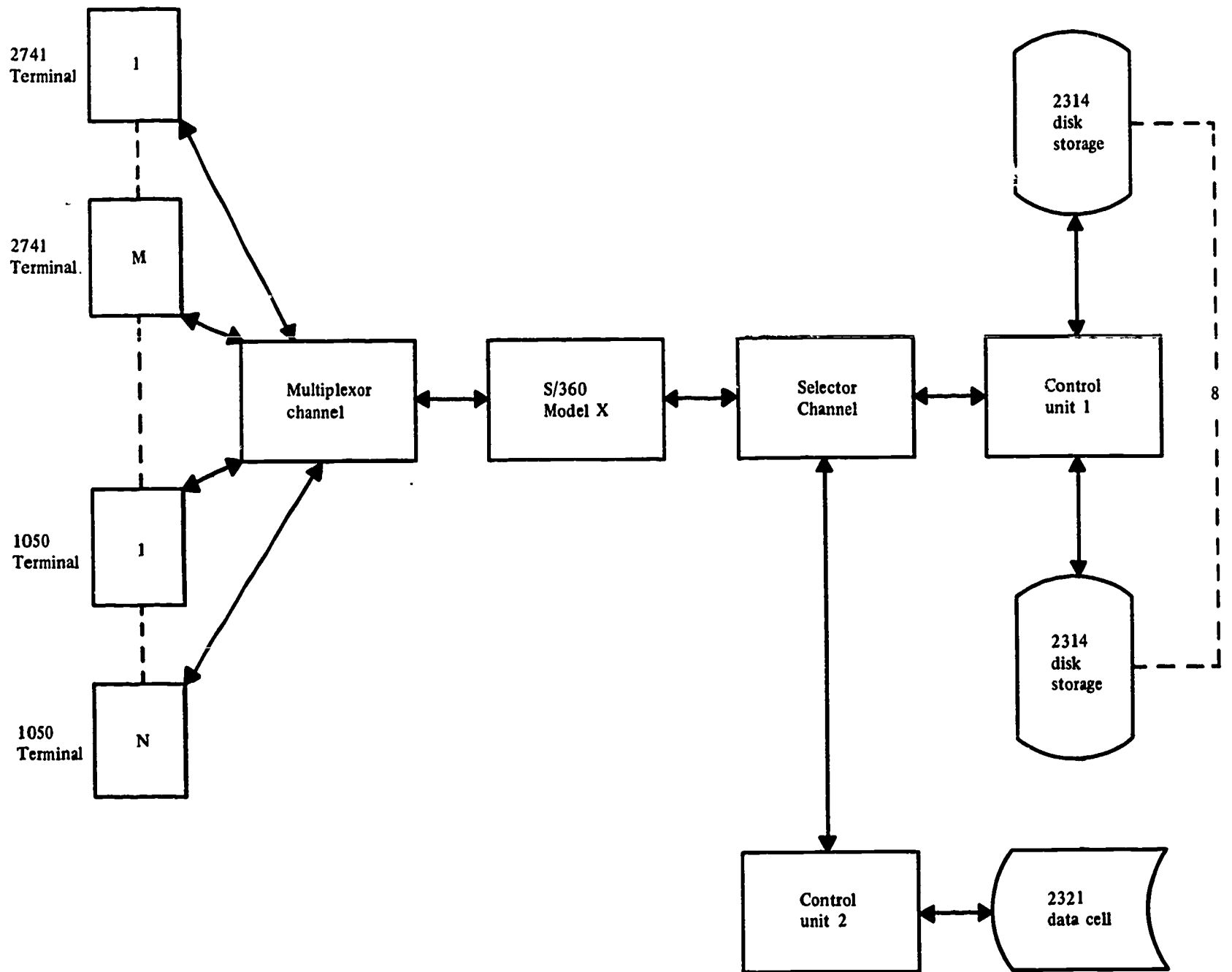


Figure 8. General system configuration simulated

### Input Parameter Development

**Problem Solving.** The study team conducted tests at an IBM 2741 terminal using typical secondary school instructional materials and a problem-solving language called APL\*. In addition, secondary school officials were contacted where these terminals have been in use. It was determined that for each student request the average turnaround time is 60 seconds, the average CPU calculation time required is .25 seconds, and the average message lengths transmitted in and out are 17.5 and 8.75 characters, respectively. These parameters were used to modify the corresponding distributions measured on the APL/360 system at IBM Research. The distribution of message types,

calculation versus various types of library operations, was unchanged (see Appendix F). Finally, the workspace size was reduced from 36,000 to 18,000 bytes.

**Administrative Inquiries.** The student accounting applications incorporated into the simulation model were attendance, guidance, and registration. Each of these areas was then subdivided to model the daily functions performed at each school. Attendance includes reporting absent students, tardy and early dismissal students, updating student records with reasons for absence (after the student has returned to school), and inquiries relative to unauthorized absences ("cuts") from class periods. Guidance inquiries enable the user

\*APL (a programming language) was developed by Dr. Kenneth Iverson, IBM Research. The language is currently undergoing research implementation at IBM Research Laboratories, Yorktown Heights, New York.

to request a student's history to be displayed before counseling, and to subsequently update the record. The final area, registration, encompasses enrolling new students and adding their records to the student file, recording students transferring from the school, and updating student and course records as program changes occur. The number of each type of job was determined on a percentage-of-enrollment basis. The percentages were fixed after consultations with school officials.

By using a percentage approach, school districts of different sizes were accurately modeled. These statistics are provided in Table 12.

Average inter origination times for each of these inquiries are shown in Appendix F. To simulate the random generation of these inquiries, average inter-origination time was modified by an exponential distribution.

## Results

Simulation results are sensitive to statistical variation as well as the logic of the simulation model and timing assumptions made by the user. Judgment must be exercised in determining the accuracy of the results. However, since major portions of the model were duplicated from an existing system, it is the opinion of the study team that the simulation results closely approximate the results which would be obtained from a live system developed from the simulated model.

All simulation runs were made with peak remote problem-solving workloads. The total real time simulated, that is, the time that represents "live" time units, such as a school period or a school day, was a function of the model region simulated and the time at which the established arithmetic means (response time and CPU time per problem-solving statement) became stabilized.

There are many results provided by the Computer System Simulator Program. Those results which are of major importance to systems design are response times and computer resource utilization.

Table 13 portrays the average response time for remote problem solving per statement entered and the remote administrative task response time per action input. These results are based upon the task priorities, with problem solving assigned the highest priority. A different priority sequence would produce different results for response time.

The performance objectives for the remote inquiry tasks are established with an average of 2.0 minutes response for the highest-priority administrative task, with the lower-priority messages queued for subsequent processing. Table 13 shows that this objective was met for all model regions except region C. In this case, it is felt that the desired administrative response time could be obtained by periodically assigning a higher priority to these tasks. If this were done, the problem-solving response time would change from

Table 12

### PERCENTAGE OF ENROLLMENT PER DAILY ADMINISTRATIVE JOB

Attendance	
*Absences	10%
Absence Reason Update	7.5%
Unauthorized Absence Inquiry	2.5%
Tardy-Early Dismissal	1.0%
Guidance	
**Student History Request	1.0%
Registration	
New Registrations	.2%
Transferring Students	.2%
Program Changes	2.0%

\*All these entries will be made during the first period of the school day.

\*\*A higher daily peak percentage of guidance requests is anticipated. However, it is expected that the remainder will occur before or after the instructional terminals are online.

its observed 2.2 seconds to some value closer to the 3.0 second objective. Time did not permit the simulation of this modification.

Table 14 contains utilization statistics, represented by percentage of time that the equipment components at the central site are utilized during the periods simulated. The equipment components presented are the CPU, high-speed

direct access storage, and low/medium-speed direct access storage. No component at the central site achieves a 100% utilization during the peak remote problem-solving and administrative task period.

Appendix F contains samples of some of the more significant simulator output obtained for the USOE model region. These include response times and equipment utilizations.

Table 13

**AVERAGE RESPONSE TIME OBSERVED IN SIMULATION**  
(All time in seconds)

Model Region	Priority							
	1	2			3	4		
	Prob. Solv.	Attendance			Guid.	Registration		
		Abs.	Cuts	Tdy.		Regis.	Trans.	Prog.
A	3.0	38	34	36	50	138	68	85
B	0.7	13	11	15	24	38	35	28
C	2.2	1407	1436	1502	Q	Q	Q	Q
USOE	1.0	87	98	97	1686	Q	Q	Q
CASE STUDY	1.0	22	20	20	88	156	67	113

Q: Message was transmitted from the administrative terminal and queued on administrative input queue within the central computing system, for processing after peak problem-solving periods.



Table 14

MAJOR EQUIPMENT UTILIZATION STATISTICS

(in percent utilized)

Model Region	Device									
	CPU	Low/Medium-Speed Direct Access Storage	High-Speed Direct Access Module*							
			1	2	3	4	5	6	7	8
A	72	31	19	19	23	21	-	-	-	-
B	65	38	2	11	10	11	11	6	6	6
C	93	19	3	20	22	16	22	3	5	3
USOE	80	46	2	10	10	11	10	6	7	8
CASE STUDY	67	47	2	18	18	18	17	6	7	7
*Use of High-Speed Direct Access Modules										
Modules	All Regions Except A and USOE		USOE - Region A							
1	Problem Solving Library		Problem Solving Library and Swap Area							
2	Problem Solving Swap Areas		Programming System Residence and Swap Area							
3	Problem Solving Swap Areas		Administrative Message Queue and Swap Area							
4	Problem Solving Swap Areas		-							
5	Problem Solving Swap Areas		Administrative Indices and Swap Area							
6	Programming Systems Residence		-							
7	Administrative Message Queue		-							
8	Administrative Indices		-							

## PART 5: SYSTEM COSTS

This section contains estimates of the annual operating cost for the remote terminal computing system that satisfies the system specifications described in Volume II.

Annual operating cost estimates were developed for four model educational regions as described in Table 15. The estimates are preliminary, since they are based upon hypothetical model regions, initial estimates of workload, and apply only to the system designs presented. Final cost estimates can be established only after a specific design has been selected for implementation at a designated location. Although the cost estimates are preliminary, the basic system design has been shown to be technically and economically feasible for the stated environment. A summary of the cost data is presented in Table 16; detail cost data is presented in Appendix D. The data processing and communication equipment selections for each model region are presented in Table 17.

Costs for development and pilot installation of a remote terminal computing system are not included. These costs are quite variable and dependent upon many factors; further, a development and implementation plan is beyond the scope of this study.

### ASSUMPTIONS

Assumptions used for developing the gross annual operating cost estimates listed in Table 16 and 17 are as follows:

1. Annual costs for the equipment are projected on a rental basis, which includes installation, maintenance, and programming systems support. Equipment rental figures were based on present IBM rental fees. No education allowance was assumed.

2. Costs for the central site data processing equipment, including the data communications control, are computed for a 300-hour per month usage for nine months per year for model regions A and B. Model C and the USOE model assume a 400-hour per month usage. The remaining three months for all regions are computed for normal prime shift usage of 176 hours per month. Monthly usage over 176 hours was computed at the current IBM rate, which is 10% of prime shift costs for extra shift use of standard computing equipment; there are no added extra shift charges for terminals and line adapters.

3. Common carrier costs for communications support are based upon representative interstate tariffs for full-time leased facilities. Established

interstate tariffs were not used in this study as these are variable by state. The interstate tariffs used are presented in Table 18.

4. For costing the common carrier facilities, all terminals were assumed to be 25 miles away from the central computer. For data transmission to a school with a single terminal, the communication facility was assumed to be a standard 150-bit-per-second leased line, with appropriate common carrier communications termination. Where more than one terminal was planned for a school, a voice-grade transmission line was assumed with appropriate termination. In this case, a shared-line adapter is required from the DP manufacturer for multiplexing and coupling the terminal signals to a single voice-grade line. For selecting common carrier service, "terminal" applies to either an instructional or an administrative terminal.

5. Cost estimates for planning, facilities acquisition, site preparation, and other one-time charges are not included, since they depend on specific implementation programs. Also, normal overhead items, such as power, light, and air conditioning, and general and administrative expense, are not included, since they depend upon local circumstances.

6. Personnel needs listed in Table 19 are estimated for normal operations after startup. Only a minimum number of computer programmers have been included for special program development, since it is assumed that such special programs would be available from a central library of programs. No overhead was applied to the personnel salaries, since this is variable from district to district.

7. Supplies costs include expenses for consumable supply items as well as the annual rental costs for the central site unit record card equipment, consisting of punches, verifier, reproducing machines, and interpreting machines. All data processing equipment is assumed to be commercially available as standard products with standard features. No equipment development costs are included in the estimates.

8. Computer/programming systems are assumed to be available and maintained according to the normal commercial practice. No programming systems development costs are included in the estimates.

### COST ESTIMATES

The total gross annual cost for the total computing system was estimated for each model region. This total computer system cost includes the costs for the data processing equipment, common carrier equipment, personnel salaries, and supplies.

Table 15  
MODEL REGIONS

Item	A		B		C		USOE	
	No. of Loc's	Total Enrolled	No. of Loc's	Total Enrolled	No. of Loc's	Total Enrolled	No. of Loc's	Total Enrolled
500	2	1,000	3	1,500	5	2,500	-	-
1,000	5	5,000	10	10,000	15	15,000	-	-
1,500	6	9,000	14	21,000	20	30,000	-	-
2,000	10	20,000	20	40,000	30	60,000	50	100,000
2,500	2	5,000	3	7,500	5	12,500	-	-
<b>Total enrolled 9-12</b>	25	40,000	50	80,000	75	120,000	50	100,000
<b>Total enrolled K-8</b>	-	120,000	-	240,000		360,000	-	300,000
<b>Total enrolled K-12</b>	-	160,000	-	320,000		480,000	-	400,000
<b>Total enrolled Jr. College (2,000 students per college)</b>	1	2,000	2	4,000	3	6,000	2	4,000
<b>Grand Total</b>	26	162,000	52	324,000	78	486,000	52	404,000
<b>District Admin. Centers</b>	1	-	2	-	3	-	2	-

Table 16  
SUMMARY ANNUAL COST ESTIMATES FOR SYSTEM  
(in thousands of dollars)

Item	Model Regions			
	A	B	C	USOE
Central Computer Site	372.3	502.1	718.7	692.7
Remote Location	224.6	448.5	673.3	499.9
<b>Equipment Total</b>	<b>596.9</b>	<b>950.6</b>	<b>1,392.0</b>	<b>1,193.6</b>
Personnel	175.0	222.0	245.0	228.0
Supplies & Unit Record	20.0	30.0	40.0	35.0
<b>Total</b>	<b>791.9</b>	<b>1,202.6</b>	<b>1,677.0</b>	<b>1,455.6</b>
<b>Total Region Operating Expense</b>	<b>86,184.0</b>	<b>172,368.0</b>	<b>258,552.0</b>	<b>214,928.0</b>
<b>% RTCCS Costs of Operating Expense</b>	<b>.86%</b>	<b>.70%</b>	<b>.65%</b>	<b>.68%</b>
Administrative Costs Assigned	307.0	614.0	921.0	688.1
Instructional Costs Assigned	484.9	588.6	756.0	767.5

Table 17  
EQUIPMENT SELECTION

Item	Model Regions			
	A	B	C	USOE
Central Site:				
--CPU Main Storage (characters)	256,000	256,000	512,000	512,000
--Direct Access Storage (characters)				
• High-speed	115,000,000	230,000,000	230,000,000	230,000,000
• Low/medium speed	400,000,000	400,000,000	400,000,000	400,000,000
--Sequential Storage (No. of magnetic tape units)	2	2	2	2
--Card Input/Output (No. of card read/punch units) (Cards per minute)	1 read 1,000 punch 300	1 read 1,000 punch 300	1 read 1,000 punch 300	1 read 1,000 punch 300
--Printer (No. and speed in lines/min.)	1 @ 600	1 @ 1,100	2 @ 1,100	2 @ 1,100
--Optical mark reader	2	3	4	4
--Communication control unit (No. of control lines)				
• Local Monitor terminal	1	1	1	1
• Secondary Schools	80	160	240	200
• Junior Colleges	3	6	9	6
• Administrative Center	4	8	12	8
<b>Total</b>	<b>88</b>	<b>175</b>	<b>262</b>	<b>215</b>
--Communication Terminations				
• Common Carrier	4	6	10	0
• DP Mfg. Adapter	83	169	252	215
--Average monthly usage (hours)				
• Summer (3 months)	176 hrs.	176 hrs.	176 hrs.	176 hrs.
• School year (9 months)	300 hrs.	300 hrs.	400 hrs.	400 hrs.
Secondary School:				
--Number of Schools	25	50	75	50
--Instructional Terminals	55	110	165	150
--Administration Terminals	25	50	75	50
<b>Total</b>	<b>80</b>	<b>160</b>	<b>240</b>	<b>200</b>

Table 17 (cont.)

Item	Model Regions			
	A	B	C	USOE
--Communication Network				
• Single Comm. Lines	4	6	10	0
• Shared Comm. Lines	23	47	70	50
Total	27	53	80	50
--Communication Terminal				
• Common Carrier	4	6	10	0
• .DP Mfg.	76	154	230	200
Junior College:				
--Number of Schools	1	2	3	2
--Instructional Terminals	3	6	9	6
--Comm. Network				
• Shared Comm. Lines	1	2	3	2
--Comm. Terminal				
• DP mfg. adapter	3	6	9	6
Administrative Center:				
--Number of centers	1	2	3	2
--Printer/Keyboard Terminals	4	8	12	8
--Comm. Network				
• Shared Comm. Lines	1	2	3	2
--Comm. Terminal				
• DP mfg. adapter	4	8	12	8

Table 18

## COMMON CARRIER INTERSTATE CHARGES

Item		Monthly Charge
150 bps Leased Line		
● Channel Termination	Central Site	\$31.25
● Channel Termination	Terminal Site	\$31.25
● Station Arrangement	Central Site	\$25.00
● Station Arrangement	Terminal	\$25.00
● Line Costs 1 - 100 miles @ 1.75/mile		\$ 1.75/mile
Voice-Grade Line (One to four shared subchannels for use with DP manufacturer-supplied line adapters.)		
● First Channel		
Service Terminal	Central Site	\$12.50
Service Terminal	Terminal Site	\$12.50
● Each Additional Channel		
Service Terminal	Central Site	\$ 7.50
Service Terminal	Terminal Site	\$ 7.50
● Line Costs 1 - 25 miles 26 - 100 miles		\$ 3.00/mile \$ 2.10/mile

Table 19

## ANNUAL COSTS FOR PERSONNEL AND SUPPLIES

Item	Model Regions							
	A		B		C		USOE	
	No.	Total Salary(\$)	No.	Total Salary(\$)	No.	Total Salary(\$)	No.	Total Salary(\$)
Director	1	16,000	1	18,000	1	20,000	1	18,000
Secretary	1	6,000	1	6,000	1	6,000	1	6,000
School Coordinator	1	15,000	2	30,000	3	45,000	2	30,000
System Manager	1	14,000	1	16,000	1	16,000	1	16,000
Operation Manager	1	12,000	1	14,000	1	14,000	1	14,000
System Analyst	2	24,000	2	24,000	2	24,000	2	24,000
Programmer	2	20,000	3	30,000	3	30,000	3	30,000
Programmer Trainee	2	14,000	2	14,000	2	14,000	2	14,000
Operator	5	30,000	6	36,000	7	42,000	7	42,000
Keypunch Operator	3	15,000	4	20,000	4	20,000	4	20,000
Clerk	1	4,000	1	4,000	1	4,000	1	4,000
Courier	1	5,000	2	10,000	2	10,000	2	10,000
<b>Total Salary (\$)</b>		<b>175,000</b>		<b>223,000</b>		<b>245,000</b>		<b>228,000</b>
Supplies and Unit Record		20,000		30,000		40,000		35,000
<b>Total Expense (\$)</b>		<b>195,000</b>		<b>252,000</b>		<b>285,000</b>		<b>263,000</b>

A school budget was computed for each region on the basis of an annual operating expense of \$532 per student in grades K-12 (for 1965-66, as described in the USOE Digest of Education Statistics). Since an annual cost for junior college students could not be obtained, the \$532 figure was also used for this population. The ratio of total computing system costs to the total budget is expressed as a percentage shown in Table 14.

To distribute costs for instructional use at the secondary school and junior colleges, the estimated value of administrative data processing services was first computed. The value for administrative data processing services was based on the experience of typical school systems around the nation, and is listed below:

Secondary Students. The pupil personnel services are valued at \$4.00 per student per year. In addition, the business administrative services for these students are valued at \$1.50 per student per year.

Elementary Students. The value for business administrative services is established at \$0.50 per student per year. In addition, 37.5% of the elementary student population receive extensive services for processing of tests, which is valued at \$0.60 per student per year.

Since junior college administrative data processing is not performed by the system, no administrative values are placed on this student population.

On the basis of the assigned values, the total administrative value of the system was computed, and subtracted from the gross annual costs to leave the net annual system costs for instruction.

The net annual instructional cost was distributed to secondary school and junior colleges on the basis of their percentage of total workload. The cost per student was determined from school enrollment and junior college enrollment for each model. The cost per student was further distributed by costs for problem solving and data processing training. For this latter distribution, it was assumed that data processing training problem sessions utilize four times the computing service as compared with the utilization for problem solving. These costs are valid only for the workload criteria established for each model region, and should not be used without reference to this workload.

## BILLING SYSTEM

All users receiving services from the central computing site should be charged for services on

a basis that will make the center financially self-sufficient, either from district funding, or through a combination of district funds and external funding sources. While many methods may be used for computing these charges, the method selected for implementation must be compatible with the school budgetary system, and any requirements to qualify for any external funding sources.

Three approaches to billing were considered, one based upon distance from the central site and actual utilization of the computing system; the second, based upon a fixed charge to the schools; and a third, based upon a combination of the first two.

A charge based upon actual utilization alone was found to be inappropriate. Since school annual budgets are prepared in advance of the school year, establishing projected charges for precise utilization may lead to substantial budgetary differences. Furthermore, utilization charges can lead to restricted uses of the system by the teacher and the student. The teacher who wants to provide more classroom demonstration uses of the system should not be penalized. An advanced student who may process more problems, or problems of greater complexity, should not be restricted from access to the system. Furthermore, the geographic distance of a school from the central site should not discriminate against user system access.

The remote terminal computing system is engaged with one commodity, educational services. Many standard elements are inherent within the total system: students, teachers, administrators, and tasks to be performed. The total system workload is predicated upon one major factor; that is, the size of the user population.

It is recommended that when only district funds are available to support the center, the annual cost to a school be based upon student population with fixed charges per student. This method for projecting costs provides the school administrators with more accurate data for budget purposes. The student and teacher are provided system access without restraints due to financial considerations.

The recommended method for assigning charges to a user is as follows:

Total Operational Costs. Each user provides the central computer management with the actual enrollment on a set date in the current school term. The total operational costs for the next year of operation are established for the central site. In addition, the cost for all remote terminal equipment and communication costs are established. A total annual operations cost figure is computed for

the center, including remote equipment and line charges. These are then prorated on the basis of current enrollment.

Administrative Services. The assigned administrative service value per elementary and secondary student receiving services is used to compute administrative costs for the budget year, using the current enrollment. The total administrative services costs are deducted from the total computer services operational budget. The remainder represents a cost to be used for instructional services.

Instructional Services. Costs for instructional services are comprised of costs for problem solving and data processing training. A per-pupil service value is assigned for all courses within the data processing training curriculum, excluding a computer concepts course. The per-pupil value is extended by the number of students to be enrolled in the data processing course. This total value is deducted from the costs for instructional services. The remainder now represents the value assigned to problem solving. The problem-solving value is divided by the total number of terminals to be used in the system during the next year to produce the

cost per terminal. The cost per terminal is the basis for problem-solving service charges to the school, and is extended by the number of terminals to be installed at the school site.

Combination Method. Where external funding is available, reimbursement may be based upon usage by individual students. For example, assistance might be based upon a formula that provides a reimbursement for each hour of student use, up to a maximum set value for any one student. Through this technique, assurance is provided to the external funding agency that availability of the system is extended to the greatest number of students, and that no small group of students is permitted the full use of the system, to the exclusion of others. Since the claim for such funds would be based upon actual usage before reimbursement, the billing method would be fixed in advance for district contributions, but based upon statistics gathered as part of the accounting routines for claiming of assistance funds.

It must be understood that the above system is designed to allocate operational costs. Fixed costs of the computer center site and buildings must be initially provided on a different basis, as must be the development costs of the system incurred before the start of actual operations.



**APPENDIX A: ANALYSIS OF CONVERSATIONAL VS BATCH PROCESSING FOR PROBLEM SOLVING**

The conversational system used for the comparison was configured with a single medium-speed processor using 200 remote terminals in the schools. Of these, 50 contained card read/punch and keyboard/hard-copy capabilities; 150 contained only the keyboard/hard-copy capability.

The remote batch system was configured with two high-speed processors to perform the workload and meet the same throughput requirements. For this system, 100 remote terminals were configured with card read/punch and keyboard/hard-copy capabilities. In addition, 50 keypunches were included.

The annual total cost of data processing equipment and communication facilities for the

remote batch entry system is 89% greater than that for the conversational system, when supporting the workload projected for the USOE model region. The lower costs for fewer terminals in the remote batch system are offset by the fact that the card read/punch terminal is more expensive than the conversational terminal. Total costs for communication equipment for the remote batch system are considerably less than the conversational system because fewer terminals are used. However, these costs are offset by the central processor costs, which are substantially higher for the remote batch system because of the increased number of jobs to be processed.

Table 20 presents a summary analysis of the comparison. The key advantage of the conversational mode for student jobs is the ability to process many sn jobs concurrently.

Table 20

**COMPARATIVE ANALYSIS OF CONVERSATIONAL VS REMOTE ENTRY BATCH MODES**

Task	Conversational Method	Remote-Batch Method
1. State the problem in machine-readable form	Typed directly into system	Prepared offline on cards
2. Correct errors in the problem statement (debugging)	Syntax errors addressed line-by-line. Logic errors addressed at any execution point. Immediate correction possible.	Errors addressed after compilation and attempted execution. Correction possible before subsequent compilation.
3. Execute the problem	Direct execution of the problem by interpretation process	Delayed execution of the problem by compilation process
4. Receive the results	Immediately received at terminal	Delayed, as 3 above
5. Change data for subsequent executive runs	Immediate changes made at the terminal	Changes prepared offline
6. Receive results of subsequent execution runs	Immediately received at terminal	Delayed, as 3 above
7. Save programs	System saves defined program at user's request	System saves defined programs at user's request
8. Store data	Data files stored	Data files stored
9. Annual cost (data processing and communications equipment only) for USOE model region	\$1,176,918	\$2,230,144

## APPENDIX B: DATA PROCESSING TRAINING COURSE OUTLINES

(Note: Topic outlines for the data processing training course outlines contained in this appendix are based on portions of a curriculum for the Ontario Department of Education, Toronto, Canada.)

### Computer Concepts

Length: Two terms, 150 hours (one class hour per day)  
Grade: 10, 11, 12, 13, 14  
Prerequisite: None

This basic course is a comprehensive appreciation of data processing concepts. Although the student is expected to master some topics in considerable detail, a general understanding of data processing and the ability to write simple programs should be the major objectives.

1. Manual data processing methods
  - a. Early manual and mechanical techniques
  - b. Early coding techniques
  - c. Flowcharting
  - d. Applications of coding
  - e. Output
2. Evolution of the electric computer
  - a. Advanced technology in modern society
  - b. Electromechanical equipment
  - c. The electronic computer
3. Physical characteristics of the computer
  - a. Central processor
  - b. Input/output devices
4. Programming the computer
  - a. Need for, and functions of, a programmer
  - b. Programming concepts
5. Role of the computer in today's society
  - a. Uses, advantages, limitations
  - b. Development of programming languages
  - c. The future of data processing
  - d. Vocational opportunities in data processing
6. Problem types
  - a. Basic arithmetic
  - b. Looping and counting
  - c. Comparing and branching
  - d. Basic input/output

### Introductory Programming

Length: Two terms, 150 hours (one class hour per day)  
Grade: 11, 12, 13, 14  
Prerequisite: Computer Concepts

The object of this course is to teach programming fundamentals. Enough of one computer language (FORTRAN, COBOL, or another higher-level language or machine language) should be presented to give the student familiarity with that language and to allow him to write and test problem programs.

#### 1. Introduction

- a. Review computer concepts

#### 2. Programming

The following topics should be covered in the language chosen:

- a. Basic input/output
- b. Data movement
- c. Comparing and branching
- d. Basic arithmetic
- e. Advanced arithmetic
- f. Data formatting
- g. Reading serial records
- h. Looping and counting
- i. Address modification
- j. File formats
- k. Subroutines

#### 3. Program testing techniques

The following topics should be covered:

- a. Disk checking
- b. Error messages on compiling
- c. Test data preparation
- d. Control cards for testing system
- e. Test runs
- f. Correction and rerun

#### 4. Documentation

#### 5. Problem types

- a. Basic arithmetic
- b. Looping and counting
- c. Comparing and branching
- d. Address modification
- e. Basic input/output

### Systems Design

Length: Two terms, 150 hours (one class hour per day)  
Grade: 12, 14  
Prerequisite: Computer Concepts, Basic Programming

Upon satisfactory completion of this course, the student should be able to design a computer system for given input/output and procedure specifications and be able to document the design. The student will choose a case study within his experience to introduce and illustrate design concepts. He will develop the design of a system from the case study for application, using sequential and direct access processing.

1. Systems design for sequential access (tape system)

- a. Output of system
- b. Input to system
- c. Processing required to produce output from input
- d. Controls
- e. Form design
- f. File consolidation
- g. Division of processing into runs
- h. Master record designs

2. Systems design using direct access (disk system)

- a. Implementation of direct access system, using general system design defined in 1, above

3. System investigation

- a. Information and documents to be gathered
- b. Information-gathering methods
- c. Documentation results

4. System analysis

- a. Objectives of analysis to pinpoint problem areas, improve operations, and decrease costs
- b. Documentation of results of system analysis

5. Case study

- a. Student will design and test a system using a simulation program. The simulation would require four processing runs on a computer.

Business Systems Programming

Length: Two terms, 150 hours (one class hour per day)

Grade: 12, 14

Prerequisite: Computer Concepts, Basic Programming

Upon completion of the course, the student has an understanding of file processing, data processing, and data handling in a business environment.

1. Programming

- a. Review of basic programming
- b. Language features used to read and write serial files
- c. Language features used to read and write direct access files

2. File processing techniques

- a. General concepts
- b. Batch processing
- c. Immediate

3. Sorting methods

- a. Methods used on tape computers
- b. Methods used on computers with direct access devices

c. Timing considerations of sorting

4. Input data editing and validating

- a. Completeness checks
- b. Validity of individual records

5. Overall system control

- a. Use of control sheets
- b. Audit trails
- c. Rerun and error correction procedures
- d. Emergency procedures

6. Report preparation

7. Monitors

8. Case study

- a. Design, flowchart, code, test and document a business system, including:
  - File maintenance program
  - Report program

Unit Record Fundamentals

Length: Two terms, 150 hours (one class hour per day)

Grade: 12, 14

Prerequisite: Computer Concepts

Some schools may wish to continue teaching the principles of unit record punched-card data processing, especially in those areas where employment may depend on a unit record background.

1. Functions

Machine functions and operating features

for each of the following:

- a. Key punch
- b. Sorter
- c. Reproducing punch
- d. Interpreter
- e. Collator
- f. Accounting machine
- g. Selection
- h. Storage

2. Functional wiring principles

- a. Card reading by machines
- b. Control panels
- c. Printing
- d. Comparing
- e. Punching
- f. Column splits
- g. Selection
- h. Storage

3. Programming

- a. Accounting machine
- b. Collator
- c. Calculator

4. Procedure development

- a. Flowcharting
- b. Three basic steps in procedures

- c. Preparation of reporting requirements
- d. Development of card design
- 5. Report Generation
  - a. Introduction
  - b. Input/output
  - c. Arithmetic
  - d. Condition codes
  - e. Advanced input/output
  - f. Case studies and review problems

## APPENDIX C: ADMINISTRATIVE FILE DESCRIPTIONS

Many of the files have specific data elements shown, and an approximation as to the number of characters that might be expected in each element. The student file is especially detailed because of its importance. Most of the data elements shown in the student file, however, are optional; no actual case of all of them. As a result, the total file size for workload analysis purposes has been based on an estimated average size, rather than a maximum size.

System Model: Student  
File Name: Student  
Character of Data:

All information on each student currently enrolled, or who has been enrolled at any time during the school year but has not yet actually enrolled. The actual record for any student would be comprised only of data supplied through registration or update procedures, or through by-products of other tasks, such as scheduling, grade reporting, attendance and test scoring, etc.

### Maximum Size Record

1. Indices to Data in Student Record  
24 Eight entries of three positions each for the information types  
150 Fifty entries of three positions each for the field types
2. Data Identification Codes within Field Types  
284 Data element codes of one position
3. Positions Required at Maximum per Information Type  
187 Personal Information  
194 Family Information  
238 Health Information  
169 Enrollment Information  
1,646 Standardized Testing Information  
13,196 Academic Information  
745 Guidance Information  
758 Other Information
4. Total Positions Required in Defined Record at Maximum: 17,591

### File Storage Requirements

In determining the amount of file storage required, the following assumptions have been made:

1. No historical data from elementary grades would be available.
2. No test data at startup except from new enrollees during year.

3. Test data scored during each year involves one battery, 1/3 of the total students.
4. Personal information relatively complete, but minimum family data.
5. No health information available at startup.
6. Minimum enrollment information.
7. No course requests for next year; current year requests at minimum.
8. Almost no guidance information at startup.
9. None of the other information during the first year.

Based on the above, the estimate of file storage allocation per student during the first year is 2000 positions.

File overflow provisions include one full track in cell-type memory per student. Track contains address of overflow trailer track. If trailer track overflows, another address is given. There is room for 10% overflows per storage card in cell.

System Model: Student  
File Name: Demographic  
Character of Data:

1. Census tract populations (age, ethnic)
2. Health district births (ethnic)
3. School zone enrollments (grade, ethnic)
4. Housing starts (type and time)
5. Housing removals
6. School capacities and program facilities
7. Parochial and private enrollments
8. Possible annual pupil address survey (ethnic)
9. Possible real estate data from property data bank (value, number of households)

All of the above data is stored with geographic coordinate tags to permit aggregation to any desired level ("community", intermediate-school planning area, etc.).

The data in this file is designed to:

1. Deal individually with small areas, ethnic groups, etc.
2. Use regression analysis instead of merely extrapolating past averages where such curve-fitting is warranted.
3. Update migration models (i.e., verify assumptions about housing preferences of various household types).
4. Use recent ethnic birth data as a sensitive current indicator of migration trends.
5. Use ratio method (on a large scale) to adjust cohort-survival estimates.
6. Make systematic and explicit use of parochial (and other private school) enrollment data and forecasts.

7. Provide long-range projections to guide the planner; use the data to produce curves of school-age population vs time in new housing developments. The results of applying these procedures are estimates of the distribution of school-age children by grade, by ethnic group, by small area (e.g. attendance zone), by year.

System Model: Student  
File Name: Census  
Character of Data:

Information on each residence within the district boundaries served. Information on each family residing at the address, and each child of school age or younger. Much of the information collected on a student at the time he registers can originate from this file, and many of the updates to the student file can also update this file at the same time. Much of the personal and family information data in the Student file is also common to this file. This file is used in conjunction with the Demographic file to produce enrollment estimates, and other projections of school building requirements.

System Model: Staff  
File Name: Applicants  
Character of Data:

Information to identify each applicant and his qualifications for the job or position. Evaluations resulting from interviews, or contacts with prior employers, special qualifications, etc. Special preferences for specific assignments when multiple openings for a job may exist.

File Name: Substitutes  
Character of Data:

Information similar to that contained in the Applicants file, plus information on the prior assignments within the district and evaluations of the work performed during such periods.

File Name: Employee  
Character of Data:

Full information identifying each employee, permanent, temporary, substitute, terminated, etc., for a defined span of time after last employment. All information necessary for payroll and income tax (dependents, etc.). A history of employment before the current employment period, plus a record of each assignment internally, pay rates, etc. A history

of all educational qualifications or experience to determine salary placement is included where applicable.

System Model: Fiscal  
File Name: Payroll  
Character of Data:

This file may be part of the Employee file in the Staff system model, or may be separately organized for internal accounting control. It contains information as to pay rates for each job classification in which employees are authorized to work, totals for each category of gross salary, and involuntary deductions. Each authorized voluntary deduction is detailed, plus totals remitted for same during the current accounting period.

File Name: Budget/General Ledger  
Character of Data:

This file contains a record for each active account code during the current year, or planned for the coming year. It contains summary figures for the original budget allocation, currently adjusted budget, and current ledger balance and encumbrance totals. It contains information on any allocation formulas for redistributing costs that are pre-defined to be distributed on a formula basis. It contains detail transactions that have been entered during the current and the past accounting period. Since detail listings are produced for each period, earlier transactions are eliminated from this source, but saved for use at the end of the year.

File Name: Vendor  
Character of Data:

This file contains a record for each active vendor for the past three years. It contains information as to the last several transactions, total volume of business done with this vendor, and the types of items supplied by this vendor.

File Name: Purchases  
Character of Data:

This file contains a record for each purchase order issued during the current year, or any issued in anticipation of the start of the coming year. It contains as much detail as is available, which may be full detail or summary data. It is updated upon receipt of the item ordered, with the date received, and actual price charged when the invoice arrives.

**File Name: Warrants Issued**  
**Character of Data:**

This file contains a record for each warrant issued, and detail as to the items or invoices being paid. The file contains data only for the current year, and a new file is started with the start of a new year. Full identification of the vendor or payee is included, with all amounts, discounts, taxes, etc.

**File Name: Budget Appropriations**  
**Character of Data:**

This contains the data on the originally adopted budget in full detail as approved or originally accumulated. It contains detail as to each adjustment of the budget approved after that point.

**File Name: Maintenance Jobs**  
**Character of Data:**

This file contains a record for each job, either specifically written for a special purpose, or a general or annual type job used for the normal type of day-to-day maintenance, etc. Information as to the budgeted or expended man-hours, and costs of labor to date, plus costs of materials expended is included.

**File Name: Construction Projects**  
**Character of Data:**

This file identifies each construction project under way. It identifies each contractor, or subcontractor, with information on amounts authorized or actually paid, and the nature of the work performed. To the extent possible, this file also contains the information necessary to perform critical path analysis of the schedule of the work under way.

**System Model: Property**  
**File Name: Equipment**  
**Character of Data:**

This file contains a record for each separately identified piece of equipment, as identified by a serial-numbered property tag; in addition, certain property not tagged, but inventoried. Records of the manner in which the property was obtained or purchased, cost, expected life span, and, of course, full identification by description, serial numbers, manufacturer, size, etc., are included.

**File Name: Facilities**  
**Character of Data:**

This file contains a record of each location of fixed facilities. From this file it is possible to determine (a) the number of square feet of different types of facilities, or (b) the use of facilities. It contains records of the improvements included, descriptions of the facilities, etc.

**File Name: Library**  
**Character of Data:**

Each book, periodical, pamphlet, etc., is separately cataloged. Obviously, considerable time is required to reach this level of automation. Initially, new books may be the only data in this file, and the business aspects of ordering books provide this data as a by-product. Under a planned program of automation, each book will eventually be included.

**File Name: Audio-Visual Materials**  
**Character of Data:**

Each filmstrip, map, etc., that is distributed on a circulating basis is included with a full description and a record of all dates scheduled, locations, etc.

**File Name: Educational Supplies**  
**Character of Data:**

Each item stored in the warehouse, with vendor numbers of vendors interested in supplying, and their previous history of bidding, etc. The quantity on hand, on order, on back-order, etc., is included, with the history of the demand for the item during each review period. Eventually, items not in the warehouse will be included, on an almost identical basis, enabling the schools to order without regard to the source of the item to be supplied.

**File Name: Maintenance Supplies**  
**Character of Data:**

Each item of maintenance material required by the job shop, trucks, job sites, etc. Since the unit of issue varies, quantity must be able to be issued in varying issue units, while maintaining control in the other unit of measurements. Substitute items can be referenced for referral in an out-of-stock condition.

**File Name: Cafeteria Supplies**

**Character of Data:**

Each item of perishable or nonperishable foodstuffs, or cafeteria supplies, such as silverware, etc., which is stored centrally, or stored locally in the school, or purchased directly. For items stored centrally, the usual demand history, and inventory quantities, on order, back-order, etc., must be contained. For items stored locally, the quantities received, and on-hand at inventory time, must be provided for, to enable computation of usage during each inventory period.

**System Model: Curriculum**

**File Name: Course**

**Character of Data:**

Each course offered in a school, or in the district at any location. Courses are identified by number and course title. Statistics as to the numbers enrolled by location can be maintained.

**File Name: Classes**

**Character of Data:**

A record for each class offered within each school is available. Information as to the course number being taught, or multiple courses if more than one is being taught concurrently, is contained, the room or rooms offered, the periods, days met, and semester of the schedule, and the instructor codes and names assigned. Numbers of students enrolled at all times are maintained; the identification numbers of the enrolled students may be included for preparation of class lists without sorting student class information from the student file.

**File Name: Test Item Bank**

**Character of Data:**

Each test item submitted by teachers throughout the area served, plus its taxonomy coding. The history of use of the item by school and date, and the analysis of responses within each school, and in total. This provides for computation of the discrimination index, and difficulty of the item, for automatic selection of test items by classification and use statistics.

**File Name: Test Conversion Tables**

**Character of Data:**

Publisher tables required to convert raw or intermediary scores to converted scores for presentation back to the schools.

**File Name: Test Scoring Keys**

**Character of Data:**

Correct responses for each standardized test to be scored.

**File Name: CAI Units**

**Character of Data:**

CAI Units in a course-writer language for instruction in data processing operation and programming techniques, or other curriculum areas in which CAI may be involved. Of interest for inclusion in this file are locally developed CAI units, or such units in the process of being developed and tested locally by staff members.



## ADMINISTRATIVE FILE LAYOUTS

FILE NAME: STUDENT

### SIZE DATA ELEMENTS

---

#### PERSONAL INFORMATION

##### Identification

8 Student Number -- assigned by computer upon registration.  
10 Social Security No. and check digit assigned upon registration.  
30 Student Name -- Last, First, Middle Initial, Name Suffix (Jr., etc.)  
1 Sex  
1 Eyecolor -- an additional identifier to locate a student by name.  
1 Race  
51

##### Birth

6 Birthdate -- Month, Day, Year -- XX/XX/XX  
25 Birthplace  
2 Birthplace code -- defines distance from school location, etc.  
1 Citizenship  
34

##### Status and Affiliations

1 Marital Status  
1 Religious Affiliation  
2

##### Residence

5 Street Number -- integers only, or P. O. Box No., etc.  
4 St. No. fraction, location, such as 1/2, 1/4, REAR, BOX, etc.  
20 Street Name, or Post Office location if Box, etc.  
4 Type of Street -- St., Ave., Blvd., Road, Lane, Crt., Plce., etc.  
5 Compass Area -- North, East, South, West, N. E., N. W., etc.  
4 Apartment, Floor, Lot No., etc.  
20 City or Post Office if unincorporated, etc.  
5 State  
5 ZIP Code  
72

### Other Data

10 Residence Phone -- may require area code in some localities.  
20 Car Yr., Type, and Licence No. if any  
30

Total: 189

FILE NAME: STUDENT

### SIZE DATA ELEMENTS

---

#### FAMILY INFORMATION

##### Father/Male Guardian

1 Relationship Code  
25 Name -- Normal first-initial-last sequence, preceded by title such as Dr., Mr., etc.  
1 Race  
1 Educational Attainment Code  
25 Employer's Name  
15 Employer's Phone and extension, with area code if required  
3 Occupation Code  
71

##### Mother/Female Guardian

1 Relationship Code  
25 Name -- Title (Miss, Mrs., etc.), first-initial-last sequence  
1 Race  
1 Educational Attainment  
25 Employer's Name  
15 Employer's Phone and extension, with area code if required  
3 Occupation Code  
71

##### Household

1 Number of older brothers in household  
1 Number of older sisters in household  
1 Number of younger brothers in household  
1 Number of younger sisters in household  
1 Number of other children in household  
3 Languages (other than English) spoken in household -- multiple 1-dig.  
1 Socio-economic level of household  
9

Dist. Revenue Qualifications

1 Tuition status  
3 Federal Assistance Qualifications -- multiple  
1-digit codes  
4

Emergency contact

25 Neighbor's name  
10 Neighbor's phone  
35

Transportation

1 Transportation Eligibility  
3 Bus Route or local carrier identification  
4

Total: 194

FILE NAME: STUDENT

SIZE DATA ELEMENTS

-----  
HEALTH INFORMATION

Medical Emergency

25 Physician's Name of student or family  
10 Physician's phone -- may require area code  
3 Health Plan Coverages -- multiple 1-digit  
codes  
38

Examinations

6 Date of last physical examination  
1 Condition Code  
6 Date of last dental examination  
1 Condition Code  
6 Date of last height/weight measurement  
3 Height -- in total inches  
3 Weight -- in total pounds  
6 Date of last visual examination  
1 Condition Code  
3 Uncorrected vision -- left eye  
3 Uncorrected vision -- right eye  
3 Corrected vision -- left eye  
3 Corrected vision -- right eye  
6 Date of last hearing examination  
1 Condition Code  
2 Hearing loss -- left ear  
2 Hearing loss -- right ear  
56

Impairments affecting schoolwork

1 Vision  
1 Hearing  
1 Speech  
1 Allergies -- multiple 1-digit codes  
1 Blood Dyscrasia, Hemophilia, etc.  
1 Diabetes  
1 Epilepsy  
1 Glandular -- multiple 1-digit codes  
1 Heart -- multiple 1-digit codes  
1 Neurological - multiple 1-digit codes  
1 Kidney  
1 Orthopedic  
1 Positive Tuberculin or chest X-ray  
1 Mental Retardation  
1 Emotional Disturbances  
1 Cultural Deprivation  
16

Immunization Status

6 Small Pox -- Initial vaccination date  
6 Small Pox -- Revaccination Date  
6 Diphtheria -- Tetanus -- Initial vaccination  
date  
6 Diphtheria -- Tetanus -- Booster vaccination  
date  
6 Measles vaccination date  
1 Poliomyelitis -- type of vaccine received  
6 Poliomyelitis vaccination series completion  
6 Tuberculin Test date  
6 Survey Chest X-ray date  
6 Full Chest X-ray date  
55

Physical Fitness Testing

6 Date Tested  
1 Test Battery Identification  
2 Year Published  
2 Level and Form used  
2 Norms used  
1 Subtest identification  
3 Raw score -- time, distance, counts, etc.  
2 National percentile norm  
2 Local percentile norm  
40 Five additional subtests of eight positions  
each  
61

Total: 226

FILE NAME: STUDENT

SIZE DATA ELEMENTS

ENROLLMENT

Grade

- 2 Grade of current school year or semester
  - 2 Grade to be used for summer school if enrolled
  - 2 Grade expected to be in during next school year or semester
- 
- 6

Credits

- 3 Cumulative credits through last semester
- 
- 3

Grade Point Averages

- 3 Academic grade points cumulative through last semester
  - 3 Total grade points cumulative through last semester
  - 2 Number of units attempted (divisor for obtaining GPA)
- 
- 8

Grade Point Percentiles by Subject Areas

- 2 Weighted GP percentile for first Subject Area -- each grade received for credit is converted to a percentile, and averaged 50-50 with any prior GP percentile if any, or used directly if first in subject area
  - 22 Eleven additional GP percentile subject areas of two positions each. Note: through this technique the most recent mark receives 50% of the total weight, the prior mark 25%, next prior 12.5%, etc.
- 
- 24

Rank in Class

- 4 Rank position in class based on cumulative total grade point average
  - 4 Number rank
  - 2 Rank Percentile -- provides a rank comparable between different size groups
- 
- 10

Next School

- 3 Summer School code if enrolled
  - 3 School to attend next year or semester
- 
- 6

Enrollment Data

- 6 Date enrolled in this school
  - 1 Enrollment type code
- 
- 7

Prior Education

- 3 Last school attended within district
  - 15 Last school attended outside district
- 
- 18

Withdrawal

- 6 Date Withdrawn from this school
  - 1 First Withdrawal reason given
  - 1 Second Withdrawal reason given
  - 3 Next School to attend within district
  - 15 Next School to attend outside district
  - 4 Follow-up actions if apparent dropout at this time
- 
- 30

District Funds Owed or Paid

- 1 1st Charge reason owed code
  - 4 Amount owed
  - 4 Date accrued
  - 1 2nd Charge reason owed code
  - 4 Amount owed
  - 4 Date accrued
  - 1 3rd Charge reason owed code
  - 4 Amount owed
  - 4 Date accrued
  - 4 Total additional amount owed accrued this school year
  - 4 Total additional amount owed accrued during past school years
  - 1 Last amount paid reason owed code
  - 4 Last amount collected
  - 4 Last date paid
  - 1 Previous amount paid reason owed code
  - 4 Previous amount collected
  - 4 Previous date paid
  - 4 Total of all previous amounts (except above two) collected this year
- 
- 57

Note: Above include all book and course fees, library fines, etc.

Total: 169

# STANDARDIZED TESTING INFORMATION

## Standard Format used for all test data

### Once per Battery -- 15 posns.

6 Date Tested  
2 Publisher Code  
3 Battery Code  
2 Year Published  
1 Form Code  
1 Level Code  
15

### Once per Subtest -- 17 posns.

2 Subtest Code  
3 Raw Score  
1 1st Norm Type Code  
3 1st Derived Score  
1 2nd Norm Type Code  
3 2nd Derived Score  
1 3rd Norm Type Code  
3 3rd Derived Score  
17

**TYPES OF TESTS:** Positions based on given estimates of subparts. In use, only the actual number of subtest modules required would be actually included in the record.

### Intelligence Tests

166 Two batteries, four subtests each battery

### Achievement Tests

740 Four batteries, ten subtests each battery

### Vocational/Interest Tests

370 Two batteries, ten subtests each battery

### College Entrance Tests

370 Two batteries, ten subtests each battery

## ACADEMIC INFORMATION

### Current Information

#### Once per class in which enrolled currently -- 100 posns.

6 Course Code  
4 Section Number of this class  
3 Instructor Code

2 First period of this schedule component  
1 No. of periods in consecutive block of this schedule component  
5 Days met for this schedule component  
1 Semester met for this schedule component  
9 Second component of this schedule  
9 Third component of this schedule  
20 Course Title  
20 Instructor Name  
2 First mark received  
2 Second mark received  
2 Third Mark received  
2 Final mark received  
4 Other nongrade marks received, comments, work habits, citizenship, etc.  
1 Conditions under which this course taken -- noncredit, repeat, etc.  
2 Credits to receive if passed, or earned at end of semester  
2 Grade points earned at end of semester  
3 Days Absent since start of course, or date enrolled in course  
1100 Eleven additional class positions in above format

### Requests for next year or semester, and tentative schedule assigned

#### Once per course requested -- 91 posns.

6 Course number requested  
1 Alternate status or preferred status  
1 Specific semester or single semester of full-year course if any  
4 Specific section requested if any  
3 Instructor Code requested if any  
1 Conditions under which course to be taken -- noncredit, repeat, etc.  
4 Specific section scheduled  
3 Instructor assigned to this section  
9 First component of schedule for this section -- see format above  
9 Second component of this schedule  
9 Third component of this schedule  
20 Course title  
20 Instructor Name  
1 Reason for rejection if could not be scheduled  
1477 Seventeen additional requests in above format

Historical Information -- Reverse chronological sequence (latest first)

School Attended -- once per each new school attended -- 62 posns.

- 25 School Name
- 25 City/State of School
- 12 First and last data attended school -- blank in last if still enrld.

GRADES 7-12 ONLY

Semester Attended -- once for each new semester attended -- 18 posns.

- 2 Grade during the semester
- 1 Semester being reported
- 12 First and last date attended during this semester
- 3 Instructional days included in this semester

Class Attended -- once for each class in which enrolled -- 66 posns.

- 6 Course Code in which enrolled -- includes group if applicable
- 20 Course Title
- 20 Instructor Name
- 2 First mark received
- 2 Second mark received
- 2 Third mark received
- 2 Final mark received
- 4 Other nongrade marks received, comments, work habits, citizenship, etc.
- 1 Conditions under which this course taken -- noncredit, repeat, etc.
- 2 Credits received for this class
- 2 Grade points earned for this class
- 3 Days Absent during this class
- 660 Eleven additional class positions in above format
- 7458 Eleven additional semesters each with twelve classes
- 124 Two additional schools expected in maximum record

GRADES K-6 ONLY

- 248 School Attended -- See above format -- four schools provided for

Year Attended -- once for each year of school

- 2 Grade during the year
- 12 First and last date in school year

Course and Grades received -- one for each course taken

- 20 Course Title
- 2 Final Mark
- 220 Eleven additional courses per year
- 1536 Six additional years of elementary school

GUIDANCE INFORMATION

Assignments

- 4 Home Room or Advisory Room No.
- 3 Home Room or Advisory Instructor Code
- 20 Home Room or Advisory Instructor Name
- 3 Counselor Instructor Code
- 20 Counselor Name
- 50

Lockers

- 5 Main Locker No.
- 6 Main Locker Combination Code
- 8 Student Number of Locker Partner
- 6 Main Locker Padlock Serial No. if not built in lock
- 5 Gym Locker No.
- 6 Gym Locker Combination Code
- 6 Gym Locker Padlock Serial No. if not built in lock
- 42

Academic

- 1 Course of study, or track
- 1 Projected college and Major
- 1 Projected college and Minor
- 2 Ultimate educational objective
- 1 Post graduate plans
- 9 1st College to which application made
- 9 2nd College
- 9 3rd College
- 33

Future Years Course Plans

- 6 A course request (including ability grp.) for 1st succeeding year
- 30 Five additional requests for 1st succeeding year
- 36 Six course requests for 2nd succeeding year
- 36 Six course requests for 3rd succeeding year
- 108

## Award Records

1	No. of times on Honor Roll or Scholastic Society in current year
1	No. of times during 1st year past
1	No. of times during 2nd year past
1	Special award or achievement code
4	Month and year awarded
<u>25</u>	Five more special awards codes and dates
33	

## Student Activities Participation

9	Student Activity group involved
1	Participation level code
<u>40</u>	Four more student activities and participation codes
50	

## Employment Experience

2	Current employment code
2	No. hours works per week currently
<u>25</u>	Current Employer name
2	Previous employment code
2	Previous No. hours works per week
<u>25</u>	Previous Employer name
<u>29</u>	Next previous experience in above format
87	

## Vocational

1	1st choice occupational interest
1	2nd choice occupational interest
1	3rd choice occupational interest
1	1st selection job values
1	2nd selection job values
1	3rd selection job values
1	1st choice job type preference
1	2nd choice job type preference
1	3rd choice job type preference
1	1st choice entry job intention
1	2nd choice entry job intention
1	3rd choice entry job intention
1	1st appraisal of personal ability
1	2nd appraisal of personal ability
<u>1</u>	3rd appraisal of personal ability
15	

## Disciplinary Actions

2	No. of times disciplinary action taken this year
2	No. of times sent home for the rest of the day only
2	No. of days under suspension for this year
<u>5</u>	Up to five 1-posn. illegal actions codes
11	

## Interviews

1	Counseling priority required per students own estimate
<u>1</u>	Counseling priority assigned by counselor
2	

## Vocational Interviews

6	Date of last interview
1	Time increments spent at last interview -- 5 minutes per increment
1	Interview results code
2	Total of all prior time increments for vocational interviews
<u>10</u>	

## Academic Interviews

10	Same format as for vocational interviews
----	--

## Behavioral Interviews

10	Same format as for vocational interviews
----	--

## Personal Interviews

10	Same format as for vocational interviews
----	--

## A. endance

2	Total absences for full day on Mondays during this year
8	Total absences for each other day of the week
10	Total absences for the previous school year
10	Full day cuts by date of week for this year
10	Period cuts by day of week for this year
20	Period cuts for the previous school year
<u>190</u>	Detail attendance day by day for this school year. One position for each day in school calendar
250	

## Performance Forecasts

2	Percentile estimate of success for 1st subject area
22	Eleven additional subject area forecasts
	<u>Note:</u> Estimate obtained through formula analysis of test scores in intelligence and achievement areas, plus aptitude tests, correlated with grade point percentiles of marks received in each subject area and attendance.
<u>24</u>	

OTHER INFORMATION

Equipment Charged

4 Equipment type code  
 4 Date Issued on loan to student  
 6 Course with which used  
14 Second piece of equipment on loan  
 28

Textbooks Charged

8 Book Code  
 4 Date Issued on loan to student  
 6 Course with which used  
180 Ten more books on loan  
 198

Library Books Charged

8 Book Code  
 4 Date checked out of Library  
120 Ten more books on loan  
 132

Library Books read during year

8 Book Code of library book returned this year  
 392 Book Codes of 49 other books returned this year  
400

FILE NAME: SUBSTITUTES (applicable to certificated only)

SIZE DATA ELEMENTS

-----  
GENERAL INFORMATION

7 Substitute Number  
 9 Social Security Number  
 20 Substitute Name, last  
 15 Substitute Name, first  
 1 Substitute Name, middle initial  
 1 Sex  
 40 Address  
 10 Telephone Number  
 60 Subjects Willing and Able to Teach (up to 15)  
 20 Schools at which Substitute Prefers to Teach (up to 10)  
 42 Days and Times Willing to Teach  
40 Special Considerations  
 265

Educational Background

20 Degrees -- Areas and Year (up to 5)  
 5 Types of Certificates  
 60 Dates Issued and Expired  
15 Special Qualifications (up to 5)  
 100

Most Recent Experience

3 School  
 32 Subjects (up to 8)  
 12 Dates  
 3 Total Hours  
 1 Performance Code  
20 Additional (to 5)  
 71

Payroll

1 Rate Code  
 5 Pay Rate  
27 Payroll Distribution (up to 3)  
 33

Voluntary Deductions

2 Deduction Code No. 1  
 4 Deduction Amount No. 1  
 18 Above pattern three more times

Year-to-Date

7 Total Pay  
 4 Total Hours  
 6 Withholding Tax  
 5 FICA  
 2 Deduction Code No. 1  
 5 Deduction Amount No. 1  
 21 Above pattern three more times

This Period

4 Total Hours Worked  
 5 Withholding Tax  
 4 FICA  
 2 Deduction Code No. 1  
 4 Deduction Amount No. 1  
 18 Above pattern three more times

Personal

1 Handicap Code  
 6 Physical Exam, Date List  
1 Award or Achievement Code  
 8

SIZE DATA ELEMENTS

Identification

7	Employee Number
9	Social Security Number
8	Certification Number
7	Retirement System Number
1	Retirement System Code
20	Name, last
15	first
15	middle
20	maiden
20	Address, Street Name and Number
20	City, State
6	City, zip code
7	Telephone Number (home)
1	Sex
1	Marital Status
6	Birthdate
25	Birthplace (City, State or County)
1	Citizenship Status
5	Census Tract
5	Precinct Code
3	Position Code, Primary
12	Position Code, additional (to 5)
1	New Teacher Code
3	Military Service (Years, Which Served)
<u>218</u>	

Location

3	Assignment
4	Location (School, Office, etc.)
2	Division Code
4	State Position Code
<u>13</u>	

Schedule

6	Subject and Section
42	Up to 7 More Periods
<u>48</u>	

5	Types of Certificates
12	First (date issued, expired)
48	Additional (to 5)
2	Total Salary Credit Experience
2	Total Experience (years)
5	Experience, type (local or elsewhere)
45	Additional (to 10)
2	Salary Step
6	Date of Employment
6	Date of Termination
2	Reason for Termination
3	Special Qualifications
11	Last Merit Increase, Amount and Date
11	Last Increment, Amount and Date
3	Total Years of Training (and fraction of years)
1	Degrees, type
4	college
2	year
6	master
52	additional (to 4)
<u>30</u>	Subjects can Teach (5) + (1)
<u>178</u>	

Payroll

1	Contract Status
3	Contracted Days in work calendar
7	Contracted Salary Rate Annual
6	Monthly
5	Daily
4	Hourly
7	Additional Salary Amount and Code
7	Additional Salary Amount and Code
7	Additional Special Pay Adjustment (one time)
2	Vacation Days Authorized
3	Sick Leave Days Authorized
9	Payroll Distribution,
	Account number 1, factor
9	2, factor
9	3, factor
<u>79</u>	

Voluntary Deductions (Twelve Standard)

2	Deduction Code No. 1
4	Deduction Amount No. 1 per pay period
66	Above pattern eleven more times
<u>72</u>	



Year-to-Date

7	Gross, calendar
7	fiscal
7	contract
6	other pay
5	Days Actual
2	Compensated, contract
2	vacation
3	sick leave
3	leave, unpaid
6	Withholding Tax
5	FICA
7	Retirement System
2	Voluntary Deduction Code No. 1
5	Deduction Amount No. 1
77	Above pattern eleven more times
7	Net Amount (Fiscal)
<u>151</u>	

This Period

6	Gross Pay
6	Contract Pay
6	Other Pay
5	Withholding Tax
4	FICA
4	Retirement
2	Voluntary Deduction Code No. 1
4	Deduction Amount No. 1
66	Above pattern eleven more times
2	Days Compensated
2	Vacation Days
3	Sick Leave Paid
3	Not Paid
2	Leave, Unpaid
<u>115</u>	

Personal

6	Physical Exam, Date Last
6	X-Ray, Date Last
1	Rating Present
3	Last Three
1	Full or Part Time
1	Return to Corp Code
1	New Teacher Source Code
1	Handicap Code
1	Award or Achievement Code
1	Special Situation Status Code
<u>22</u>	

New Teacher Information

1	Preelection Rating
1	Reason for Selecting Area
2	Years Experience Allowed on Salary
1	Taught School Last Year (yes or no)
2	Years Experience (outside Area)
2	Years Experience (in Area)
<u>9</u>	

FILE NAME: EMPLOYEE FILE -- Non-Certificated

SIZE DATA ELEMENTS

Identification

7	Employee Number
9	Social Security Number
8	Classification Number
7	Retirement System Number
1	Retirement System Code
20	Name, last
15	first
15	middle
20	maiden
20	Address, Street Name and Number
20	City, State
6	Zip Code
5	Census Tract
5	Precinct Code
7	Telephone Number (home)
1	Marital Status
1	Sex
6	Birthdate
25	Birthplace (City, State or County)
1	Citizenship Status
3	Military Service (Years, Which Served)
3	Position Code, Primary
12	Additional (to 5)
<u>217</u>	

Location

3	Assignment
4	Location (school, office, etc.)
2	Division Code
4	State Position Code
<u>13</u>	

Service

2 Total Salary Credit Experience  
 2 Total Experience (Years)  
 5 Experience, Type (local or elsewhere)  
 45 Additional (to 10)  
 54

Salary

2 Salary Step  
 6 Date of Employment  
 6 Date of Termination  
 2 Reason for Termination  
 3 Special Qualifications  
 11 Last Merit Increase, Amount and Date  
 11 Last Increment, Amount and Date  
 2 Total Years Schooling  
 1 Degrees, type  
 4 college  
 2 year  
 6 master  
 42 additional (to 4)  
 98

Payroll

6 Time Period of Pay  
 7 Salary Schedule Rate, Annual  
 6 Monthly  
 5 Daily  
 4 Hourly  
 7 Additional Salary Amount and Code  
 7 Additional Salary Amount and Code  
 7 Additional Special Pay Adjustment (one time)  
 2 Vacation Days Authorized  
 3 Sick Leave Authorized  
 9 Payroll Distribution Account Number 1,  
 Factor  
 9 2, Factor  
 9 3, Factor  
 81

Voluntary Deductions (Twelve Standard)

3 Industrial Insurance  
 4 Bonds (Amount, Denomination)  
 4 UGN  
 4 First Medical  
 4 Second Medical  
 5 Optional Deductions  
 10 Dues and Code (up to 2)  
 2 Deduction Code No. 1  
 4 Deduction Amount No. 1 per pay period  
 66 Above pattern eleven more times  
 106

Year-to-Date

7 Gross, Calendar  
 7 Fiscal  
 6 Other Pay  
 5 Days Actual  
 2 Compensated, Vacation  
 3 Sick Leave  
 3 Leave, Unpaid  
 6 Withholding Tax  
 5 FICA  
 7 Retirement System  
 2 Voluntary Deduction Code No. 1  
 5 Deduction Amount No. 1  
 77 Above pattern eleven more times  
 7 Net Amount (fiscal)  
 142

This Period

6 Gross Pay  
 6 Other Pay  
 5 Withholding Tax  
 4 FICA  
 4 Retirement  
 2 Voluntary Deduction Code No. 1  
 4 Deduction Amount No. 1  
 66 Above pattern eleven more times  
 2 Days Compensated  
 2 Vacation Days  
 2 Sick Leave Paid  
 Not Paid  
 2 Leave, Unpaid  
 105

Personal

6 Physical Exam, Date Last  
 6 X-Ray, Date Last  
 1 Rating Present  
 3 Last Three  
 1 Full or Part Time  
 1 Handicap Code  
 1 Award or Achievement Code  
 1 Special Situation Status Code  
 20

FILE NAME: EQUIPMENT

SIZE DATA ELEMENTS

-----  
 7 Item Number  
 10 Manufacturer's Serial Number  
 5 Item Class (projector, desk...)  
 30 Description (Grn Bell & Howell 35mm)

6	Location -- Building and Room
7	Responsible Person
8	Cost
8	Depreciated Value at End of Previous Accounting Period
2	Age at Delivery (years)
6	Date of Delivery
5	Vendor Number
5	Purchase Order Number
2	Estimated Life
1	Condition Code
1	Use Code (instruction, maintenance, surplus)
4	Date Warranty Expires
<u>107</u>	

FILE NAME: FACILITIES

SIZE DATA ELEMENTS

Locations Summary

4	Location Number
30	Name
40	Address
7	Telephone
7	Head Administrator
3	Classification (use)
1	Type Construction
6	Size (area)
8	Site Size
6	Floor Space
3	Class or Conference Rooms
1	Large Meeting Rooms
5	Capacity
5	Capacity
5	Capacity
1	Special Area
5	Capacity
1	Kitchen
5	Students, male
5	female
4	Certified Staff
4	Non-Certified Staff
4	Standard Student Capacity
4	Maximum Student Capacity
<u>95</u>	

Rooms

3	Location Number
4	Building Number
3	Room Number
3	Classification (use)

6	Floor Space
5	Maximum Capacity
5	Number of Seats
1	Limitations
1	Special
<u>31</u>	

FILE NAME: LIBRARY

SIZE DATA ELEMENTS

Textbook Control (one per textbook title)

2	Subject Area
3	Text Number
4	Number at School
4	Number on Order
4	Required This Year
4	Estimated Next Year's Requirement
4	Number Assigned to Teachers
4	Number Needing Repair or Replacement
5	Evaluation of Effectiveness
<u>34</u>	

FILE NAME: AUDIO-VISUAL MATERIALS

SIZE DATA ELEMENTS

General Information

6	Subject Area (3 maximum)
1	Type Procurement (rent, loan...)
5	Cost of Rental (per unit of rental time)
1	Time Period of Rental or Loan
5	Supplier Number
20	Title or Description
200	Synopsis
2	Audience Level (Adult, primary...)
6	Date Ordered or Purchased
6	Date to be Returned
7	Responsible Location
<u>259</u>	

Reservations -- Audio-Visual Material

5	Date Required
2	Days Required
4	Building
3	Room Number
7	Person Number
<u>21</u>	

Additional Reservations (variable)

FILE NAME: EDUCATIONAL SUPPLIES

SIZE DATA ELEMENTS

7	Catalog No. (no in warehouse sequence)
8	Vendor Order Number
100	Description
1	Unit of Measure Code
3	Standard Pack
6	On Hand
6	On Order
6	Back-Ordered
6	Committed
6	Minimum Balance
7	Unit Cost
6	Year-to-Date Receipts
6	Year-to-Date Issues
6	Last Year's Usage
6	Number of Transactions Since Last Receipt
5	Date of Last Activity
6	Quantity Used Since Last Receipt
2	Lead Time in Weeks
4	Average Weekly Usage
6	Economic Order Quantity
5	Vendor Number
<u>3</u>	Shelf Life
211	

FILE NAME: COURSE

SIZE DATA ELEMENTS

<u>Courses Offered (one per course)</u>	
3	School Number
25	Course Title
4	Course Number
20	Prerequisites (up to 5)
2	Class Level
4	Laboratory or Concurrent Required Course, if any
<u>2</u>	Number of Sections Offered
60	

FILE NAME: CLASS

SIZE DATA ELEMENTS

<u>Individual Section Information (one per course section)</u>	
2	Section Number
3	Meeting Room
1	Period
1	Length
7	Teacher Number
3	Maximum Allowed in Section
3	Actual Number in Section
3	Textbooks Number
<u>2</u>	Volumes Issued
25	



**APPENDIX D: COST DETAIL FOR MODEL  
REGIONS AND USOE REGION**

**DETAIL ANNUAL COST ESTIMATES**

(Regions A, B, C, USOE)

Item	A	B	C	USOE
<b>Central Site Equipment</b>	(cost in thousands of dollars)			
<b>1. Computing Equipment</b>	302.0	382.6	528.4	528.4
<b>2. Communications</b>				
-Control Unit (DP mfg.)	31.8	42.9	76.5	73.5
-Adapter Unit (DP mfg.)	7.0	14.0	19.5	16.9
<b>Total</b>	<b>38.8</b>	<b>56.9</b>	<b>96.0</b>	<b>90.4</b>
-Comm. Line Term: Secondary Schools:				
. Comm. Adapter (DP mfg.)	18.2	37.0	55.2	48.0
. Common Carrier Term.	10.9	20.7	31.7	21.0
<b>Total</b>	<b>29.1</b>	<b>57.7</b>	<b>86.9</b>	<b>69.0</b>
-Comm. Line Term: Junior Colleges:				
. Comm. Adapter (DP mfg.)	.7	1.4	2.2	1.4
. Common Carrier Term.	.3	.7	1.0	.7
<b>Total</b>	<b>1.0</b>	<b>2.1</b>	<b>3.2</b>	<b>2.1</b>
-Comm. Line Term: Admin. Centers:				
. Comm. Adapter (DP mfg.)	1.0	1.9	2.9	1.9
. Common Carrier Term.	.4	.9	1.3	.9
<b>Total</b>	<b>1.4</b>	<b>2.8</b>	<b>4.2</b>	<b>2.8</b>
-Subtotal: Common Carrier	11.6	22.3	34.0	22.6
-Subtotal: DP mfg.	58.7	97.2	156.3	141.7
<b>Total Comm.</b>	<b>70.3</b>	<b>119.5</b>	<b>190.3</b>	<b>164.3</b>
<b>3. Total Centra. Site</b>				
-Subtotal: Common Carrier	11.6	22.3	34.0	22.6
-Subtotal: DP mfg.	360.7	479.8	684.7	670.1
<b>Total</b>	<b>372.3</b>	<b>502.1</b>	<b>718.7</b>	<b>692.7</b>
<b>Secondary School</b>				
<b>1. DP mfg. supplied</b>				
-Instructional Terminals	55.8	111.5	167.3	152.1
-Admin. Terminals	105.6	211.2	316.8	211.2
-Comm. Adapter	18.2	37.0	55.2	48.0
<b>Total</b>	<b>179.6</b>	<b>359.7</b>	<b>539.3</b>	<b>411.3</b>

DETAIL ANNUAL COST ESTIMATES (cont)

Item	A	B	C	USOE
<b>Secondary School</b>	<b>(cost in thousands of dollars)</b>			
<b>2. Provided by Common Carrier</b>				
-Comm. Lines	22.8	45.5	68.3	45.0
-Adapters and Term.	10.9	20.7	31.6	21.0
<b>Total</b>	<b>33.7</b>	<b>66.2</b>	<b>99.9</b>	<b>66.0</b>
<b>3. Total Secondary Schools</b>	<b>213.3</b>	<b>425.9</b>	<b>639.2</b>	<b>477.3</b>
<b>Junior Colleges</b>				
<b>1. Provided by DP mfg.</b>				
-Instructional Terminals	3.0	6.1	9.1	6.1
-Comm. Adapter	.7	1.4	2.1	1.4
<b>Total</b>	<b>3.7</b>	<b>7.5</b>	<b>11.3</b>	<b>7.5</b>
<b>2. Provided by Common Carrier</b>				
-Comm. Lines	.9	1.8	2.7	1.8
-Adapters and Term.	.3	.7	1.0	.7
<b>Total</b>	<b>1.2</b>	<b>2.5</b>	<b>3.7</b>	<b>2.5</b>
<b>3. Total Junior Colleges</b>	<b>4.9</b>	<b>10.0</b>	<b>15.0</b>	<b>10.0</b>
<b>Administrative Centers</b>				
<b>1. DP Mfg.</b>				
-Keyboard/Printer Terminals	4.1	8.1	12.2	8.1
-Comm. Adapter	1.0	1.9	2.9	1.9
<b>Total</b>	<b>5.1</b>	<b>10.0</b>	<b>15.1</b>	<b>10.0</b>
<b>2. Provided by Common Carrier</b>				
-Lines	.9	1.8	2.7	1.8
-Adapters and Term.	.4	.8	1.3	.8
<b>Total</b>	<b>1.3</b>	<b>2.6</b>	<b>4.0</b>	<b>2.6</b>
<b>3. Total Administration Ctrs.</b>	<b>6.4</b>	<b>12.6</b>	<b>19.1</b>	<b>12.6</b>
<b>Total Equipment Costs</b>				
-Common Carrier	47.8	93.6	141.6	93.7
-DP Mfg.	549.1	857.0	1,250.4	1,098.9
<b>Total</b>	<b>596.9</b>	<b>950.6</b>	<b>1,392.0</b>	<b>1,192.6</b>
<b>Personnel and Supplies</b>	195.0	252.0	285.0	263.0
<b>Gross Total Annual Costs</b>	<b>791.9</b>	<b>1,202.6</b>	<b>1,677.0</b>	<b>1,455.6</b>
<b>Total Annual Operating Budget @ \$532 Student</b>	<b>86,184.0</b>	<b>172,368.0</b>	<b>258,522.0</b>	<b>214,928.0</b>
<b>% of School Budget for DP services</b>	<b>0.86%</b>	<b>0.70%</b>	<b>0.65%</b>	<b>0.68%</b>

DETAIL ANNUAL COST ESTIMATES (cont)

Item	A	B	C	USOE
<b>Administrative Value</b>				
<u>Secondary Students</u>				
1. Pupil Personnel Services @ \$4.00/Student	160.0	320.0	480.0	400.0
2. Business Admin. Services @ \$1.50/Student	60.0	120.0	180.0	150.0
<b>Total</b>	<b>220.0</b>	<b>440.0</b>	<b>660.0</b>	<b>550.0</b>
<u>Elementary Students</u>				
1. Business Admin. services @ \$.50/Student	60.0	120.0	180.0	150.0
2. Testing: 37-1/2% of Students @ \$.60/Student	27.0	54.0	81.0	67.5
<b>Total</b>	<b>87.0</b>	<b>174.0</b>	<b>261.0</b>	<b>217.5</b>
<b>Total Administrative Value</b>	<b>307.0</b>	<b>614.0</b>	<b>921.0</b>	<b>767.5</b>
<b>Instructional Value (per student basis)</b>				
<u>Secondary Students</u>				
1. Problem Solving	7.03	4.26	3.65	4.04
2. DP Training	4.30	2.61	2.23	2.47
<b>Total</b>	<b>11.33</b>	<b>6.87</b>	<b>5.88</b>	<b>6.51</b>
<u>Junior College Students</u>				
1. Problem Solving	8.96	5.44	4.65	5.20
2. DP Training	7.04	4.27	3.65	4.09
<b>Total</b>	<b>16.00</b>	<b>9.77</b>	<b>8.31</b>	<b>9.29</b>
<b>Instructional Value for Total Enrollment</b>	<b>484.9</b>	<b>588.6</b>	<b>756.0</b>	<b>688.1</b>

APPENDIX E: COST DETAIL FOR CASE STUDY REGION

DETAIL ANNUAL COST ESTIMATES FOR CASE STUDY REGION

ITEM	CASE STUDY REGION COST	ITEM	CASE STUDY REGION COST
<b>CENTRAL SITE EQUIPMENT</b>			
1. Computing Equipment	\$ 382,614		
2. Communications		-Communications Line Terminals:	
-Control Unit (DP Mfg.)	73,533	Administrative Centers	
-Communications Adapter Units (DP Mfg.)	16,896	.D.C. Schools	
-Communications Line Terminals: Secondary Schools		Communications Adapter (DP Mfg.)	\$ 960
.D.C. Schools			
Communications Adapter (DP Mfg.)	8,880	.Alexandria	
		Communications Adapter (DP Mfg.)	480
.Alexandria			
Communications Adapter (DP Mfg.)	2,160	.Arlington	
		Communications Adapter (DP Mfg.)	480
.Arlington			
Communications Adapter (DP Mfg.)	3,600	.Fairfax	
		Communications Adapter (DP Mfg.)	960
.Fairfax			
Communications Adapter (DP Mfg.)	16,080	.Falls Church	
		Communications Adapter (DP Mfg.)	240
.Falls Church			
Communications Adapter (DP Mfg.)	480	.Montgomery	
		Communications Adapter (DP Mfg.)	960
.Montgomery			
Communications Adapter (DP Mfg.)	14,160	<b>TOTAL COMMUNICATIONS</b>	
Common Carrier Terminals	600	-Common Carrier Subtotal	600
	14,760	-DP Mfg. Subtotal	141,789
		<b>TOTAL</b>	<b>142,389</b>
-Communications Line Terminals: Junior Colleges		<b>3. TOTAL CENTRAL SITE</b>	
.Montgomery		-Common Carrier Subtotal	600
Communications Adapter (DP Mfg.)	1,200	-DP Mfg. Subtotal	524,403
		<b>TOTAL</b>	<b>525,003</b>
.Northern Virginia		<b>SECONDARY SCHOOL EQUIPMENT</b>	
Communications Adapter (DP Mfg.)	720	1. <u>D. C. Schools</u>	
		-DP Mfg. supplied	
		.Instructional Terminals	26,364
		.Administrative Terminals	46,464
		.Communications Adapter	8,880
		<b>TOTAL</b>	<b>81,708</b>



DETAIL ANNUAL COST ESTIMATES FOR CASE STUDY REGION (Cont)

ITEM	CASE STUDY REGION COST	ITEM	CASE STUDY REGION COST
<b>SECONDARY SCHOOL EQUIPMENT (Continued)</b>			
-Provided by Common Carrier		-Provided by Common Carrier	
. Communications Lines	\$ 2,514	. Communications Lines	\$ 252
TOTAL	2,514	. Adapters and Termination	90
		TOTAL	342
<u>-D.C. Schools Total</u>	84,222	<u>-Falls Church Total</u>	6,060
<b>2. Alexandria</b>		<b>6. Montgomery</b>	
-DP Mfg. Supplied		-DP Mfg. Supplied	
. Instructional Terminals	6,084	. Instructional Terminals	44,616
. Administrative Terminals	12,672	. Administrative Terminals	71,808
. Communications Adapters	2,160	. Communications Adapters	14,160
TOTAL	20,916	TOTAL	130,578
-Provided by Common Carrier		-Provided by Common Carrier	
. Communications Lines	947	. Communications Lines	6,621
. Adapters and Termination	270	. Adapters and Termination	6,318
TOTAL	1,217	TOTAL	12,939
<u>-Alexandria Total</u>	22,133	<u>-Montgomery Total</u>	143,517
<b>3. Arlington</b>		<b>7. Secondary Schools Total</b>	
-DP Mfg. Supplied		-DP Mfg. Supplied	405,948
. Instructional Terminals	12,168	-Provided by Common Carrier	28,108
. Administrative Terminals	12,672	TOTAL	434,056
. Communications Adapter	3,600		
TOTAL	28,440		
-Provided by Common Carrier		<b>JUNIOR COLLEGE EQUIPMENT</b>	
. Communications Lines	922	<b>1. Montgomery</b>	
. Adapters and Termination	360	-DP Mfg. Supplied	
TOTAL	1,282	. Instructional Terminals	5,070
<u>-Arlington Total</u>	29,722	. Communications Adapters	1,200
		TOTAL	6,270
<b>4. Fairfax</b>		-Provided by Common Carrier	
-DP Mfg. Supplied		. Communications Lines	551
. Instructional Terminals	50,700	. Adapters and Termination	360
. Administrative Terminals	71,808	TOTAL	911
. Communications Adapters	16,080	<u>-Montgomery Total</u>	7,181
TOTAL	138,588	<b>2. Northern Virginia</b>	
-Provided by Common Carrier		-DP Mfg. Supplied	
. Communications Lines	7,924	. Instructional Terminals	3,042
. Adapters and Termination	1,890	. Communications Adapters	720
TOTAL	9,814	TOTAL	3,762
<u>-Fairfax Total</u>	148,402	-Provided by Common Carrier	
<b>5. Falls Church</b>		. Communications Lines	245
-DP Mfg. Supplied		. Adapters and Termination	90
. Instructional Terminals	1,014	TOTAL	335
. Administrative Terminals	4,224	<u>-Northern Virginia Total</u>	4,097
. Communications Adapters	480		
TOTAL	5,718		

DETAIL ANNUAL COST ESTIMATES FOR CASE STUDY REGION (cont)

ITEM	CASE STUDY REGION COST	ITEM	CASE STUDY REGION COST
<b>JUNIOR COLLEGE EQUIPMENT (Continued)</b>			
3. Junior College Total		- Provided by Common Carrier	
- DP Mfg. Supplied	\$ 10,032	. Communications Lines	\$ 497
- Provided by Common Carrier	1,246	. Adapters and Terminals	90
TOTAL	11,278	TOTAL	587
<b>ADMINISTRATIVE CENTER EQUIPMENT</b>		- Fairfax Total	5,603
1. D. C. Schools		5. Falls Church	
- DP Mfg. Supplied		- DP Mfg. Supplied	
. Keyboard/Printer Terminals	4,056	. Keyboard/Printer Terminal	1,041
. Communications Adapters	960	. Communications Adapter	240
TOTAL	5,016	TOTAL	1,284
- Provided by Common Carrier		- Provided by Common Carrier	
. Communications Lines	187	. Communications Lines	252
TOTAL	187	. Adapters and Termination	90
- D. C. Schools Total	5,203	TOTAL	342
2. Alexandria		- Falls Church Total	1,596
- DP Mfg. Supplied		6. Montgomery	
. Keyboard/Printer Terminals	2,028	- DP Mfg. Supplied	
. Communications Adapters	480	. Keyboard/Printer Terminal	4,056
TOTAL	2,508	. Communications Adapter	960
- Provided by Common Carrier		TOTAL	5,016
. Communications Lines	316	- Provided by Common Carrier	
. Adapters and Terminals	90	. Communications Lines	374
TOTAL	406	. Adapters and Termination	270
- Alexandria Total	2,914	TOTAL	644
3. Arlington		- Montgon Total	5,660
- DP Mfg. Supplied		7. Administrative Center Total	
. Keyboard/Printer Terminal	2,028	- DP Mfg. Supplied	21,318
. Communications Adapters	480	- Provided by Common Carrier	2,414
TOTAL	2,508	TOTAL	23,732
- Provided by Common Carrier		<b>TOTAL EQUIPMENT COSTS</b>	
. Communications Lines	158	- Common Carrier	32,368
. Communications Adapters	90	- DP Mfg.	961,701
TOTAL	248		
- Arlington Total	2,756	<b>PERSONNEL AND SUPPLIES</b>	252,000
4. Fairfax			
- DP Mfg. Supplied		<b>GROSS TOTAL ANNUAL COSTS</b>	1,246,069
. Keyboard/Printer Terminal	4,056		
. Communications Adapters	960		
TOTAL	5,016		

DETAIL ANNUAL COST ESTIMATES FOR CASE STUDY REGION (cont)

ITEM	CASE STUDY REGION COST	ITEM	CASE STUDY REGION COST
<b>CASE STUDY REGION OPERATING BUDGETS</b>			
<b>1. Secondary Schools</b>		<b>-Business Administrative Services</b>	
-D. C. Schools	\$ 82,268,000	@ \$1.50 per student	\$ 129,250
-Alexandria	9,702,800	<b>TOTAL</b>	<b>473,918</b>
-Arlington	21,198,288		
-Fairfax	54,255,730	<b>2. Elementary Students</b>	
-Falls Church	1,535,462	<b>-Business Administrative Services</b>	
-Montgomery	74,787,059	@ \$.50 per student	159,237
<b>TOTAL</b>	<b>243,747,339</b>	<b>-Testing 37-1/2% of students</b>	
		@ \$.60 per student	71,656
<b>2. Junior Colleges (Instruction only)</b>		<b>TOTAL</b>	<b>230,893</b>
-Montgomery Junior College	2,062,509		
-Northern Virginia Community College	1,208,600	<b>3. Total Administrative Value</b>	<b>704,811</b>
<b>TOTAL</b>	<b>3,271,109</b>		
<b>3. Total Operating Budgets</b>	<b>247,018,448</b>	<b>INSTRUCTIONAL VALUES</b>	
<u>% of Budget for DP Services</u>	<u>.50%</u>	<b>1. Secondary Students</b>	
		<b>-Problem Solving @ \$5.95</b>	
		per student	512,571
		<b>2. Junior College Students</b>	
		<b>-Problem Solving @ \$7.18</b>	
		per full-time student (4,025)	28,687
		<b>3. Total Instructional Value</b>	<b>541,258</b>
<b>ADMINISTRATIVE VALUES</b>			
<b>1. Secondary Students</b>			
-Pupil Personnel Services @ \$4.00 per student	344,668		

APPENDIX F: SIMULATION

Addendum 1

System Configuration Simulated, by Model Region

Model region	A	B	C	USOE
Terminals simulated				
*Type 2741	68	135	203	167
Type 1050	25	50	75	50
System/360				
Model	40H	50M	50I	50I
Relative processing speed	0.4	1.0	1.0	1.0
Core Allocation (1000's of bytes)				
Problem-solving supervisor	70	70	70	70
Student workspaces (18,000 bytes each)	90	90	288	288
DOS with modifications	25	25	25	25
QTAM	5	5	5	5
Adm inquiry programs (12,000 bytes ea.)	36	36	84	84
**Line buffer poll	30	30	30	30
Total	256	256	502	502

\*All problem-solving sessions were simulated at these terminals, which were operating continuously, and which generated the same average number of sessions as the actual larger number of terminals operating on a scheduled basis.

\*\*This amount of buffer storage was judged to be adequate, although the operation of this dynamic buffer pool was not simulated.

Addendum 2

Problem Solving

Distribution of Student Response Times

15-Point Continuous Distribution Function = 56.2 seconds

Cumulative Probability	Student Response Time, seconds
.00	2.5545
.06	5.1090
.21	10.2180
.32	15.3270
.41	20.4360
.54	30.6540
.63	40.8720
.69	51.0900
.77	71.5260
.83	91.9620
.88	127.7250
.95	212.0235
.98	293.7675
.99	370.4025
1.00	510.9000

Addendum 3

Problem Solving

Distribution of Calculation Time Required on 360/50

10-Point continuous distribution function  
Mean = 25 seconds

Cumulative Probability	Calculate Time Required, seconds
.000	.01
.780	.10
.830	.20
.850	.30
.880	.50
.940	1.00
.960	1.30
.970	1.70
.974	2.00
1.000	6.25

Addendum 4

Problem Solving

Distribution of Message Lengths, Terminal to Processor

4-Point Continuous Distribution Function  
Mean = 17.5 Characters

<u>Cumulative Probability</u>	<u>Characters</u>
.0	2
.5	10
.8	20
1.0	80

Addendum 5

Problem Solving

Distribution of Message Lengths, Processor to Terminal

4-Point Continuous Distribution Function  
Mean = 8.75 Characters

<u>Cumulative Probability</u>	<u>Characters</u>
.0	1
.5	5
.8	10
1.0	40

Addendum 6

Problem Solving

Distribution of Message Types

4-Point Discrete Probability Function

Message

<u>Type</u>	<u>Function</u>
1	Sign on (beginning of session) (Not handled by this function)
2	Load (previously saved workspace)
3	Drop (previously saved workspace) Add (new user)
4	Save (current workspace) Off (end session and save workspace) Copy (requested information from saved workspace)
5	Calculate (interpreter)

Cumulative Probability

Message Type

.028	2
.033	3
.066	4
1.000	5

Addendum 7

Administrative Inquiry

Mean Inter-origination times for beginning segments of administrative messages, terminal to processor, seconds. Characters/segment. Number of segments.

	Mean Inter-origination, seconds					Input		Output	
	A	B	C	USOE	Case Study	Char/Seg	No. of Seg	Char/Seg	No. of Seg
Cuts	23.4	11.7	7.8	9.3	10.9	10	1	100	1
Absence Reason Update	7.8	3.9	2.6	3.1	3.6	10	1	24	1
Tardies -- Early Dismissal	58.5	29.2	19.5	23.4	27.2	12	1	24	1
New Student Registrations	292.5	146.2	97.5	117.0	136.0	100	5	24	1
Leaving Students	292.5	146.2	97.5	117.0	136.0	10	2	24	1
Program Changes	58.5	29.2	19.5	23.4	27.2	10	2	24	1
Guidance Requests	58.5	29.2	19.5	23.4	27.2	10	2	500	5

Addendum 8

Administrative Inquiry

Distribution, Exponential, used to calculate inter-origination times for beginning segments of administrative messages, terminal to processor.

24-Point Continuous Distribution Function

<u>Cumulative Probability</u>	<u>Factor</u>	<u>Cumulative Probability</u>	<u>Factor</u>
.0000	.0000	.9000	.2300
.1000	.0104	.9200	.2520
.2000	.0222	.9400	.2810
.3000	.0355	.9500	.2990
.4000	.0509	.9600	.3200
.5000	.0690	.9700	.3500
.6000	.0915	.9800	.3900
.7000	.1200	.9900	.4600
.7500	.1380	.9950	.5300
.8000	.1600	.9980	.6200
.8400	.1830	.9990	.7000
.8800	.2120	.9997	.8000

Problem-Solving Model

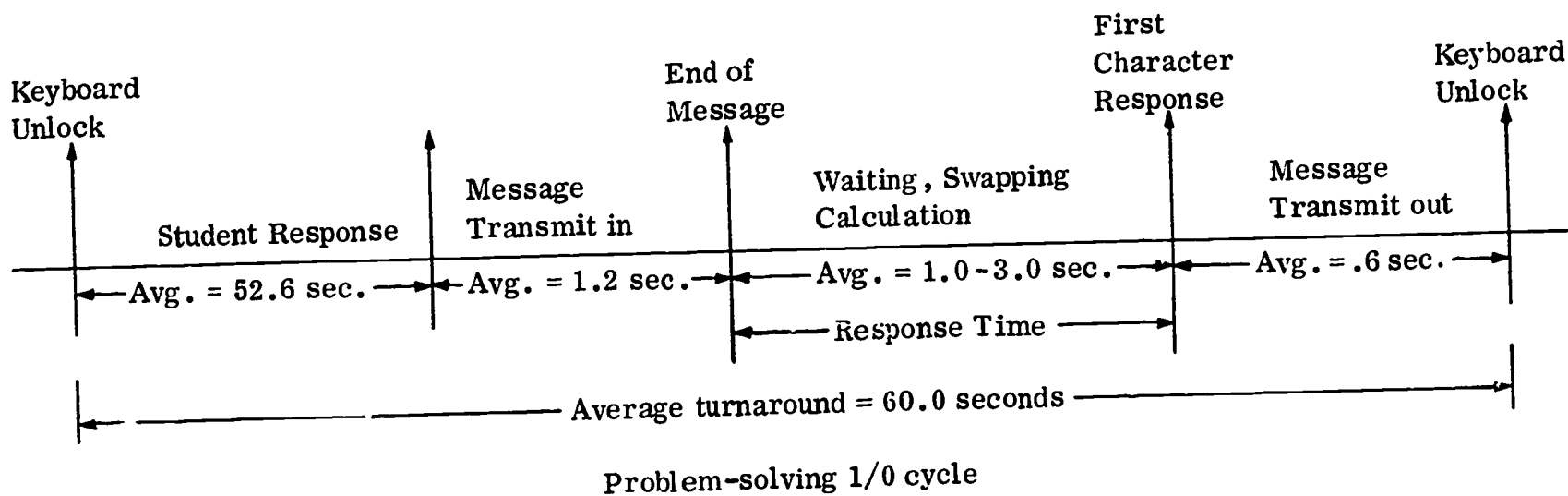
Following the processing of a problem-solving device interrupt, control is given to the problem-solving scheduler to determine if there is some new task which can be performed. When an administrative device interrupt occurs, control is given to the administrative scheduler if the system has been idle, or control returns to the interrupted process if the system has been busy.

The problem-solving scheduler first initiates a "swap" operation, if necessary. Swapping is an integral part of time-sharing and results in a flow of workspaces from main storage to direct access storage and from direct access storage back in main storage. Swapping removes those inactive workspaces from main storage for which there is no current request pending. When there are no inactive workspaces in main storage, but there is an active workspace in direct access storage, then the workspace swapped out is the one which has received the largest amount of processing time since its original entry into main storage for the CPU to service; that is, for as long as a peak demand persists.

When a user workspace is selected to use the CPU, a maximum time slice of 100 milliseconds is provided. This, in conjunction with the swapping operation, gives short-duration jobs priority over long-duration jobs. The net result is a lower average response time than if all requests had been queued and processed serially. A user expects a quick response to a simple request. However, he must be content to wait longer to receive the results of a complex operation.

If there are no swaps to be initiated, the problem-solving supervisor checks to see if there are any active workspaces in main storage. If so, the workspace is selected which has received the least number of time slices since its original arrival in main storage. Control is then given to the problem-solving language processor, which begins the processing of the current request or resumes processing where it has been interrupted. If there are no active workspaces in main storage, control is passed to the administrative scheduler.

The overall sequence of events associated with a single student request, in the environment as well as within the processor, is as shown.



Response time is defined as the total time between end of message and receipt of the first response character from the computer. After the last character has been typed out, the keyboard unlocks and the user decides what his next entry is to be. He then enters this message and depresses the end-of-message key. Next, the computer performs the requested operation and sends a message back to the terminal. These messages are assumed to be random in function, length, frequency, and CPU processing requirements.

To characterize these random messages, the simulator uses random number generators and modified empirical functions. In this manner, the "conversation" between the user and the computer is simulated. There are as many concurrent conversations in the simulation as there are active problem-solving terminals.

In order to obtain the required first response, the problem-solving supervisor must be optimized to handle these specialized functions with the least possible overhead. The currently implemented APL/360 supervisor consumes less than .1% of the CPU time. Based on this, the problem-solving supervisor overhead was considered negligible and not simulated.

#### Administrative Inquiry Model

This model calculates the average time between message generations of each task, and simulates sending these messages from the terminals to the central processing unit. The input is handled by a communication control program, which queues the messages in priority sequence. (Attendance tasks are assigned highest priority; guidance, intermediate; and registration, lowest.)

When the problem-solving scheduler has no tasks for the central processing unit, the DOS/360 scheduler checks the input queue for administrative messages to be processed. If there is administrative input, a task is activated, processed by the appropriate message-processing program, and the

response is placed on a message output queue. The response is subsequently sent to the originating terminal by the communication control program, as central processing unit time becomes available.

Processing times were modeled for all message-processing programs, as well as the communication control program and all functions of DOS/360.

#### Addendum 10

##### Flowcharts of Simulation Model

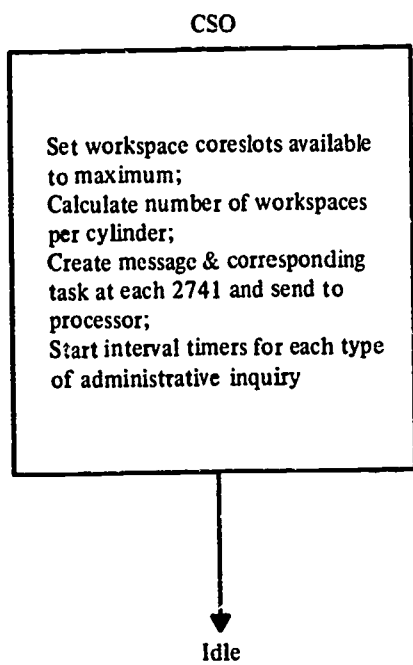
The special terms used in the flowcharts are defined below:

ALG0, 1, 2	Parameters that adjust the priorities for the selection of workspaces to be swapped from disk to core. ALG0 = 0, ALG1 = 1, ALG2 = 2
PERCORE	Array of identifiers of student workspaces located in core
PERDISK	Array of identifiers of student workspaces on swap disks
ARM	Cylinder location of disk access arm on swap disk
MAXARM	Last cylinder location in use on swap disk
QUONT	Number of time slices a student workspace has received since it last entered core
QUONTMIN	Minimum and maximum values of
QUONTMAX	QUONT used for controlling the selection of student workspaces for processing and for swapping, respectively

Process times shown in the flowcharts are for a 360/50. Multiply by 2.5 to obtain those used to simulate a 360/40.

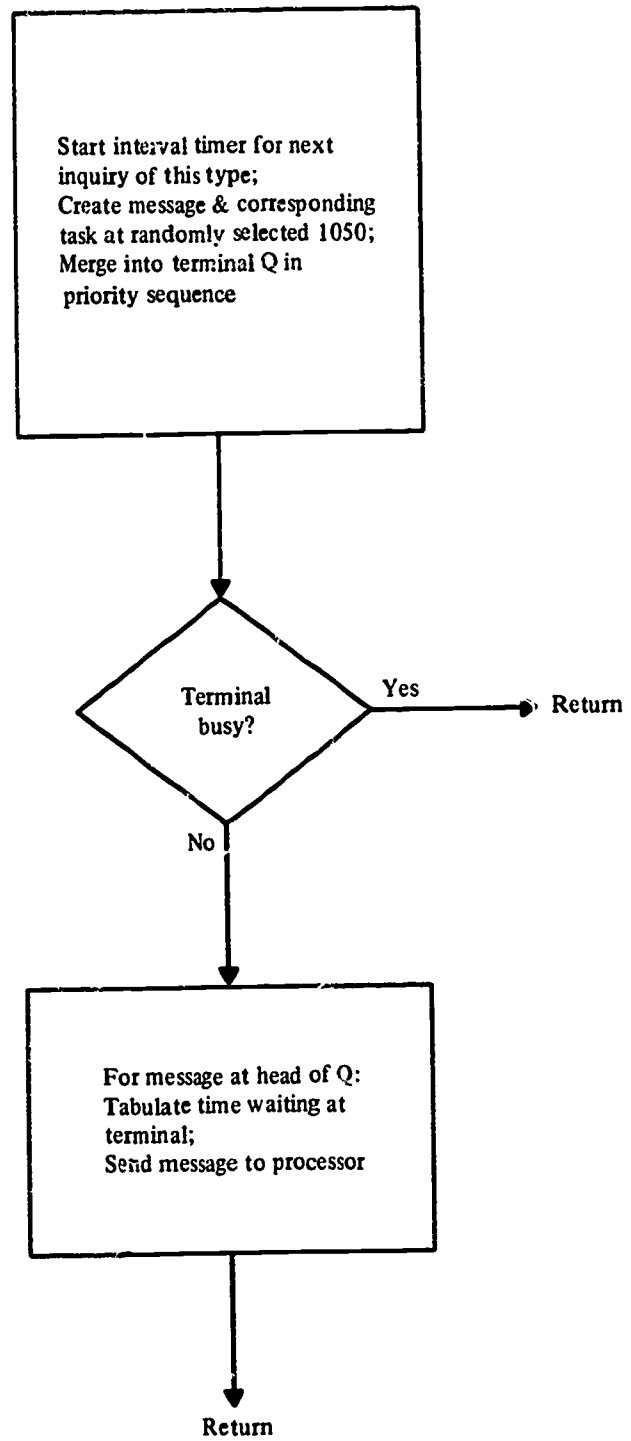


INITIALIZATION



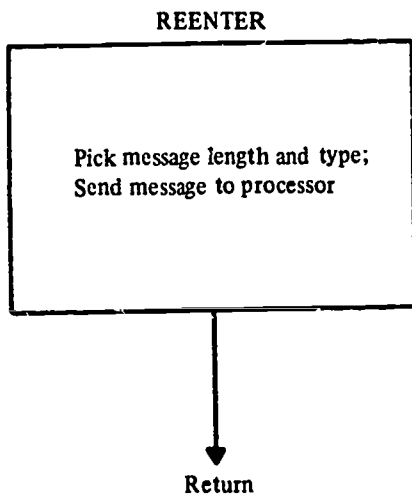
Administrative inquiry interval timer timeout:

CUTINIT, ABSINIT, TDYINIT, REGINIT  
LEVINIT, CHGINIT, GUIDINIT



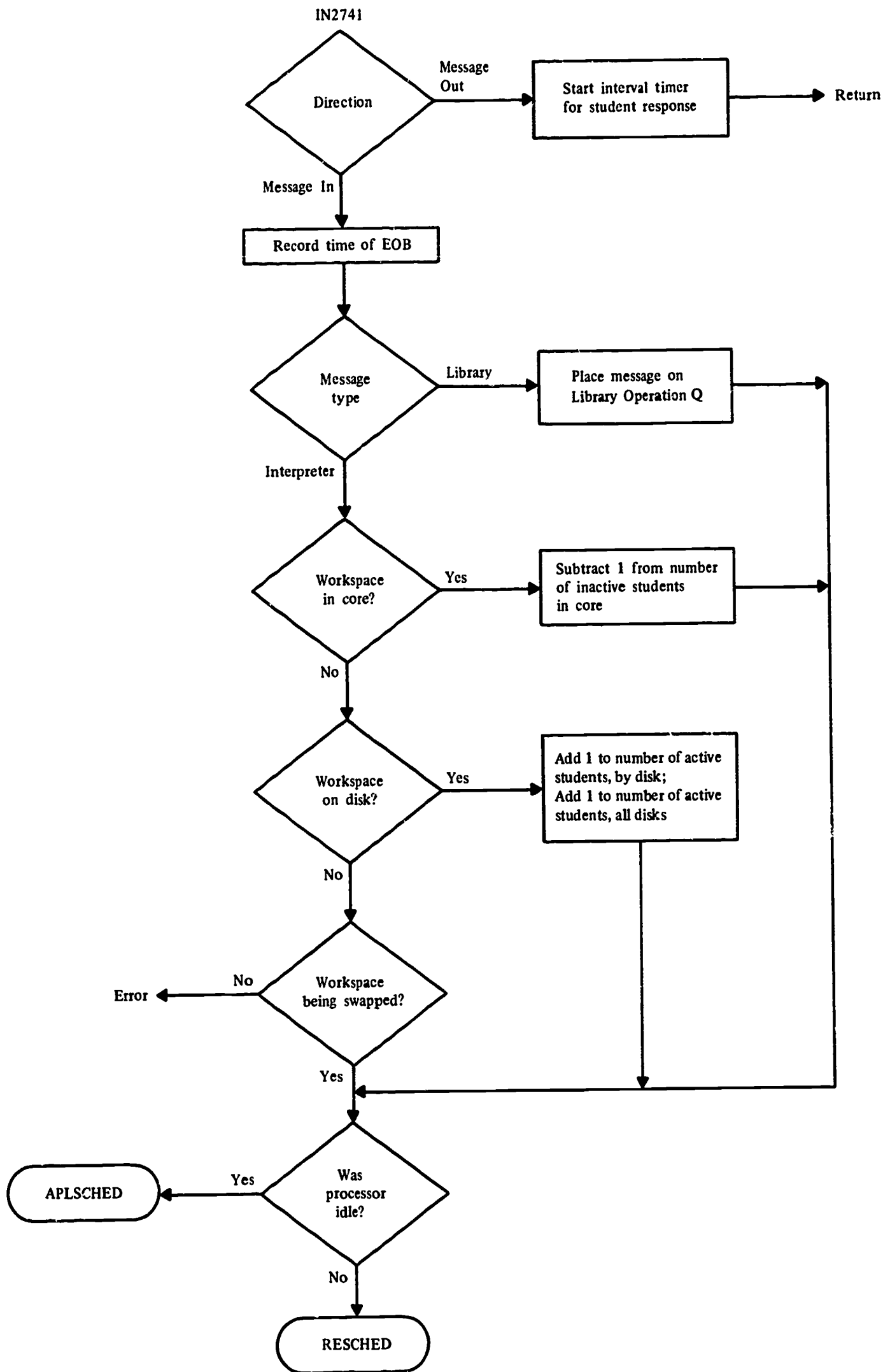
ENVIRONMENT INTERRUPTS

Student response interval timer timeout:

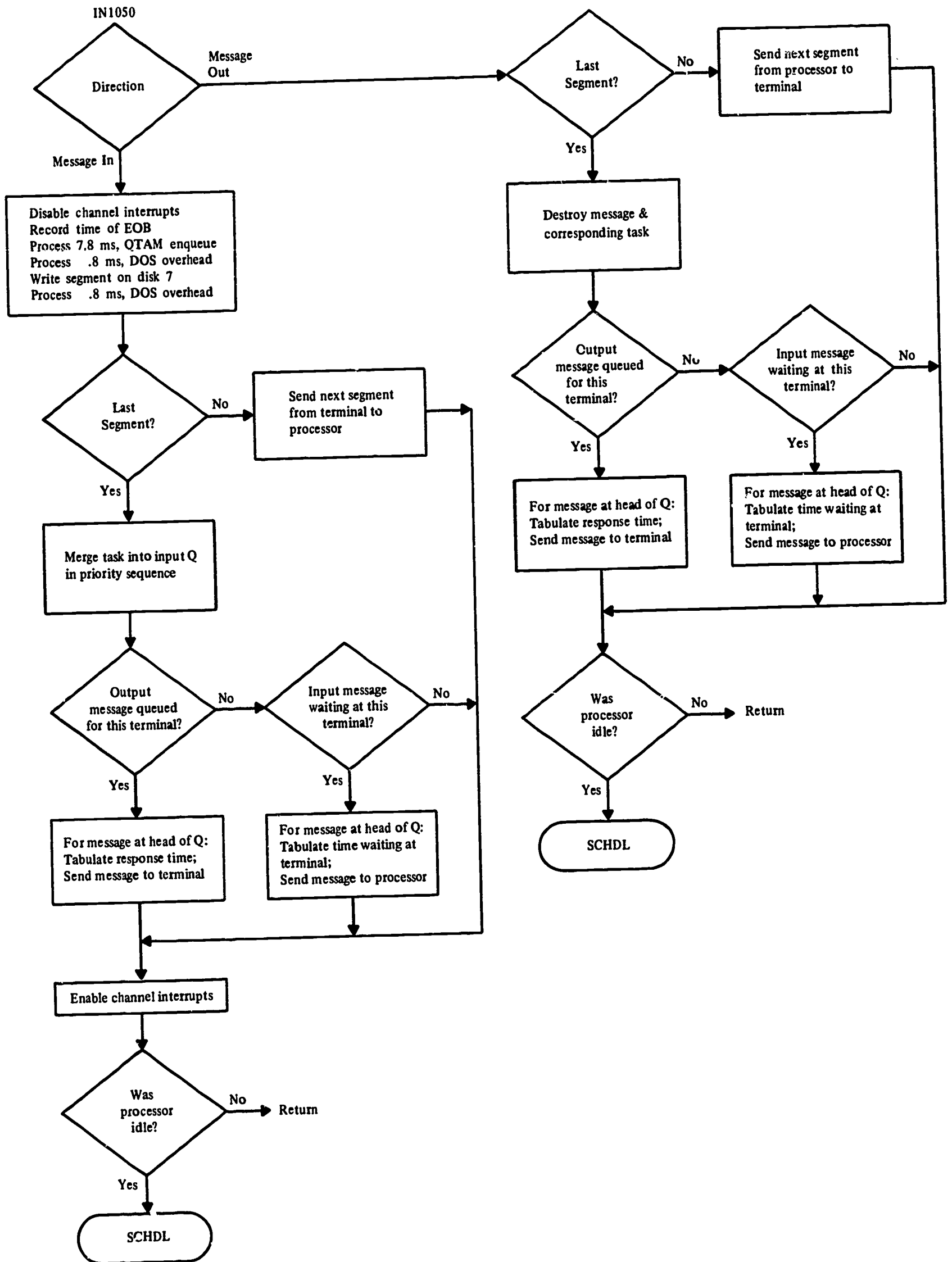


PROCESSOR INTERRUPTS

Multiplexer channel, 2741:

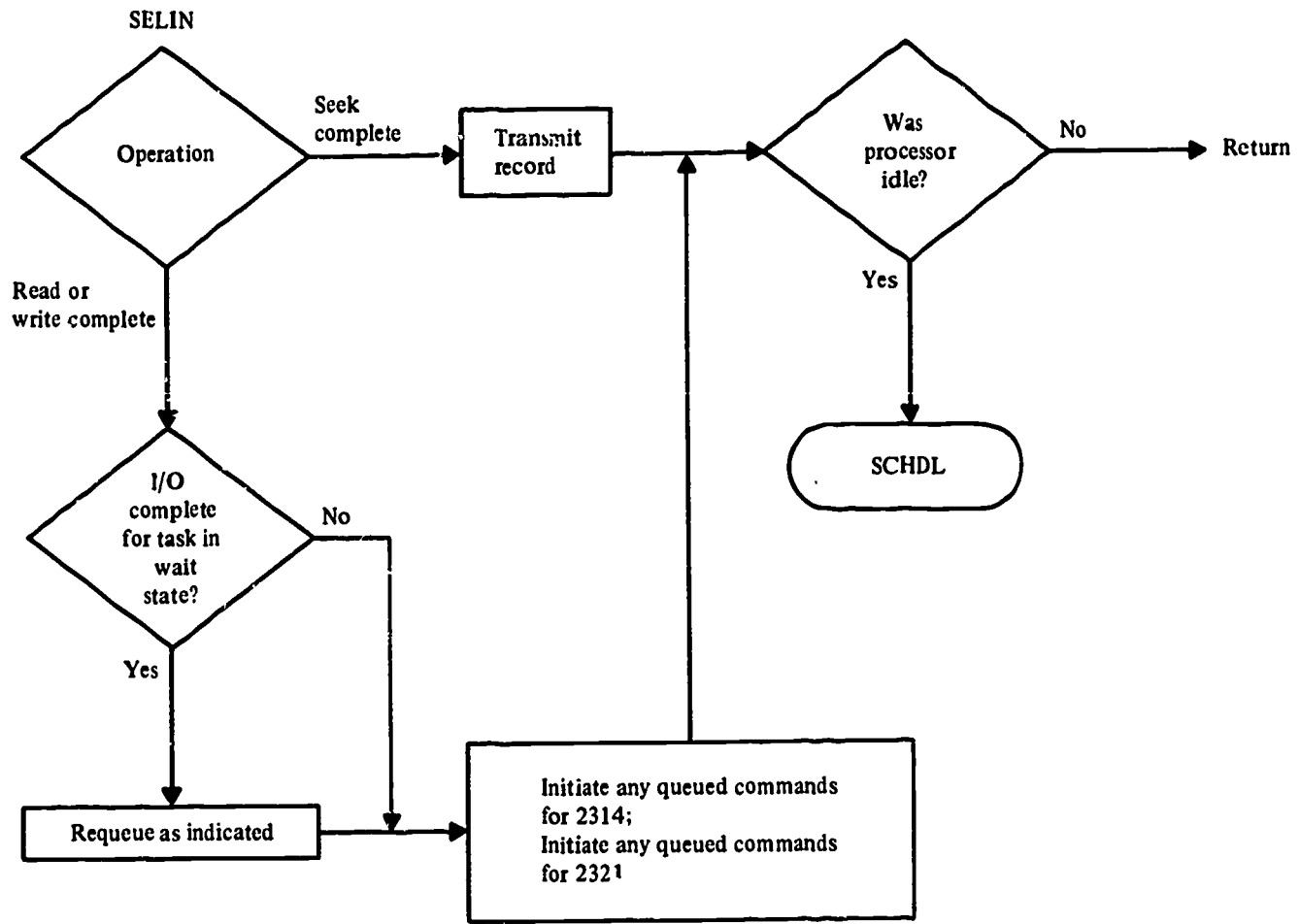


PROCESSOR INTERRUPTS (CONT'D)  
 Multiplexer channel: 1050

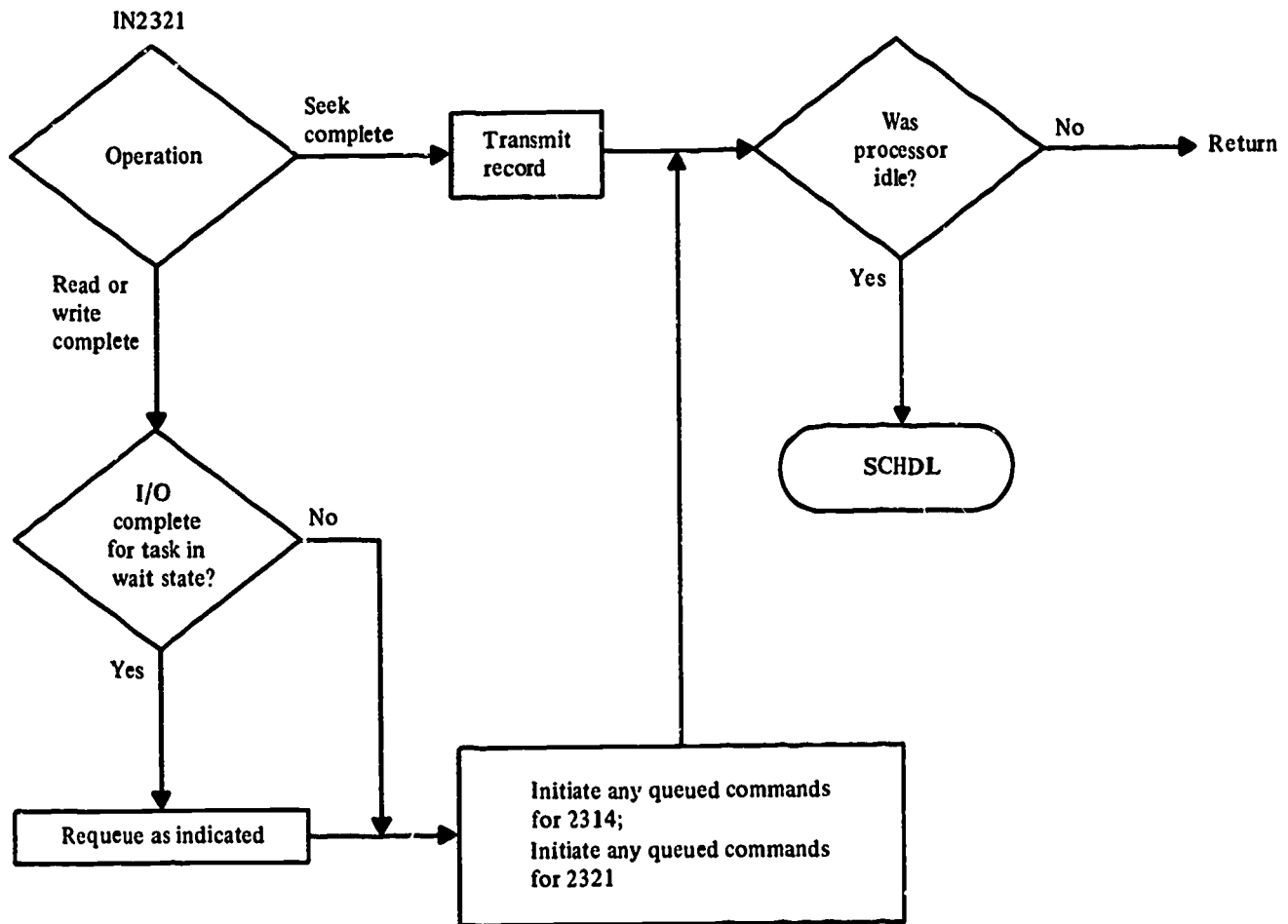


PROCESSOR INTERRUPTS (CONT'D)

Selector channel, 2314, administrative inquiry disk:

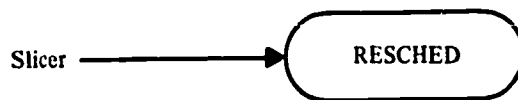


Selector channel, 2321:

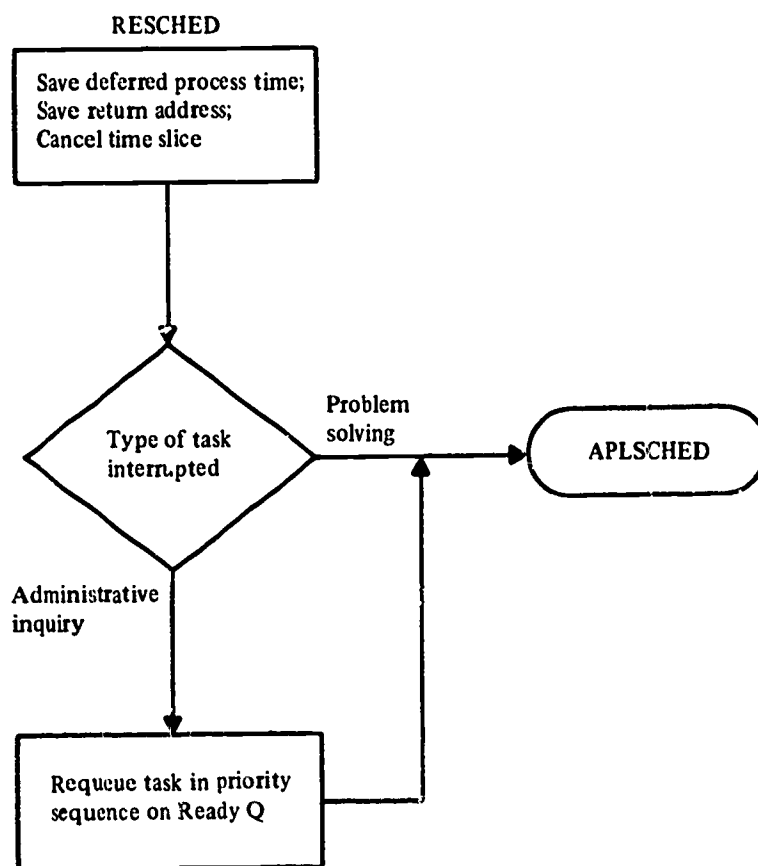


PROCESSOR INTERRUPTS (CONT'D)

Time slice interval timer timeout:

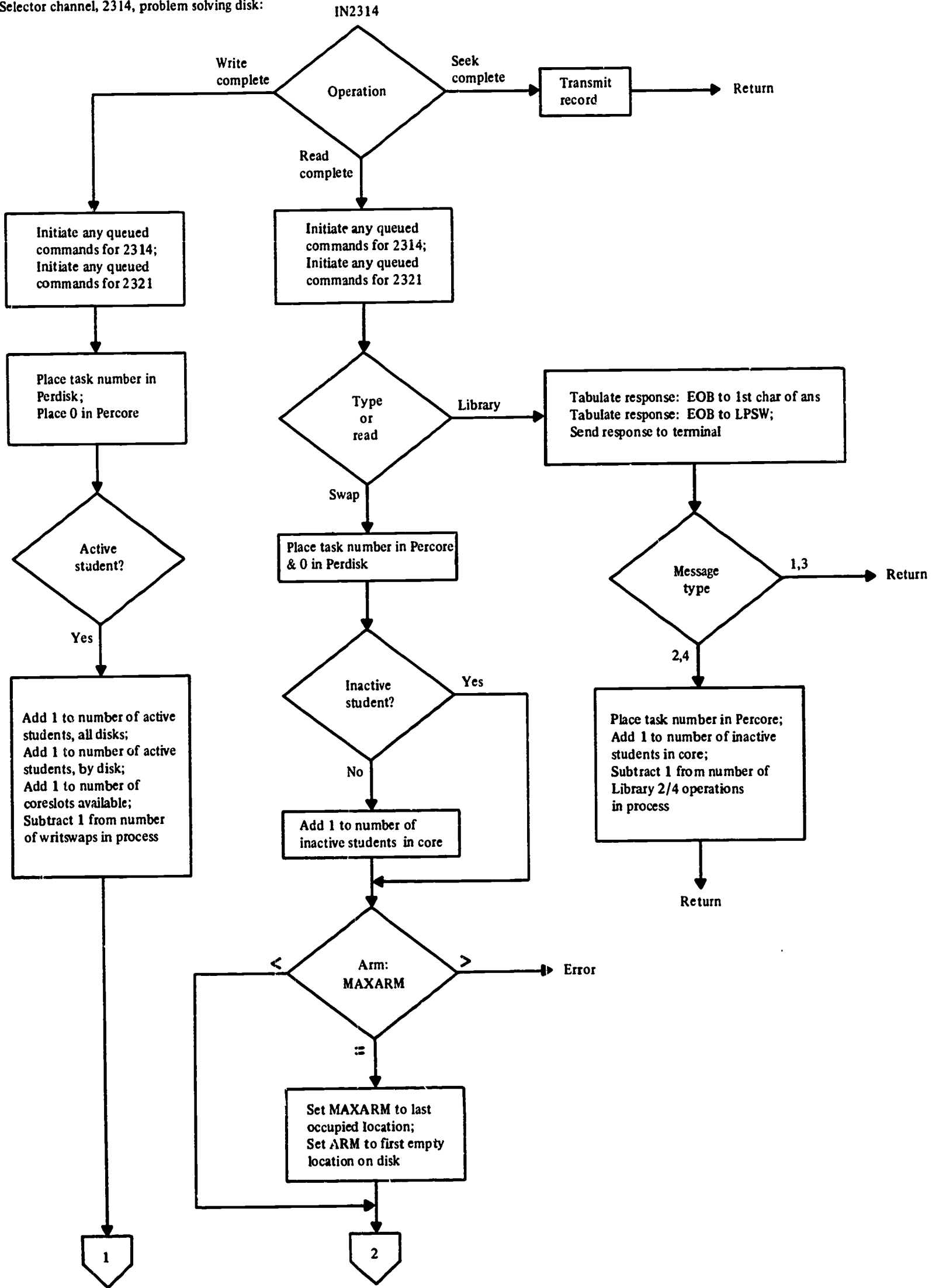


Problem solving I/O interrupt rescheduler:

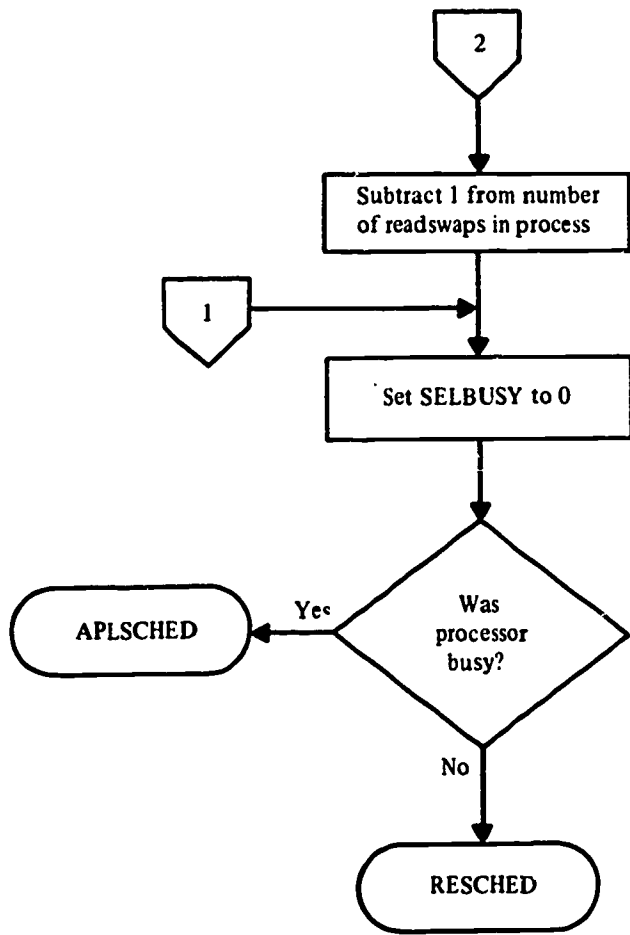


PROCESSOR INTERRUPTS (CONT'D)

Selector channel, 2314, problem solving disk:

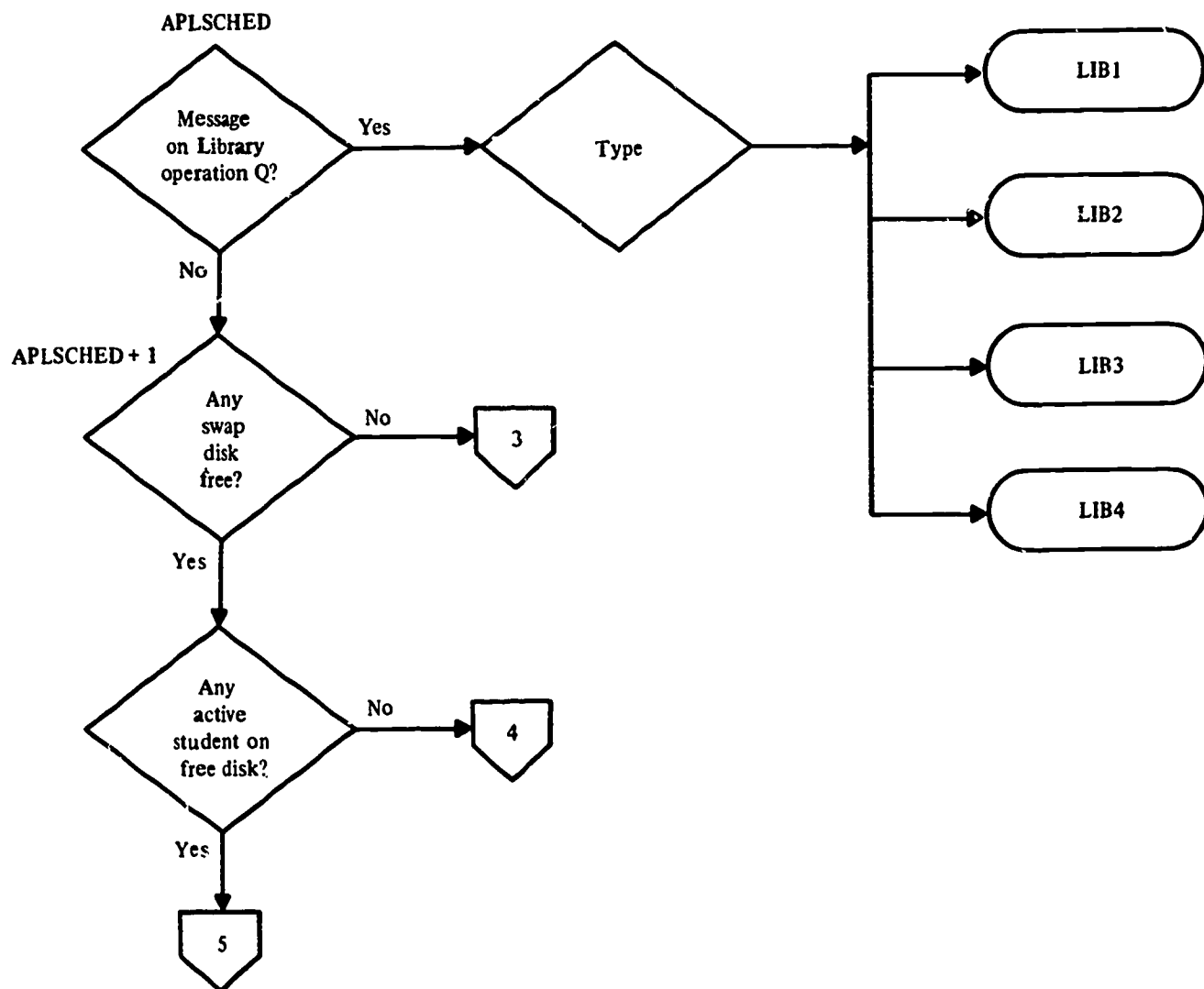


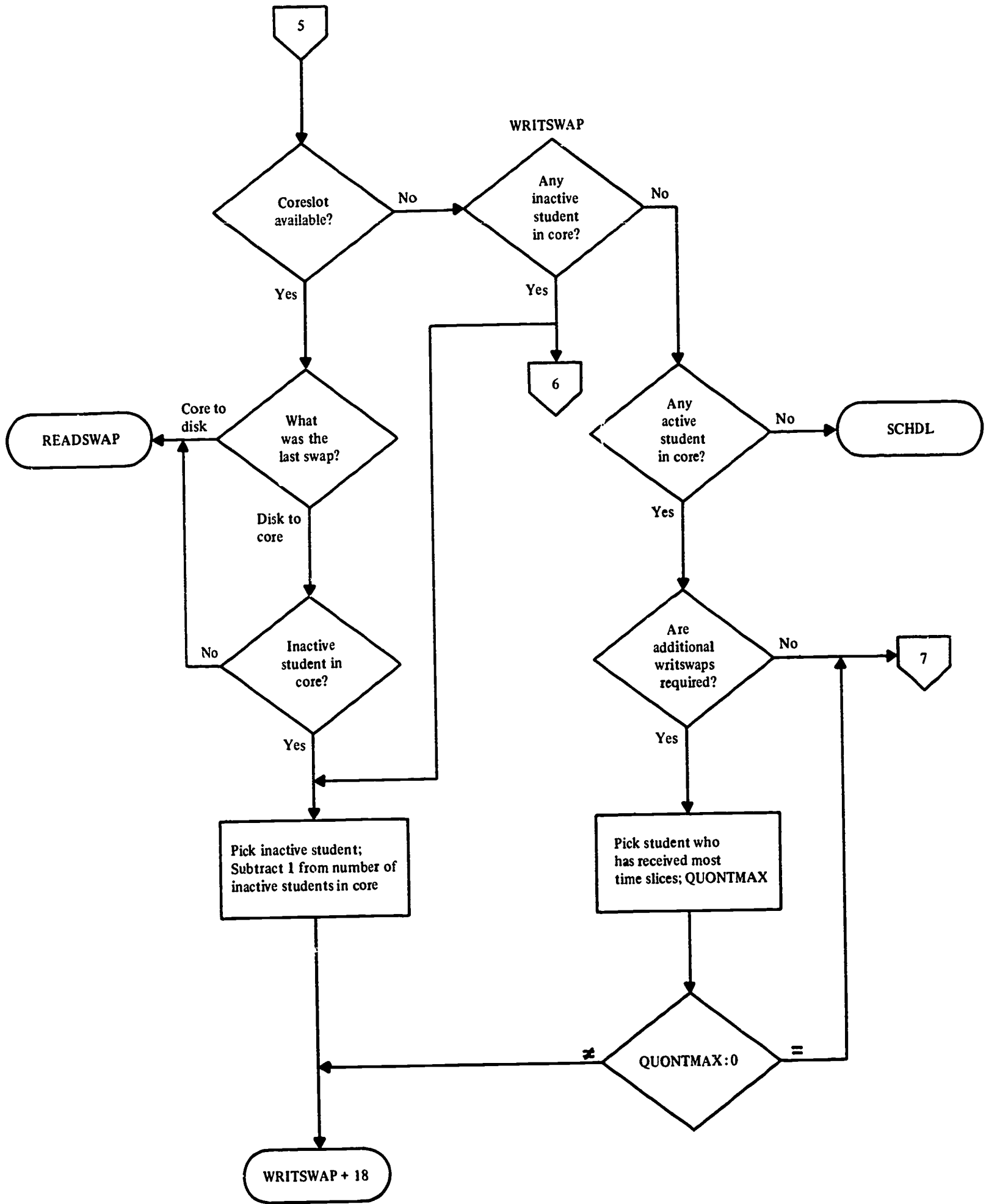
PROCESSOR INTERRUPTS (CONT'D)



SCHEDULING ROUTINES

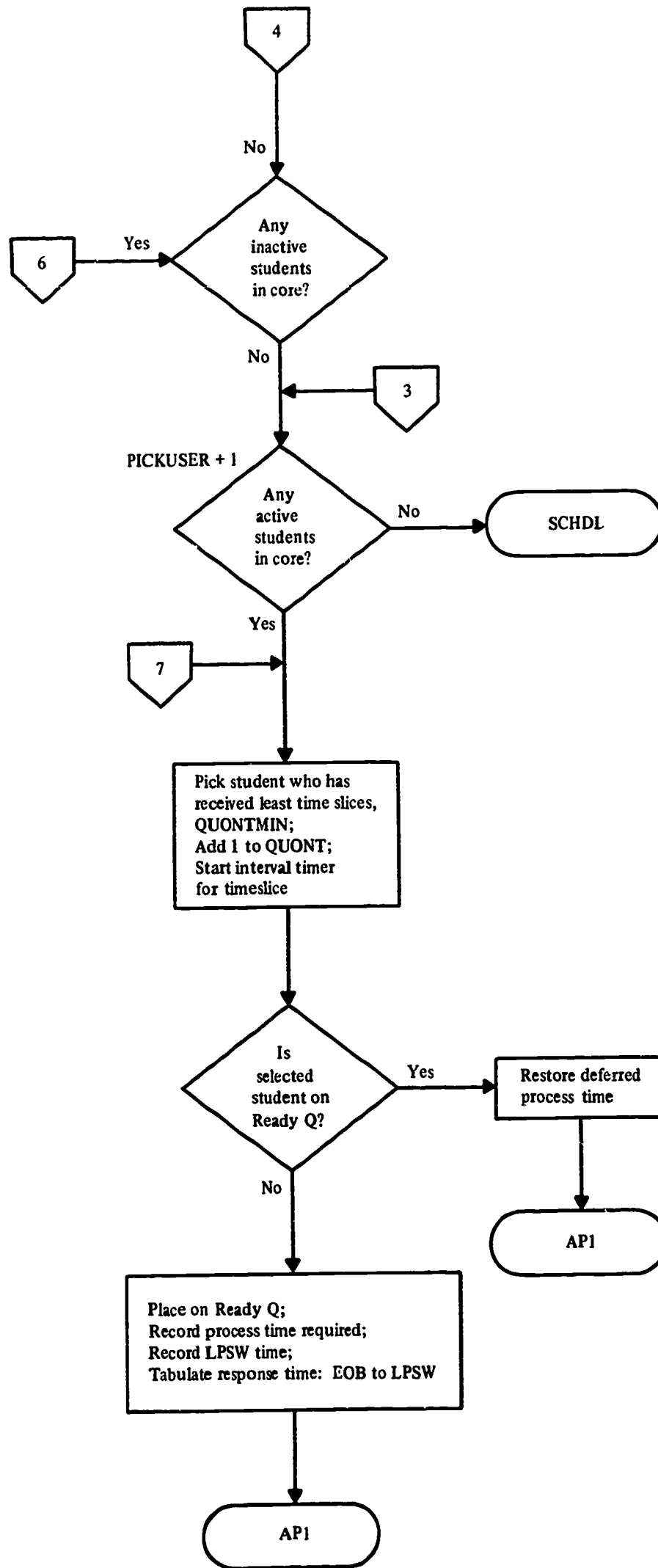
Problem solving scheduler:





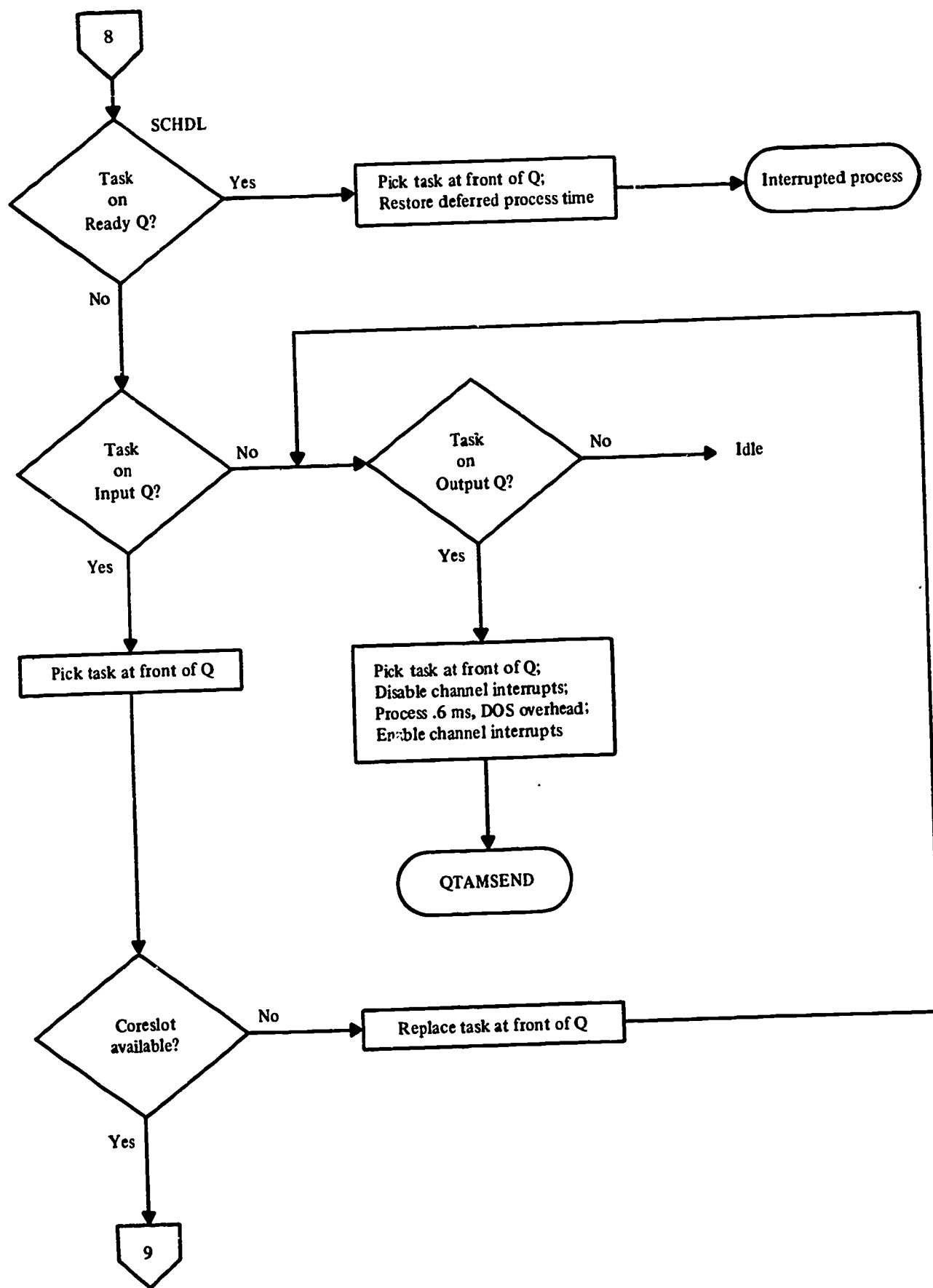


SCHEDULING ROUTINES (CONT'D)

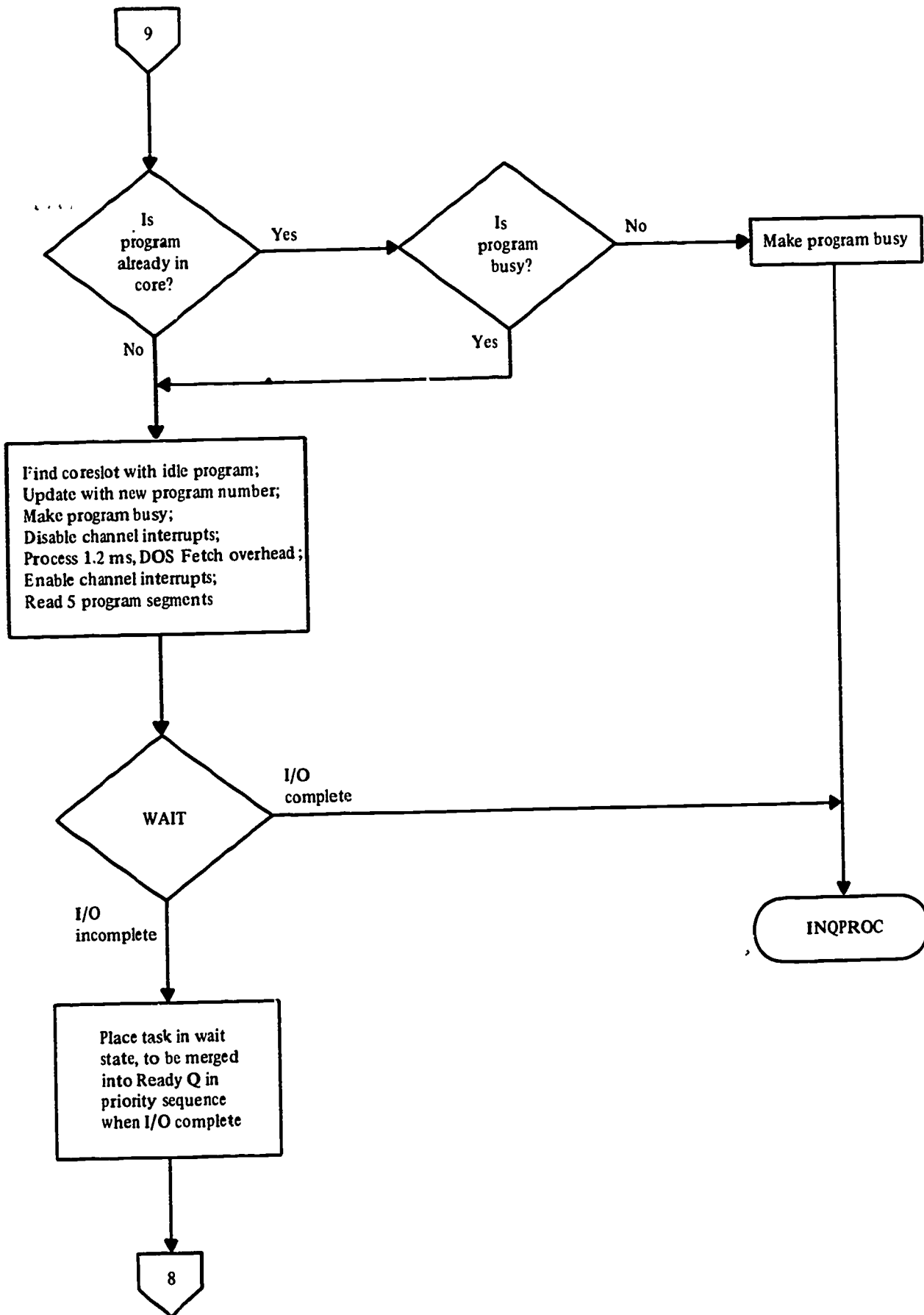


SCHEDULING ROUTINES (CONT'D)

Administrative inquiry scheduler:

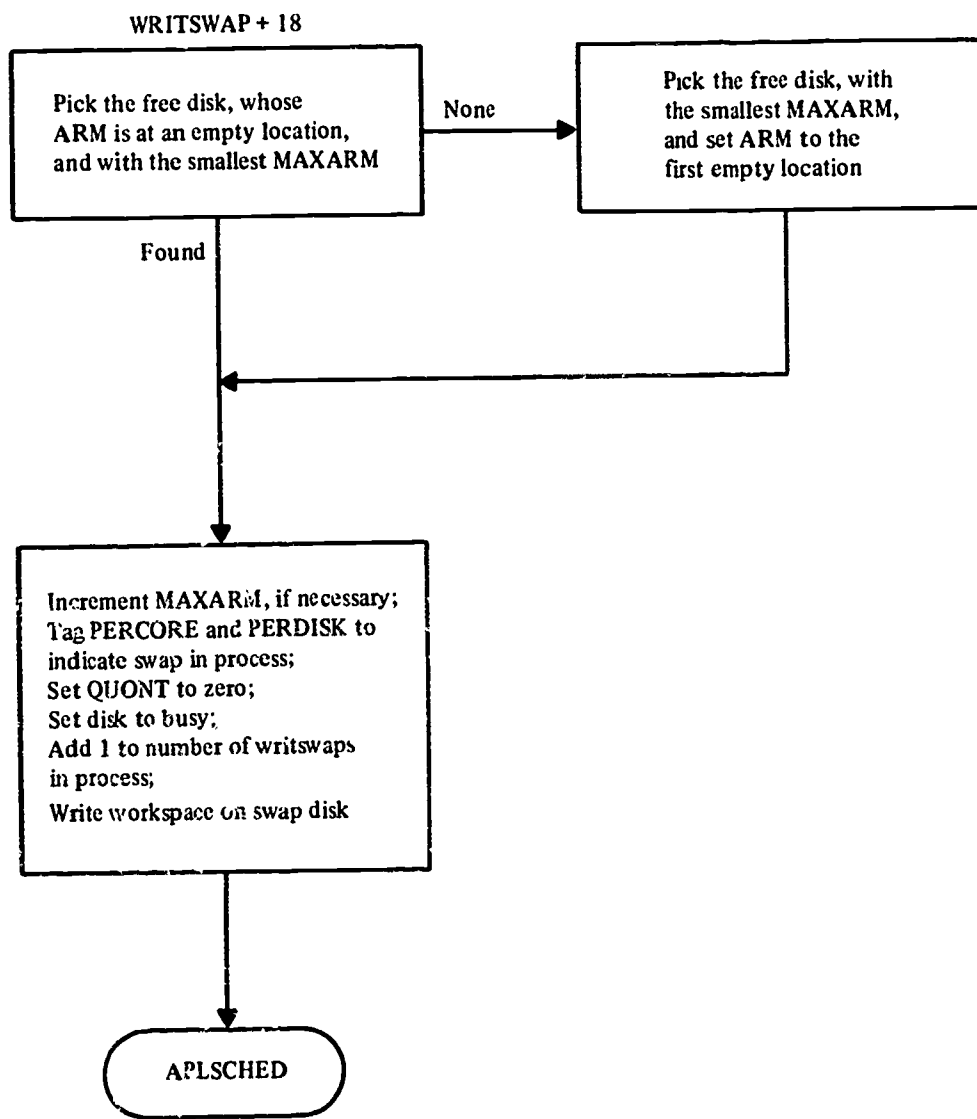


SCHEDULING ROUTINES (CONT'D)



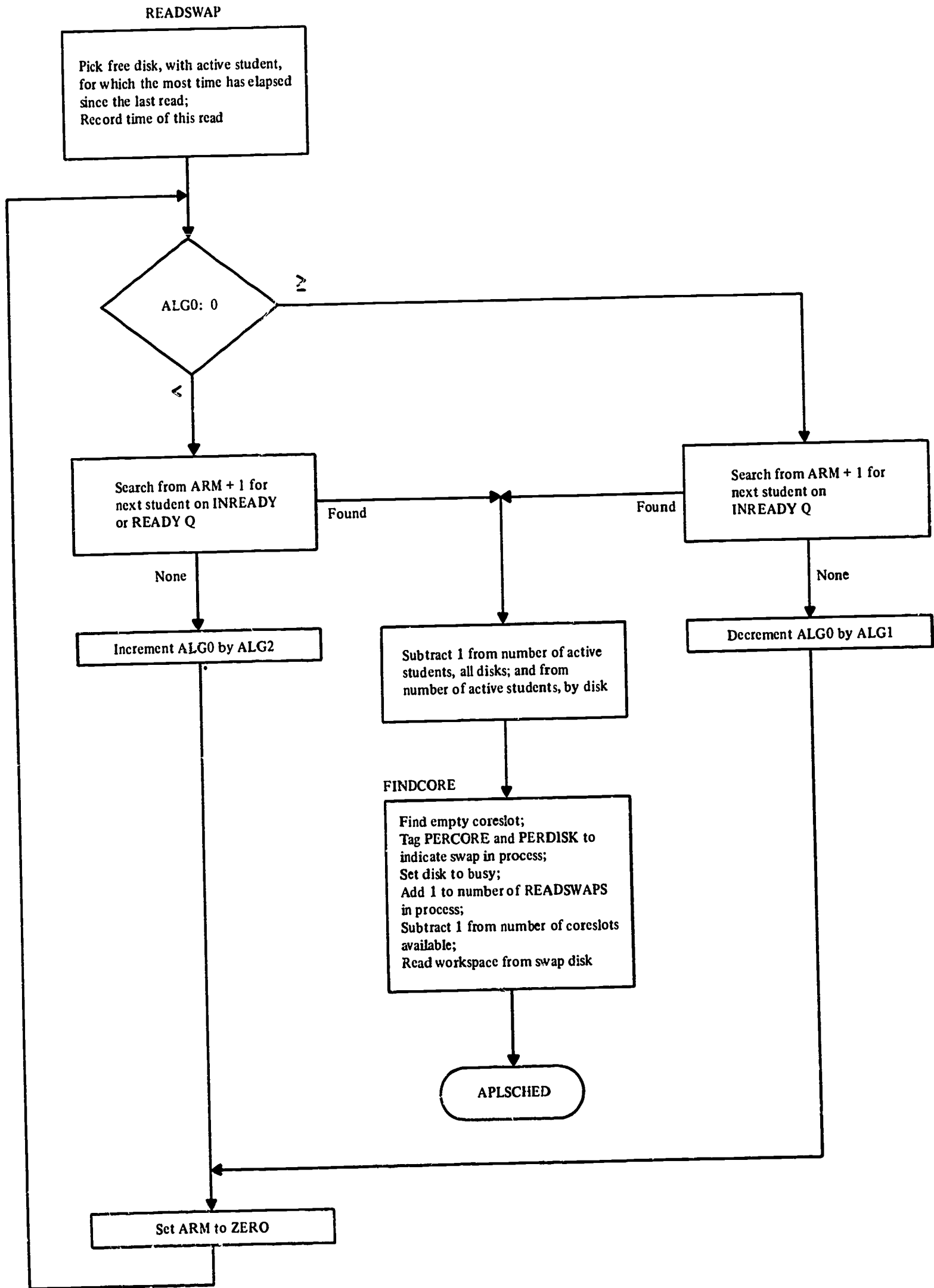
PROCESSING ROUTINES

Problem solving, swap from core to disk:



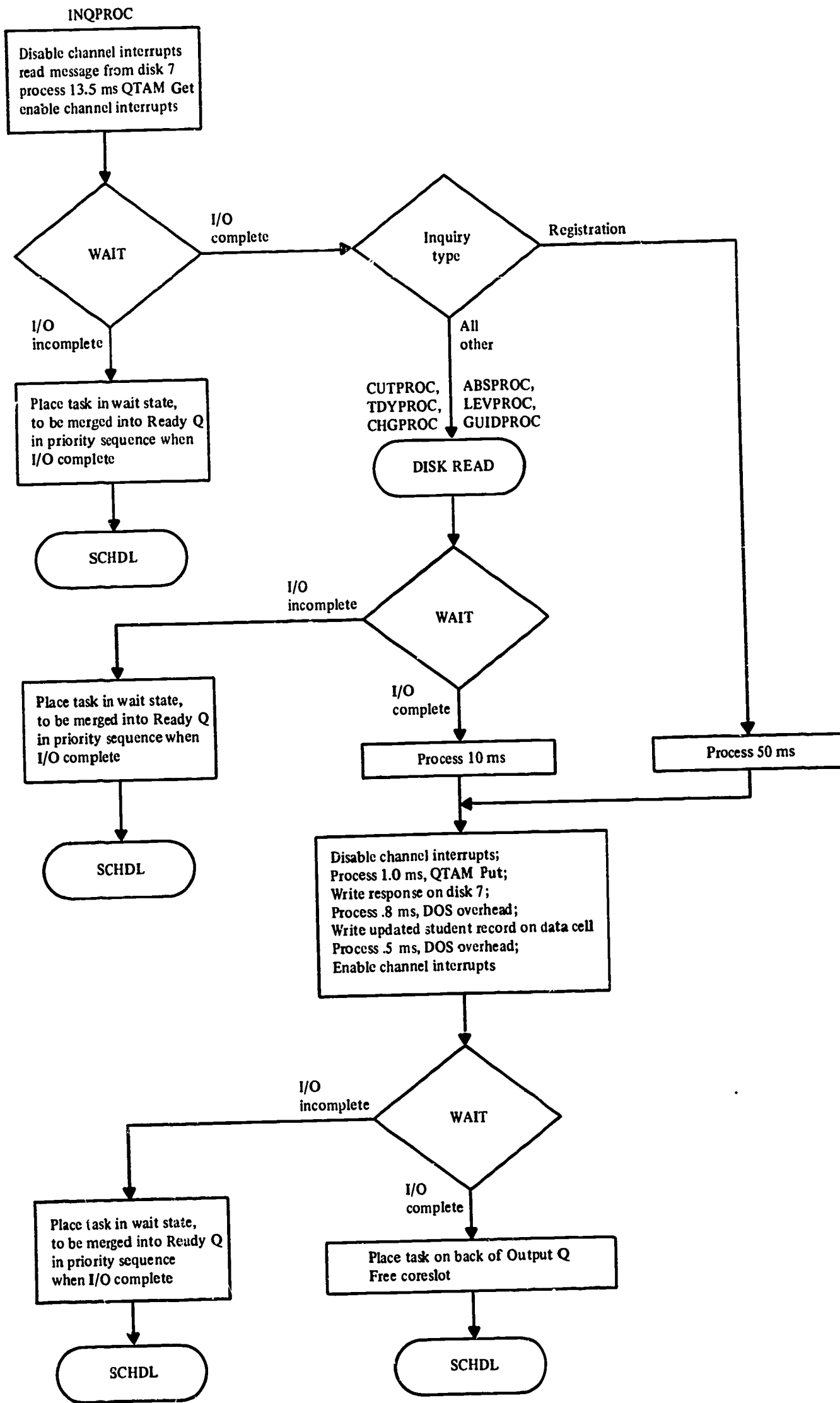
PROCESSING ROUTINES (CONT'D)

Problem solving, swap from disk to core:



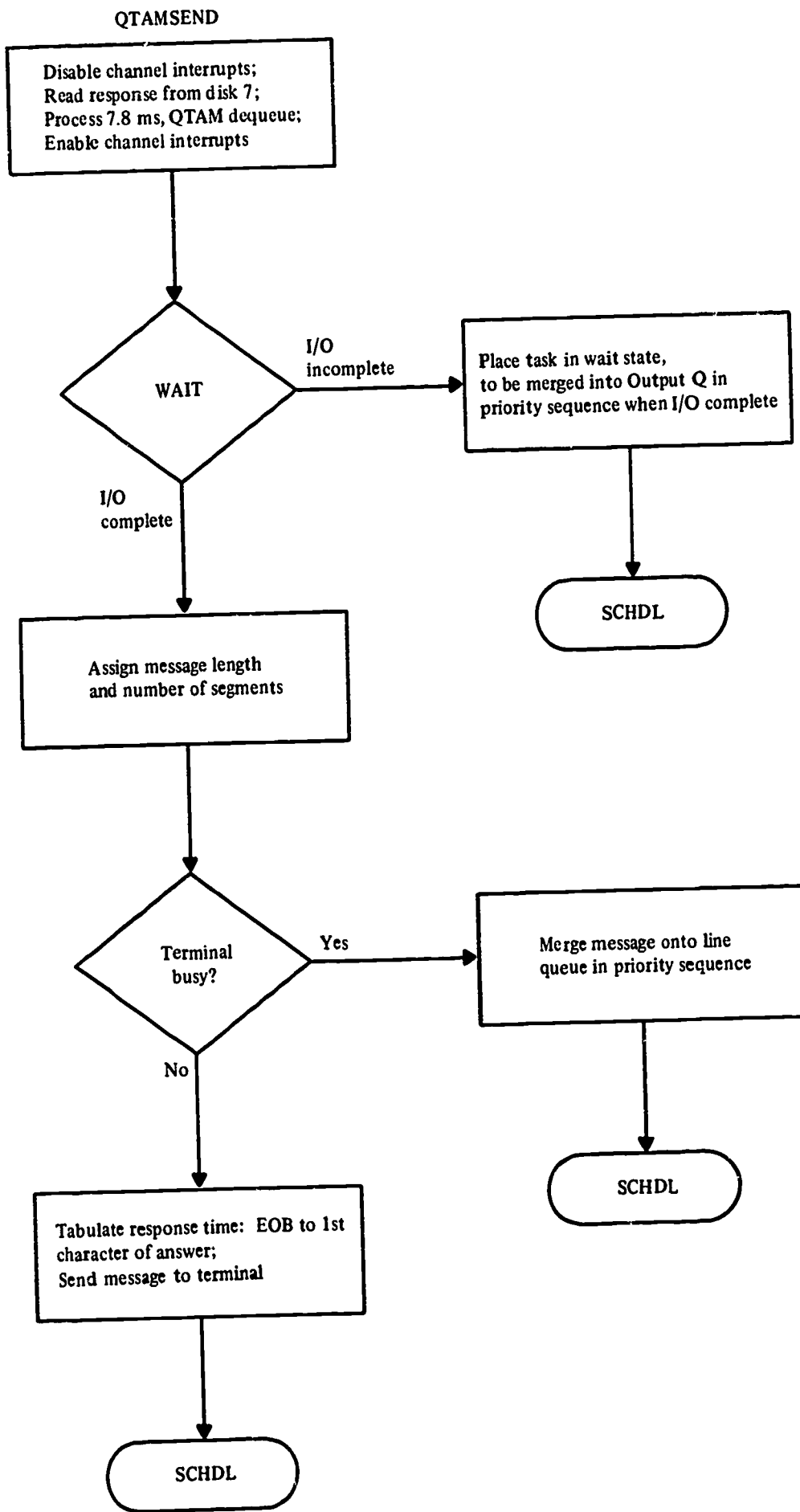
PROCESSING ROUTINES (CONT'D)

Administrative inquiry processing:

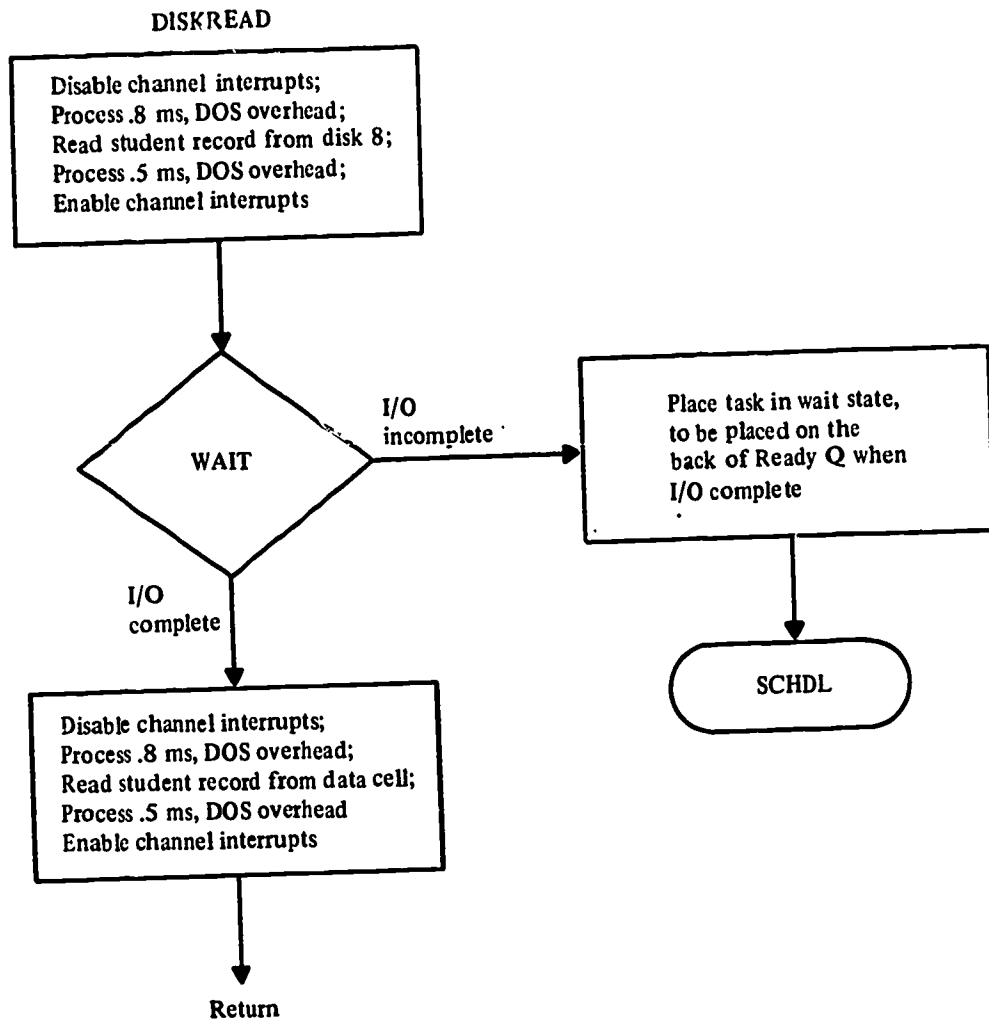


PROCESSING ROUTINES (CONT'D)

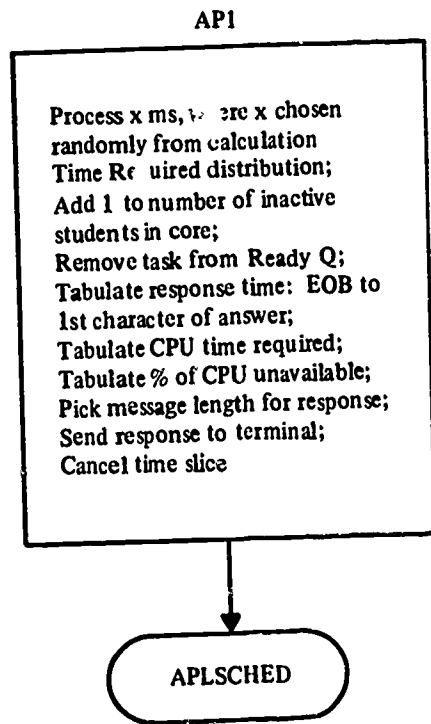
Administrative inquiry, send response to terminal:



PROCESSING ROUTINES (CONT'D)  
Administrative inquiry, read student record:

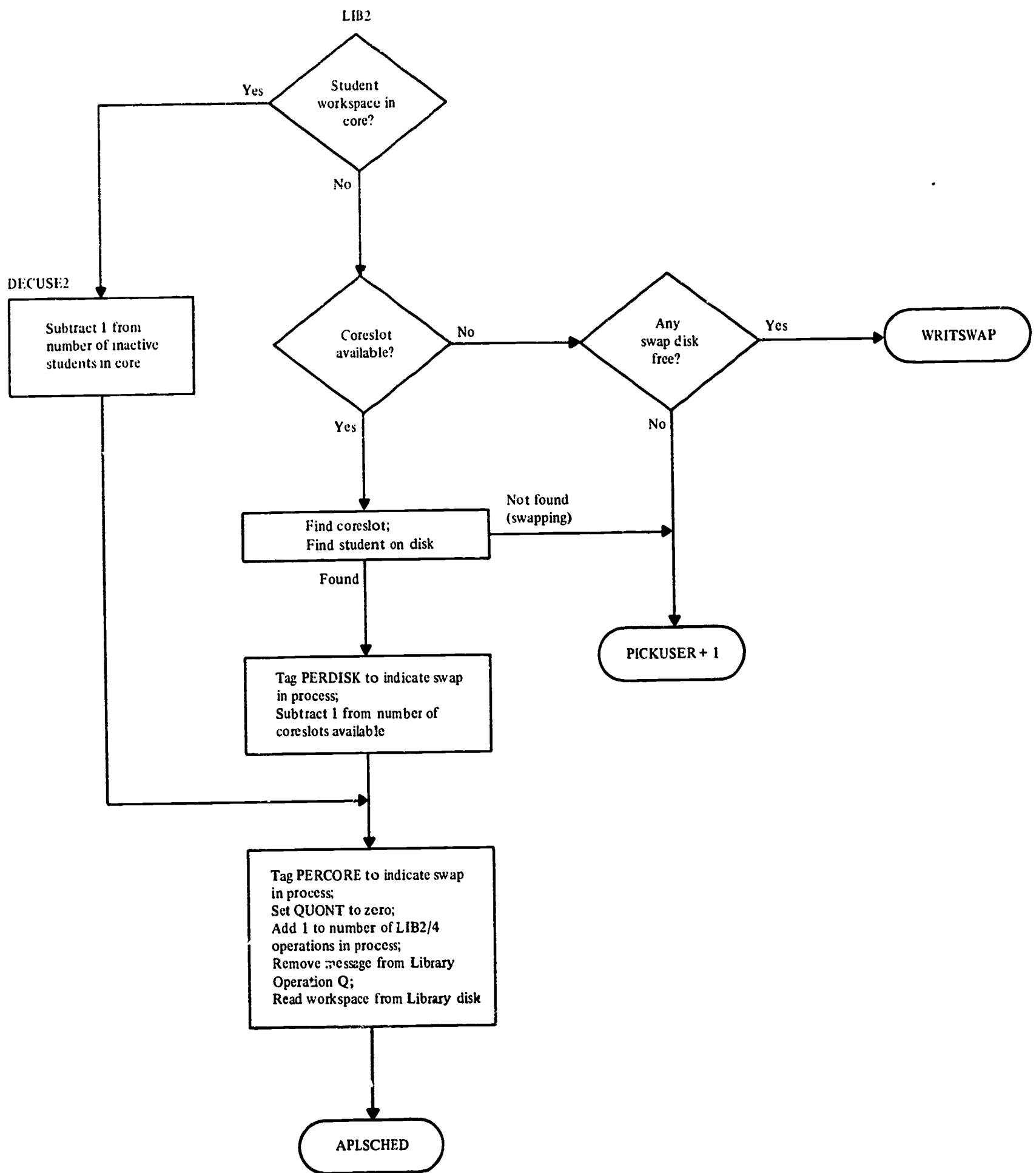


PROCESSING ROUTINES (CONT'D)  
Problem solving, student request for calculation:



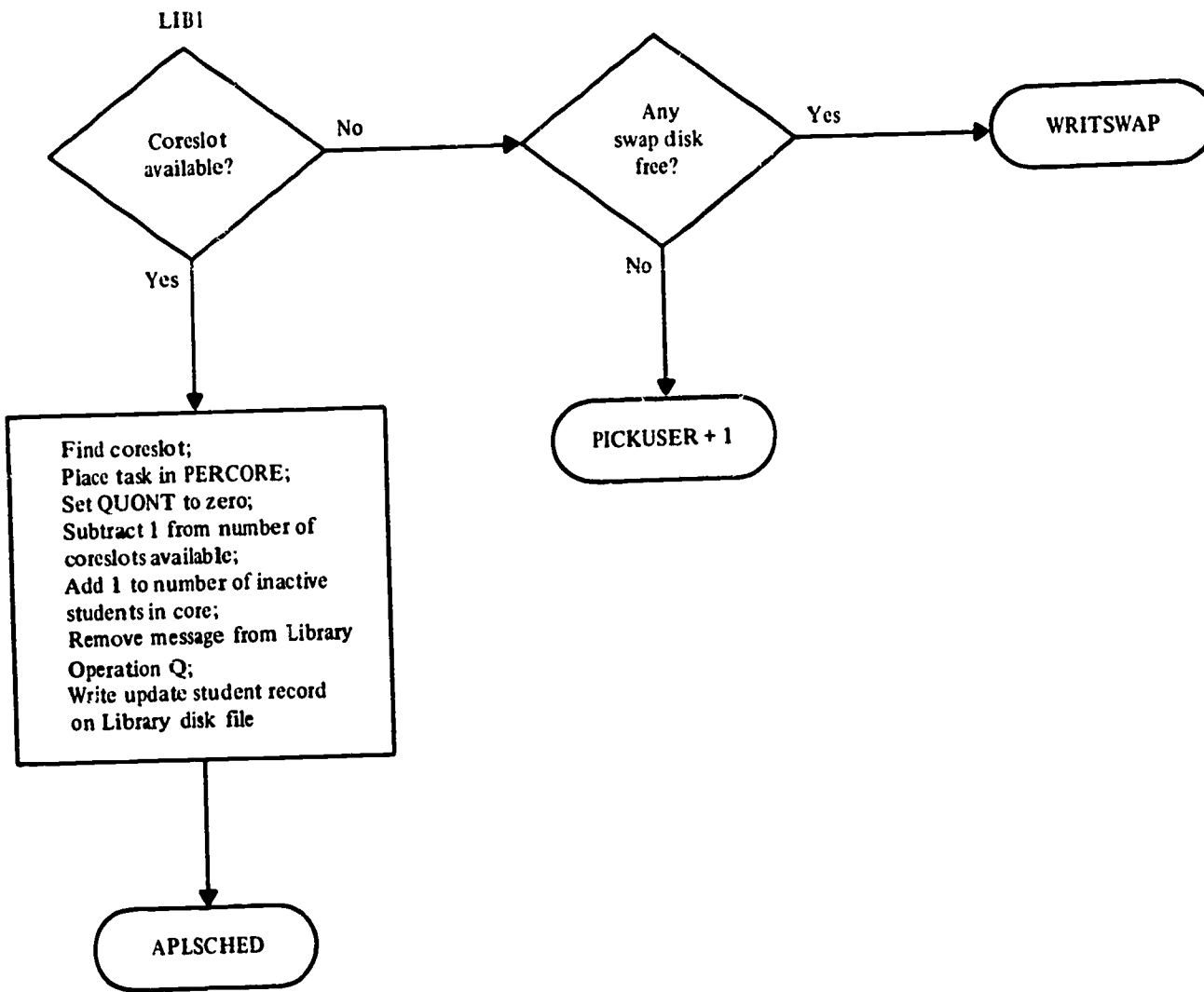


Problem solving, student request for load:

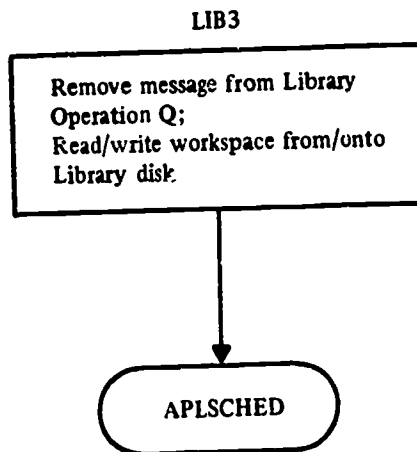


PROCESSING ROUTINES (CONT'D)

Problem solving, student request for sign on:

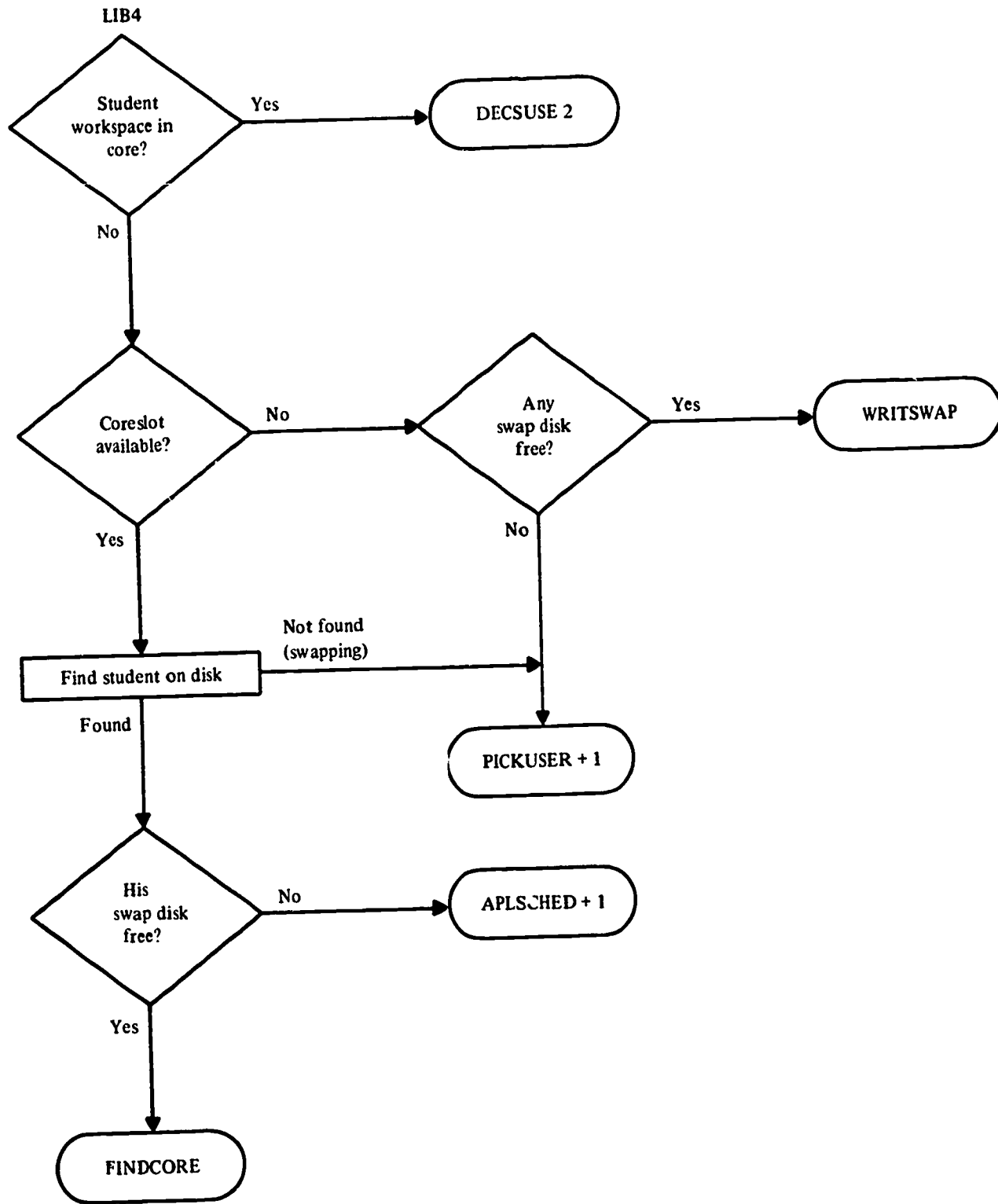


Problem solving, student request for drop, add, or lib:



PROCESSING ROUTINES (CONT'D)

Problem solving, student request for save, off, or copy:



## Addendum 11

### Sample Simulator Results

This section contains samples of some of the more significant simulator output obtained for the USOE Model Region. These are described below.

- |                          |   |                                  |   |
|--------------------------|---|----------------------------------|---|
| 1. Processor Information | Includes processor utilization  | 4. Distribution Tables 1,2,3,4,8 | Various administrative inquiry response times, as indicated. Time unit is .1 ms.  |
| 2. Channel Statistics    | Where channels 1-167 are multiple. Subchannels used for instructional terminals, channels 226-277 are multiplexer subchannels used for administrative terminals and channel 302 is the selector channel. Utilization of the multiplexer subchannels is computed on the basis of a 14.7-character-per-second transmission rate, which is not true for information transmitted from a keyboard. | 5. Distribution Table 11         | Problem-solving response time, from the end of the student request until the first channel of the answer begins to type. Time unit is .1 ms.  |
| 3. I/O Device Statistics | Device Type Device is a dummy device used to model the time-slicing interval timer. Device Type 2311 is actually a 2314 and for modeling simplicity drive number 1 shows all Reads whereas in the actual system a portion of these READS would be WRITES.   | 6. Distribution Table 12         | Problem-solving response time, from the end of the student request until the beginning of the first timeslice received. Time unit is .1 ms.   |
|                          |   | 7. Distribution Table 13         | Problem-solving Calculation Time Required. The mean of the parent distribution is .25 sec. The time unit is .1 ms. There are fewer entries in this table than in Distribution Table because the minimal CPU time for library operations was not modeled.  |
|                          |   | 8. Distribution Table 14         | Problem-solving percentage of CPU which appears to be unavailable after the beginning of first timeslice received. The 1st entry in the table shows that for 6.5% of the requests the CPU was 0% unavailable (100% available) the 19th entry shows that for 50.1% of the request the CPU was 18% or less unavailable (82% or more available), and so forth. |

\*\*\*\*\*  
 \*  
 \* PROCESSOR INFORMATION \*  
 \*  
 \*\*\*\*\*

PROCESSOR NUMBER 0, CURRENTLY IDLE, REPRESENTS THE SYSTEM ENVIRONMENT.

TOTAL PROCESSOR UTILIZATION .0000  
 UTILIZATION DUE TO CHANNEL INTERFERENCE .0000  
 INTERVAL TIMER CURRENTLY ENABLED

THE CURRENT VALUES OF THE PROCESSOR ATTRIBUTES ARE

CIR	CMES	CTASK	CCOM	
20	333	334		
RIR	RMES	RTASK	RCOM	RNOTE
20	3			

PROCESSOR NUMBER 1 CURRENTLY IDLE

TOTAL PROCESSOR UTILIZATION .7954  
 UTILIZATION DUE TO CHANNEL INTERFERENCE .0321  
 INTERVAL TIMER CURRENTLY ENABLED

THE CURRENT VALUES OF THE PROCESSOR ATTRIBUTES ARE

CIR	CMES	CTASK	CCOM	
671	552	404	583	
RIR	RMES	RTASK	RCOM	RNOTE
671	251			

\*\*\*\*\*  
 \*  
 \* CHANNEL STATISTICS \*  
 \*  
 \*\*\*\*\*

CHANNEL	TYPE	UTILIZATION	TOTAL READS	TOTAL WRITES	STATUS
1	M 1	.0274	57	57	IDLE
2	M 1	.0249	53	53	IDLE
3	M 1	.0387	73	73	IDLE
4	M 1	.0315	63	63	IDLE
5	M 1	.0347	63	63	IDLE
6	M 1	.0283	53	53	IDLE
7	M 1	.0481	84	84	IDLE
8	M 1	.0481	84	84	IDLE
9	M 1	.0331	69	69	IDLE
10	M 1	.0372	61	61	IDLE
11	M 1	.0275	69	69	IDLE
12	M 1	.0319	59	59	IDLE
13	M 1	.0194	52	52	IDLE
14	M 1	.0372	67	67	IDLE
15	M 1	.0326	64	64	IDLE
16	M 1	.0381	75	75	IDLE
17	M 1	.0283	59	59	IDLE
18	M 1	.0284	58	58	IDLE
19	M 1	.0280	53	53	IDLE
20	M 1	.0232	49	49	IDLE
21	M 1	.0232	49	49	IDLE
22	M 1	.0321	63	63	IDLE
23	M 1	.0408	90	89	IDLE
24	M 1	.0373	79	80	IDLE
25	M 1	.0236	46	46	IDLE
		.0296	58	58	IDLE
		.0413	68	68	IDLE

26	M	1	.0230	57	57	IDL F
27	M	1	.0276	60	61	IDL F
28	M	1	.0228	49	49	IDL E
29	M	1	.0279	49	49	IDL F
30	M	1	.0342	67	67	IDL E
31	M	1	.0303	60	60	IDL E
32	M	1	.0300	59	59	IDL F
33	M	1	.0265	64	64	IDL F
34	M	1	.0346	67	67	IDL F
35	M	1	.0250	65	65	IDL F
36	M	1	.0297	60	60	IDL F
37	M	1	.0293	51	51	IDL E
38	M	1	.0304	59	59	IDL F
39	M	1	.0436	78	78	IDL F
40	M	1	.0340	71	71	IDL E
41	M	1	.0372	69	69	IDL F
42	M	1	.0296	64	64	IDL F
43	M	1	.0247	52	52	IDL F
44	M	1	.0288	57	57	IDL F
45	M	1	.0339	66	66	IDL F
46	M	1	.0202	45	45	IDL F
47	M	1	.0352	64	64	IDL F
48	M	1	.0233	52	52	IDL F
49	M	1	.0368	69	69	IDL F
50	M	1	.0323	70	70	IDL F
51	M	1	.0259	59	59	IDL F
52	M	1	.0366	74	74	IDL F
53	M	1	.0326	61	61	IDL F
54	M	1	.0250	50	50	IDL E
55	M	1	.0291	62	62	IDL E
56	M	1	.0241	50	50	IDL F
57	M	1	.0239	45	45	IDL F
58	M	1	.0374	69	69	IDL F
59	M	1	.0228	43	43	IDL E
60	M	1	.0289	70	70	IDL F
61	M	1	.0370	64	64	IDL F
62	M	1	.0264	56	56	IDL E
63	M	1	.0273	58	58	IDL E
64	M	1	.0269	50	50	IDL E
65	M	1	.0308	56	56	IDL F
66	M	1	.0221	44	45	IDL F
67	M	1	.0406	75	75	IDL F
68	M	1	.0391	70	70	IDL F
69	M	1	.0265	42	42	IDL F
70	M	1	.0239	62	62	IDL F
71	M	1	.0317	64	64	IDL F
72	M	1	.0390	69	69	IDL F
73	M	1	.0449	81	81	IDL F
74	M	1	.0483	77	77	IDL F
75	M	1	.0390	72	72	IDL F
76	M	1	.0331	69	69	IDL F
77	M	1	.0236	46	46	IDL E
78	M	1	.0345	60	60	IDL F
79	M	1	.0260	68	68	IDL F
80	M	1	.0269	61	61	IDL F
81	M	1	.0396	59	59	IDL F
82	M	1	.0234	48	48	IDL F
83	M	1	.0395	69	69	IDL F
84	M	1	.0299	64	64	IDL E
85	M	1	.0310	66	66	IDL E
86	M	1	.0196	38	38	IDL E
87	M	1	.0396	77	77	IDL F
88	M	1	.0266	56	56	IDL F
89	M	1	.0353	57	57	IDL E
90	M	1	.0278	53	53	IDL F
91	M	1	.0284	63	62	IDL F
92	M	1	.0319	63	63	IDL F
93	M	1	.0272	60	60	IDL F
94	M	1	.0242	47	47	IDL E
95	M	1	.0188	42	42	IDL F
96	M	1	.0277	68	68	IDL F
97	M	1	.0216	41	41	IDL F
98	M	1	.0309	69	69	IDL E
99	M	1	.0302	63	63	IDL F

100	M	1	.0333	71	71	IOI F
101	M	1	.0233	44	44	IOI F
102	M	1	.0204	48	48	IOI F
103	M	1	.0198	36	36	IOI E
104	M	1	.0329	68	68	IOI F
105	M	1	.0346	69	69	IOI F
106	M	1	.0196	54	54	IOI F
107	M	1	.0301	61	61	IOI E
108	M	1	.0309	62	62	IOI E
109	M	1	.0180	40	40	IOI E
110	M	1	.0310	69	69	IOI F
111	M	1	.0309	59	59	IOI E
112	M	1	.0299	51	51	IOI E
113	M	1	.0259	52	52	IOI E
114	M	1	.0310	59	59	IOI F
115	M	1	.0217	48	48	IOI F
116	M	1	.0349	75	75	IOI E
117	M	1	.0271	56	56	IOI F
118	M	1	.0277	55	55	IOI E
119	M	1	.0275	56	56	IOI E
120	M	1	.0331	62	62	IOI F
121	M	1	.0192	42	42	IOI F
122	M	1	.0350	78	78	IOI F
123	M	1	.0261	63	63	IOI E
124	M	1	.0197	44	44	IOI F
125	M	1	.0300	49	49	IOI F
126	M	1	.0397	81	81	IOI E
127	M	1	.0401	74	74	IOI F
128	M	1	.0407	79	79	IOI E
129	M	1	.0303	56	56	IOI E
130	M	1	.0310	61	61	IOI E
131	M	1	.0195	49	49	IOI E
132	M	1	.0328	53	53	IOI E
133	M	1	.0346	64	64	IOI F
134	M	1	.0220	59	59	IOI E
135	M	1	.0319	62	62	IOI F
136	M	1	.0376	71	71	IOI F
137	M	1	.0272	56	56	IOI F
138	M	1	.0322	60	60	IOI F
139	M	1	.0216	47	47	IOI E
140	M	1	.0337	66	66	IOI F
141	M	1	.0338	65	65	IOI F
142	M	1	.0282	55	55	IOI F
143	M	1	.0336	69	69	IOI E
144	M	1	.0375	63	63	IOI E
145	M	1	.0319	71	71	IOI E
146	M	1	.0220	46	46	IOI E
147	M	1	.0230	51	51	IOI E
148	M	1	.0331	68	68	IOI E
149	M	1	.0399	79	79	IOI F
150	M	1	.0285	47	47	IOI F
151	M	1	.0338	68	68	IOI E
152	M	1	.0356	74	74	IOI E
153	M	1	.0332	64	64	IOI E
154	M	1	.0242	52	52	IOI F
155	M	1	.0335	64	64	IOI E
156	M	1	.0345	70	70	IOI E
157	M	1	.0207	43	43	IOI F
158	M	1	.0273	60	60	IOI E
159	M	1	.0291	53	53	IOI F
160	M	1	.0215	48	48	IOI F
161	M	1	.0276	60	60	IOI F
162	M	1	.0250	60	60	IOI F
163	M	1	.0281	68	68	IOI F
164	M	1	.0309	62	61	BUSY
165	M	1	.0302	59	59	IOI F
166	M	1	.0247	51	51	BUSY
167	M	1	.0234	47	47	IOI F
168	M	1	.0000	0	0	IOI E
169	M	1	.0000	0	0	IOI E
170	M	1	.0000	0	0	IOI F
171	M	1	.0000	0	0	IOI E
172	M	1	.0000	0	0	IOI E
173	M	1	.0000	0	0	IOI F

174	M	1	.0000	0	0	IDLE
175	M	1	.0000	0	0	IDLE
176	M	1	.0000	0	0	IDLE
177	M	1	.0000	0	0	IDLE
178	M	1	.0000	0	0	IDLE
179	M	1	.0000	0	0	IDLE
180	M	1	.0000	0	0	IDLE
181	M	1	.0000	0	0	IDLE
182	M	1	.0000	0	0	IDLE
183	M	1	.0000	0	0	IDLE
184	M	1	.0000	0	0	IDLE
185	M	1	.0000	0	0	IDLE
186	M	1	.0000	0	0	IDLE
187	M	1	.0000	0	0	IDLE
188	M	1	.0000	0	0	IDLE
189	M	1	.0000	0	0	IDLE
190	M	1	.0000	0	0	IDLE
191	M	1	.0000	0	0	IDLE
192	M	1	.0000	0	0	IDLE
193	M	1	.0000	0	0	IDLE
194	M	1	.0000	0	0	IDLE
195	M	1	.0000	0	0	IDLE
196	M	1	.0000	0	0	IDLE
197	M	1	.0000	0	0	IDLE
198	M	1	.0000	0	0	IDLE
199	M	1	.0000	0	0	IDLE
200	M	1	.0000	0	0	IDLE
201	M	1	.0000	0	0	IDLE
202	M	1	.0000	0	0	IDLE
203	M	1	.0000	0	0	IDLE
204	M	1	.0000	0	0	IDLE
205	M	1	.0000	0	0	IDLE
206	M	1	.0000	0	0	IDLE
207	M	1	.0000	0	0	IDLE
208	M	1	.0000	0	0	IDLE
209	M	1	.0000	0	0	IDLE
210	M	1	.0000	0	0	IDLE
211	M	1	.0000	0	0	IDLE
212	M	1	.0000	0	0	IDLE
213	M	1	.0000	0	0	IDLE
214	M	1	.0000	0	0	IDLE
215	M	1	.0000	0	0	IDLE
216	M	1	.0000	0	0	IDLE
217	M	1	.0000	0	0	IDLE
218	M	1	.0000	0	0	IDLE
219	M	1	.0000	0	0	IDLE
220	M	1	.0000	0	0	IDLE
221	M	1	.0000	0	0	IDLE
222	M	1	.0000	0	0	IDLE
223	M	1	.0000	0	0	IDLE
224	M	1	.0000	0	0	IDLE
225	M	1	.0000	0	0	IDLE
226	M	1	.2324	0	0	IDLE
227	M	1	.0628	51	52	IDLE
228	M	1	.0650	51	33	BUSY
229	M	1	.1626	40	29	BUSY
230	M	1	.1155	62	47	IDLE
231	M	1	.1252	43	38	BUSY
232	M	1	.1266	58	47	BUSY
233	M	1	.0909	54	41	BUSY
234	M	1	.2489	42	32	BUSY
235	M	1	.0354	44	42	BUSY
236	M	1	.1569	40	24	IDLE
237	M	1	.0995	43	47	BUSY
238	M	1	.1327	38	27	BUSY
239	M	1	.0841	42	40	BUSY
240	M	1	.1075	45	39	IDLE
241	M	1	.1649	53	35	BUSY
242	M	1	.1110	52	51	BUSY
243	M	1	.1031	41	35	BUSY
244	M	1	.1902	41	38	BUSY
245	M	1	.1901	55	43	BUSY
246	M	1	.0378	46	41	BUSY
247	M	1	.1992	43	31	IDLE
248	M	1	.0413	56	59	IDLE
				38	36	BUSY



249	M	1	.0977	41	33	BUSY
250	M	1	.1001	46	36	BUSY
251	M	1	.1244	61	43	BUSY
252	M	1	.2123	48	46	BUSY
253	M	1	.0542	38	34	BUSY
254	M	1	.0488	40	29	BUSY
255	M	1	.0925	46	37	BUSY
256	M	1	.2204	56	55	BUSY
257	M	1	.1720	48	46	BUSY
258	M	1	.1405	54	38	BUSY
259	M	1	.1435	41	37	BUSY
260	M	1	.1084	41	36	BUSY
261	M	1	.1581	43	39	BUSY
262	M	1	.2452	64	63	BUSY
263	M	1	.2190	59	56	BUSY
264	M	1	.1038	39	39	BUSY
265	M	1	.1322	56	42	BUSY
266	M	1	.1177	37	35	BUSY
267	M	1	.1402	36	38	BUSY
268	M	1	.1838	37	43	BUSY
269	M	1	.1916	57	49	BUSY
270	M	1	.2214	58	48	BUSY
271	M	1	.2442	69	52	BUSY
272	M	1	.2219	45	48	BUSY
273	M	1	.0546	35	31	BUSY
274	M	1	.1157	41	38	BUSY
275	M	1	.2078	48	48	BUSY
276	M	1	.0000	0	0	IDLE
277	M	1	.0000	0	0	IDLE
278	M	1	.0000	0	0	IDLE
279	M	1	.0000	0	0	IDLE
280	M	1	.0000	0	0	IDLE
281	M	1	.0000	0	0	IDLE
282	M	1	.0000	0	0	IDLE
283	M	1	.0000	0	0	IDLE
284	M	1	.0000	0	0	IDLE
285	M	1	.0000	0	0	IDLE
286	M	1	.0000	0	0	IDLE
287	M	1	.0000	0	0	IDLE
288	M	1	.0000	0	0	IDLE
289	M	1	.0000	0	0	IDLE
290	M	1	.0000	0	0	IDLE
291	M	1	.0000	0	0	IDLE
292	M	1	.0000	0	0	IDLE
293	M	1	.0000	0	0	IDLE
294	M	1	.0000	0	0	IDLE
295	M	1	.0000	0	0	IDLE
296	M	1	.0000	0	0	IDLE
297	M	1	.0000	0	0	IDLE
298	M	1	.0000	0	0	IDLE
299	M	1	.0000	0	0	IDLE
300	M	1	.0000	0	0	IDLE
301	S		.0000	0	0	IDLE
302	S		.3955	19589	17640	BUSY

\*\*\*\*\*  
 \* I/O DEVICE STATISTICS \*  
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DEVICE TYPE	NUMBER	UTILIZATION	TOTAL READS	TOTAL WRITES	STATUS
DEVICE	1	.7614	0	0	IDLE
2311	1	.0208	608	0	IDLE
	2	.0990	2333	2402	IDLE
	3	.1007	2365	2432	IDLE
	4	.1077	2564	2625	BUSY
	5	.1039	2493	2556	IDLE
	6	.0637	3976	0	BUSY
	7	.0748	1754	4117	IDLE
	8	.0784	1750	1755	IDLE
2321	1	.4630	1746	1753	BUSY

\*\*\*\*\*  
 \* DISTRIBUTION TABLES \*  
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\* DISTL 1 \*

WAIT TIME UNTIL TERMINAL AVAILABLE -- 1050 ONLY

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION		
1906	83405.278	433408.030		
UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER
0	1718	90.136	90.1	9.8
600000	105	5.508	95.6	4.3
1200000	32	1.678	97.3	2.6
1800000	27	1.416	98.7	1.2
2400000	5	0.262	99.0	0.9
3000000	1	0.052	99.0	0.9
3600000	12	0.629	99.6	0.3
4200000	1	0.052	99.7	0.2
4800000	3	0.157	99.8	0.1
5400000	2	0.104	100.0	0.0

REMAINING FREQUENCIES ARE ALL ZERO

\* DISTL 2 \*

CUT INQUIRY RESPONSE TIME EOB TO 1ST CHAR OF ANSWER (INTERVALS = .1 MINUTE)

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION		
344	983808.691	640256.016		
UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER
0	0	0.000	0.0	100.0
60000	0	0.000	0.0	100.0
120000	11	3.197	3.1	96.8
180000	12	3.488	6.6	93.3
240000	12	3.488	10.1	89.8
300000	12	3.488	13.6	86.3
360000	14	4.069	17.7	82.2
420000	17	4.941	22.6	77.3
480000	15	4.360	27.0	72.9
540000	10	2.906	29.9	70.0
600000	9	2.616	32.5	67.4
660000	12	3.488	36.0	63.9
720000	25	7.267	43.3	56.6
780000	13	3.779	47.0	52.9
840000	11	3.197	50.2	49.7
900000	13	3.779	54.0	45.9
960000	8	2.325	56.3	43.6
1020000	5	1.453	57.8	42.1
1080000	5	1.453	59.3	40.6
1140000	8	2.325	61.6	38.3
1200000	10	2.906	64.5	35.4
1260000	8	2.325	66.8	33.1
1320000	12	3.488	70.3	29.6
1380000	16	4.651	75.0	25.0
1440000	7	2.034	77.0	22.9
1500000	7	2.034	79.0	20.9
1560000	5	1.453	80.5	19.4
1620000	7	2.034	82.5	17.4
1680000	7	2.034	84.5	15.4

1740000	1	0.290	84.8	15.1
1800000	6	1.744	86.6	13.3
1860000	3	0.872	87.5	12.5
1920000	7	2.034	89.5	10.4
1980000	0	0.000	89.5	10.4
2040000	8	2.325	91.8	8.1
2100000	10	2.906	94.7	5.2
2160000	1	0.290	95.0	4.9
2220000	2	0.581	95.6	4.3
2280000	3	0.872	96.5	3.4
2340000	2	0.581	97.0	2.9
2400000	1	0.290	97.3	2.6
2460000	1	0.290	97.6	2.3
2520000	0	0.000	97.6	2.3
2580000	1	0.290	97.9	2.0
2640000	3	0.872	98.8	1.1
2700000	2	0.581	99.4	0.5
2760000	2	0.581	100.0	0.0

REMAINING FREQUENCIES ARE ALL ZERO

\* DISTL 3 \*

ABSENSE REASON UPDATE RESPONSE TIME EOB TO 1ST CHAR OF ANSWER (INTERVALS = .1 MINUTE)

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION			
1104	874841.649	598528.062			
UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	
0	0	0.000	0.0	100.0	
60000	3	0.271	0.2	99.7	
120000	45	4.076	4.3	95.6	
180000	46	4.166	8.5	91.4	
240000	49	4.438	12.9	87.0	
300000	40	3.623	16.5	83.4	
360000	54	4.891	21.4	78.5	
420000	62	5.615	27.0	72.9	
480000	47	4.257	31.3	68.6	
540000	46	4.166	35.5	64.4	
600000	43	3.894	39.4	60.5	
660000	46	4.166	43.5	56.4	
720000	62	5.615	49.1	50.8	
780000	38	3.442	52.6	47.3	
840000	35	3.170	55.7	44.2	
900000	40	3.623	59.4	40.5	
960000	37	3.351	62.7	37.2	
1020000	30	2.717	65.4	34.5	
1080000	34	3.079	68.5	31.4	
1140000	26	2.355	70.9	29.0	
1200000	26	2.355	73.2	26.7	
1260000	39	3.532	76.8	23.1	
1320000	22	1.992	78.8	21.1	
1380000	26	2.355	81.1	18.8	
1440000	19	1.721	82.8	17.1	
1500000	23	2.083	84.9	15.0	
1560000	17	1.539	86.5	13.4	
1620000	11	0.996	87.5	12.5	
1680000	10	0.905	88.4	11.5	
1740000	3	0.271	88.6	11.3	
1800000	7	0.634	89.3	10.6	
1860000	6	0.543	89.8	10.1	
1920000	17	1.539	91.3	8.6	
1980000	16	1.449	92.8	7.1	
2040000	15	1.358	94.2	5.7	
2100000	16	1.449	95.6	4.3	
2160000	9	0.815	96.4	3.5	
2220000	6	0.543	97.0	2.9	
2280000	3	0.271	97.2	2.7	
2340000	7	0.634	97.9	2.0	
2400000	2	0.181	98.0	1.9	
2460000	5	0.452	98.5	1.4	
2520000	5	0.452	99.0	0.9	

2580000	5	0.452	99.4	0.5
2640000	3	0.271	99.7	0.2
2700000	2	0.181	99.9	0.0
2760000	1	0.090	100.0	0.0

REMAINING FREQUENCIES ARE ALL ZERO

\* DISTL 4 \*

TARDY-EARLY DISMISSAL RESPONSE TIME EOB TO 1ST CHAR OF ANSWER (INTERVALS = .1 MINUTE)

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION			
133	972506.135	640000.041			
UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	
0	0	0.000	0.0	100.0	
60000	0	0.000	0.0	100.0	
120000	4	3.007	3.0	96.9	
180000	5	3.759	6.7	93.2	
240000	6	4.511	11.2	88.7	
300000	7	5.263	16.5	83.4	
360000	5	3.759	20.3	79.6	
420000	9	6.766	27.0	72.9	
480000	4	3.007	30.0	69.9	
540000	3	2.255	32.3	67.6	
600000	1	0.751	33.0	66.9	
660000	7	5.263	38.3	61.6	
720000	3	2.255	40.6	59.3	
780000	4	3.007	43.6	56.3	
840000	2	1.503	45.1	54.8	
900000	6	4.511	49.6	50.3	
960000	3	2.255	51.8	48.1	
1020000	6	4.511	56.3	43.6	
1080000	2	1.503	57.8	42.1	
1140000	8	6.015	63.9	36.0	
1200000	8	6.015	69.9	30.0	
1260000	3	2.255	72.1	27.8	
1320000	2	1.503	73.6	26.3	
1380000	4	3.007	76.6	23.3	
1440000	1	0.751	77.4	22.5	
1500000	1	0.751	78.1	21.8	
1560000	2	1.503	79.6	20.3	
1620000	5	3.759	83.4	16.5	
1680000	2	1.503	84.9	15.0	
1740000	0	0.000	84.9	15.0	
1800000	3	2.255	87.2	12.7	
1860000	1	0.751	87.9	12.0	
1920000	4	3.007	90.9	9.0	
1980000	0	0.000	90.9	9.0	
2040000	4	3.007	93.9	6.0	
2100000	3	2.255	96.2	3.7	
2160000	0	0.000	96.2	3.7	
2220000	1	0.751	96.9	3.0	
2280000	0	0.000	96.9	3.0	
2340000	0	0.000	96.9	3.0	
2400000	0	0.000	96.9	3.0	
2460000	0	0.000	96.9	3.0	
2520000	0	0.000	96.9	3.0	
2580000	0	0.000	6.4	93.5	
2640000	0	0.000	6.4	93.5	
2700000	0	0.000	6.4	93.5	
2760000	0	0.000	6.4	93.5	
2820000	0	0.000	6.4	93.5	
2880000	0	0.000	6.4	93.5	
2940000	0	0.000	6.4	93.5	
3000000	0	0.000	6.4	93.5	
3060000	0	0.000	6.4	93.5	
3120000	0	0.000	6.4	93.5	
3180000	0	0.000	6.4	93.5	
3240000	0	0.000	6.4	93.5	
3300000	0	0.000	6.4	93.5	
3360000	0	0.000	6.4	93.5	

3420000	0	0.000	6.4	93.5
3480000	0	0.000	6.4	93.5
3540000	0	0.000	6.4	93.5
3600000	0	0.000	6.4	93.5
3660000	0	0.000	6.4	93.5
3720000	0	0.000	6.4	93.5
3780000	0	0.000	6.4	93.5
3840000	0	0.000	6.4	93.5
3900000	0	0.000	6.4	93.5
3960000	0	0.000	6.4	93.5
4020000	1	0.806	7.2	92.7
4080000	0	0.000	7.2	92.7
4140000	0	0.000	7.2	92.7
4200000	0	0.000	7.2	92.7
4260000	0	0.000	7.2	92.7
4320000	0	0.000	7.2	92.7
4380000	0	0.000	7.2	92.7
4440000	0	0.000	7.2	92.7
4500000	0	0.000	7.2	92.7
4560000	1	0.806	8.0	91.9
4620000	0	0.000	8.0	91.9
4680000	0	0.000	8.0	91.9
4740000	0	0.000	8.0	91.9
4800000	0	0.000	8.0	91.9
4860000	0	0.000	8.0	91.9
4920000	0	0.000	8.0	91.9
4980000	0	0.000	8.0	91.9
5040000	1	0.806	8.8	91.1
5100000	0	0.000	8.8	91.1
5160000	1	0.806	9.6	90.3
5220000	0	0.000	9.6	90.3
5280000	0	0.000	9.6	90.3
5340000	0	0.000	9.6	90.3
5400000	0	0.000	9.6	90.3
5460000	0	0.000	9.6	90.3
5520000	0	0.000	9.6	90.3
5580000	0	0.000	9.6	90.3
5640000	0	0.000	9.6	90.3
5700000	0	0.000	9.6	90.3
5760000	1	0.806	10.4	89.5
5820000	0	0.000	10.4	89.5
5880000	0	0.000	10.4	89.5
5940000	0	0.000	10.4	89.5
6000000	0	0.000	10.4	39.5
OVERFLOW	111	89.516	100.0	0.0

AVERAGE VALUE OF OVERFLOW 18537927.783

\* DISTL 8 \*

GUIDANCE COUNSELOR REQUEST RESPONSE TIME EOB TO 1ST CHAR OF ANSWER (INTERVALS = .1 MINUTE)

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION			
124	16857977.274	6778880.843			
UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	
0	0	0.000	0.0	100.0	
60000	0	0.000	0.0	100.0	
120000	0	0.000	0.0	100.0	
180000	0	0.000	0.0	100.0	
240000	0	0.000	0.0	100.0	
300000	1	0.806	0.8	99.1	
360000	0	0.000	0.8	99.1	
420000	0	0.000	0.8	99.1	
480000	1	0.806	1.6	98.3	
540000	0	0.000	1.6	98.3	
600000	1	0.806	2.4	97.5	
660000	0	0.000	2.4	97.5	
720000	0	0.000	2.4	97.5	

780000	0	0.000	2.4	97.5
840000	0	0.000	2.4	97.5
900000	0	0.000	2.4	97.5
960000	2	1.612	4.0	95.9
1020000	0	0.000	4.0	95.9
1080000	0	0.000	4.0	95.9
1140000	0	0.000	4.0	95.9
1200000	0	0.000	4.0	95.9
1260000	0	0.000	4.0	95.9
1320000	0	0.000	4.0	95.9
1380000	0	0.000	4.0	95.9
1440000	0	0.000	4.0	95.9
1500000	0	0.000	4.0	95.9
1560000	1	0.806	4.8	95.1
1620000	0	0.000	4.8	95.1
1680000	1	0.806	5.6	94.3
1740000	0	0.000	5.6	94.3
1800000	0	0.000	5.6	94.3
1860000	0	0.000	5.6	94.3
1920000	1	0.806	6.4	93.5
1980000	0	0.000	6.4	93.5
2040000	0	0.000	6.4	93.5
2100000	0	0.000	6.4	93.5
2160000	0	0.000	6.4	93.5
2220000	0	0.000	6.4	93.5
2280000	0	0.000	6.4	93.5
2340000	0	0.000	6.4	93.5
2400000	0	0.000	6.4	93.5
2460000	0	0.000	6.4	93.5
2520000	0	0.000	6.4	93.5
2580000	0	0.000	96.9	3.0
2640000	1	0.751	97.7	2.2
2700000	3	2.255	100.0	0.0

REMAINING FREQUENCIES ARE ALL ZERO

\* DISTL 11 \*

APL, RESPONSE TIME EOB TO FIRST CHARACTER OF ANSWER (INTERVALS = .1 SECOND)

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION			
10064	9924.312	49344.001			
UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	
0	0	0.000	0.0	100.0	
1000	831	8.257	8.2	91.7	
2000	4978	49.463	57.7	42.2	
3000	1973	19.604	77.3	22.6	
4000	526	5.226	82.5	17.4	
5000	205	2.036	84.5	15.4	
6000	159	1.579	86.1	13.8	
7000	111	1.102	87.2	12.7	
8000	73	0.725	87.9	12.0	
9000	69	0.685	88.6	11.3	
10000	72	0.715	89.3	10.6	
11000	64	0.635	90.0	9.9	
12000	64	0.635	90.6	9.3	
13000	55	0.546	91.2	8.7	
14000	39	0.387	91.6	8.3	
15000	29	0.288	91.8	8.1	
16000	33	0.327	92.2	7.7	
17000	26	0.258	92.4	7.5	
18000	25	0.248	92.7	7.2	
19000	24	0.238	92.9	7.0	
20000	21	0.208	93.1	6.8	
21000	27	0.268	93.4	6.5	
22000	17	0.168	93.6	6.3	
23000	17	0.168	93.7	6.2	
24000	18	0.178	93.9	6.0	

25000	22	0.218	94.1	5.8
26000	9	0.089	94.2	5.7
27000	12	0.119	94.3	5.6
28000	16	0.158	94.5	5.4
29000	18	0.178	94.7	5.2
30000	11	0.109	94.8	5.1
31000	13	0.129	94.9	5.0
32000	16	0.158	95.1	4.8
33000	14	0.139	95.2	4.7
34000	9	0.089	95.3	4.6
35000	7	0.069	95.4	4.5
36000	12	0.119	95.5	4.4
37000	8	0.079	95.6	4.3
38000	9	0.089	95.7	4.2
39000	5	0.049	95.7	4.2
40000	2	0.019	95.7	4.2
41000	5	0.049	95.8	4.1
42000	15	0.149	95.9	4.0
43000	6	0.059	96.0	3.9
44000	6	0.059	96.0	3.9
45000	8	0.079	96.1	3.8
46000	5	0.049	96.2	3.7
47000	7	0.069	96.2	3.7
48000	7	0.069	96.3	3.6
49000	11	0.109	96.4	3.5
50000	14	0.139	96.6	3.3
51000	8	0.079	96.6	3.3
52000	2	0.019	96.7	3.2
53000	1	0.009	96.7	3.2
54000	4	0.039	96.7	3.2
55000	5	0.049	96.8	3.1
56000	4	0.039	96.8	3.1
57000	4	0.039	96.8	3.1
58000	2	0.019	96.9	3.0
59000	8	0.079	96.9	3.0
60000	3	0.029	97.0	2.9
61000	4	0.039	97.0	2.9
62000	3	0.029	97.0	2.9
63000	4	0.039	97.1	2.8
64000	1	0.009	97.1	2.8
65000	4	0.039	97.1	2.8
66000	3	0.029	97.2	2.7
67000	4	0.039	97.2	2.7
68000	6	0.059	97.3	2.6
69000	1	0.009	97.3	2.6
70000	4	0.039	97.3	2.6
71000	2	0.019	97.3	2.6
72000	2	0.019	97.3	2.6
73000	4	0.039	97.4	2.5
74000	2	0.019	97.4	2.5
75000	2	0.019	97.4	2.5
76000	3	0.029	97.5	2.4
77000	3	0.029	97.5	2.4
78000	3	0.029	97.5	2.4
79000	4	0.039	97.6	2.3
80000	1	0.009	97.6	2.3
81000	5	0.049	97.6	2.3
82000	4	0.039	97.7	2.2
83000	4	0.039	97.7	2.2
84000	1	0.009	97.7	2.2
85000	6	0.059	97.8	2.1
86000	0	0.000	97.8	2.1
87000	2	0.019	97.8	2.1
88000	4	0.039	97.8	2.1
89000	4	0.039	97.9	2.0
90000	1	0.009	97.9	2.0
91000	1	0.009	97.9	2.0
92000	3	0.029	97.9	2.0
93000	1	0.009	97.9	2.0
94000	1	0.009	97.9	2.0
95000	4	0.039	98.0	1.9
96000	0	0.000	98.0	1.9
97000	1	0.009	98.0	1.9
98000	4	0.039	98.0	1.9
99000	1	0.009	98.0	1.9

100000	3	0.029	98.1	1.8
101000	1	0.009	98.1	1.8
102000	2	0.019	98.1	1.8
103000	4	0.039	98.1	1.8
104000	5	0.049	98.2	1.7
105000	2	0.019	98.2	1.7
106000	2	0.019	98.2	1.7
107000	1	0.009	98.2	1.7
108000	2	0.019	98.3	1.6
109000	1	0.009	98.3	1.6
110000	1	0.009	98.3	1.6
111000	3	0.029	98.3	1.6
112000	2	0.019	98.3	1.6
113000	2	0.019	98.3	1.6
114000	1	0.009	98.4	1.5
115000	3	0.029	98.4	1.5
116000	2	0.019	98.4	1.5
117000	3	0.029	98.4	1.5
118000	1	0.009	98.4	1.5
119000	2	0.019	98.5	1.4
120000	0	0.000	98.5	1.4
121000	2	0.019	98.5	1.4
122000	2	0.019	98.5	1.4
123000	0	0.000	98.5	1.4
124000	0	0.000	98.5	1.4
125000	2	0.019	98.5	1.4
126000	0	0.000	98.5	1.4
127000	2	0.019	98.5	1.4
128000	0	0.000	98.5	1.4
129000	4	0.039	98.6	1.3
130000	1	0.009	98.6	1.3
131000	0	0.000	98.6	1.3
132000	0	0.000	98.6	1.3
133000	1	0.009	98.6	1.3
134000	1	0.009	98.6	1.3
135000	3	0.029	98.6	1.3
136000	1	0.009	98.6	1.3
137000	1	0.009	98.7	1.2
138000	2	0.019	98.7	1.2
139000	2	0.019	98.7	1.2
140000	1	0.009	98.7	1.2
141000	1	0.009	98.7	1.2
142000	0	0.000	98.7	1.2
143000	0	0.000	98.7	1.2
144000	0	0.000	98.7	1.2
145000	0	0.000	98.7	1.2
146000	0	0.000	98.7	1.2
147000	0	0.000	98.7	1.2
148000	2	0.019	98.7	1.2
149000	0	0.000	98.7	1.2
150000	0	0.000	98.7	1.2
151000	0	0.000	98.7	1.2
152000	1	0.009	98.7	1.2
153000	4	0.039	98.8	1.1
154000	0	0.000	98.8	1.1
155000	1	0.009	98.8	1.1
156000	2	0.019	98.8	1.1
157000	0	0.000	98.8	1.1
158000	0	0.000	98.8	1.1
159000	0	0.000	98.8	1.1
160000	0	0.000	98.8	1.1
161000	0	0.000	98.8	1.1
162000	0	0.000	98.8	1.1
163000	2	0.019	98.8	1.1
164000	0	0.000	98.8	1.1
165000	1	0.009	98.8	1.1
166000	0	0.000	98.8	1.1
167000	0	0.000	98.8	1.1
168000	2	0.019	98.9	1.0
169000	0	0.000	98.9	1.0
170000	2	0.019	98.9	1.0
171000	2	0.019	98.9	1.0
172000	2	0.019	98.9	1.0
173000	1	0.009	98.9	1.0
174000	0	0.000	98.9	1.0
175000	2	0.019	99.0	0.9
176000	1	0.009	99.0	0.9



177000	1	0.009	99.0	0.9
178000	0	0.000	99.0	0.9
179000	1	0.009	99.0	0.9
180000	1	0.009	99.0	0.9
181000	0	0.000	99.0	0.9
182000	0	0.000	99.0	0.9
183000	0	0.000	99.0	0.9
184000	0	0.000	99.0	0.9
185000	0	0.000	99.0	0.9
186000	0	0.000	99.0	0.9
187000	1	0.009	99.0	0.9
188000	1	0.009	99.0	0.9
189000	0	0.000	99.0	0.9
190000	1	0.009	99.0	0.9
191000	1	0.009	99.0	0.9
192000	2	0.019	99.1	0.8
193000	1	0.009	99.1	0.8
194000	1	0.009	99.1	0.8
195000	0	0.000	99.1	0.8
196000	1	0.009	99.1	0.8
197000	0	0.000	99.1	0.8
198000	0	0.000	99.1	0.8
199000	0	0.000	99.1	0.8
200000	1	0.009	99.1	0.8
201000	0	0.000	99.1	0.8
202000	0	0.000	99.1	0.8
203000	0	0.000	99.1	0.8
204000	0	0.000	99.1	0.8
205000	2	0.019	99.1	0.8
206000	0	0.000	99.1	0.8
207000	0	0.000	99.1	0.8
208000	3	0.029	99.1	0.8
209000	1	0.009	99.2	0.7
210000	0	0.000	99.2	0.7
211000	0	0.000	99.2	0.7
212000	1	0.009	99.2	0.7
213000	1	0.009	99.2	0.7
214000	1	0.009	99.2	0.7
215000	1	0.009	99.2	0.7
216000	0	0.000	99.2	0.7
217000	1	0.009	99.2	0.7
218000	0	0.000	99.2	0.7
219000	1	0.009	99.2	0.7
220000	2	0.019	99.2	0.7
221000	0	0.000	99.2	0.7
222000	0	0.000	99.2	0.7
223000	0	0.000	99.2	0.7
224000	0	0.000	99.2	0.7
225000	2	0.019	99.3	0.6
226000	0	0.000	99.3	0.6
227000	0	0.000	99.3	0.6
228000	0	0.000	99.3	0.6
229000	0	0.000	99.3	0.6
230000	0	0.000	99.3	0.6
231000	1	0.009	99.3	0.6
232000	0	0.000	99.3	0.6
233000	0	0.000	99.3	0.6
234000	0	0.000	99.3	0.6
235000	0	0.000	99.3	0.6
236000	1	0.009	99.3	0.6
237000	0	0.000	99.3	0.6
238000	0	0.000	99.3	0.6
239000	1	0.009	99.3	0.6
240000	1	0.009	99.3	0.6
241000	0	0.000	99.3	0.6
242000	1	0.009	99.3	0.6
243000	0	0.000	99.3	0.6
244000	0	0.000	99.3	0.6
245000	0	0.000	99.3	0.6
246000	0	0.000	99.3	0.6
247000	0	0.000	99.3	0.6
248000	0	0.000	99.3	0.6
249000	0	0.000	99.3	0.6
250000	0	0.000	99.3	0.6
251000	0	0.000	99.3	0.6
252000	1	0.009	99.3	0.6

253000	0	0.000	99.3	0.6
254000	0	0.000	99.3	0.6
255000	0	0.000	99.3	0.6
256000	0	0.000	99.3	0.6
257000	0	0.000	99.3	0.6
258000	0	0.000	99.3	0.6
259000	0	0.000	99.3	0.6
260000	0	0.000	99.3	0.6
261000	0	0.000	99.3	0.6
262000	0	0.000	99.3	0.6
263000	0	0.000	99.3	0.6
264000	0	0.000	99.3	0.6
265000	0	0.000	99.3	0.6
266000	0	0.000	99.3	0.6
267000	0	0.000	99.3	0.6
268000	0	0.000	99.3	0.6
269000	0	0.000	99.3	0.6
270000	1	0.009	99.3	0.6
271000	0	0.000	99.3	0.6
272000	0	0.000	99.3	0.6
273000	0	0.000	99.3	0.6
274000	0	0.000	99.3	0.6
275000	0	0.000	99.3	0.6
276000	0	0.000	99.3	0.6
277000	0	0.000	99.3	0.6
278000	1	0.009	99.3	0.6
279000	0	0.000	99.3	0.6
280000	0	0.000	99.3	0.6
281000	0	0.000	99.3	0.6
282000	0	0.000	99.3	0.6
283000	0	0.000	99.3	0.6
284000	0	0.000	99.3	0.6
285000	0	0.000	99.3	0.6
286000	0	0.000	99.3	0.6
287000	0	0.000	99.3	0.6
288000	0	0.000	99.3	0.6
289000	0	0.000	99.3	0.6
290000	0	0.000	99.3	0.6
291000	0	0.000	99.3	0.6
292000	0	0.000	99.3	0.6
293000	0	0.000	99.3	0.6
294000	1	0.009	99.3	0.6
295000	0	0.000	99.3	0.6
296000	0	0.000	99.3	0.6
297000	0	0.000	99.3	0.6
298000	1	0.009	99.4	0.5
299000	0	0.000	99.4	0.5
300000	0	0.000	99.4	0.5
301000	0	0.000	99.4	0.5
302000	0	0.000	99.4	0.5
303000	0	0.000	99.4	0.5
304000	0	0.000	99.4	0.5
305000	1	0.009	99.4	0.5
306000	0	0.000	99.4	0.5
307000	1	0.009	99.4	0.5
308000	0	0.000	99.4	0.5
309000	0	0.000	99.4	0.5
310000	0	0.000	99.4	0.5
311000	0	0.000	99.4	0.5
312000	0	0.000	99.4	0.5
313000	0	0.000	99.4	0.5
314000	0	0.000	99.4	0.5
315000	1	0.009	99.4	0.5
316000	0	0.000	99.4	0.5
317000	0	0.000	99.4	0.5
318000	0	0.000	99.4	0.5
319000	0	0.000	99.4	0.5
320000	0	0.000	99.4	0.5
321000	0	0.000	99.4	0.5
322000	0	0.000	99.4	0.5
323000	0	0.000	99.4	0.5
324000	0	0.000	99.4	0.5
325000	0	0.000	99.4	0.5
326000	0	0.000	99.4	0.5
327000	1	0.009	99.4	0.5

328000	0	0.000	99.4	0.5
329000	0	0.000	99.4	0.5
330000	0	0.000	99.4	0.5
331000	1	0.009	99.4	0.5
332000	0	0.000	99.4	0.5
333000	0	0.000	99.4	0.5
334000	0	0.000	99.4	0.5
335000	0	0.000	99.4	0.5
336000	0	0.000	99.4	0.5
337000	0	0.000	99.4	0.5
338000	0	0.000	99.4	0.5
339000	0	0.000	99.4	0.5
340000	0	0.000	99.4	0.5
341000	0	0.000	99.4	0.5
342000	0	0.000	99.4	0.5
343000	0	0.000	99.4	0.5
344000	0	0.000	99.4	0.5
345000	1	0.009	99.4	0.5
346000	0	0.000	99.4	0.5
347000	1	0.009	99.4	0.5
348000	0	0.000	99.4	0.5
349000	0	0.000	99.4	0.5
350000	0	0.000	99.4	0.5
351000	0	0.000	99.4	0.5
352000	1	0.009	99.4	0.5
353000	0	0.000	99.4	0.5
354000	0	0.000	99.4	0.5
355000	0	0.000	99.4	0.5
356000	0	0.000	99.4	0.5
357000	0	0.000	99.4	0.5
358000	0	0.000	99.4	0.5
359000	0	0.000	99.4	0.5
360000	0	0.000	99.4	0.5
361000	0	0.000	99.4	0.5
362000	0	0.000	99.4	0.5
363000	0	0.000	99.4	0.5
364000	0	0.000	99.4	0.5
365000	0	0.000	99.4	0.5
366000	0	0.000	99.4	0.5
367000	0	0.000	99.4	0.5
368000	0	0.000	99.4	0.5
369000	1	0.009	99.4	0.5
370000	2	0.019	99.5	0.4
371000	0	0.000	99.5	0.4
372000	0	0.000	99.5	0.4
373000	0	0.000	99.5	0.4
374000	0	0.000	99.5	0.4
375000	0	0.000	99.5	0.4
376000	0	0.000	99.5	0.4
377000	1	0.009	99.5	0.4
378000	0	0.000	99.5	0.4
379000	0	0.000	99.5	0.4
380000	1	0.009	99.5	0.4
381000	0	0.000	99.5	0.4
382000	0	0.000	99.5	0.4
383000	0	0.000	99.5	0.4
384000	0	0.000	99.5	0.4
385000	0	0.000	99.5	0.4
386000	0	0.000	99.5	0.4
387000	0	0.000	99.5	0.4
388000	0	0.000	99.5	0.4
389000	0	0.000	99.5	0.4
390000	0	0.000	99.5	0.4
391000	0	0.000	99.5	0.4
392000	0	0.000	99.5	0.4
393000	0	0.000	99.5	0.4
394000	0	0.000	99.5	0.4
395000	0	0.000	99.5	0.4
396000	0	0.000	99.5	0.4
397000	0	0.000	99.5	0.4
398000	1	0.009	99.5	0.4
399000	0	0.000	99.5	0.4
400000	0	0.000	99.5	0.4
401000	1	0.009	99.5	0.4
402000	0	0.000	99.5	0.4
403000	0	0.000	99.5	0.4

404000	0	0.000	99.5	0.4
405000	1	0.009	99.5	0.4
406000	0	0.000	99.5	0.4
407000	0	0.000	99.5	0.4
408000	0	0.000	99.5	0.4
409000	0	0.000	99.5	0.4
410000	0	0.000	99.5	0.4
411000	0	0.000	99.5	0.4
412000	1	0.009	99.5	0.4
413000	0	0.000	99.5	0.4
414000	0	0.000	99.5	0.4
415000	0	0.000	99.5	0.4
416000	0	0.000	99.5	0.4
417000	0	0.000	99.5	0.4
418000	0	0.000	99.5	0.4
419000	0	0.000	99.5	0.4
420000	0	0.000	99.5	0.4
421000	0	0.000	99.5	0.4
422000	1	0.009	99.5	0.4
423000	0	0.000	99.5	0.4
424000	0	0.000	99.5	0.4
425000	0	0.000	99.5	0.4
426000	0	0.000	99.5	0.4
427000	0	0.000	99.5	0.4
428000	0	0.000	99.5	0.4
429000	0	0.000	99.5	0.4
430000	0	0.000	99.5	0.4
431000	0	0.000	99.5	0.4
432000	0	0.000	99.5	0.4
433000	0	0.000	99.5	0.4
434000	1	0.009	99.5	0.4
435000	0	0.000	99.5	0.4
436000	0	0.000	99.5	0.4
437000	0	0.000	99.5	0.4
438000	0	0.000	99.5	0.4
439000	0	0.000	99.5	0.4
440000	0	0.000	99.5	0.4
441000	0	0.000	99.5	0.4
442000	0	0.000	99.5	0.4
443000	1	0.009	99.6	0.3
444000	0	0.000	99.6	0.3
445000	0	0.000	99.6	0.3
446000	0	0.000	99.6	0.3
447000	0	0.000	99.6	0.3
448000	0	0.000	99.6	0.3
449000	1	0.009	99.6	0.3
450000	0	0.000	99.6	0.3
451000	0	0.000	99.6	0.3
452000	0	0.000	99.6	0.3
453000	0	0.000	99.6	0.3
454000	0	0.000	99.6	0.3
455000	0	0.000	99.6	0.3
456000	0	0.000	99.6	0.3
457000	0	0.000	99.6	0.3
458000	0	0.000	99.6	0.3
459000	1	0.009	99.6	0.3
460000	1	0.009	99.6	0.3
461000	0	0.000	99.6	0.3
462000	0	0.000	99.6	0.3
463000	0	0.000	99.6	0.3
464000	0	0.000	99.6	0.3
465000	1	0.009	99.6	0.3
466000	0	0.000	99.6	0.3
467000	0	0.000	99.6	0.3
468000	0	0.000	99.6	0.3
469000	0	0.000	99.6	0.3
470000	0	0.000	99.6	0.3
471000	0	0.000	99.6	0.3
472000	1	0.009	99.6	0.3
473000	0	0.000	99.6	0.3
474000	0	0.000	99.6	0.3
475000	0	0.000	99.6	0.3
476000	0	0.000	99.6	0.3
477000	1	0.009	99.6	0.3
478000	0	0.000	99.6	0.3
479000	0	0.000	99.6	0.3

480000	0	0.000	99.6	0.3
481000	0	0.000	99.6	0.3
482000	0	0.000	99.6	0.3
483000	0	0.000	99.6	0.3
484000	0	0.000	99.6	0.3
485000	0	0.000	99.6	0.3
486000	0	0.000	99.6	0.3
487000	0	0.000	99.6	0.3
488000	0	0.000	99.6	0.3
489000	0	0.000	99.6	0.3
490000	0	0.000	99.6	0.3
491000	0	0.000	99.6	0.3
492000	0	0.000	99.6	0.3
493000	0	0.000	99.6	0.3
494000	1	0.009	99.6	0.3
495000	0	0.000	99.6	0.3
496000	0	0.000	99.6	0.3
497000	0	0.000	99.6	0.3
498000	0	0.000	99.6	0.3
499000	0	0.000	99.6	0.3
500000	0	0.000	99.6	0.3
501000	0	0.000	99.6	0.3
502000	0	0.000	99.6	0.3
503000	0	0.000	99.6	0.3
504000	0	0.000	99.6	0.3
505000	1	0.009	99.6	0.3
506000	1	0.009	99.6	0.3
507000	0	0.000	99.6	0.3
508000	0	0.000	99.6	0.3
509000	0	0.000	99.6	0.3
510000	0	0.000	99.6	0.3
511000	0	0.000	99.6	0.3
512000	0	0.000	99.6	0.3
513000	1	0.009	99.7	0.2
514000	1	0.009	99.7	0.2
515000	0	0.000	99.7	0.2
516000	0	0.000	99.7	0.2
517000	0	0.000	99.7	0.2
518000	0	0.000	99.7	0.2
519000	0	0.000	99.7	0.2
520000	0	0.000	99.7	0.2
521000	0	0.000	99.7	0.2
522000	0	0.000	99.7	0.2
523000	0	0.000	99.7	0.2
524000	0	0.000	99.7	0.2
525000	0	0.000	99.7	0.2
526000	0	0.000	99.7	0.2
527000	0	0.000	99.7	0.2
528000	0	0.000	99.7	0.2
529000	0	0.000	99.7	0.2
530000	0	0.000	99.7	0.2
531000	0	0.000	99.7	0.2
532000	0	0.000	99.7	0.2
533000	0	0.000	99.7	0.2
534000	0	0.000	99.7	0.2
535000	0	0.000	99.7	0.2
536000	0	0.019	99.7	0.2
537000	2	0.000	99.7	0.2
538000	0	0.000	99.7	0.2
539000	0	0.000	99.7	0.2
540000	0	0.000	99.7	0.2
541000	1	0.009	99.7	0.2
542000	0	0.000	99.7	0.2
543000	0	0.000	99.7	0.2
544000	0	0.000	99.7	0.2
545000	0	0.000	99.7	0.2
546000	0	0.000	99.7	0.2
547000	0	0.000	99.7	0.2
548000	0	0.000	99.7	0.2
549000	0	0.000	99.7	0.2
550000	0	0.000	99.7	0.2
551000	0	0.000	99.7	0.2
552000	0	0.000	99.7	0.2
553000	0	0.000	99.7	0.2
554000	0	0.000	99.7	0.2
555000	0	0.000	99.7	0.2

556000	1	0.009	99.7	0.2
557000	0	0.000	99.7	0.2
558000	1	0.009	99.7	0.2
559000	0	0.000	99.7	0.2
560000	0	0.000	99.7	0.2
561000	1	0.009	99.7	0.2
562000	0	0.000	99.7	0.2
563000	0	0.000	99.7	0.2
564000	0	0.000	99.7	0.2
565000	0	0.000	99.7	0.2
566000	0	0.000	99.7	0.2
567000	0	0.000	99.7	0.2
568000	0	0.000	99.7	0.2
569000	0	0.000	99.7	0.2
570000	0	0.000	99.7	0.2
571000	0	0.000	99.7	0.2
572000	0	0.000	99.7	0.2
573000	0	0.000	99.7	0.2
574000	0	0.000	99.7	0.2
575000	0	0.000	99.7	0.2
576000	1	0.009	99.7	0.2
577000	0	0.000	99.7	0.2
578000	0	0.000	99.7	0.2
579000	0	0.000	99.7	0.2
580000	0	0.000	99.7	0.2
581000	0	0.000	99.7	0.2
582000	0	0.000	99.7	0.2
583000	0	0.000	99.7	0.2
584000	0	0.000	99.7	0.2
585000	0	0.000	99.7	0.2
586000	0	0.000	99.7	0.2
587000	0	0.000	99.7	0.2
588000	0	0.000	99.7	0.2
589000	0	0.000	99.7	0.2
590000	0	0.000	99.7	0.2
591000	0	0.000	99.7	0.2
592000	0	0.000	99.7	0.2
593000	0	0.000	99.7	0.2
594000	0	0.000	99.7	0.2
595000	0	0.000	99.7	0.2
596000	0	0.000	99.7	0.2
597000	0	0.000	99.7	0.2
598000	0	0.000	99.7	0.2
599000	0	0.000	99.7	0.2
600000	0	0.000	99.7	0.2
OVERFLOW	22	0.218	100.0	0.0

AVERAGE VALUE OF OVERFLOW 762339.454

\* DISTL 12 \*

APL, RESPONSE TIME EOB TO LPSW (INTERVALS = .1 SECOND)

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION			
10063	1026.860	524.000			
UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	
0	0	0.000	0.0	100.0	
1000	5880	58.431	58.4	41.5	
2000	3660	36.370	94.8	5.1	
3000	443	4.402	99.2	0.7	
4000	64	0.635	99.8	0.1	
5000	12	0.119	99.9	0.0	
6000	4	0.039	100.0	0.0	

REMAINING FREQUENCIES ARE ALL ZERO

APL, CPU TIME REQUIRED (INTERVALS = .1 SECOND)

ENTRIES IN TABLE  
9456

MEAN ARGUMENT  
2702.092

STANDARD DEVIATION  
7360.000

UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER
0	0	0.000	0.0	100.0
1000	7378	78.024	78.0	21.9
2000	465	4.917	82.9	17.0
3000	176	1.861	84.8	15.1
4000	145	1.533	86.3	13.6
5000	146	1.543	87.8	12.1
6000	119	1.258	89.1	10.8
7000	102	1.078	90.2	9.7
8000	127	1.343	91.5	8.4
9000	116	1.226	92.7	7.2
10000	113	1.195	93.9	6.0
11000	64	0.676	94.6	5.3
12000	57	0.602	95.2	4.7
13000	50	0.528	95.7	4.2
14000	28	0.296	96.0	3.9
15000	27	0.285	96.3	3.6
16000	23	0.243	96.6	3.3
17000	23	0.243	96.8	3.1
18000	10	0.105	96.9	3.0
19000	16	0.169	97.1	2.8
20000	14	0.148	97.2	2.7
21000	6	0.063	97.3	2.6
22000	3	0.031	97.3	2.6
23000	8	0.084	97.4	2.5
24000	5	0.052	97.4	2.5
25000	5	0.052	97.5	2.4
26000	7	0.074	97.5	2.4
27000	5	0.052	97.6	2.3
28000	6	0.063	97.6	2.3
29000	8	0.084	97.7	2.2
30000	5	0.052	97.8	2.1
31000	6	0.063	97.8	2.1
32000	5	0.052	97.9	2.0
33000	7	0.074	98.0	1.9
34000	6	0.063	98.0	1.9
35000	9	0.095	98.1	1.8
36000	5	0.052	98.2	1.8
37000	7	0.074	98.2	1.7
38000	8	0.084	98.3	1.7
39000	8	0.084	98.4	1.6
40000	3	0.031	98.5	1.6
41000	4	0.042	98.5	1.5
42000	9	0.095	98.6	1.5
43000	3	0.031	98.7	1.4
44000	7	0.074	98.7	1.4
45000	10	0.105	98.8	1.4
46000	5	0.052	98.9	1.3
47000	2	0.021	98.9	1.3
48000	7	0.074	99.0	1.2
49000	5	0.052	99.1	1.2
50000	6	0.063	99.1	1.1
51000	4	0.042	99.2	1.1
52000	8	0.084	99.3	1.0
53000	4	0.042	99.3	1.0
54000	9	0.095	99.4	1.0
55000	6	0.063	99.5	0.9
56000	6	0.063	99.5	0.9
57000	7	0.074	99.6	0.8
58000	5	0.052	99.7	0.8
59000	6	0.063	99.7	0.7
60000	7	0.074	99.8	0.7
61000	7	0.074	99.9	0.6
62000	4	0.042	99.9	0.6
63000	4	0.042	100.0	0.5

REMAINING FREQUENCIES ARE ALL ZERO

APL, PERCENT OF CPU UNAVAILABLE 100(1-CPU TIME REQUIRED/ELAPSED TIME) (INTERVALS = 1 PERCENT)

ENTRIES IN TABLE	MEAN ARGUMENT	STANDARD DEVIATION			
9456	25.701	23.375			
UPPER LIMIT	OBSERVED FREQUENCY	PERCENT OF TOTAL	CUMULATIVE PERCENTAGE	CUMULATIVE REMAINDER	
0	623	6.588	6.5	93.4	
1	384	4.060	10.6	89.3	
2	394	4.166	14.8	85.1	
3	227	2.400	17.2	82.7	
4	201	2.125	19.3	80.6	
5	206	2.178	21.5	78.4	
6	162	1.713	23.2	76.7	
7	210	2.220	25.4	74.5	
8	221	2.337	27.7	72.2	
9	198	2.093	29.9	70.1	
10	235	2.485	32.3	67.6	
11	232	2.453	34.8	65.1	
12	206	2.178	37.0	62.9	
13	222	2.347	39.3	60.6	
14	196	2.072	41.4	58.5	
15	217	2.294	43.7	56.2	
16	202	2.136	45.8	54.1	
17	190	2.009	47.8	52.1	
18	214	2.263	50.1	49.8	
19	185	1.956	52.0	47.9	
20	174	1.840	53.9	46.0	
21	156	1.649	55.5	44.4	
22	152	1.607	57.1	42.8	
23	150	1.586	58.7	41.2	
24	145	1.533	60.3	39.6	
25	123	1.300	61.6	38.3	
26	135	1.427	63.0	36.9	
27	107	1.131	64.1	35.8	
28	107	1.131	65.2	34.7	
29	105	1.110	66.4	33.5	
30	112	1.184	67.5	32.4	
31	84	0.888	68.4	31.5	
32	83	0.877	69.3	30.6	
33	89	0.941	70.2	29.7	
34	89	0.941	71.2	28.7	
35	76	0.803	72.0	27.9	
36	89	0.941	72.9	27.0	
37	74	0.782	73.7	26.2	
38	64	0.676	74.4	25.5	
39	86	0.909	75.3	24.6	
40	75	0.793	76.1	23.8	
41	70	0.740	76.8	23.1	
42	67	0.708	77.5	22.4	
43	54	0.571	78.1	21.8	
44	74	0.782	78.9	21.0	
45	56	0.592	79.5	20.4	
46	63	0.666	80.2	19.7	
47	63	0.666	80.8	19.1	
48	65	0.687	81.5	18.4	
49	52	0.549	82.1	17.8	
50	65	0.687	82.7	17.2	
51	64	0.676	83.4	16.5	
52	51	0.539	84.0	15.9	
53	48	0.507	84.5	15.4	
54	69	0.729	85.2	14.7	
55	67	0.708	85.9	14.0	
56	57	0.602	86.5	13.4	
57	52	0.560	87.1	12.8	
58	52	0.549	87.6	12.3	
59	57	0.602	88.2	11.7	
60	51	0.539	88.8	11.1	
61	57	0.602	89.4	10.5	
62	42	0.444	89.8	10.1	
63	50	0.528	90.3	9.6	



64	46	0.486	90.8	9.1
65	49	0.518	91.3	8.6
66	38	0.401	91.7	8.2
67	39	0.412	92.2	7.7
68	39	0.412	92.6	7.3
69	31	0.327	92.9	7.0
70	39	0.412	93.3	6.6
71	38	0.401	93.7	6.2
72	35	0.370	94.1	5.8
73	34	0.359	94.4	5.5
74	35	0.370	94.8	5.1
75	33	0.348	95.2	4.7
76	27	0.285	95.4	4.5
77	31	0.327	95.8	4.1
78	36	0.380	96.2	3.7
79	26	0.274	96.4	3.5
80	27	0.285	96.7	3.2
81	30	0.317	97.0	2.9
82	31	0.327	97.4	2.5
83	36	0.380	97.7	2.2
84	26	0.274	98.0	1.9
85	23	0.243	98.3	1.6
86	27	0.285	98.5	1.4
87	15	0.158	98.7	1.2
88	18	0.190	98.9	1.0
89	27	0.285	99.2	0.7
90	17	0.179	99.4	0.5
91	16	0.169	99.5	0.4
92	12	0.126	99.7	0.2
93	10	0.105	99.8	0.1
94	9	0.095	99.9	0.0
95	6	0.063	99.9	0.0
96	2	0.021	99.9	0.0
97	1	0.010	100.0	0.0

REMAINING FREQUENCIES ARE ALL ZERO

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