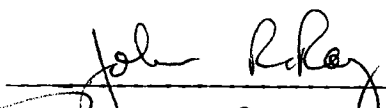
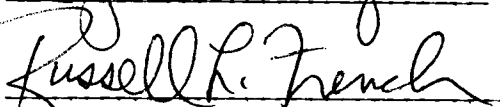
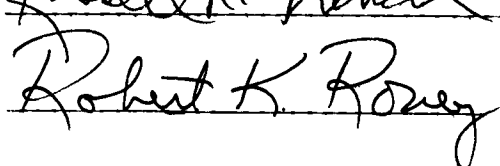


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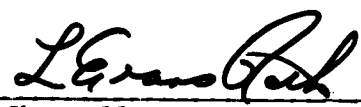
I am submitting herewith a dissertation written by George Allen Mundrake entitled "An Assessment of the Current Status of Computerized Scheduling of Secondary School Classes." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education, with a major in Curriculum and Instruction.


George A. Wagoner, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:


Vice Chancellor
Graduate Studies and Research

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AN ASSESSMENT OF THE CURRENT STATUS OF COMPUTERIZED
SCHEDULING OF SECONDARY SCHOOL CLASSES

A Dissertation

Presented for the

Doctor of Education

Degree

The University of Tennessee, Knoxville

George Allen Mundrake

March 1980

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Not to be overlooked are those who have participated in the study as respondents to the questionnaires and as interviewees in the case studies.

ABSTRACT

The primary problem of this study was to assess the current status of computerized scheduling of classes at the secondary level. The study answered five questions: (1) What types of school environments typically use computerized scheduling of classes? (2) What types of processing techniques are used by schools in conjunction with available scheduling programs, and what adaptations can be made to the programs to schedule most efficiently? (3) What types of hardware are used for scheduling of classes by computer? (4) What types of computer software are most widely used for computerized class scheduling? (5) What options or features of scheduling systems are perceived by users as most effective for scheduling students in their school systems?

A school applications questionnaire and a technical information questionnaire were sent to 393 school systems listed by State Departments of Education as users of computerized scheduling. Matched pairs of questionnaires were received from 183 school systems currently using computerized scheduling. A third questionnaire was developed to collect information from personnel in school data processing installations using the three predominant scheduling systems. Visits were made to three school systems to develop case studies describing their scheduling environment.

Major findings of the study were:

1. Sizes of schools using computerized scheduling varied widely, ranging from under 500 to over 100,000 students per system. Of 183 systems, 131 used computerized scheduling for five to twelve years.

2. Over one-half of the schools funded scheduling through the general budget. About one-half owned or leased the computer used for scheduling; 21.9 percent of the 183 systems used the computer facilities of an intermediate school district, regional unit, or state-owned consortium.

3. Most schools followed a fairly traditional pattern in scheduling. Students were scheduled into modules in only five systems, with 19 to 27 modules in a school day. The majority of the remaining schools had a school day of 5 to 7 periods with 46 to 55 minutes per period.

4. A variety of options for scheduling was available in most scheduling packages. The most often-used options in this study were balancing by sex, semester, and section balancing; lockout restrictions to prevent student overloads and to group students by ability, grade level, and prerequisite courses; and restrictions of school resources such as teachers, rooms, meeting times, and special facilities.

5. Additional records were generated by scheduling packages for most school systems. In addition to the student schedules, which were used by students and various offices within the school, records of grade reporting, attendance, academic transcripts, room utilization reports, and curricular research were generated.

6. The most widely used brand of computer for school scheduling was IBM (51.9 percent of 183 school systems). The remaining schools were divided among seven other brands. About one-half of the systems classified their computers are large; about one-fourth, as medium; and about one-fourth, as small systems.

7. About one-half of the systems used mostly computerized scheduling systems, with 71.6 percent using the computer to help in building the master schedule. Only 17.5 percent used the computer to build the master schedule.

8. The majority of school systems used scheduling packages supported by IBM. SSS/360 was the most widely used package, followed by SOCRATES and NCR's SCHOLARS packages.

9. Three systems used as case studies scheduled with SSS/360, SOCRATES, and SCHOLARS packages.

10. Personnel involved with scheduling were the principal and guidance counselor at the school level and a technical representative at the data processing center. A major problem in scheduling was communications among those personnel, which was alleviated by the use of special forms to facilitate the scheduling process. Timetables, Gantt charts, and student request and master schedule data forms were used as communications tools.

Major conclusions of the study were:

1. Computerized scheduling can be used in a variety of school environments in schools of varying sizes with widely differing scheduling needs.

2. Scheduling can establish a data base for other school records and functions.

3. A crucial factor in computerized school scheduling is the working relationship between school personnel and data processing center personnel.

4. Major cost factors in computerized scheduling are the number of computer scheduling runs and the number of forms printed. Costs can be controlled by limiting these factors.

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CHAPTER I

INTRODUCTION

Ever since Herman Hollerith developed the first punched card tabulating equipment for the Census Bureau in the late 1800's, the use of data processing equipment has been a part of most institutions within our society. Educational institutions have used electronic data processing equipment since the employment of a punched card system for processing of payroll records in Detroit City Schools in 1918.¹

The use of data processing equipment for educational applications sharply increased during the 1950's. During this period the number of installations and applications increased markedly. The applications included the scheduling of classes by computer. Andrew and Moir² defined class scheduling in this way:

Scheduling is the process of matching the requests or requirements of individual students to the available resources of instructional personnel and facilities.

This definition of scheduling illustrates the desire of school administrators to provide for efficiency of school operation, flexibility for individualization of the curriculum, and availability of information for decision making.

¹James F. Cunningham, Jr., "Machine Data Processing for Educational Administrators: Problems and Solutions" (unpublished Doctoral dissertation, The University of Tennessee, Knoxville, 1961), p. 77.

²Gary M. Andrew and Robert E. Moir, Information-Decision Systems in Education (Itasca: F. E. Peacock Publishers, 1970), p. 79.

In the past twenty years computerized class scheduling has developed rapidly. Most of the advances have been in the area of computer hardware (machines), which have led to more sophisticated software (programs) for class scheduling. Early computer scheduling programs made necessary the use of large amounts of human clerical effort. Today several programming packages are available for school scheduling. These programs have been developed and updated by manufacturers and independent users of computers. Such programs make possible the scheduling of entire schools in a matter of minutes rather than hours as done by hand.

Every school scheduling package is unique; however, there are procedures common to the use of the computer to schedule classes. The computer may be used in conjunction with a manual registration system where the computer is used to prepare scheduling reports such as individual student schedules and class lists. The use of the computer in this type of processing assumes that the master schedule or timetable of courses offered by the school has already been developed. On the other hand, the computer may be used to build or to aid in building the master schedule and to assign students to the classes they request. The assignment procedure is called class loading or sectioning.

A. STATEMENT OF THE PROBLEM

The problem of this study was to assess the current status of computerized scheduling of classes in secondary schools to provide current users and potential users with information for adopting or improving a system or changing to another system.

B. QUESTIONS

Five major questions were identified to be answered. These questions included:

1. What types of school environments typically use computerized scheduling of classes?
2. What types of processing techniques are used by schools in conjunction with available scheduling programs, and what adaptations can be made to the programs to schedule most efficiently?
3. What types of hardware are used for scheduling of classes by computer?
4. What types of computer software are most widely used for computerized class scheduling?
5. What options or features of scheduling systems are perceived by users as most effective for scheduling students in their school systems?

C. IMPORTANCE OF THE STUDY

The importance of the study may be illustrated by three points: (1) advantages of computerized scheduling in general, (2) the widespread use of computers to schedule classes, and (3) the ease in tailoring a system to an individual school's needs. Anderson³ listed several reasons for adopting a computerized scheduling system:

³G. Ernest Anderson, "School Scheduling by Computer," Automated Education Handbook (Detroit: Automated Education Center, 1965), p. 39.

1. Considerable hand work is saved.
2. Output from the computer can give information that was difficult to obtain by hand.
3. It is possible to experiment with schedules or simulate without commitment to the schedule.
4. Final schedules may be delayed until near the opening date of school in order to include new students or make changes in existing student schedules.
5. Neat, consistent, printed schedules, class lists, and other reports may easily be provided in quantity for users.
6. Classes are balanced as much as possible; similar classes have about the same number of students.
7. Costs for clerical work and the clerical workload are reduced.

Hunt⁴ added the following advantages to Anderson's list:

1. The opening of the school year can be smooth and uncomplicated with computerized scheduling.
2. Rooms and teachers are used in the optimum patterns.
3. Professional workers have more time for guidance, planning, and teaching.

The widespread use of the computer to schedule classes is indicated in the following passage by Andrew and Moir:⁵

⁴Carmela P. Hunt, Construction of a Computer Assisted Master Schedule: Administrative Guide-SCRIBE (Waltham: Honeywell, Inc., 1975), p. 2.

⁵Gary M. Andrew and Robert E. Moir, Information-Decision Systems In Education (Itasca: F. E. Peacock Publishers, 1970), p. 79.

In larger units, particularly at the secondary level, the problem of scheduling becomes quite burdensome Individual "free-standing" scheduling programs are currently in wide spread use; they alleviate much of the cut-and-try work necessary to match students, available spaces, and qualified instructional personnel.

The ability of a scheduling system to adapt to the particular needs of a school is important when considering adoption, revision, or replacement of a computerized scheduling program package. The importance of adaptability was emphasized in an IBM⁶ publication by the following introductory remark about their product:

The operational steps described in the various work flows need not be rigidly adhered to, nor must all depicted reports be prepared. The educational user is encouraged to substitute his local approach for the illustrated data collection methods and procedural sequences. Only those reports or report options which are most useful to the educational institution should be chosen. This will allow for a tailoring of the program product and eliminate unnecessary computer run time.

Smith⁷ summarized the importance of the study in the following statement:

At no other point in the flow of activities within a school system do its academic and administrative interests converge more closely than in the process of scheduling students to classes It is here that plans for the range of subject matter and size of classes are tempered by the problems of limited number of teachers, classrooms, and facilities.

D. METHODS OF PROCEDURE

The following major steps were taken in this study:

⁶ IBM, EPIC: SOCRATES Student Scheduling System for Educational Institutions--General Information (White Plains: IBM, 1973), p. 10.

⁷ Edgar T. Smith, "The Computer in Student Scheduling (IBM 'CLASS')", Educational Data Processing: New Dimensions and Prospects (Boston: Houghton Mifflin Co., 1967), p. 183.

1. An extensive review of related research was made to determine items to be used on the questionnaires and topics for the interviews at selected schools as case studies. The review included an ERIC (Educational Resource Information Center) search of literature by computer, an exploration of literary indices, and a review of technical manuals obtained from software vendors.

2. The researcher developed a set of prototype questionnaires for school applications and technical information dealing with the scheduling of classes by computer. Visitations were made to four experts in the field of computerized class scheduling to establish content validity of the questionnaires.

3. Letters of inquiry were sent to all State Departments of Education within the continental United States. The letter requested up to ten names and addresses of school systems in the state that used computerized class scheduling. Follow-up letters were sent to states that did not respond. Gaps in the sample were filled by the researcher actively seeking the names and addresses of school systems while attending the annual Association of the Educational Data Systems conference in 1978 in Atlanta.

4. The questionnaires were mailed to the representative sample. Follow-up letters were later sent to those school systems not responding.

5. The school applications and technical information questionnaires were paired and tabulated to obtain descriptive information about the current status of computerized scheduling of classes.

6. Visitations were made to three of the participating school systems as case studies to present a descriptive profile of the most commonly used scheduling systems.

7. A final report was prepared to present the current status of computerized class scheduling in secondary schools.

E. LIMITATIONS OF THE STUDY

Some possible limitations of the study include:

1. Development of newer scheduling systems may have occurred between the time of the administration of the surveys and the presentation of the final report.

2. Increases in the rate of technological change in the area of computer hardware may affect the long-range value of this study as a source of information for implementation or selection of a computerized scheduling system.

3. The list of school systems using computerized scheduling of classes was obtained from State Departments of Education. Some school systems listed by their State Department were not using computerized class scheduling. In some cases the State Departments listed several schools within the same school system that used the same data processing facilities; in that case only one survey was sent back to represent several schools.

4. One follow-up letter was sent to school systems who had returned only one of the two questionnaires or who had not responded. Respondents in this study included only those systems that returned both questionnaires.

F. DEFINITION OF TERMS

Effort has been made to define terms as they occur throughout the report; however, due to the number of unique terms associated with computerized scheduling of classes, a glossary of terminology is included in Appendix A of this report.

G. ORGANIZATION OF THE STUDY

Chapter I introduces the problem, questions to be addressed, methods of procedure, importance of the study, and limitations.

Chapter II reports a review of related literature from studies, books, and articles. Chapter III includes information on available school scheduling packages.

Chapter IV gives a detailed description of the procedures taken to address the problem. This chapter includes the steps taken in analysis of the data obtained through the school application and technical information questionnaires.

Chapter V presents the data from the two questionnaires and case studies. Chapter VI summarizes the study and presents the findings, conclusions, and recommendations.

The Appendix is divided into five parts. The parts show support documents used during the collection and analysis of the data and a glossary of terminology related to the scheduling of classes by computer.

CHAPTER II

REVIEW OF RELATED LITERATURE

The results of an extensive search of related literature are presented in this chapter. The majority of the literature was published during the late 1960's during the time of accelerated development of computer hardware and software for scheduling purposes. Possible reasons for the decline in the frequency of literature related to the use of computerized scheduling of classes after 1970 may include:

1. The "coming of age" of computerized scheduling as a viable school administrative tool,
2. The decline of school enrollment causing a decrease in the development of scheduling programs,
3. A shift in the administrative policy concerning scheduling of students back to computer-assisted scheduling by means of class loading, or
4. An interactive result of all the above reasons.

The review of books, research studies, and articles indicated an interactive relationship of all factors.

The steps taken in the review of related literature included two computer searches of literature by ERIC (Educational Resources Information Center). The first search proved fruitless because of a narrow selection of terms used for the search. The second attempt yielded several sources of information in the form of articles; however, many

articles were not related to scheduling of classes but of scheduling school buses or other topics. Much of the information presented in this chapter was acquired through visitations, telephone calls to school systems and vendors of scheduling software, and by scanning several guides to periodical literature. The general subject matter areas reviewed included computers, school administrators, science, educational curriculum, guidance in education, and computer-related association conference proceedings.

The organization of this chapter includes related literature from books, research studies, and articles. Vendor information about available scheduling packages is reported in Chapter II of this study.

A. BOOKS

Several books on the use of electronic data processing equipment in the school are available. Most of these books aided in this study in the area of development of the questionnaire to assess the current status of computerized class scheduling. The books provided a starting point for obtaining a general background for understanding the types of scheduling systems available.

Most of the books contained a chapter on scheduling of classes by computer. These books included works by Grossman and Howe,¹ Kaimann

¹Alvin Grossman and Robert L. Howe, Data Processing for Educators (Chicago: Educational Methods Incorporated, 1965), 362 p.

and Marker,² and Bushnell and Allen.³ The books by Kaimann and Marker and Bushnell and Allen were collections of articles by various authors.

Wiley and Bishop⁴ offered a wealth of background information on scheduling and specific examples of scheduling using the SSSS school scheduling program (Stanford School Scheduling System). The authors also gave a listing of schools that were using the SSSS program.

B. RESEARCH STUDIES

Most of the studies found in the area of computerized school scheduling were developmental, descriptive, or comparative. The developmental studies were useful in providing potential users with information about the adoption or adaptation of different computerized scheduling systems. Hunt⁵ published a user's manual for the Honeywell SCRIBE scheduling system which emphasized the development of a computer-assisted master schedule using the SCRIBE system. The publication provided specific examples of computer output and forms. The manual was an outcome of Hunt's master's thesis on the subject of scheduling with the Honeywell SCRIBE scheduling system.

²Richard A. Kaimann and Robert W. Marker, Educational Data Processing: New Dimensions and Prospects (Boston: Houghton Mifflin Company, 1967) 326 p.

³Don D. Bushnell and Dwight W. Allen, The Computer in American Education (New York: John Wiley and Sons, Inc., 1967) 300 p.

⁴W. Deane Wiley and Lloyd K. Bishop, The Flexibly Scheduled High School (West Nyack: Parker Publishing Company, Inc., 1968) 208 p.

⁵Carmela P. Hunt, Construction of a Computer Assisted Master Schedule: Administrative Guide--SCRIBE (Waltham, Mass.: Honeywell Corporation, 1975) 103 p.

Burkoski and Korotkin⁶ published results of Project CASE (Computing Activities in Secondary Education). The project included a descriptive profile of schools using computers in areas of administration and academic studies. The questionnaire encompassed the following areas of inquiry:

1. General information about the school (enrollment, etc.)
2. Instructional applications
3. Computer budgeting
4. Computer hardware

The study was a survey using a 25.0 percent stratified random sample of all secondary schools in the country to gain a profile of computerization from 1970 to 1975. Surveys were first sent to principals of schools. Amplification studies later added detail to areas of hardware and other technical information not available from school personnel.

The study aided the researcher in planning the current study. The breaking of the questionnaire into school applications and technical information was a result of the CASE project. One finding of the CASE project dealing with the percentage of use of the computer in the areas of strictly administrative use of the computer and instructional use showed a decline between 1970 and 1975 from 62.5 percent administrative use to 54.1 percent usage. The decline indicated that in 1975 over half of the computer use time was in the area of administrative

⁶William J. Burkoski and Arthur L. Korotkin, "Computing Activities in Secondary Education," Educational Technology (Vol. XVI, No. 1, January, 1976), pp. 9-23.

activities, including the scheduling of classes. Of the 54.1 percent of administrative use, 35.5 percent was designated as student accounting (attendance records), resource management (inventories, scheduling, etc.), and research. Scheduling was reported as a viable activity for administrators using the computer as a tool.

A descriptive study by Krahn⁷ identified the benefits of computerized scheduling of classes in Wisconsin high schools in 1973-1974. The study involved 124 high schools in Wisconsin. The results indicated that scheduling by computer was advantageous as shown by responses to a questionnaire directed at the following areas:

1. Professional time involved in scheduling,
2. Nonprofessional time involved in scheduling,
3. Ability of scheduling program to be modified for unique situations,
4. Ability of computerized systems to allow students to satisfy course requests,
5. Ability of the system to allow for better use of existing facilities and teachers, and
6. Ability of the scheduling system to handle variations in enrollment sizes, grade levels, modular schedules, computer-built schedules, etc.

⁷ Kenneth A. Krahn, "An Investigation to Determine the Extent of Satisfaction with Computer Scheduling in Wisconsin Schools" (unpublished Specialist Degree thesis, The University of Wisconsin--Superior, 1974).

The findings of the study indicated that professional and nonprofessional time was reduced by using computerized scheduling by 66.1 percent for professional help and 54.0 percent for nonprofessional help. Students were able to schedule more classes, and teachers were able to offer teacher-designed course structures in 79.1 percent of the schools. Courses having multiple sections were better balanced by using computers in 69.3 percent of the schools. Of the schools, 62.5 percent reported that improvements were needed in areas of small-group scheduling, large-group scheduling, and individualized or independent study.

Krahn found that, among 124 schools studied, greater satisfaction with computer scheduling was reported by these schools: (1) Schools with enrollments up to 600 as compared to schools with enrollments greater than 600, (2) junior high schools as compared to middle or senior high schools, (3) schools that scheduled all semester courses as compared to schools that scheduled all-year courses or a combination of all-year and semester, (4) schools that employed a modular schedule as compared to schools that used traditional schedules or combinations of various types of schedules, and (5) schools that used a computer both to generate a master schedule and to load students into that schedule as compared to schools that used a computer to load students into a manually constructed schedule.

Heller, Chaffee, and Davison⁸ reported results of a study that

⁸Robert W. Heller, Leonard W. Chaffee, and Ronald G. Davison, "Two Computer-Based School Scheduling Programs Analyzed," NASSP Bulletin (Vol. 58, No. 380, March, 1974), pp. 64-82.

compared two school scheduling programs. The study, designated Project PASS, compared the International Business Machines' program CLASS (Class Load and Student Scheduling) with GASP (General Academic Simulations Program) which was developed by the Massachusetts Institute of Technology.

Several difficulties were reported in the comparison of the CLASS and GASP scheduling systems. The major difficulty was that CLASS was primarily a class loading type of program. Under this system the master schedule is manually constructed using information from computer-generated reports such as conflict reports and tallies. The GASP program was designed to computer-generate a master schedule using time variables, teacher availability and other variables in conjunction with student course requests. The comparisons were also made on two different computer systems--the IBM 1401 and the IBM 7090 computer.

The areas of comparison included analysis of costs, personnel requirements, staff training procedures, technical difficulties, and general and specific comparisons.

Two schools were selected as pilot schools. The first school was in an urban setting with 2,200 students. The second school was a suburban school with 1,100 students. Separate records were kept on each of the two schools and each of the two scheduling programs. The cost analysis of the two systems included all personnel costs and machine charges for each method of scheduling.

The effectiveness of training of personnel reportedly may have hindered the study, since the personnel involved had never used the

GASP system for school scheduling. This lack of experience added to the cost of using the GASP programs, extra costs that might not have occurred had the personnel been versed in the system before the study.

Results of the study indicated that the GASP program was costlier than the CLASS system; however, the difficulty in comparing the two systems and the cost of training personnel for the GASP system were reported as the major reasons for increased costs. Additional knowledge of data processing techniques was needed to use GASP, beyond the knowledge developed through using CLASS.

Heller, Chaffee, and Davison identified settings in which each system would work better. The GASP system would best fit educational institutions that are undertaking curriculum changes or experiencing sharp increases in enrollment. The CLASS program worked well for more traditional types of schools or those which maintain a constant enrollment with a few changes in curriculum.

Gruman⁹ conducted a study of six different school scheduling programs including the following computerized programs:

1. A program for the IBM 7090 originally developed by G. Ernest Anderson, Jr., and made available to the Palo Alto School District in California and modified slightly by that district, called the Palo Alto program;
2. A Control Data Corporation (CDC) program developed by Control Data in Palo Alto, called the CDC program;

⁹ Allen J. Gruman, "A Comparison of Computer Programs for the Assignment of Students to Classes: Report of an Experimental Study," AEDS Journal (Vol. 4, No. 1, Winter, 1966-67), pp. 7-15.

3. NCR program developed at Dayton, Ohio (similar to the Palo Alto program), called the NCR program;

4. A program written for Service Bureau Corporation (SBC) by L. E. Marsters, called the SBC program;

5. The SOCRATES program developed by Charles Wilkes;

6. A program developed at Wellesley, Massachusetts, by a group headed by Charles Rose, called the H 2200 program.

All six of the programs were similar in that they all were class-loading programs. Each of the six programs was used to generate schedules for 2,079 students in Carlmont High School, Belmont, California. Initial runs were made on the SOCRATES and CDC programs to test the scheduling data. Because of differences in inputs, processes, and reports generated by each program, the author found it difficult to compare the effectiveness of the six systems. The total number of unscheduled course requests in the SOCRATES program was significantly lower than for the other five. The Palo Alto, CDC, and NCR programs resulted in almost identical numbers of rejects at each grade level. The SBC program was most successful in scheduling students who requested more singleton and doubleton courses. These differences in scheduling success may be attributed to the ability of SBC program to modify maximum class sizes if needed to reduce the number of students with conflicts. In contrast to the other five programs, SOCRATES assigned students to as many classes as possible, regardless of conflicts. Programs which do not have the capability of partially scheduling students have a larger number of conflicts.

The results from the Palo Alto, CDC, and NCR programs were so similar that Gruman described them as equally successful. Because of the differences among the six programs in special features and output formats, comparisons could not be meaningfully made. Gruman concluded that any one of the six programs in this study could be the "best" one for an individual school, since such a decision rests on a number of factors other than those he studied. Modifying maximum class sizes, using percentage intervals of various sizes, could increase the total number of students scheduled. Such a procedure, which might allow an increased enrollment of one or more students on each scheduling pass, would allow personnel to study the effect of seat allotments on scheduling success. Additional modifications to the program's input and procedures, which often can be learned only with successive experiences with the same program, can increase scheduling success.

This study was useful in the development of the questionnaire for school scheduling applications used in the present study. The Gruman study identified several versions of programs available. For example, IBM has several models of computers using several versions of programs for school scheduling, such as the ALPHA and BETA SOCRATES, the UPDATE system, the SSS/360, the EPIC:SOCRATES, the CLASS program, and the GASP program, among others. Because of the number available, comparisons of programs is difficult. In addition, the possibility that a program may be used on several different manufacturers' equipment with slight modifications complicates such comparisons.

C. ARTICLES

The most abundant source of information on computerized scheduling was in the form of articles. Major sources of these articles were the NASSP Bulletin (National Association of Secondary School Principals), the AEDS Journal and the AEDS Monitor (Association for Education Data Systems), Educational Technology, and Data Processing for Education.

Early articles (prior to 1970) on computerized school scheduling primarily dealt with the decision to use the computer for scheduling of classes, illustrations of computerized scheduling applications, and descriptions of techniques for computerized scheduling. The more current articles also revived the issue of whether to continue to use computerized scheduling. These articles indicated the widespread use of computerized scheduling programs, giving an indication that such programs were a viable part of the educational system.

By arranging the reviewed articles into chronological order, it was possible to trace the development of scheduling software. Such an arrangement also provided information for development of the survey instrument and visitation questions.

The first scheduling programs were developed in the late 1950's. Purdue University developed one of the first workable programs for class scheduling in 1956.¹⁰ At that time enrollment in secondary schools was in a period of expansion. The need for such programs continued to

¹⁰ Ralph A. Van Dusseldorp and Duane E. Richardson, "Class Scheduling by Computer," AEDS Journal (Vol. 4, No. 1, Winter, 1966-67), p. 52.

grow as a result of increased emphasis on better use of limited educational resources in the early 1960's. The Trump¹¹ plan for allocation of student time, i.e., use of 40.0 percent of student time for large-group instruction, 40.0 percent for small-group instruction, and 20.0 percent for individualized instruction, was among the factors that accelerated the need for more sophisticated scheduling. During the same time, the computer industry was in a period of rapid development. Between 1953 and 1969, International Business Machines introduced a series of ten new computers which had up to twelve models for each series.¹² These combinations greatly increased the growth of computer scheduling.

During the 1960's several articles were published dealing with how scheduling systems work. Oakford, Allen, and Chatterton¹³ explained the scheduling algorithm of the SSSS (Stanford School Scheduling System) in terms of the equations used to schedule students. In the same issue of the Association for Educational Data Systems Journal, Van Dusseldorp and Richardson¹⁴ gave a less technical

¹¹J. Lloyd Trump, "New Directions in Scheduling and Use of Staff in the High School," California Journal of Secondary Education, No. 33, October, 1958, pp. 362-372.

¹²Steven L. Mandell, Computers and Data Processing: Concepts and Applications (St. Paul, MN: West Publishing Company, 1979), p. 67.

¹³Robert V. Oakford, Dwight W. Allen, and Lynne A. Chatterton, "School Scheduling--Practice and Theory," AEDS Journal (Vol. 4, No. 1, Winter, 1966-67), pp. 16-50.

¹⁴Ralph A. Van Dusseldorp and Duane E. Richardson, "Class Scheduling by Computer," AEDS Journal (Vol. 4, No. 1, Winter, 1966-67), pp. 51-60.

explanation of the UPDATE scheduling program (Unlimited Potential Data through Automation Technology in Education) which was developed by The University of Iowa at the IEIC (Iowa Education Information Center).

In 1964 the first issue of The Journal of Educational Data Processing contained four articles on available scheduling systems. These articles included one by Holz¹⁵ about the use of GASP (Generalized Academic Simulation Program), Wilkes¹⁶ discussing the use of SOCRATES (Scheduling of Classes Realized by Effortless Systemization--early version), and Smith¹⁷ illustrating the advantages of using the CLASS program (Class Load and Scheduling System). Smith also discussed the STUDENT package (Scheduling Technique Using Defined INcrements of Time). A fourth article by Gould¹⁸ described methods of collecting data for student scheduling.

Many articles in the 1960's offered school administrators information on successful applications and techniques used for

¹⁵Robert E. Holz, "Computer-Assisted Scheduling," Journal of Educational Data Processing (Vol. 1, No. 1, February, 1964), pp. 36-41.

¹⁶Charles F. Wiles, "SOCRATES: A System for Student Scheduling," Journal of Educational Data Processing (Vol. 1, No. 1, February, 1964), pp. 46-52.

¹⁷Edgar T. Smith, "The Computer in Student Scheduling (IBM 'CLASS')," Journal of Educational Data Processing (Vol. 1, No. 1, February, 1964), pp. 53-60.

¹⁸Mary Frances Gould, "Data Collection: A Challenge in Student Scheduling," Journal of Educational Data Processing (Vol. 1, No. 1, February, 1964), pp. 42-45.

scheduling by computer. Counce and Davis¹⁹ took a general approach to administrative data processing in an article discussing the data processing activities of the Memphis City Schools. They indicated a high degree of satisfaction in their new approach to scheduling using an IBM RAMAC computer. Bush²⁰ offered an introduction to scheduling for potential users of scheduling programs by listing the five types of information all scheduling programs use--students, teachers, rooms, time, and courses.

The late 1960's marked the beginning of the third generation of scheduling technology as indicated by Weinberg²¹ in an article urging the use of computer programs for scheduling purposes. Weinberg reinforced the reality that the hardware of the time was no longer the obstacle in the way of progress, rather that the schools were holding back on the use of computers.

Along with the "coming of age" of school scheduling by computer, experts of this time period placed more emphasis on the use of scheduling for administrative planning in conditions of limited educational resources. Jensen²² pointed out that the information derived from

¹⁹Shelby Counce and Robert E. Davis, "Data Processing in a Large School System," NASSP Bulletin (Vol. 47, No. 280, February, 1963), pp. 137-145.

²⁰Robert N. Bush, "Decision for the Principal: Hand or Computer Scheduling," NASSP Bulletin (Vol. 48, No. 291, April, 1964), pp. 141-146.

²¹Norman Weinberg, "Class Scheduling--Third Generation," AEDS Monitor (Vol. VI, No. 11, June, 1968), pp. 3-4.

²²Ronald L. Jensen, "The Scheduling Program as a Gaming Device for Administrative Planning," Educational Technology (May, 1971), pp. 43-45.

scheduling could serve administrators in the planning under conditions of rapid change. Information derived from scheduling could be used for establishing trends and for making intermediate range staffing and room utilization decisions.

More emphasis was placed on new approaches to the scheduling process. Harr and Richardson,²³ Allen,²⁴ and several others cited the advantages and disadvantages of "flexible scheduling" or a method by which subject matter may be taught in various group sizes at various lengths of periods by various teachers. Allen warned that flexible scheduling permitted good education but did not guarantee better education, an indication that philosophy and scheduling needed to be carefully thought out in selection and use of scheduling programs.

The end of the 1960's produced additional articles on available scheduling packages. Wolford²⁵ explained the differences in the scheduling systems (called Schedules F and H) and described the features of each of the systems. These differences indicated the trend toward continuous updating of existing scheduling systems by major computer manufacturers. At about the same time Morgan and McCaffrey²⁶ gave an

²³Gordon Harr and Gordon Richardson, "Let's Plan for a Flexible Schedule," AEDS Monitor (Vol. VII, No. 8, May, 1969), pp. 1-2.

²⁴Dwight W. Allen, "A New Perspective on the Computerization of School Schedules," Education Technology (Vol. VIII, No. 4, February, 1968), pp. 8-10.

²⁵Harry E. Wolford, "A Critique of the Student Scheduling Software of 'That Other Computer Company'," AEDS Monitor (Vol. 7, No. 6, January, 1969), pp. 4-6.

²⁶Don L. Morgan and Kenneth J. McCaffrey, "The Status of Scheduling Services Provided by IEIC," AEDS Monitor (Vol. 6, No. 10, May, 1968), p. 6.

update on the status of available scheduling services of The University of Iowa's Iowa Education Information Center (IEIC). This article indicated the trend toward continuous improvements of the UPDATE and GASP scheduling programs.

Early in the 1970's the concept of flexible modular scheduling continued to gain recognition. Shockloss²⁷ provided an article that indicated that a complex modular flexible scheduling changeover was made without the use of a computer with much hand work and consumption of time. The author expressed the belief that "packaged programs" did not keep pace with modular scheduling. Wiese²⁸ proposed a system of scheduling where students select courses in the spring; and then from a tally of their requests, a master schedule is built manually. The computer was used in his system to prepare section cards during the summer for use in an arena scheduling procedure early in the fall. Under this method the master schedule was prepared before the students selected their courses for the next year. In an article by Ubben²⁹ in 1976, the computer was used with a standard class loading program (not identified by name in the article) to generate a fluid block scheduling arrangement which is similar to flexible modular scheduling. In Ubben's study a fluid block schedule reduced the total number of sections

²⁷ Daniel P. Shockloss, "Changing to Modular Flexible Scheduling," NASSP Bulletin (Vol. 57, No. 396, January, 1973), pp. 79-88.

²⁸ Charles R. Wiese, "Let the Students Do It--Successful Self-Scheduling for Classes," NASSP Bulletin (Vol. 56, No. 363, April, 1972), pp. 76-81.

²⁹ Gerald C. Ubben, "A Fluid Block Schedule," NASSP Bulletin (Vol. 60, No. 397, February, 1976), pp. 104-111.

built into the master schedule. In fluid block scheduling a basic group of courses was scheduled into a three-course block of time. Each student then was scheduled into one of the blocks in the master schedule and was rotated among the three courses offered in that block. For example, a three-hour block could include math, science, and English. A student scheduled into that block would be fitted into the three courses in a pattern that fits with other three-course blocks. Three blocks could thus offer math each of the three hours, with a group of students taking math each of the three hours. In the second hour, one group could be scheduled into math, a second into science, and a third into English, rotating into a different course for the third hour.

Several "how to" articles and benefits of scheduling-by-computer articles continued to appear in the middle 1970's. In the "how to" articles, Snite³⁰ presented some hints on the use of the SSS/360 (Student Scheduling System) program to help avoid some of the conflicts generated by an imperfect master schedule. Oakford and Salazar³¹ prescribed procedures to analyze a conflict matrix under the SSSS scheduling system and the GASP system. The explanation included formulas and techniques for building a master schedule using information

³⁰Albert J. Snite, "Do 'Closed' Classes Cut Your Scheduling Success?," AEDS Monitor (Vol. 10, No. 1, July-August, 1971), pp. 6-7.

³¹R. V. Oakford and A. Salazar, "Effective Use of the Conflict Matrix in Automated Scheduling," Journal of Educational Data Processing (Vol. 12, No. 2, 1975), pp. 23-33.

about conflicts. In 1974, Raucher³² explained the use of the EPIC: SOCRATES master schedule builder, a system which was new at that time. He indicated in his article that only five percent of the secondary schools in the United States used a fully automated system for building a master schedule. Raucher also estimated that 75.0 percent of the schools having an enrollment over 500 students per building used a form of semi-automated scheduling procedures, and only 20.0 percent used a fully manual system.

Wagoner and Brown³³ discussed ways to use SSS/360 efficiently, particularly for a school with block courses, mini-courses, semester courses, and full-year courses. They also discussed ways in which the output from SSS/360, the tally and conflict matrix, can be used to build a better master schedule. After the master schedule is built, simulation runs can provide a great deal of information that can be used to revise and improve the master schedule so that the maximum number of students can be scheduled by computer. Special features of SSS/360, such as sex balance, alternate courses, partial scheduling, and study halls at specified times, can be used to the school's benefit.

Some of the articles of the late 1970's highlighted the issue of whether to use standard class-loading programs or to use student self-scheduling. Both systems may involve the use of the computer;

³²Steve M. Raucher, "Computerized Master Schedule Generation--A New Approach," AEDS Journal (Vol. 8, No. 2, Winter, 1974), pp. 51-63.

³³George A. Wagoner and Betty J. Brown, "Class Scheduling for Secondary Schools," The Journal of Data Education (Vol. 16, No. 1, October, 1975), pp. 11-14.

however, self-scheduling is usually accomplished by card-pulling (arena or "college-type" scheduling). These practices indicated a regression back to the early days of unit-record data processing. Three articles by Eichorn,³⁴ Wall,³⁵ and Chesler³⁶ defended the use of arena scheduling or card-pulling. Eichorn and Chesler advocated strict versions of the arena-scheduling procedure, while Wall advocated the use of pre-registration and course requests to help to build a master schedule prior to the arena scheduling session. Wall³⁷ later published an article that suggested that those selecting the class loading types of programs or the self-scheduling system should carefully weigh the advantages and disadvantages of each system. Duvall³⁸ also indicated that the use of student self-scheduling was an efficient and economical means of scheduling classes.

Tilwick³⁹ provided an opposing article advocating the use of computer class schedules. He listed several reasons for using computer

³⁴ John P. Eichorn, "College Scheduling for the High School," NASSP Bulletin (Vol. 60, No. 404, December, 1976), pp. 93-94.

³⁵ F. Edward Wall, "With 1,670 Students, Student Self-scheduling Works Well for Us," NASSP Bulletin (Vol. 60, No. 397, February, 1976), pp. 99-103.

³⁶ Nathan Chesler, "Arena Scheduling," NASSP Bulletin (Vol. 61, No. 413, December, 1977), pp. 109-110.

³⁷ F. Edward Wall, "Class Schedules--Computer Loaded or Student Self-Scheduling," NASSP Bulletin (Vol. 63, No. 427, May, 1979), pp. 93-97.

³⁸ David B. Duvall, "Student Self Scheduling--Does It Really Work?," American Secondary Education (Vol. 5, No. 3, June, 1975), pp. 3-7.

³⁹ Richard L. Tilwick, "Student Self Scheduling: An Unintentional Deception," NASSP Bulletin (Vol. 59, No. 394, November, 1975), pp. 114-117.

scheduling and gave a list of negative aspects of student self-scheduling. Some of these included the following:

1. Staff members may be unhappy because of the possible overloading of classes.
2. An adequate racial balance in classes may be difficult to attain where court orders persist.
3. Late students to registration will receive the leftover classes; at a 10.0 percent absentee rate, many students could have problems getting needed courses.
4. Some students are necessarily scheduled first--the ones at the end of the line will probably complain.
5. Instruction time may be lost when students must pull cards.
6. If the procedure is undertaken prior to instructional days, the additional staffing may become a costly proposition.

D. SUMMARY

This chapter presented the results of an extensive review of related literature in the form of books, studies, and articles appearing in educational data processing publications. One of the major difficulties in the review of related research was classifying the information. Scientific, instructional, and administrative publications all discussed scheduling as an issue in education. That diversity indicated the importance of school scheduling by computer in the overall operation of the schools in carrying out the policy of school administrators.

The educational philosophies of the school personnel described in the related literature seemed to be as numerous as the number of scheduling applications available. A strong relationship between the type of scheduling system used and the educational philosophy of the institution the system served is evident from literature.

Chapter III presents several scheduling systems available to secondary school administrators. Descriptions are based on information obtained from vendors, technical manuals, and users of the various systems.

CHAPTER III

AVAILABLE SCHOOL SCHEDULING SYSTEMS

Several scheduling systems are available for scheduling students into classes at the secondary school level. Usually these "packages" include several programs to accomplish the task of scheduling; therefore, the user of the package purchases a scheduling system rather than a program.

This chapter is organized to present a classification of the available systems and further breaks down each classification to illustrate some available systems. Not all systems are presented in this chapter. Several systems have many versions or updates. In addition, several "homemade" packages or adaptations have been developed by users to meet the special needs of their own school applications.

The examples used in this chapter are presented with the steps taken in each system for scheduling of classes. These steps are illustrated in system flowchart form using standard systems flowcharting symbols. Figure 1 presents these symbols and their meanings in this report. The flowcharts are written under the rules for flowcharting by the HIPO method (hierarchy, input, process, and output). The procedure involves the establishment of time sequence in order or hierarchy, following by three symbols which depict input used, process performed, and output generated. Using this method assumes that the output from one process becomes the input for the next process within the hierarchy of events.

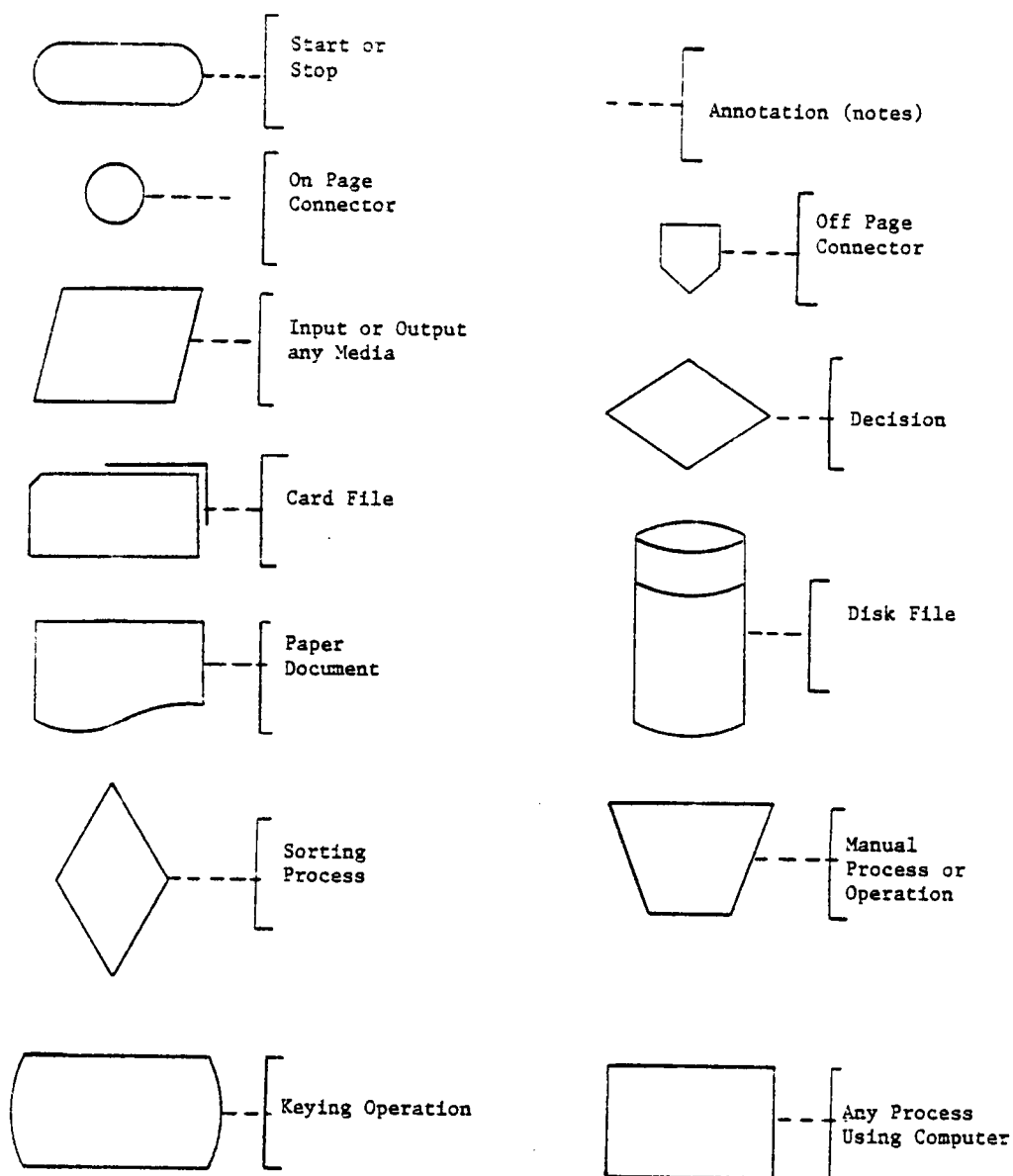


Figure 1. Systems flowcharting symbols.

Side-by-side (horizontal) placement of symbols represents input and outputs or processes that may occur simultaneously. Top-to-bottom (vertical) placement of symbols represents input, processes, or output that occur in sequence. The flowcharts in this chapter depicting the available school scheduling systems are alike in many ways, because all three are flowcharted by the HIPO method. Each flowchart will identify one or more phases in the scheduling system, with the HIPO components identified for each phase. The output from one phase will generally be the input for the next phase. Annotation symbols are used to clarify the terminology unique to each scheduling system or to identify the external resources including personnel, hardware, and software.

A. CLASSIFICATIONS OF SCHEDULING SYSTEMS

Scheduling systems using computers may be classified into three general categories. These categories include (1) arena-type scheduling, (2) manual or computer-assisted master schedule building with computerized class loading, and (3) computer-built master schedule with computerized class loading. The degree of manual intervention under each of the three classifications decreases with increased usage of the computer for the entire scheduling task. Under the arena-type scheduling process the computer is used primarily to generate cards for classes and to prepare class rolls and schedule cards for individual students. In this application the master schedule is usually prepared manually. The other two types of systems depend more on the computer to build the master schedule and to "load classes" using a program that

matches the student's course needs with available course offerings.

Under these types of scheduling, the student does not have to physically "pull cards" to gain access to classes.

B. ARENA-TYPE SCHEDULING

Several versions of the arena scheduling systems are in use in school systems. The versions depend on the method used to build the master schedule and the type of media used to prepare class lists and individual student schedules. The terms "college-type scheduling," "card pulling," and "student self-scheduling" usually depict this type of scheduling systems. The type of media or means of recording student and master schedule information may also alter the terminology used to describe the scheduling process. If the medium used is card, the process may be termed "card pulling"; if CRT (cathode ray tube) terminals or printing terminals are used to key the information to a disk, the system may be termed computer-assisted registration or CARS (computer-assisted registration system). Nevertheless, the student must be present or have someone substitute in order to "register" or schedule his or her classes.

The master schedule must be prepared in advance of the registration of students in all forms of computerized scheduling of classes. In the arena-type scheduling system the development of the master schedule is usually done manually, based upon past needs of the school system. The needs of students are generally met through prior experience. It is possible for school officials to determine the needs of students by

means of a pre-registration or pre-scheduling process. Using the pre-registration process, the school personnel may determine how many students want a course, how many people want a specific combination of courses, and in some cases, when the courses are wanted. This process may be done manually by tallying the requests or allowing the computer to make tallies of the requests. If the computer is used for this purpose, the master schedule is said to be manually constructed with computer assistance or computer assisted.

Figure 2 illustrates the use of an arena-type scheduling system without pre-registration or computer-assisted master schedule building. In that system the principal or other school administrator in charge of the master schedule must prepare the schedule without course requests from students as input to that preparation. Past experience usually is the basis for determining the master schedule.

After the master schedule is prepared, information is keyed into a course information file which includes teacher information, course descriptions, and time and place of meeting for each section. The information is listed for editing purposes. After editing a computer program is used to generate individual student course cards, one card for each seat available in each section.

Student information is keyed into student header records. At this point the arena process may be implemented. At a central location students pick up their student header cards and proceed through the arena, selecting course cards for the sections for which they plan to enroll. Information from the student header cards is transferred to

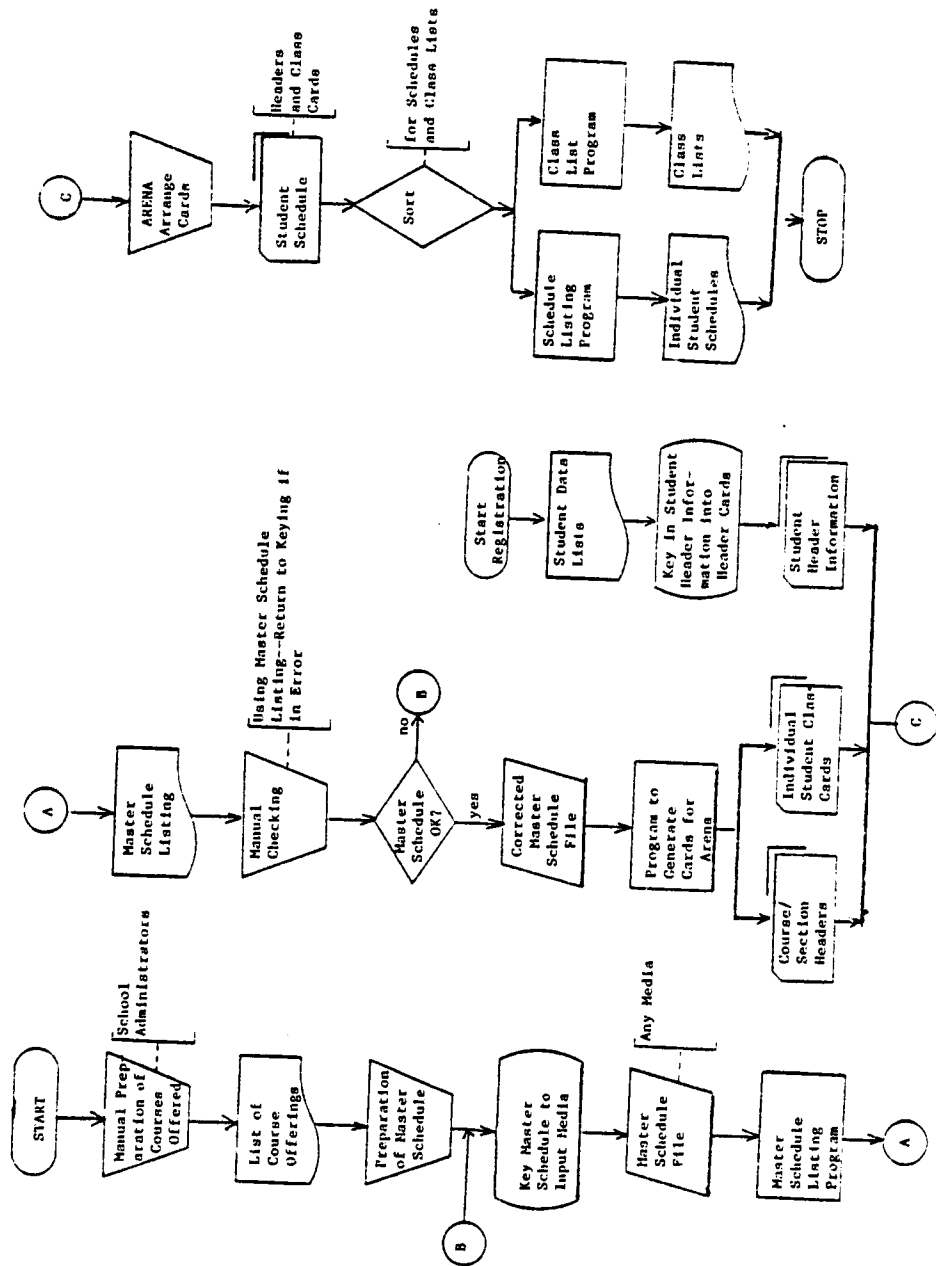


Figure 2. Arena scheduling system flowchart (without computer-assisted master schedule).

the individual course cards by computer or unit-record equipment. These cards represent the student schedule file. The student schedule file is used to generate both student schedules and, after resorting, class lists for teachers. At this point the scheduling process is complete. The file may be used for other school applications such as grade reporting or attendance record keeping.

Figure 3 shows the steps in the process for arena scheduling with pre-registration and computer-assisted master schedule building. A first step is the preparation of lists of possible course offerings. Each student then submits a student request sheet. Student requests are keyed into a file which is used to produce a tally and conflict matrix. The master schedule is based on information generated by the course tally and conflict matrix. At this point administrators must decide which courses will be offered and construct the master schedule. Like arena scheduling without the use of the computer to build the master schedule, this system punches individual student course cards for all seats in all sections offered. Student header cards are prepared from student request data.

Students report to a central location and pick up their student header cards, proceed through the arena, and select individual course cards for all the sections in which they plan to enroll. This combination of student and course information becomes the student schedule file. Individual student schedules and class lists are prepared from the student schedule file information.

In this system student requests are the basis for the generation of the master schedule. In Figure 2 the student requests follow

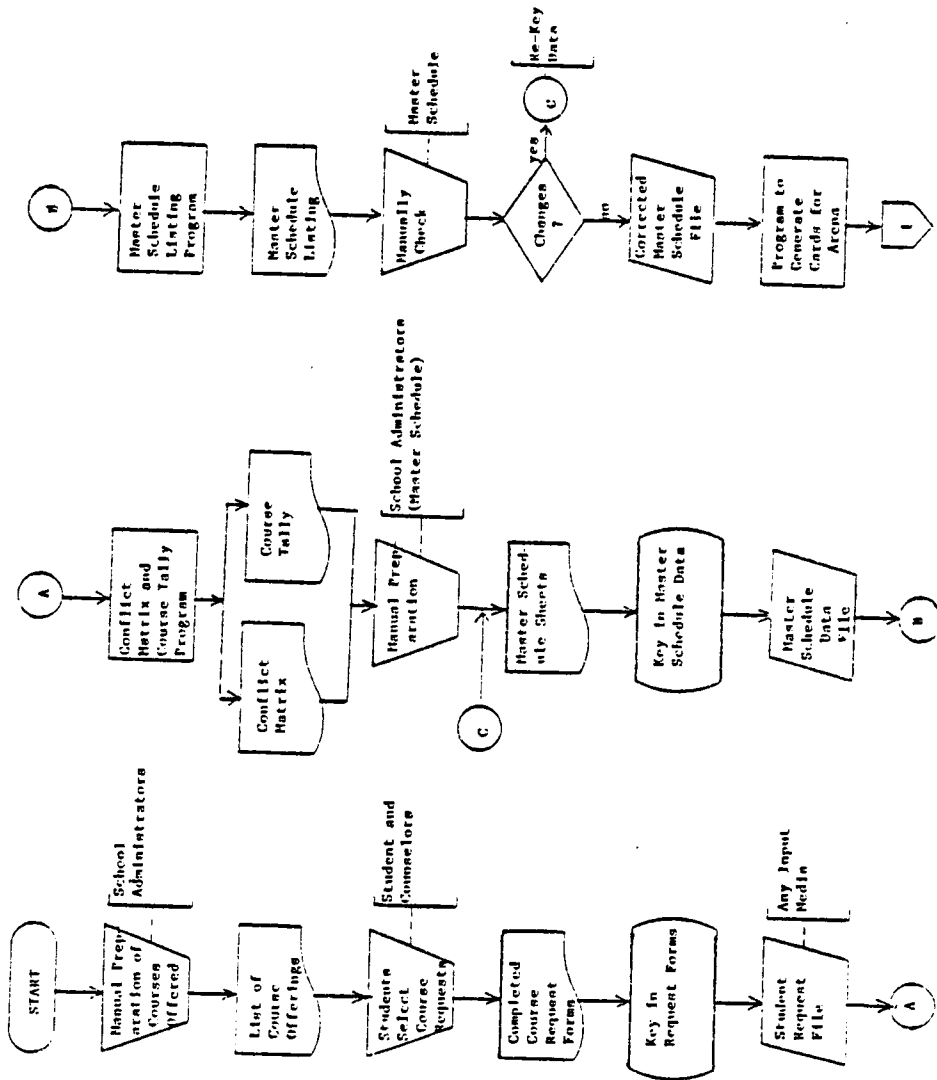


Figure 3. Arena scheduling flowchart (with computer-assisted master schedule).

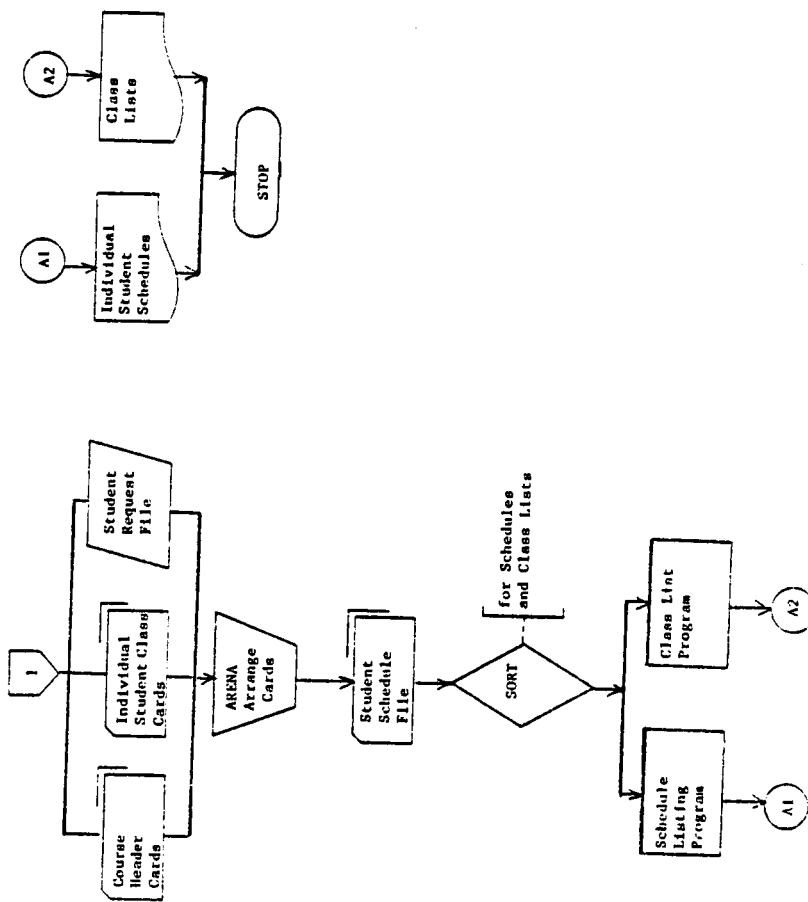


Figure 3. (Continued)

preparation of the master schedule. When student requests are not used to build the master schedule, students must fit their needs to the master schedule. Figure 3 shows how student information is created ahead of the master schedule.

C. COMPUTERIZED CLASS LOADING SYSTEMS

The second classification of school scheduling systems includes the use of the computer to load classes based on information from student course request records and a file of course offerings or the school's master schedule. In this system the master schedule may be manually prepared or use the computer to aid in the preparation of the master schedule. The preparation of the master schedule is usually done with the information generated in course tally programs and programs that check student course requests and courses offered for potential conflicts in requests for one-section and two-section courses. Such conflicts are termed singleton and doubleton conflicts in some systems.

The class loading programs take the place of the "arena" by allowing the computer to match the student requests with the offerings of the school. The algorithm or method used to load the classes is similar among the different scheduling programs. Options are available to allow the user to force the scheduling of students with conflicting courses. In this situation these students must be hand scheduled or the master schedule must be adapted to allow the students to schedule.

Several class loading systems are available for scheduling of classes. These systems include:

1. CLASS (Class Load and Student Scheduling System)--IBM
2. SAP (A part of SSSS--Stanford School Scheduling System)--
Stanford University
3. SCRIBE (System for Computerized Reporting of Information for
Better Education)--Honeywell
4. SSS/360 (School Scheduling System 360)--IBM
5. STUDENT (Scheduling Technique Using Defined ENcrements of
Time)--IBM
6. Alpha SOCRATES (Scheduling of Classes Realized Automatically
Through Effortless Systemization)--IBM
7. Beta SOCRATES--IBM
8. UPDATE (Unlimited Data Potential through Automation in
Education)--University of Iowa
9. SCHOLARS (School Automated Record System)--NCR
10. CDC (Control Data Corporation)
11. TSC (Time Share Corporation)--for Use on Digital Equipment
Corporation computers

This list does not include a variety of "homemade" or "in-house" programs prepared by individual users. Programs are also in use that are earlier or newer versions of the programs listed, and in some cases there are programs in use that are no longer supported by the original developers.

Most of the class loading packages share similar types of options. Therefore, three scheduling systems will be presented under this category as typical of class loading programs. These three include the SSS/360

(School Scheduling System 360) from IBM, the SCRIBE (System for Computerized Reporting of Information for Better Education) from Honeywell, and SCHOLARS (School Automated Record System) from National Cash Register.

SSS/360

The Student Scheduling System/360 was developed in the mid-1960's for use on the International Business Machines' Series 360 computers. The system includes a series of programs that assist school administrators in preparation of a master schedule and a program to load students into classes. The information for this example was derived from three IBM publications. The first publication gave a general overview of the scheduling system.¹ The second publication documented use of the tally and conflict matrix programs that may be used by school administrators to help develop the master schedule.² The third publication documents the actual class loading program or the program that assigns the students to classes.³

The system algorithm for the SSS/360 program is typical of the class loading types of scheduling packages. Figure 4 illustrates in flowchart form the steps taken to schedule students. Like the arena

¹International Business Machines Corporation, Student Scheduling System/360: Application Description (New York, the Corporation, 1966).

²International Business Machines Corporation, Student Scheduling System/360: The Tally and Conflict Matrix Programs (360A-US-06X) User's Manual (New York, the Corporation, 1966).

³International Business Machines Corporation, Student Scheduling System/360: The Scheduler Program (360A-US-07X) User's Manual (New York, the Corporation, 1966).

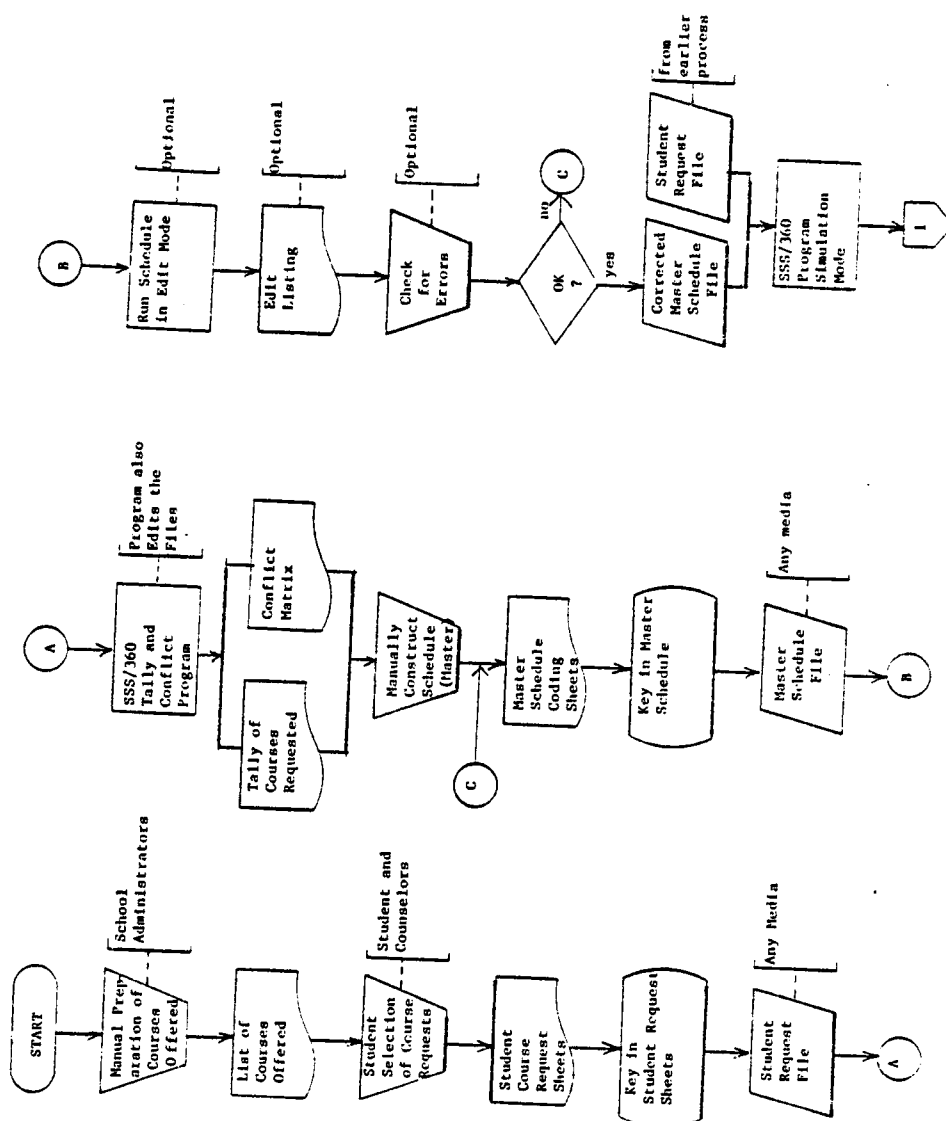


Figure 4. SSS/360 system flowchart.

system with pre-registration and computer-assisted master schedule building shown in Figure 3 (pages 37 and 38), SSS/360 allows students to request courses ahead of master schedule building. The first page of Figure 4 illustrates the procedure. After student request files and the master schedule files are completed, SSS/360 begins the steps that characterize a class-loading system. The computer is used to place students into sections of classes, rather than allowing these students to select sections.

Several scheduling runs are made in SSS/360 in its simulation mode, following an optional edit run. The simulation mode allows the user to schedule students without commitment to the result of the scheduling run. Each simulation run produces an analysis of all the course requests of students who cannot be scheduled into every one of their requests and an updated master schedule. These reports are used to improve the master schedule or to make changes in student requests if the master schedule cannot be changed. When the optimal schedule has been built, the program is run in schedule mode. During this run the final output of the scheduling process is generated. Output may include a grade card file, conflict listing, individual student schedules, class lists, updated master schedule, attendance cards, and address labels. Students who could not schedule all requests are hand scheduled.

Several options are available on the SSS/360 system. One of the major problems in any scheduling system is the assignment of study halls and lunch periods. The SSS/360 system allows for automatic study

halls for free periods. The assignment of study halls may be further enhanced by allowing the user to schedule a given number of consecutive study halls.

Lunch periods may be overlapped or staggered depending on the needs of the school system. If the lunch period is at the same time for all students, a common course card can be used to give all students lunch at the same hour.

The size limits of the scheduling program are great enough to schedule most school systems. The school may have up to 99 periods per day, up to 40 course requests per student, up to 777 course offerings per school, up to 99 sections for each course, and up to 4 semesters per year in one computer run. In addition, output of the system is written to a disk file to allow the user to generate any number of duplicate schedules, class lists, or course cards.

SCRIBE

SCRIBE (System for Computerized Reporting of Information for Better Education) was developed by Honeywell for its Student Processing System. The SPS includes a scheduling sub-system along with an attendance accounting sub-system and a grade reporting sub-system. The scheduling sub-system is the initial registration for all students. The attendance accounting and grade reporting sub-systems use the information generated by the scheduling sub-system.

The major sources of information about the Honeywell system came from Hunt⁴ and a corporate publication describing the SCRIBE system.⁵ Hunt's publication gave specific illustrations of the SCRIBE scheduling system in application. The Honeywell publication gave general information about the system algorithm and sample output from the system.

Like the SSS/360 scheduling system, the SCRIBE scheduling system provides information for users to construct a master schedule manually based on student course request information. The system is divided into three major phases. These phases include the preliminary analysis phase, the master schedule simulation phase, and the production phase.

The first phase involves the development of the master schedule through analysis of the student requests and the course offerings of the school. The master schedule is not constructed until the second phase of the system. The information generated by the first phase includes a simple tally of course requests, a course title list, a student elections list, a selective course request list, and a potential conflict matrix. This information is necessary to develop the master schedule. The first phase is similar to that of the SSS/360 system shown in Figure 4 (pages 42 and 43). The two systems are similar up to the point where the student request file is generated. SCRIBE is different from that point in that it adds a program which analyzes the

⁴ Carmela P. Hunt, Construction of a Computer-Assisted Master Schedule: Administrative Guide: SCRIBE (Waltham, Mass.: Honeywell Corporation, 1975). 103 p.

⁵ Honeywell Corporation, SCRIBE Student Processing System: Summary Description (Waltham, Mass.: the Corporation, 1974). 28 p.

requests of students. This analysis includes a student elections list, a course title list, and a selective course list, in addition to a course tally and a conflict matrix. The student elections list shows the courses requested by each student, grouped as required, optional, and alternate courses. The selective course list shows students who requested specified courses, which may be added or dropped from the master schedule if the administration chooses to do so.

The second phase of the system involves the actual construction of the master schedule and a simulation of the schedule against the requests of the students. The reports generated by the second phase of the system include a resource matrix arranged by teacher and room, a student course conflict report giving each student who is in conflict with the master schedule, a scheduled students open-period report, an updated course master list, and a summary of students scheduled, unscheduled, and partially scheduled. The information from the second phase is used to fine-tune the master schedule for a final production phase.

Once the optimum scheduling arrangements are made, the final phase or production phase prepares individual student schedules, cards for grade and attendance reports, class lists, teacher and room utilization reports, and lunch and study hall lists.

Figure 5 illustrates the three phases of the Honeywell SCRIBE system for scheduling classes. The similarity between the SSS/360 and the Honeywell system is evident. The limits of the system (using the smallest configuration of hardware) will fit most school situations

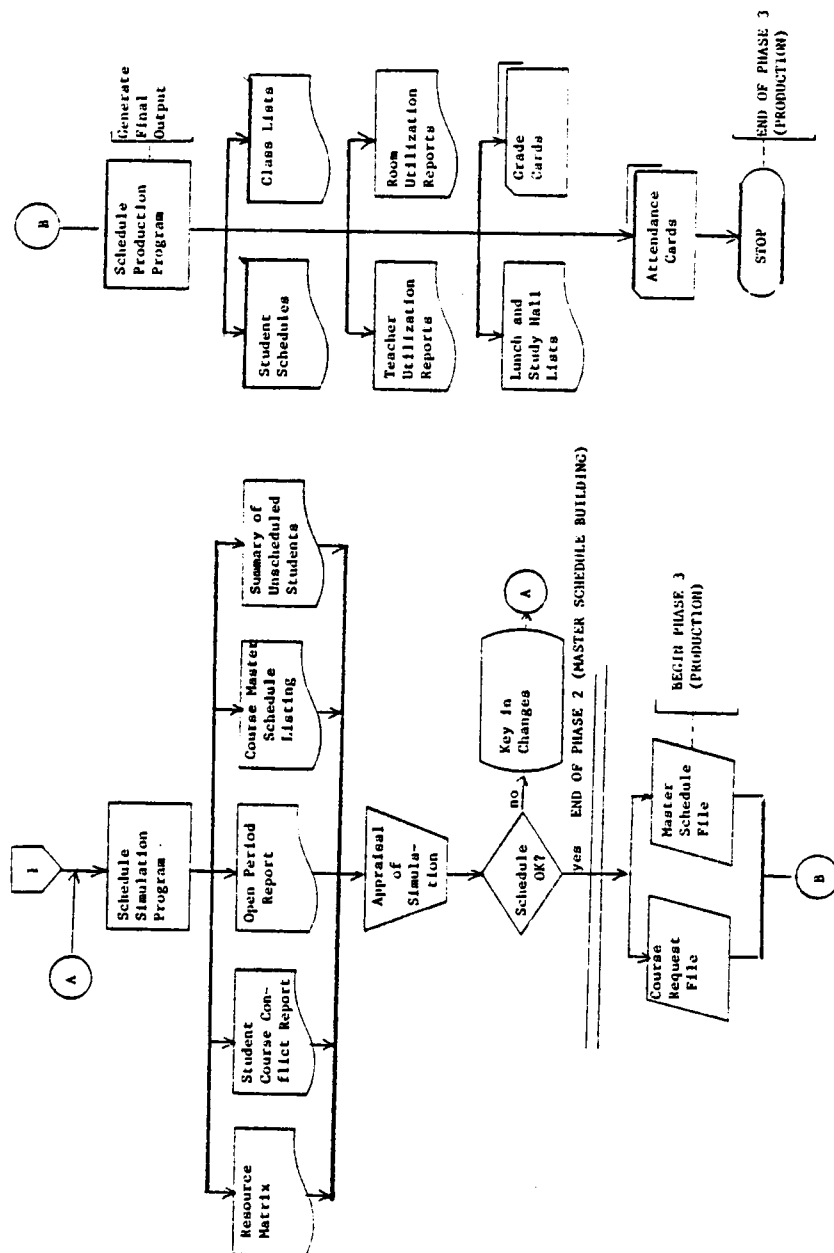


Figure 5. (Continued)

with up to 500 courses per school, up to 99 sections per course, up to 48 course requests per student, up to 99 periods or modules a day, and up to a 12-day class cycle. The system was designed to handle traditional as well as flexible modular scheduling or the ability to give students different class meeting times in a cycle of up to 12 days.

SCHOLARS

The National Cash Register (NCR) scheduling package named SCHOLARS (School Automated Record System) again is part of an overall system for maintaining school data records. The entire system includes a scheduling package and attendance, test evaluation, academic history, and grade reporting sub-systems. The primary source of information about this system was in the form of company published booklets. The NCR SCHOLARS Student Scheduling booklet⁶ was the major source of information.

The SCHOLARS system is divided into two phases. The first phase is the tally phase. The tally phase provides a simple tally of student course requests and potential conflict matrices. The system also groups the course requests into four categories including mandatory courses, preferred courses, optional courses, and alternative courses. The requests are also grouped by sex, racial group, ethnic group, shift, grade, ability level, semester requested, and mandatory, preferred, and optional courses. School administrators thus may have a variety of information for construction of the master schedule. Unlike the SSS/360

⁶NCR Corporation, NCR SCHOLARS Student Scheduling (Dayton: the Corporation, 1974) 14 p.

schedule system, the NCR SCHOLARS system gives an alphabetic description of the course on the potential conflict matrix which proves valuable for constructing the master schedule.

The system provides a course verification list by student to assure accuracy of the student requests. A combination of requests list is also provided to isolate students who request the same course configurations. This listing is useful in building the master schedule in a way to avoid offering those courses at the same time. Having the courses at different times minimizes the number of unscheduled students.

The next step in the first phase is the building of the master schedule based on data from the reports. The master schedule is built manually in a procedure similar to that of SSS/360. The master schedule file and student request file then are combined for a simulation run. That procedure produces a class period analysis, updated master schedule, unscheduled student matrix, and incomplete schedule report.

When an optimal schedule has been built, phase two, the production phase, schedules the students. SCHOLARS generates output similar to SSS/360 and SCRIBE; in addition, SCHOLARS provides teacher availability reports, room availability reports, and study hall requirements reports. The study hall requirements report is helpful in assigning students to study hall sections by period, by day, and by semester.

Figure 6 shows the system flowchart for the NCR SCHOLARS scheduling system. The parameters of the system provide adequate scheduling capability for most schools. The system allows for up to 30 requests

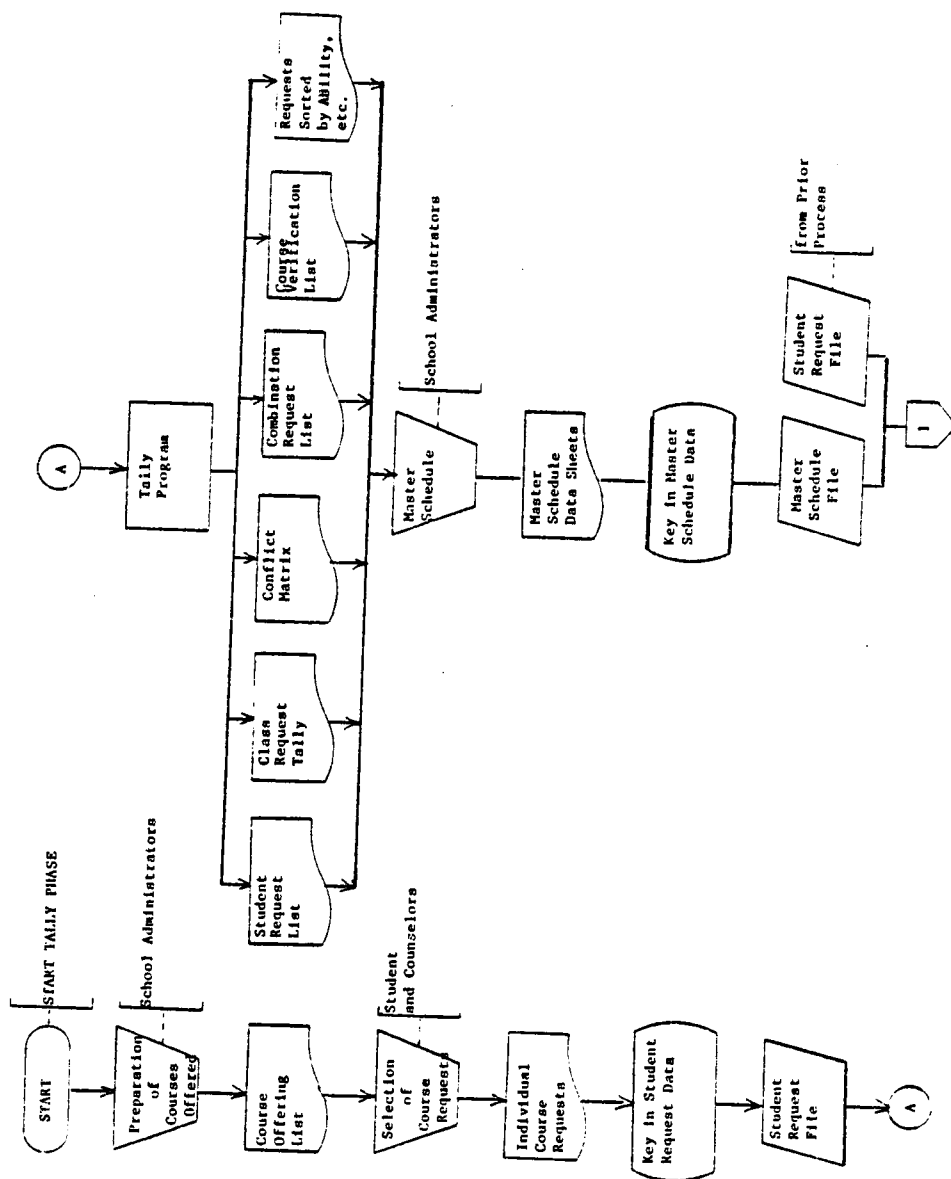


Figure 6. SCHOLARS scheduling system flowchart.

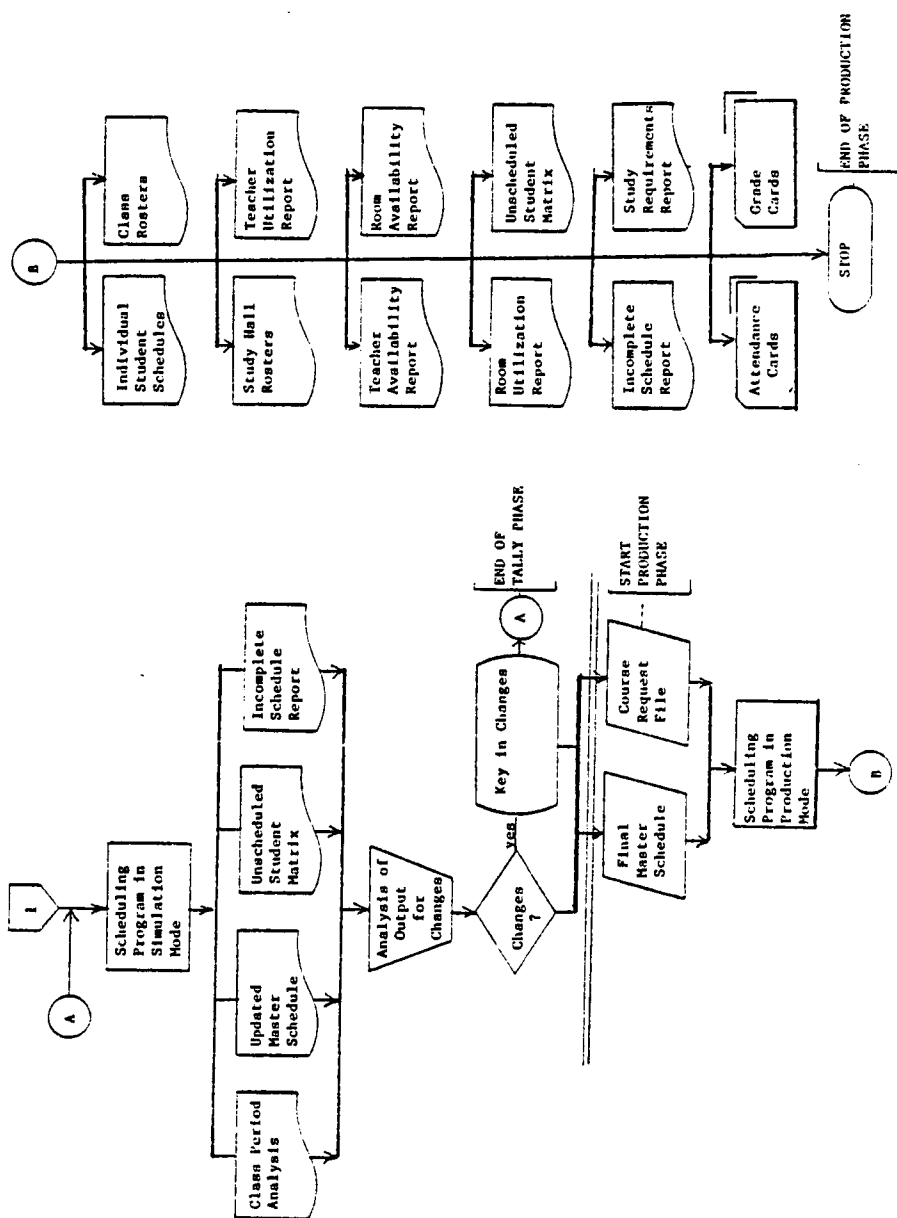


Figure 6. (Continued)

per student, 70 periods or modules per day, 4 shifts per day (increasing the ability to handle up to 280 modules per day), 8-day cycling periods, and multiple semesters.

D. COMPUTER-BUILT MASTER SCHEDULE SYSTEMS

The third classification of computerized scheduling systems is the type of system that uses the computer to build the master schedule. Under this type of system the user inputs the resources of the school such as rooms, teachers, times, courses offered, and student requests. The computer matches all of these resources and generates an optimal schedule for the school.

The use of systems that develop a master schedule is restricted to large-scale computers because of the volume of data necessary to build a master schedule. Some of the programs to build master schedules are used in conjunction with class-loading programs to allow the user to build the master schedule in one computer run and then load the classes in a subsequent run. Such is the case of the SCHOOLMASTER program developed by Brandon and Snediker⁷ of International Business Machines. The EPIC:SOCRATES system and the SSSS (Stanford School Scheduling System) also allow the user to choose between computer-assisted and computer-built master schedule development.

The two systems selected as typical of the computer-built master schedule system were the GASP (General Academic Simulation Program) and

⁷James T. Brandon and James M. Snediker, SCHOOLMASTER (New York: International Business Machines Corporation, 1966) 90 p.

the ERIC:SOCRATES systems. GASP was developed by The Massachusetts Institute of Technology. EPIC:SOCRATES is available through International Business Machines as part of an overall system for maintaining academic records. Several other systems have been developed that build master schedules. Among these are the NEEDS (New England Educational Data Systems) programs and the DDCS (Daily Demand Computer Scheduling) system developed by Brigham Young University in the late 1960's. The DDCS program was designed to schedule students on a daily basis.

GASP

The major source of information for the GASP III scheduling system was found to be the user's manual developed by William B. Kehl⁸ of Massachusetts Institute of Technology. The GASP program was first developed in 1961 by MIT under the direction of Robert E. Holz. The second version was developed in 1963, and the third version or GASP III was developed in 1966 for the IBM 7094 computers and in 1967 for the IBM 360 computer.

The GASP system uses four "dimensions" to schedule students to classes; these are time, instructors, rooms, and students. The general algorithm of the system is heuristic rather than optimal, i.e., the programs are designed to develop a workable rather than optimal solution to the scheduling problem. This design allows and encourages the user of the system to try new scheduling configurations.

⁸William B. Kehl, 360 GASP III Generalized Academic Simulation Programs (New York: International Business Machines Corporation, 1967) 288 p.

Student course requests are recorded in a manner similar to the computer-assisted class scheduling systems. Students request courses using a general list of course offerings developed by the school administrators. A data file of student course requests and constraints for the student (academic ability grouping, grade level, time constraints, etc.) are matched against the resources of the school. The resources of the school may include the available resources of the school (rooms, teachers, and classes) and the associated restrictions or constraints of these resources (time constraints of instructors, special-purpose rooms, etc.). The requests and resources are matched to build a "framework" or GASP file which may be further changed or updated until a usable schedule is reached.

Once the file has been modified to meet the needs of the school and the students, associated reports are generated for the normal administration of the school. The output of the system is similar to that of other scheduling systems. The output may include individual student schedules, class lists, room schedules, instructor schedules, and punched-card outputs for grade reporting and attendance accounting.

Unlike the simulation runs of the computer-assisted master schedule building programs, GASP generates several intermediate reports on the status of the scheduling system. These reports list such things as instructor conflicts or student conflicts. In addition to these intermediate reports, the user has a wide choice of output formats. For example, the user may choose an array-type schedule for students or a matrix type. The array type lists the courses and meeting times and

places down a page; the matrix type lists the days of the week in columns and gives the course, meeting times, and place under each daily heading in order of period or module.

The major difference of the GASP system as compared to other types of systems is that the ultimate goal of the system is a "reasonable schedule" rather than an optimal schedule. The system uses heuristics (probability and randomization) rather than a set combination of algorithms for development of schedules. The user may stop the process once a workable schedule has been obtained. The system promotes experimentation and innovation.

EPIC:SOCRATES

Four major sources of information were used to present the EPIC: SOCRATES scheduling system. These included the general information guide,⁹ an implementation self-study text,¹⁰ a user's guide,¹¹ and an operator's guide¹² provided by IBM.

⁹International Business Machines Corporation, EPIC:SOCRATES Student Scheduling System for Educational Institutions General Information (New York: the Corporation, 1973) 35 p.

¹⁰International Business Machines Corporation, EPIC:SOCRATES Implementation Self Study Student Text (New York: the Corporation, 1976) 302 p.

¹¹International Business Machines Corporation, EPIC:SOCRATES Student Scheduling System for Educational Institutions User's Guide (New York: the Corporation, 1973) 229 p.

¹²International Business Machines Corporation, EPIC:SOCRATES Student Scheduling System for Educational Institutions Operations Guide (New York: the Corporation, 1976) 173 p.

Three versions of SOCRATES have been developed for use on IBM equipment. The first two versions were the ALPHA SOCRATES and the BETA SOCRATES. Both of these systems were class-loading scheduling systems. The ALPHA version was developed for use on the 1400 series of computers in 1965. The BETA system was developed in Long Island, New York, in 1967. This version expanded the system to handle flexible modular scheduling. The current version, called EPIC:SOCRATES, was expanded to give the user the option of allowing the computer to build the master schedule.

The general system design of SOCRATES involves six sub-systems, which are (1) student registration, (2) resource allocation, (3) student assignment, (4) scheduling evaluation, (5) schedule reporting, and (6) data file maintenance. Each of these sub-systems allows the user to evaluate along the way and make changes in the schedule before total commitment to the schedule.

Figure 7 illustrates the general flow of data through the EPIC:SOCRATES system and the inputs, processes, and outputs generated by the system. The first phase or preliminary processing phase is similar to that of any class-loading system. Student request information acts as input for a tally-verification program, which produces a course tally, a course verification, and a student verification report. A conflict matrix is also prepared because the administrator may choose to build the master schedule manually. The verification process continues until the data are ready for the scheduling process.

The reports produced by the preliminary processing phase are used in a manual process to complete a set of three resource information

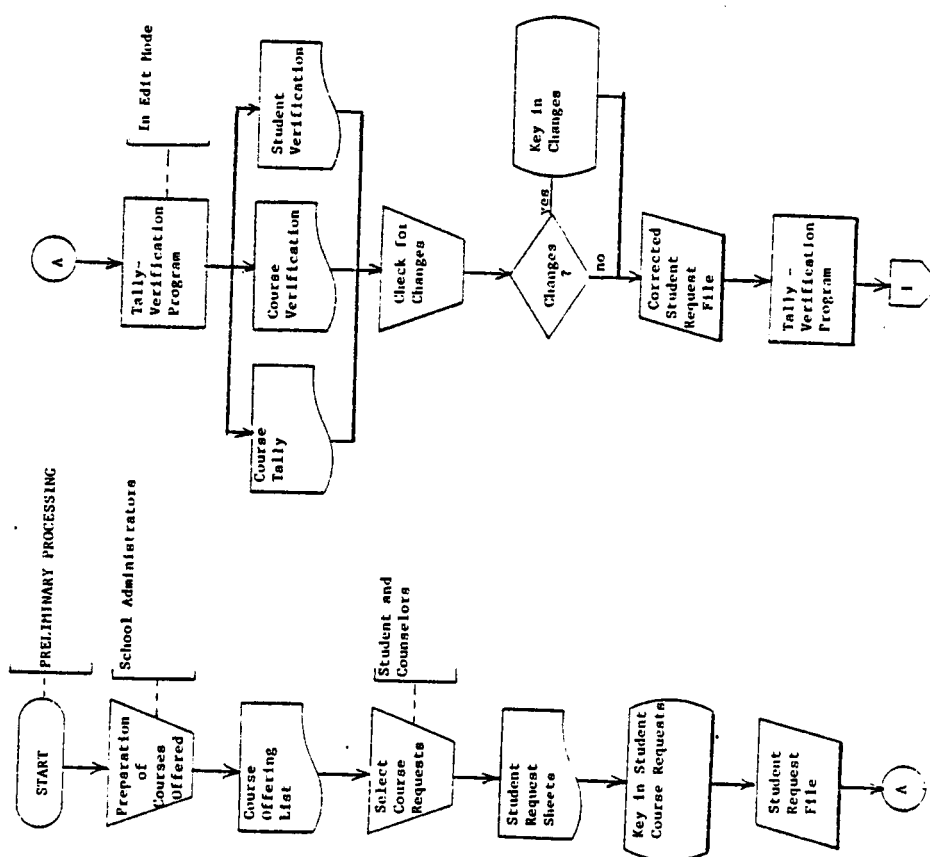


Figure 7. EPIC:SOCRATES system flowchart.

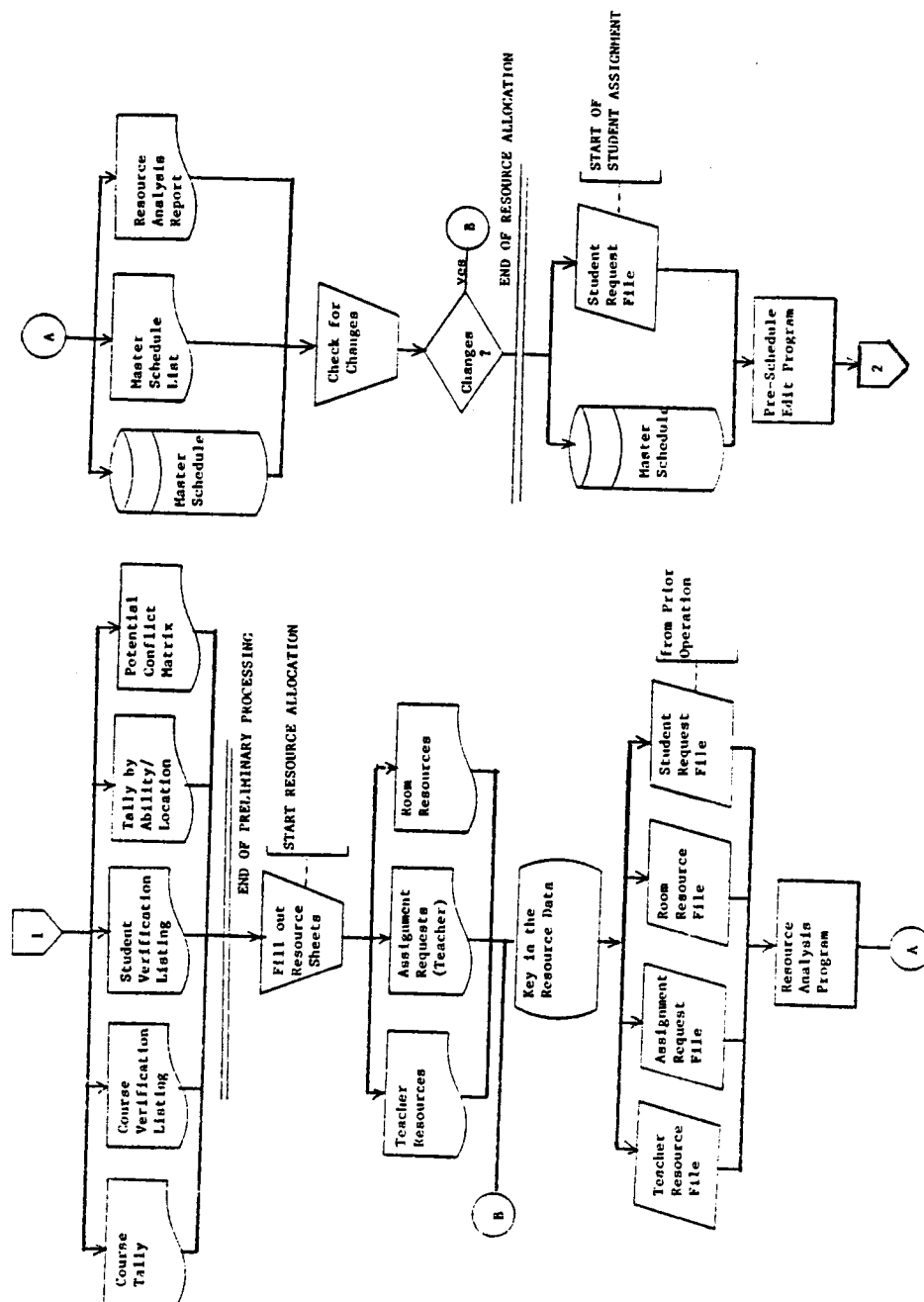


Figure 7. (Continued)

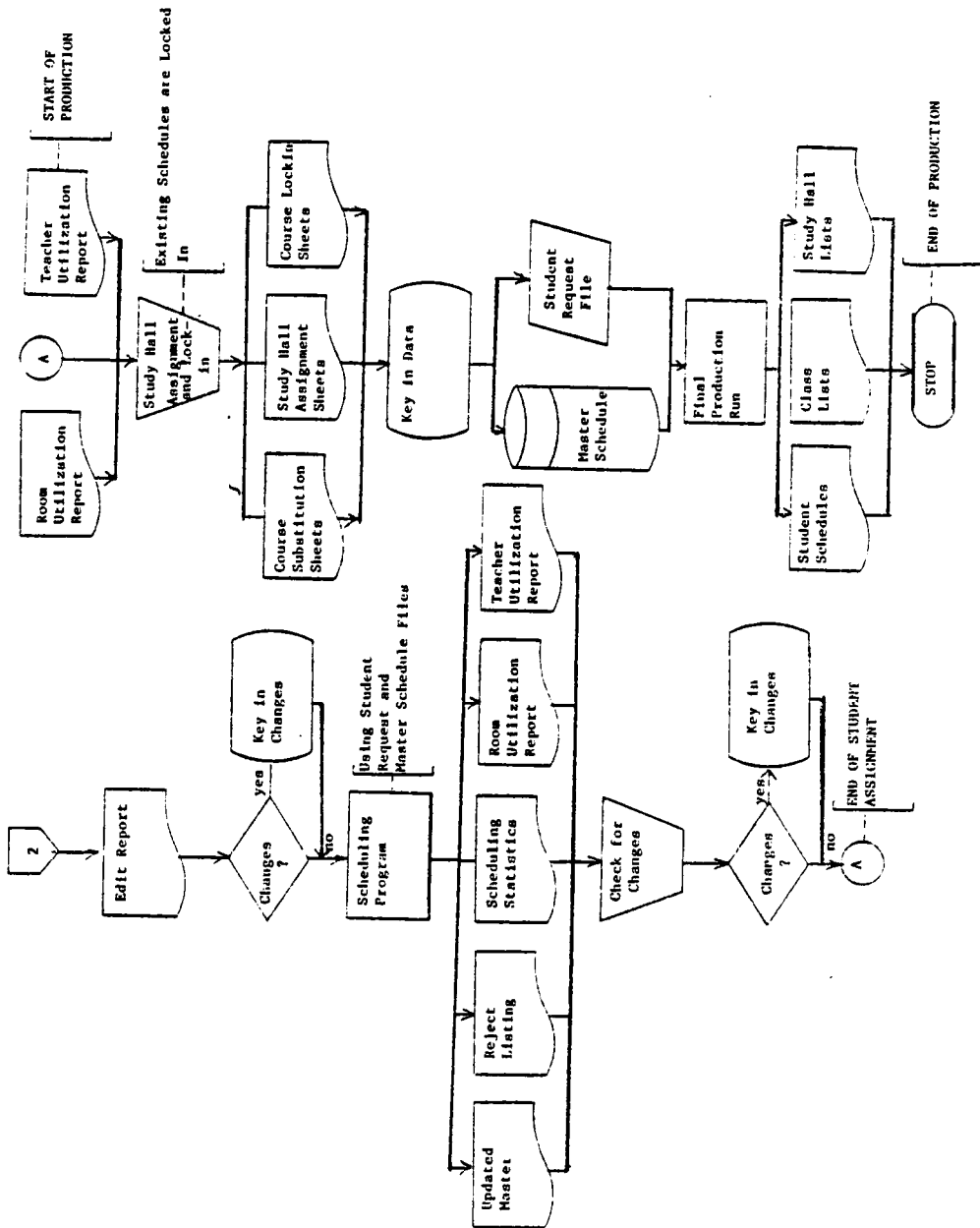


Figure 7. (Continued)

forms, which include (1) teacher resources, (2) assignment requests, and (3) room resources. This information is used to build three files, which are input for the resource analysis program. The resource analysis program, along with a student request file, builds a master schedule. The output from this program includes the master schedule file, a master schedule list, and resource analysis report. The resource analysis report includes teacher and room utilization. When all data are acceptable to the administrator, the student assignment phase begins with a pre-schedule edit. The edit is followed by a standard class-loading program, which operates as a simulation run until optimal scheduling is achieved. Reports in this phase are similar to those of other class-loading scheduling systems. Classes scheduled do not include study halls.

Individual student schedules are not printed in this phase. Instead acceptable schedules and partial schedules are stored on disk as a result of several scheduling passes. Courses are scheduled on a priority level, beginning with highest priority given to one-section courses, next priority to two-section courses, and then all courses with three or more sections.

The final phase or production phase begins with the assignment of students to study halls for all of their free periods. Information about study halls is furnished by the room utilization and teacher utilization reports. At the same time course substitution specifications and course lockin specifications are entered into the system. Courses to be substituted can be specified before the final production run,

allowing administrators to drop or add courses near the opening of school. Lockin specifications prevent changes in schedules that have already been produced while study hall assignments are being made. The final phase provides output similar to that of other programs that do not build the master schedule.

The major difference between SOCRATES and systems that do not build master schedules is that input information and scheduling output can be stored in a data base, which is updated, not replaced, in the various phases of the scheduling system. A data maintenance sub-system saves that information.

E. SCHEDULING OPTIONS AVAILABLE

All of the systems described in this chapter are designed to meet the needs of individual schools for the scheduling of their classes. Various options are available to meet those needs. Selection of a system depends to some extent on the choices of options that will fit the needs of the school. SSS/360, SCHOLARS, SCRIBE, and EPIC:SOCRATES all have some options in common. All four are class-loading programs; all provide for semester balance, sex balance, section balance, course-to-course linkage, large- and small-group instruction, split classes, alternate courses, co-requisite courses, course substitutions, automatic study halls, lunch period scheduling, and partial scheduling, as shown in Table I.

Three systems, SCHOLARS, SCRIBE, and EPIC:SOCRATES, provide options for racial balance, ethnic balance, teacher free-time requests,

TABLE I
COMPARISON OF OPTIONS AND LIMITATIONS OF
FOUR WIDELY USED SCHEDULING SYSTEMS

Description	SSS/360	SCHOLARS	SCRIBE	EPIC:SOCRATES
<u>Options Available</u>				
Class Loading	yes	yes	yes	yes
Semester Balance	yes	yes	yes	yes
Sex Balance	yes	yes	yes	yes
Section Balance	yes	yes	yes	yes
Course-to-Course Linkage	yes	yes	yes	yes
Large/Small Group Instruction	yes	yes	yes	yes
Split Classes	yes	yes	yes	yes
Alternate Courses	yes	yes	yes	yes
Co-requisite Courses	yes	yes	yes	yes
Course Substitution	yes	yes	yes	yes
Automatic Study Hall	yes	yes	yes	yes
Lunch Period Scheduling	yes	yes	yes	yes
Partial Scheduling	yes	yes	yes	yes
Racial Balance	no	yes	yes	yes
Ethnic Balancing	no	yes	yes	yes
Teacher Free Time Requests	no	yes	yes	yes
Grade Level Restriction	no	yes	yes	yes
Prerequisite Course Restriction	no	yes	yes	yes
Section Election	no	no	yes	yes

TABLE I (Cont'd)

Description	SSS/360	SCHOLARS	SCRIBE	EPIC:SOCRATES
<u>Options Available (Cont'd)</u>				
Teacher Election	no	no	yes	yes
Room Restrictions for Students	no	no	yes	yes
Ability Level of Students	no	no	yes	yes
Schedule Locking	no	no	yes	yes
Update Scheduling	no	no	yes	yes
Computer-Built Master Schedule	no	no	no	yes
<u>Limitations</u>				
Maximum Number of Periods or Modules Per Day	99	70	99	100
Maximum Number of Course Offerings	777	na*	500	na
Number of Sections of Course	99	na	99	na
Maximum Number of Student Requests Per Student	40	30	48	99
Maximum Number of Cycles	1	8	12	8
Maximum Number of Semesters	4	"Multiple" **	na	5

*Information not available.

**System documentation does not specify a maximum number.

grade level restrictions, and prerequisite courses. However, through manipulation of input some of these options may be built into the SSS/360 system. For example, teacher free-time requests can be considered as the master schedule is manually built. Different student request sheets for each grade level with course numbers unique to each grade level can effectively group students by grade level.

Section election, teacher election, room restrictions for students, ability levels of students, schedule locking, and update schedule are available in the SCRIBE and EPIC:SOCRATES systems. Through manipulation of student request input, some of these options can be used in SSS/360 and SCHOLARS. For example, different course numbers can be restricted to certain ability levels. Course numbers can be assigned by teacher or section, if desired, which limits those sections or teachers to certain groups of student requests. Schedule locking and update schedule can be used only with systems that retain the student schedules generated in simulation runs. Only SOCRATES has the capability to build a master schedule.

All scheduling systems have certain limitations. The maximum number of periods or modules to be scheduled in a day must be specified in any system. The four systems reported here have a maximum number of periods or modules varying from 70 to 100. Two systems specify the maximum number of course offerings: SSS/360, 777, and SCRIBE, 500. Both of those systems also specify a maximum number of sections per course of 99. The maximum number of student requests per student vary from 30 for SCHOLARS to 99 for EPIC:SOCRATES. SSS/360 allows 40 requests, and SCRIBE allows 48 requests per student.

Each system is capable of scheduling a certain number of days in a cycle to permit the description of special irregular day patterns. SSS/360 can schedule on a six-day cycle; SCHOLARS and EPIC:SOCRATES can schedule on an eight-day cycle; SCRIBE offers a 12-day cycle. SSS/360 and EPIC:SOCRATES specify a maximum number of semesters to be scheduled in a scheduling run.

CHAPTER IV

PROCEDURES FOR COLLECTING AND ANALYZING DATA

The purpose of this chapter is to show procedures involved in assessing the current status of computerized school scheduling in the United States. This chapter presents the procedures used to (1) determine the schools to be sampled, (2) develop the school applications and technical information questionnaires, (3) collect and follow up returned questionnaires, (4) analyze the returned questionnaires, (5) develop the case study interview questionnaire, and (6) report on the case studies.

A. DETERMINATION OF THE SAMPLE

One of the difficult tasks in this study was the determination of the sample of school systems to be surveyed. The major deterrents to the use of a statistically determined stratified random sample were:

1. The prohibitive cost that would have been incurred in sampling all secondary schools to isolate schools that use a computerized school scheduling system,

2. The use of schools with high enrollments would have biased the outcome in favor of scheduling systems that require large computer systems,

3. The use of vendor-provided lists of school systems would have left out user-made or non-vendor-provided scheduling systems, and

4. The vendors of scheduling software maintain a policy of not giving information about users of their software in order to maintain a confidential relationship.

The primary source of address information for this study was the State Departments of Education. A letter was sent to all of the State Departments of Education within the continental United States. Initial letters were sent to all 50 states and the District of Columbia. The letter was directed to the Commissioner of Education and requested the names and addresses of up to ten schools in the state that were using the computer to schedule students into classes (see Appendix B--Letter to State Departments of Education).

The same letter was used as a follow-up to non-responding states with an additional reminder message. As the names and addresses of schools came in, they were keyed to a disk data file which was later used to generate address labels for mailing questionnaires and results of the study. The number of names and addresses received from each state ranged from zero to almost one hundred for states with regional computing centers serving several school systems. In some cases only the service centers or names of school systems were listed. In those cases addresses were located in Patterson's American Education.¹

Seven states listed eleven to thirteen school systems using computerized scheduling. All of those school systems were included in the sample for this study. Other states listed fewer than ten school

¹Patterson's American Education (Mt. Prospect, IL: Educational Directory, Inc., 1978).

systems, and all of the reporting school systems were used for those states. Five states sent directories of all school systems in their states; for those states, ten school systems were selected to give a geographic distribution within the state.

Names of schools from non-responding states were gathered by the researcher while attending the 1978 meeting of the Association of Education Data Systems in Atlanta, Georgia. If State Departments of Education did not submit names of school systems, members from those states were asked to give the names and addresses of up to ten schools in their states using computerized scheduling. These members were given a memorandum that explained the purpose of the study, a self-addressed stamped envelope, and a sheet to record the names and addresses for return (see Appendix B--Memo to AEDS Members and Address Sheet).

A total of 393 names and addresses of school systems or data processing centers was accumulated by these methods. Forty-eight states and the District of Columbia responded with names and addresses. Table II shows the breakdown by state.

B. DEVELOPMENT OF THE SCHOOL APPLICATIONS AND TECHNICAL INFORMATION QUESTIONNAIRES

An extensive search of related literature yielded an abundant amount of information for the development of the survey instruments in this study. From this review a delineation between information applying to the school applications of computerized scheduling systems and

TABLE II
QUESTIONNAIRE RESPONSES BY STATE OR DISTRICT

State or District*	Number Sent	Received School Applications			Received Technical Questionnaire			Matched Pairs	Percentage
		Questionnaire		Total	Questionnaire		Total		
		First	Second		First	Second			
Alabama	9	1	2	3	1	1	2	2	22.2
Arizona	5	1	2	3	1	2	3	3	60.0
Arkansas	10	1	4	5	1	2	3	1	10.0
California	8	3	2	5	4	2	6	4	50.0
Colorado	9	5	1	6	5	1	6	6	66.7
Connecticut	10	1	2	3	1	2	3	3	30.0
Delaware	6	1	2	3	1	2	3	3	50.0
District of Columbia	10	0	2	2	0	1	1	1	10.0
Florida	11	6	2	8	6	2	8	8	72.7
Georgia	4	2	1	3	2	1	3	2	50.0
Idaho	9	5	1	6	5	1	6	6	66.7
Illinois	5	4	2	6	4	1	5	5	100.0
Indiana	9	6	0	6	5	1	6	6	66.7
Iowa	5	1	3	4	1	3	4	4	80.0
Kansas	7	3	1	4	3	1	4	4	57.1
Kentucky	13	1	3	4	0	3	3	3	23.1
Louisiana	7	5	1	6	5	1	6	6	85.7
Maine	6	4	2	6	3	2	5	4	66.7
Maryland	4	2	0	2	2	0	2	2	50.0
Massachusetts	8	0	2	2	0	2	2	2	25.0

TABLE II (Cont'd)

State or District*	Number Sent	Received School Applications Questionnaire			Received Technical Questionnaire			Matched Pairs	Percentage
		First		Total	First		Total		
		Second	Third		Second	Third			
Michigan	10	2	3	5	3	1	4	4	40.0
Minnesota	10	4	3	7	5	2	7	7	70.0
Mississippi	5	0	0	0	0	0	0	0	0.0
Missouri	7	1	2	3	1	1	2	2	28.6
Montana	3	0	0	0	0	0	0	0	0.0
Nebraska	4	3	1	4	3	1	4	4	100.0
Nevada	9	1	0	1	0	1	1	1	11.1
New Hampshire	12	3	3	6	2	1	3	3	25.0
New Jersey	7	3	3	6	3	3	6	6	85.7
New Mexico	5	3	0	3	3	0	3	3	60.0
New York	13	5	4	9	5	3	8	8	61.5
North Carolina	7	1	1	2	1	0	1	1	14.3
North Dakota	8	5	1	6	6	0	6	6	75.0
Ohio	11	2	4	6	2	3	5	5	45.5
Oklahoma	10	4	1	5	3	1	4	4	40.0
Oregon	6	3	2	5	3	1	4	4	66.7
Pennsylvania	7	1	2	3	1	2	3	3	42.9
Rhode Island	4	2	1	3	2	1	3	3	75.0
South Carolina	10	3	3	6	4	2	6	6	60.0
South Dakota	4	3	1	4	4	0	4	4	100.0

TABLE II (Cont'd)

State or District*	Number Sent	Received School Applications			Received Technical Questionnaire			Matched Pairs	Percentage
		Questionnaire			Questionnaire				
		First	Second	Total	First	Second	Total		
Tennessee	9	3	2	5	3	2	2	5	55.6
Texas	8	1	4	5	2	4	6	4	50.0
Utah	9	4	2	6	7	0	7	6	66.7
Vermont	6	1	0	1	1	0	1	1	16.7
Virginia	13	2	2	4	2	1	3	3	23.1
Washington	10	1	5	6	3	3	6	6	60.0
West Virginia	10	2	1	3	2	1	3	3	30.0
Wisconsin	11	5	1	6	6	0	6	6	54.5
Wyoming	10	0	2	1	0	0	0	0	0.0
Totals	393	120	89	209	127	65	192	183	
Percentages	100.0	30.5	22.6	53.2	32.3	16.5	48.9	46.6	

*Alaska and Hawaii excluded.

information related to the technical aspects of scheduling was evident. Because of this delineation two questionnaires were developed, one for the school personnel and one for school technical representatives or those in charge of the actual computer processing.

A search through users' guides and other scheduling program documentation aided in the development of several prototype questionnaires for both applications. The prototypes were refined by the use of visitations to experts in charge of scheduling in three large school systems and colleges providing scheduling services for area high schools. Visits were made to Oak Ridge and Nashville, Tennessee, and Atlanta, Georgia, to visit three city school systems and George Peabody College.

The questionnaires were typed on large sheets and reduced to make them less cumbersome for respondents. Samples of the two questionnaires are in Appendix C of this report. The surveys were duplicated so that they could be folded and returned to the researcher by business-reply mail.

The questionnaires were sent to 393 school systems or school data processing service centers in October, 1978. The mailing included a cover letter that explained the purpose of the study and gave instructions for completion, a consent form that is required for research by the Helsinki Accords of 1975, and the two questionnaires. Copies of the cover letter and questionnaire with consent form are shown in Appendix B.

C. QUESTIONNAIRE RETURNS AND FOLLOW-UP

Returns of questionnaires were by business-reply mail. Questionnaires were arranged in folders by state, and addresses were checked off on the master list as they were returned. Code numbers matched the school applications questionnaire with the technical information surveys.

The results of two mailings are shown in Table II, pages 71-73. The percentages of returns based on total numbers sent are given for each state. The total percentages of returns for the first mailing were 30.5 percent for school applications questionnaires and 32.3 percent for the technical information questionnaires. The total numbers of returns were 120 for school applications surveys and 127 for technical information questionnaires.

The second mailing was made to non-responding schools or data processing representatives. The two questionnaires, the first cover letter, and a follow-up memorandum were sent to individual schools or data processing representatives that (1) did not respond at all, (2) responded to the school applications questionnaire only, or (3) responded to the technical information questionnaire only. A handwritten note was added to the memorandum indicating which questionnaire was needed. A copy of the memorandum is in Appendix C.

Four weeks after the first mailing a second copy of both questionnaires was sent to all school systems that had not yet responded. Eighty-nine school systems responded to the school applications

questionnaire after the second mailing, for 22.6 percent of the total questionnaires sent. Sixty-five, or 16.5 percent, of the total technical information questionnaires were returned after the second mailing.

Total return for the school applications questionnaire after both mailings was 209, or 53.2 percent of the total sent. However, eight of those returns were from school systems which are not currently using computerized scheduling. In the second mailing, non-respondents were instructed to return only questionnaires which they had not completed. However, four school systems returned both the specified questionnaire and the one already completed. Nine were from school systems which did not forward the technical questionnaires and did not provide an address to which the follow-up questionnaire could be sent. Five were received from school systems for which no technical information questionnaire was received, even after the follow-up mailing.

The technical information questionnaires returned were 192 out of 393, or 48.9 percent of the total. Two of those questionnaires were returned by school systems no longer using computerized scheduling. Three were duplicates, returned by school systems who responded twice to the questionnaire when the follow-up mailing specified that they were to respond only to the school applications questionnaire. Three questionnaires were from systems which did not give an address to which the school applications questionnaires could be sent. One technical questionnaire was received for which no school applications questionnaire was received.

Without a response to both questionnaires for a school system, the profile of a school's scheduling system was incomplete. By itself, the school applications questionnaire could apply to school systems which schedule manually and did not use computerized scheduling. The technical information questionnaire furnished information about the hardware and scheduling packages that could not always be furnished by the school personnel. The school applications questionnaire described options available to school administrators; the technical information questionnaire described the characteristics of a scheduling systems that implemented those choices. Because of the interrelationship between information on the two questionnaires, only questionnaires were used for which matched pairs were received.

The two mailings yielded 183 matched pairs of questionnaires for analysis. This figure represented 46.6 percent of the total number of questionnaires sent or a loss of 6.6 percent of the school applications questionnaires and 2.2 percent of the technical information questionnaires because of matching the pairs of questionnaires (Table II, pages 71-73).

D. PROCEDURES FOR ANALYSIS OF THE QUESTIONNAIRE DATA

Procedures for analysis of the questionnaire data involved three basic steps. The first step was to code the data into computer-usable form. Two coding templates were used to convert the data from the questionnaires to coding forms. The coding forms are shown in Appendix D. The coding sheet information was then punched into standard

eighty-column data processing cards and was later placed on a disk file for the DEC-10 computer for analysis.

The second step involved the use of user-developed software for analysis of the data and commercially available statistical analysis software packages. The analysis of data was performed on the Digital Equipment Corporation's Model 10 computer housed in The University of Tennessee Computer Center, using the DEC statistical package.

Analysis of the data included tallies and percentages. Because the questionnaires were in the form of a checklist and the study is descriptive in nature, analysis was restricted to these forms. No comparative analysis was made.

The third step involved the combining and dividing of data into tables for presentation of useful information. This step involved the classification of information by types of school scheduling systems, types of computers, and other related groupings.

E. VISITATIONS AND REPORTING OF CASE STUDIES

The purpose of the case studies was to provide specific examples of the three most widely used computerized scheduling systems. The interview questionnaire was used to supplement the questionnaires for school applications and technical information. The questionnaires were directed toward the managerial functions related to the scheduling of classes by computer. These functions included planning, organizing, staffing, directing, controlling, and innovating. The questionnaires were primarily directed toward the information related to the technical

information questionnaires because the computer installations were visited during the case study investigations.

Three school data processing installations were visited for the case studies. These installations were selected because of the type of school scheduling systems used and the geographic areas. The three school systems used SSS/360, the SCRIBE, and the EPIC:SOCRATES systems, the three most widely used systems. Locations of the installations were in the Southeast, the Far West, and the Northeast parts of the United States.

Narrative descriptions of the case study visits are reported in Chapter V, and a summary of the findings is located in Chapter VI. Appendix E contains a copy of the visitation questionnaire.

CHAPTER V

PRESENTATION OF THE DATA

This chapter reports the analysis of the data for the study which assessed the current status of computerized scheduling of classes. This chapter presents data collected from school applications questionnaires, technical information questionnaires, and case study visitations to three school systems using the most popular scheduling systems. This chapter is organized into three sections, each describing a major source of data and the current status of computerized class scheduling.

The school applications questionnaire assessed the environment of schools using computerized class scheduling. The technical information questionnaire was used to collect data on the hardware and available software for meeting the scheduling needs of the schools completing the school applications questionnaire. The case studies present a profile of systems using the three most often used scheduling program packages.

A. SCHOOL APPLICATIONS QUESTIONNAIRES

The first part of the school applications questionnaire asked for general information about the school system: name and address of the system and respondent, the number of years the system has used computerized scheduling, the number of different scheduling systems used, and enrollment information. Table III shows how many responding school systems had used computerized scheduling for each of several

TABLE III

YEARS OF USE OF COMPUTERIZED SCHEDULING
BY RESPONDING SCHOOLS

Years	Number	Percent of Total (N = 183)
1 - 4	12	6.6
5 - 8	54	29.5
9 - 12	77	42.1
13 - 16	15	8.2
17 - 20	7	3.8
No Response	<u>18</u>	<u>9.8</u>
Totals	183	100.0

categories of time. Of 183 school systems 54.1 percent have used computerized scheduling for nine or more years. Only 12 systems, or 6.6 percent, indicated that they had used the computer for under five years. The most frequent range reported was nine to twelve years, or 42.1 percent of the total respondents. No school system reported using the computer for scheduling for more than 20 years.

School system enrollments ranged from under 500 students to over 100,000 students. No one enrollment size of school system used computerized scheduling more than others, as Table IV shows. A majority of school systems (50.3 percent) had an enrollment of fewer than 5,500 students. Three fourths of the responding systems had enrollments of fewer than 20,000 students.

Of the reporting school systems, 153, or 83.7 percent, indicated that they had used three or fewer different scheduling packages. The range of the number of different scheduling packages was one to seven. The most frequent number of different packages was two with 68, or 37.2 percent, of the school systems.

None of the school systems charged a student fee for scheduling services. The majority provided funding through their general budget. Sixty-three, or 34.4 percent, had a specialized budget appropriation for funding (see Table V). A large share of scheduling service was provided by school systems (47.5 percent) or a state or regional consortium. (21.9 percent). Private service bureaus or universities or colleges provided school scheduling services for about one fifth of the systems (13.7 percent and 7.1 percent, respectively). Six, or 3.3 percent,

TABLE IV
TOTAL STUDENT ENROLLMENT IN
RESPONDING SCHOOL SYSTEMS

Enrollment	Number	Percent of Total (N = 183)	Cumulative Percent
Under 5000	1	0.5	0.5
500-999	7	3.8	4.3
1,000-1,499	15	8.2	12.5
1,500-1,999	13	7.1	19.6
2,000-2,499	14	7.7	27.3
2,500-2,999	12	6.6	33.9
3,000-3,499	11	6.0	39.9
3,500-3,999	5	2.7	42.6
4,000-4,999	10	5.5	48.1
5,000-5,499	4	2.2	50.3
5,500-6,499	11	6.0	56.3
6,500-7,499	5	2.7	59.0
7,500-8,499	4	2.2	61.2
8,500-9,499	6	3.3	64.5
9,500-11,999	6	3.3	67.8
12,000-19,999	15	8.2	76.0
20,000-29,999	16	8.7	84.7
30,000-39,999	7	3.8	88.5
40,000-59,999	4	2.2	90.7
60,000-99,999	1	0.5	91.2
Over 100,000	<u>2</u>	<u>1.1</u>	<u>92.3</u>
Total Responses	169	92.3	92.3
No Response	<u>14</u>	<u>7.7</u>	<u>7.7</u>
Totals	183	100.0	100.0

TABLE V
SOURCES OF FUNDING AND SERVICES FOR COMPUTERIZED
SCHEDULING USED BY RESPONDING SCHOOL SYSTEMS

Description	Number of Responses	Percent of Total (N = 183)
<u>Source of Funding</u>		
Specialized Budget Appropriation	63	34.4
Part of General Records-Keeping Budget	102	55.7
Special Student Fees	0	0.0
Other	8	4.4
No Response	10	5.5
<u>Source of Scheduling Services</u>		
Private Service Bureau	25	13.7
School-Owned or Leased Equipment	87	47.5
Nearby College or University	13	7.1
Another Larger School System	6	3.3
Intermediate School Unit, Regional Unit or State Consortium	40	21.9
Other	12	6.6

of the systems used the facilities of a larger school system for scheduling.

Schools used a variety of configurations of the school day and year for scheduling and for the number of scheduling runs per year. Table VI summarizes responses to the item "Check all descriptions that apply to your school." Most systems (84.2 percent) scheduled by semester; most had double periods or longer blocks. About one-third scheduled by quarter, and 37.7 percent had split-day classes. One-third re-enrolled students each semester or quarter, indicating several scheduling runs per year. However, 45.4 percent had only one scheduling run per year.

Table VII shows the responses to the number of class periods or modules per day and the duration of these periods. Scheduling 14 or more periods in a school day would indicate the use of modules in the scheduling system. Two-thirds of the school systems had a school day of five to seven periods. A majority of systems (54.1 percent) used a class period of 46 to 55 minutes. Only eight, or 4.4 percent, used periods of 11 to 30 minutes, indicating the use of modular scheduling.

Many of the scheduling programs had a number of options available for the school system and the student. The options available on most programs are listed in Table VIII. The school systems surveyed used four balancing options. Almost one-half (47.5 percent) used the sex balance option to assure that both females and males were scheduled into certain sections or courses, if both sexes had requested them. The balancing option most used was the one that provides optimal balancing

TABLE VI
 DESCRIPTIONS OF ORGANIZATION OF SCHOOL SYSTEMS USING
 COMPUTERIZED SCHOOL SCHEDULING

Descriptor	Number of Responses*	Percent of Total (N = 183)
Semester Basis	154	84.2
Quarter Basis	66	36.1
Nine-week Courses	43	23.5
Six-week Courses	10	5.5
Mini-Courses	32	17.5
Split Days (MWF-TR) Classes	69	37.7
Double Periods	101	55.2
Block Courses (More than Two Periods)	110	60.1
Re-enrollment Each Semester or Quarter	61	33.3
Several Scheduling Runs Per Year	84	45.9
One Scheduling Run Per Year	83	45.4
Multi-Campus School	26	14.2
Rotating Schedules (Individual Classes Meeting at Different Times Each Day)	19	10.4

*Some systems responded to more than one category.

TABLE VII
NUMBER AND DURATION OF PERIODS IN SCHOOL DAY
OF SCHOOLS USING COMPUTERIZED SCHEDULING

Range	Number	Percent of Total (N = 183)
<u>Periods Per Day</u>		
5 to 7	122	66.7
8 to 10	37	20.3
11 to 13	4	2.1
14 to 18	5	2.7
19 to 27	5	2.7
No Response	10	5.5
<u>Duration of Periods in Minutes</u>		
11 to 30	8	4.4
31 to 45	40	21.9
46 to 55	99	54.1
Over 55	14	7.6
No Response	22	12.0

TABLE VIII
 OPTIONS IN SCHEDULING PACKAGES USED BY RESPONDING
 SCHOOL SYSTEMS IN COMPUTERIZED SCHEDULING

Description	Number of Responses*	Percent of Total (N = 183)
<u>Balancing</u>		
Sex Balance of Classes	87	47.5
Class Size Balance of Several Sections of Same Class	159	86.9
Semester Balance	85	46.4
Racial or Ethnic Balance	26	14.2
<u>Lockout or Restrictions</u>		
Ability Restrictions (Ability Grouping)	68	37.2
Grade Level Restrictions	90	49.2
Prerequisite Courses	51	27.9
Student Overload Restrictions	124	67.8
<u>Student Options</u>		
Selection of a Particular Teacher	50	27.3
Selection of a Particular Time or Section	82	44.8
Course Substitutions	62	33.9
Alternative Courses	97	53.0
Co-Requisite Courses	15	8.2
<u>Other Options</u>		
Room Restrictions for Certain Classes	64	35.0
Automatic Study Hall for Free Periods	92	50.3
Lunch Period Restrictions	49	26.8
Course Sequencing	25	13.7
Others	5	2.7

*Multiple responses by many school systems.

among several sections of the same course. That option attempts to schedule students to the greatest possible extent in equal numbers among sections. Semester balance was used by 85 school systems, or 46.4 percent; and racial and ethnic balance options by 26, or 14.2 percent, of the systems.

Restrictions on assignment of students to classes are available in many scheduling program packages. Students can be scheduled according to ability, grade levels, or prerequisite courses; and students can be prescheduled for only the number of courses that do not cause an overload. Those four options were used by a number of school systems. Sixty-eight, or 37.2 percent, restricted students to certain courses according to their ability groups. Ninety systems, or 49.2 percent, restricted student scheduling for certain courses to specified grade levels. Fifty-one, or 27.9 percent, restricted some courses to those students who had the prerequisite courses. Over two-thirds (67.8 percent) restricted students to less than the overload schedule.

Five student options were used. Fifty systems (27.3 percent) allowed students to select a particular teacher, and 82 or 44.8 percent allowed students to select a particular time or section of a course. Students could choose substitute courses, alternative courses, and co-requisite courses. Sixty-two school systems (33.9 percent) provided the option of course substitution. This option allows the student to be scheduled into a course other than the requested course, and that course will meet the curriculum requirements for the school. Ninety-seven systems allowed the student to select alternate courses or those

courses that are scheduled in place of requested courses, but do not meet the requirements of the curriculum in the same way as a substitute course. Fifteen systems allowed students to schedule co-requisite courses.

Other options allowed scheduling of certain rooms for specialized classes for 64, or 35.0 percent, of the systems; automatic study hall for free periods, used by 50.3 percent of the systems; restriction of lunch to specified periods, used by 26.8 percent; and sequencing of courses, used by 13.7 percent of the systems. Five systems reported that they used other options in addition to those listed on the survey form. These included semester selection of a course, double sessions of the same course, and three responses dealing with time priority of students entering an arena scheduling area.

Ideally, a scheduling program generates computer-produced schedules for all students. However, because of unusual combinations of course requests, overloading, lack of space or course offerings, and other restrictions, optimal computer scheduling may not be possible. School systems too, may be unable to offer computer scheduling to all students in their schools, or they may choose not to computer schedule some schools within their system. Table IX describes the extent to which schedules were generated by computer in the 183 systems surveyed. Sixty-eight, or 37.2 percent, of the systems generated computer schedules for 99.0 percent or more of their students. Over two-thirds provided computer-generated schedules for 95.0 percent of their students.

TABLE IX
 PERCENTAGE OF STUDENTS IN RESPONDING SCHOOL SYSTEMS
 RECEIVING SCHEDULES GENERATED BY COMPUTER

Percentage of Students	Number of Systems	Percent of Total (N = 183)	Cumulative Percent
99 - 100	68	37.2	37.2
97 - 98	28	15.3	52.5
95 - 96	29	15.9	68.4
90 - 94	22	12.0	80.4
80 - 89	10	5.4	85.8
70 - 79	4	2.2	88.0
50 - 69	3	1.6	89.6
1 - 49	4	2.2	91.8
No Response	<u>15</u>	<u>8.2</u>	<u>100.0</u>
Totals	183	100.0	

Computer-generated records can be used for various purposes in the school. Guidance offices, principals' offices, and a central information area are the primary users of student schedule information within the administrative area of the school. Table X shows the percentage of systems that made use of the student schedules for purposes other than supplying the individual student with a copy of his or her schedule.

Scheduling information can be used for other purposes, too. The primary uses in systems surveyed were for attendance records, transcripts of academic records, grade reporting, and class rolls for teachers (see Table X). About one-half of the systems used the reports on room use for maintenance personnel. Fifty-six systems, or 30.6 percent, used the information generated for projection of their budget and as research data. Some of the other uses added by the respondents included follow-up studies of students after graduation, class load lists for teacher assignment, enrollment projections, and establishment of a school data base.

B. TECHNICAL INFORMATION QUESTIONNAIRE

The technical information questionnaire was designed to be completed by individuals familiar with the actual processing of class scheduling data. These individuals included personnel from the school data processing centers, private service bureaus, university or college computer centers, or state-owned regional units or consortiums. The information sought from these persons may not have been available from the school personnel.

TABLE X

USES OF STUDENT SCHEDULES AND SCHEDULING INFORMATION
BY RESPONDING SCHOOL SYSTEMS

Use	Number of Responses*	Percent of Total (N = 183)
<u>Uses of Student Schedules</u>		
Principal's Office	151	82.5
Student Health Service (School Nurse)	74	40.4
Guidance Office	176	96.2
Central Information Desk	108	59.0
Others	25	13.7
<u>Uses of Scheduling Information</u>		
Attendance Record Keeping	132	72.1
Academic Records (Transcripts)	134	73.2
Curriculum Studies	77	42.1
Room Utilization Reports for School Maintenance Personnel	92	50.3
Grade Reporting	151	82.5
Class Rolls for Teachers	169	92.3
Budget Projection and Research	56	30.6
Others	11	6.0

*Some systems responded to more than one category.

The technical questionnaire began with a description of the hardware used to schedule classes. Preliminary questions were directed to the brand name and size of the computer. In determining the brand of the computer used, a list of major computer manufacturers was presented to the technical representatives, and they were asked to check all brands that applied to their class scheduling system. Table XI presents these findings. Over one-half (51.9 percent) of the 183 school systems reported that they use IBM equipment. NCR hardware was used by 8.2 percent of the users. Burroughs, Digital Equipment Corporation (DEC), Honeywell, and Univac were used by six to eight percent of the total 183 systems. Control Data and Wang hardware were used by only 2.2 percent of the total. No response was given for the use of Data General equipment.

In the category of other manufacturers, 19 or 10.4 percent reported the use of equipment by companies such as Mohawk, Hazeltine, Textronix, Digitec, and International Telephone and Telegraph (ITT). These manufacturers actually produce peripheral input and output devices which do not qualify as a computer system. These are only add-on equipment for input and output of data to the central processing unit (CPU) of the computer; therefore, several respondents reported more than one type of computer system in use.

The size of the computers used was indicated by the number of thousands (K) of computer words or bytes of storage available in the primary storage area of the central processing unit or mainframe of the computer. More sophisticated scheduling programs require large amounts

TABLE XI
 COMMERCIAL BRANDS OF COMPUTERS USED FOR SCHEDULING
 OF CLASSES BY RESPONDING SCHOOL SYSTEMS

Brand	Number*	Percent of Total (N = 183)
Burroughs	12	6.6
Control Data	2	1.1
Digital Equipment Corporation	13	7.1
Honeywell	14	7.7
IBM	95	51.9
NCR	15	8.2
Univac	14	7.7
Wang	2	1.1
Other Computers	19	10.4

*Some school systems indicated more than one brand of computer.

of primary storage to handle large data tables required when scheduling students to classes. Because of this requirement, 136, or 74.3 percent, of the technical representatives reported that they used computers that were considered medium or large (from 96K to over 256K of storage). Table XII presents this information and also shows that almost one-half (48.6 percent) of the computers were considered to be large. Smaller computer systems are used primarily for arena scheduling and some class-loading programs with few options. Twenty-seven computer systems were listed as small.

Scheduling systems range from computerized systems to arena scheduling, which uses the computer only to generate punched cards and to process those punched cards into printed reports for the school and students. A majority (54.1 percent) of the school systems in this study had mostly computerized systems. Only 32, or 17.5 percent, of the systems used the computer to build the master schedule, a feature of more complex scheduling programs. Table XIII lists the different types of systems used by the 183 school systems surveyed in the study.

Scheduling systems include those which allow interaction with the system through trial runs that preserve the schedules already build for individual students. Subsequent runs try to build optimal schedules for only those students who did not schedule on earlier runs. Other systems generate new schedules for all students on all runs until optimal scheduling occurs; no schedules are preserved until the final run. Other programs print reports from schedules compiled in the arena or card-pulling procedure. This process requires more hand work by personnel and little work in arranging individual schedules by the

TABLE XII
 SIZE OF COMPUTER SYSTEMS USED FOR SCHEDULING
 OF CLASSES BY RESPONDING SCHOOL SYSTEMS

Size*	Number	Percent of Total (N = 183)
Large (over 256K)	89	48.6
Medium (96+ to 256K)	47	25.7
Small (1 to 96K)	27	14.8
No Response	<u>20</u>	<u>10.9</u>
Total	183	100.0

*1K = 1024 or 2^{10} storage units when referring to a computer's primary storage capacity.

TABLE XIII

TYPES OF SCHEDULING SYSTEMS USED IN RESPONDING SCHOOL
SYSTEMS FOR COMPUTERIZED SCHEDULING OF CLASSES

Description	Number of Responses*	Percent of Total (N = 183)
Mostly computerized	99	54.1
Mostly computerized with unit record equipment (sorters, reproducers, etc.) as support devices	39	21.3
Computerized with manually kept records for updating or individual schedule changes	30	16.4
Computer-built master schedule	32	17.5
Computer-assisted master schedule building (conflict matrix, course tally, etc.) to aid in construction of the master schedule	131	71.6
Manually constructed master schedule with computerized class loading	86	47.0
Other descriptions (included arena scheduling)	12	6.6

*Some responded to more than one category.

computer. Almost three-fourths of the systems in the study used a program that creates new schedules on each run. Sixty systems (32.8 percent) updated the schedule file without disturbing existing schedules. Seventy-six, or 41.5 percent, used an arena or card-pulling procedure and printed schedules by computer. Table XIV summarizes the results of the survey. Some school systems used a combination of scheduling procedures, using the computer to reach the optimal level for most schedules, then supplemented its work with other scheduling procedures for some students.

Some of the commonly used scheduling packages described in Chapter III of this study were listed on the technical information survey. The technical representatives were asked to check all of the packages that they have used and also to circle the package that they were currently using. Table XV reports the scheduling systems in use. The majority of the programs were provided by IBM with 60 users of SOCRATES scheduling system, 42 users of the SSS/360 package, and two users of CLASS. SOCRATES programs were most frequent in use with 32.8 percent of the 183 respondents. Honeywell's SCRIBE and NCR's SCHOLARS ranked third and fourth with fifteen and fourteen users, respectively. Two users each were reported for GASP, CLASS, and NEEDS. No responses were given for the usage of SSSS (Stanford University program) and DDCS (Daily Demand Computer Scheduling). Both of these systems encourage experimentation away from traditional scheduling.

A large number of respondents (39) reported other scheduling packages. These included programs to produce schedules from an arena

TABLE XIV
 DESCRIPTIONS OF PROCESSES USED IN SCHOOL SYSTEMS FOR
 COMPUTERIZED SCHEDULING OF CLASSES

Processes*	Number of Responses**	Percent of Total (N = 183)
Use simulation scheduling runs, generating new schedules on each batch run until an optimal scheduling run is met	134	73.2
Allow most students to schedule and then update a disk, tape, card, or printed file without disturbing existing schedules	60	32.8
Schedule classes by using an "arena" or "card-pulling" procedure and then print out schedules by computer	76	41.5
Others	10	5.4

*Process as stated on questionnaire.

**Some responded to more than one category.

TABLE XV
 TYPES OF SCHEDULING SOFTWARE IN USE FOR SCHEDULING
 OF CLASSES BY COMPUTER

Software	Number	Percent of Total
SOCRATES (IBM)	60	32.8*
SSS/360 (IBM)	42	23.0*
SCRIBE (Honeywell)	15	8.2*
SCHOLARS (NCR)	14	7.7
EDPAC (University of Iowa)	4	2.2
GASP	2	1.1
CLASS (IBM)	2	1.1
NEEDS	2	1.1
Others	39	21.0
No Response	<u>3</u>	<u>1.8</u>
Totals	183	100.0

*Used for case studies.

procedure, "homemade" scheduling programs, and some packages designed for on-line computer-assisted registration systems. Table XIII (page 98) indicated that 6.6 percent of the school systems used arena scheduling. Table XIV showed that 41.5 percent used card-pulling procedures. Further investigation revealed that about 20 of the 183 school systems used the arena procedure in conjunction with a program to generate tally and conflict matrix reports to help build the master schedule. They did not use the computer to load classes.

Often users need to adapt program packages to meet their particular scheduling needs. The changes may be in the form of adaptations for different input and output hardware and media, or for conversion to a new computer system. Such changes are reported in Table XVI. Almost three-fourths (72.1 percent) of the technical information respondents reported that they made changes in the type of input media used for scheduling. Eighty-one, or 44.3 percent, made changes in the output type or format, and 90 reported complete changes from one system to another.

Two major types of data entered into a computer for scheduling are student request data and master schedule data. These data must be recorded on some type of computer-compatible medium. The media may be in the form of punched cards, magnetic disk, magnetic tape, scanning sheets for optical mark recognition devices, or mark sensed cards. The oldest computer-compatible medium is the punched card, which dates back to the late 1800's with Herman Hollerith's development of the tabulating system for the Census Bureau. In the computerized scheduling

TABLE XVI
TYPES OF CHANGES MADE IN SCHEDULING PROGRAM TO MEET
NEEDS OF SCHOOLS SCHEDULING CLASSES BY COMPUTER

Change	Number of Responses*	Percent of Total (N = 183)
Adaptations for differing input media	132	72.1
Changes in output type or format	81	44.3
Changes from one computer system to another	90	49.2
Other changes	50	27.3

*Some of the school systems indicated more than one type of change.

of classes, cards dominate the media with 67.2 percent of the respondents. Optical mark recognition media ranked second with 44.3 percent of the respondents as shown in Table XVII. Key to disk or key to magnetic tape was used by 24.1 percent of the school systems. Mark sensed cards were least used as input media. Twenty of the respondents indicated that they used other forms of media for input of master schedule or student request data. Almost all wrote that they used "terminals" which indicates that they used either key-to-disk or key-to-tape input devices. The terminals would add to the figures for magnetic tape and magnetic disk media in Table XVII; however, their rank would still be third as input media.

C. CASE STUDY VISITATIONS

The researcher visited three installations using computerized school scheduling. The three installations used the three scheduling systems that were most widely used among respondents in this study. One system used EPIC:SOCRATES, a second system used SSS/360, and the third system used SCRIBE. The three school systems were located in three different regions of the United States.

Case Study A (EPIC:SOCRATES)

The school installation visited for the EPIC:SOCRATES system is located in the Northeastern United States. The installation served several schools as a regional computer center. Prior to the establishment of the regional center, scheduling services were provided by a nearby state university.

TABLE XVII
TYPES OF INPUT MEDIA USED FOR STUDENT REQUEST
OR MASTER SCHEDULE DATA

Input Medium	Number*	Percent of Total (N = 183)
Optical Mark Recognition	81	44.3
Keypunching into Cards	123	67.2
Key to Disk	27	14.8
Mark Sense Cards	9	4.9
Key to Magnetic Tape	17	9.3
Other Input Media	20	10.9

*Some schools indicated more than one type of media for input of student request or master schedule data.

The regional center encountered some problems while changing to the SOCRATES scheduling system from SSS/360. The major problems were caused by the total commitment approach and a lack of adequate documentation for SOCRATES. The change was made to enhance the options available to schools and to give better "in-house" control over scheduling activities. The hardware in use included an IBM Model 370 computer with card, tape, and disk peripheral equipment.

Planning, organizing, and staffing. Schools using the scheduling service of this regional computer center did so on a voluntary basis. One person from the regional center was responsible for the entire scheduling of a school requesting scheduling services. Others involved were the liaison coordinator and the school coordinator. The school coordinator was usually a principal, assistant principal, or guidance counselor. Principals were charged with master schedule development, and guidance counselors worked with student requests. Two meetings were scheduled each year with users; however, most communication was on a one-to-one basis between regional center personnel and school personnel. One of the major problems encountered was the understanding of how the master schedule could be manipulated for optimal scheduling results. This problem was alleviated by the one-to-one contact.

Directing and controlling. Other communication problems were reduced by establishing a calendar of scheduling events, using a service request form on each step of the process and offering a "standard" service which included basic output from scheduling common to most schools. The most widely used options included mass change techniques,

student priority, elective and alternative courses, and add-on scheduling. The least used options were racial balancing, location scheduling, shift scheduling, and ethnic balancing. Control of cost was maintained by setting limits on the number of scheduling runs (three) and number of copies generated by the computer. Forms were designed by the regional center for input and output. Deadlines are established to assure schedule readiness.

Innovating. The regional center used a master schedule builder in pilot mode. Center personnel found problems in adequate documentation and cumbersome amounts of input data necessary for master schedule building. The center planned to add optical mark recognition devices to the system to reduce keypunching costs. Master schedule and student request data would be entered by that medium. The ability to prioritize students in scheduling and mass change techniques were the major strong points of the system. Improvements the center personnel would like to make include improvements in modular scheduling, better graphic display of instructional time, and flagging and alleviating of problems of several consecutive study halls in schedules.

Case Study B (SSS/360)

The installation for the SSS/360 system was located in the Southeastern part of the United States. The installation was part of a city school system that served schools in the city and its suburbs. The hardware for the scheduling of classes included an IBM 370 Model 158 computer with three optical mark recognition devices for input of master schedule and student request data. The optical mark recognition devices

were also used for over 100 different applications in the school system including payroll, testing, attendance, and other administrative and academic tasks.

Planning, organizing, and staffing. All schools in the system used the scheduling services of the installation. Principals and guidance personnel represented the schools, and coordinators or liaison persons directed schools through the scheduling process. Principals worked primarily with the master schedule, and guidance counselors made changes in the student request files by filling out drop and add forms. Since the installation processed most of the administrative data of the schools, communication among school personnel and the installation was continuous. Problems encountered in communication were usually in areas of understanding the master schedule manipulation, which was enhanced by user meetings.

Directing and controlling. Control was maintained in the scheduling system by using standardized system-wide forms designed by the installation. Training sessions were provided on a periodic basis on the use of the forms. Rigid timetables are maintained to assure target deadlines in the scheduling process are met. Options most widely used in the scheduling package were semester balancing, sex balance, ability restrictions, prerequired courses, overload restrictions, and rotating schedules. Alternate and substitute course options were allowed for students, also. Schools in the system used scheduling three times a year (on a quarter basis). Within each of these times schools were allowed three runs to gain the optimal scheduling situation to

control costs. Forms for input and output of the scheduling procedure were designed by the school system, and amounts of output were limited to control costs.

Innovating. Innovations in the scheduling system had been in the area of input cost reduction through the use of optical mark recognition devices. The installation had been using master schedule building on a limited basis. Plans for the future included further development of the use of master schedule building by computer.

Case Study C (Honeywell--SCRIBE)

The installation visited for the Honeywell--SCRIBE system was located in the Western United States. The installation served an urban area that had a highly mobile population. This factor had a direct impact on the scheduling of students to classes because of continuous dropping and adding of students. The system evolved from the installation's earlier use of the Schedule G program. Earlier systems used were SOCRATES and the IBM 1401 CLASS scheduling system. The hardware included a Honeywell 6000 system, which followed a Honeywell 200. Two reasons for the change to the SCRIBE scheduling system were the hardware change and problems in modifying the Schedule G program.

Planning, organizing, and staffing. All schools in the system were required to use the scheduling program. The school liaison officer was charged with scheduling the classes. School personnel included principals (for development of the master schedule), counselors (for input of course request information), and data processing coordinators (for organizing the process). Training programs were

provided for principals, counselors, and occasionally office staff. Teachers had no involvement in the scheduling process. A major area of misunderstanding among school personnel of the scheduling program was the development and manipulation of the master schedule. The problem was reduced through the assignment of a liaison officer to coordinate the scheduling activities.

Directing and controlling. Control of processing was handled through a timetable of scheduling events. Costs were limited by restricting the number of copies of output received by the schools. Not more than six copies of student schedules, four copies of class rolls, and three sets of address labels were provided as standard output to reduce costs. The most frequently used options were the linking of courses and block courses. Alternate-day classes and flexible modular scheduling were also used. An additional in-house option for racial count was developed for HEW reports.

Innovating. The installation personnel reported that they had investigated the use of a master schedule builder program. In their opinion it was too cumbersome because of their highly mobile population and changing needs of schools in their system. They believed that the high number of dropped and added students, along with their varying course needs, would make it difficult to provide accurate student request information for building a feasible master schedule by computer. They continued to build the master schedule manually because they believed that it provided the best service for their schools.

CHAPTER VI

SUMMARY

The problem of this study was to assess the current status of computerized scheduling of classes at the secondary school level. Five questions related to this problem were answered in the study.

1. What types of school environments typically use computerized scheduling of classes?

2. What types of processing techniques are used by schools in conjunction with available scheduling programs, and what adaptations can be made to the programs to schedule most efficiently?

3. What types of hardware are used for scheduling of classes by computer?

4. What types of computer software are most widely used for computerized class scheduling?

5. What options or features of scheduling systems are perceived by users as most effective for scheduling students in their school systems?

A. PROCEDURES

To arrive at answers to the five questions, two questionnaires were developed to gather data on school applications and technical information about computer scheduling. Pairs of questionnaires were sent to 393 different school systems or data processing installations

providing scheduling services. After the first mailing 22.65 percent of the questionnaires were returned. A follow-up letter, cover letter, and appropriate questionnaires were sent to the non-responding systems. After the second mailing, 53.18 percent of school applications questionnaires and 48.86 percent of technical information questionnaires had been returned. Although 209 school application questionnaires and 192 technical information questionnaires were returned, 183 (46.57 percent) were used as matched pairs for analysis.

A third questionnaire was developed for visitations to systems using the three most popular school scheduling packages. Case studies were used to provide a descriptive profile of systems using those programs. Questions were directed toward the management of the scheduling process including the managerial functions of planning, organizing, staffing, directing, controlling, and innovating the scheduling process.

B. SCHOOL APPLICATIONS FINDINGS

The following major findings are based on data gathered from the school applications questionnaires:

1. One hundred and thirty-one school systems, or 71.6 percent, of the 183 respondents had used computerized scheduling for five to twelve years. Their school systems ranged in size from under 500 to over 100,000 students. However, over one-half reported enrollments of less than 5,500.

2. Over one-half, or 55.7 percent, of the systems reported that scheduling was funded through the general budget, without special

allocations for its costs. About one-half, or 46.5 percent, owned or leased the computer used for scheduling. Those who did not own or lease a computer still used computerized scheduling; 21.9 percent of the 183 respondents used the scheduling services of an intermediate school district, regional unit, or state-owned consortium.

3. Most systems followed a fairly traditional scheduling pattern. In 145 systems, or 84.2 percent, classes were scheduled by semester. Over one-half, or 55.2 percent, used double periods; 60.1 percent used block courses which required scheduling of students into two or more hours for one class. One scheduling run per year was used by 45.4 percent of the 183 systems, but 45.9 percent used several runs per year. Only 10.4 percent used rotating schedules, a less traditional approach to scheduling. Two-thirds of the 183 systems scheduled 5 to 7 periods daily. Only five systems, or 2.7 percent, used modular scheduling, with 19 to 27 modules in a school day. Class periods ranged from 11 minutes to over 55 minutes. Ninety-nine, or 54.1 percent, of the systems scheduled classes for 46 to 55 minutes per period.

4. Various options are available in most scheduling packages. The most widely used balancing option was among several sections of the same course, attempting to schedule equal numbers of students in each section; 86.9 percent of the systems used that option. Nearly one-half used sex balancing (47.5 percent) and semester balancing (46.4 percent).

5. Four lockout restrictions were used in various school systems. Sixty-eight, or 37.2 percent, grouped students into sections by their ability. About one-half (90 systems, or 49.2 percent)

restricted registration in certain classes to given grade levels.

Fifty-one, or 27.9 percent, restricted enrollment in certain courses to students with prerequisite courses. Some computer packages allowed such restrictions. Over two-thirds (124 systems, or 67.8 percent) blocked out student overloads.

6. Some scheduling packages allowed students to select options. Two options allowed them to select a particular teacher, time, or section. Fifty systems, or 27.3 percent, of the responding 183 systems used teacher selection options; 82, or 44.8 percent, used the time or section option. Sixty-two, or 33.9 percent, allowed students to choose substitute courses for those they were not able to schedule. Ninety-seven, or 53.0 percent, built in alternative selections; a student could be scheduled into an alternative course that was not a curricular substitute for the non-scheduled course. Only 15 school systems, or 8.2 percent, used the co-requisite course option, which schedules students into two or more courses linked together in the scheduling program.

7. Scheduling packages provided other options to facilitate scheduling of the total school program. Sixty-four systems, or 35.0 percent, used the room restriction option in packages that built the master schedule by computer. About one-half (50.3 percent) used the option that schedules students into study halls for free periods. Forty-nine, or 26.8 percent, restricted the lunch period as part of the requirements of scheduling. Twenty-five, or 13.7 percent, used the course sequencing option. Five systems reported they used other options: semester selection for a course (1 system), double sessions

of the same course (1 system), and assigning priority to certain groups of students in arena scheduling (3 systems).

8. A school system generally sets a level of acceptance for total number of students scheduled on a computer run. In this study 68, or 37.2 percent of the systems, sought a 99.0 percent level. Additional scheduling runs were used if 2.0 percent or more of the students did not schedule. A total of 52.5 percent achieved 97.0 percent scheduling by the last scheduling run. Reported percentages for scheduling ranged from less than 50.0 percent to 100.0 percent. In some cases school systems reported percentages of computerized scheduling based on total school system enrollment, not on number of students actually included in the computerized scheduling process.

9. A computerized scheduling system can generate records in addition to the schedules provided to students. A number of school systems reported that the student schedules were used by the principal's office (82.5 percent of the 183 school systems); school health service (40.4 percent); guidance office (96.2 percent); and central information desk (59.0 percent). Scheduling information was used for attendance records in 72.1 percent of the 183 systems; for academic transcripts in 73.2 percent; for curriculum studies in 42.1 percent; and for room utilization reports in 82.5 percent of the 183 systems. The scheduling system can create records needed for grade reporting with most scheduling packages. Output from scheduling was used for grade reporting in 151, or 82.5 percent, of the 183 responding school systems. Class rolls were generated by computer in 169, or 92.3 percent, of the

systems. Fifty-six, or 30.6 percent, of the school systems used scheduling output for budget projection and research.

C. TECHNICAL INFORMATION FINDINGS

The following findings relate to the analysis of data from the technical information questionnaires distributed to school systems using computerized scheduling.

1. IBM computers were the most-used brand of computers in computer scheduling; 95, or 51.9 percent, of the 183 school systems used IBM computers. Remaining school systems were about equally divided among Burroughs, Digital Equipment Corporation, Honeywell, NCR, and Univac; 36.9 percent of the school systems used those brands. Two school systems each used Control Data and Wang computers. Nineteen systems used other brands not specified. Eighty-nine, or 48.6 percent, of the 183 respondents classified their computers as large; 47, or 25.7 percent, classified theirs as medium in size; and 27, or 14.8 percent, listed their computers as small in size.

2. Scheduling packages vary from those that build the master schedule, allow a number of options to the scheduler and the student, and generate multiple updated scheduling runs, to those that merely print the output created in arena scheduling. A majority of the school systems, 99, or 54.1 percent, used mostly computerized scheduling systems. Only 32 systems, or 17.5 percent, used the computer to build the master schedule. The computer assisted in building the master schedule by generating a conflict matrix and tally in 131, or 71.6

percent, of the school systems. Other types of systems reported were systems using unit record equipment, manually constructed master schedules, and arena scheduling. An updated tape, disk, or card file which retained the schedules generated to date was used in 60, or 32.8 percent, of the systems. Most of the school systems (134, or 73.2 percent) generated new schedules on all scheduling runs; no student schedules were retained for the next run. Seventy-six, or 41.5 percent, used some form of arena scheduling.

3. The majority of school systems used scheduling packages supported by IBM. Forty-two, or 23.0 percent, used SSS/360; 60, or 32.8 percent, used SOCRATES; and 2, or 1.1 percent, used CLASS. Other types used were GASP, EDPAC, SSSS, NEEDS, DDCS, SCRIBE, and SCHOLARS. Twenty-one percent of the school systems adapted the package for use on a different computer system than the one for which it was originally written. Fifty made other unspecified changes.

4. Punched cards were the most often-used medium for master schedule and student request data; 123, or 67.2 percent, of the 183 school systems used card media. Next in frequency of use was optical mark recognition or scanning sheets; 81, or 44.3 percent, of the systems used that medium. Other reported media were key to disk (27, or 14.8 percent, of the systems); mark sense cards (9, or 4.9 percent); and key to tape (17, or 9.3 percent).

D. CASE STUDY FINDINGS

Three school systems were interviewed about their scheduling systems at their data processing facilities with the researcher. The following findings are related to the visitations.

1. Principals and guidance counselors were the personnel most often given the major responsibility for scheduling within the school. Teachers were not actively involved in the administration of the scheduling process.

2. All three systems found that one of their major problems was communication between their personnel and school administrators about the manipulation of the master schedule for optimal scheduling. Most met with the principal or guidance personnel to work out the master schedule and to alleviate problems. One system provided a short training session each year for all personnel using scheduling services.

3. One school system used SOCRATES, one used SSS/360, and one used the Honeywell SCRIBE scheduling program. Two systems used IBM computers and one used a Honeywell computer. All three schools had designed special forms to facilitate the scheduling process, including time tables, Gantt charts, and student request or master schedule data forms. Two of the three schools used optical mark recognition for input of the student request or master schedule data.

4. The three school systems used a variety of options available in their scheduling packages. All three tried master schedule building by computer but reverted to computer-assisted master schedule building.

5. All three systems limited the number of scheduling runs and the number of copies of each type of output in order to control scheduling costs. Two systems limited the number of scheduling runs to three; the third system allowed schools only a standard number of copies of each report generated.

E. CONCLUSIONS

Based on the findings of this study, the following conclusions can be drawn:

1. Computerized scheduling can be used in a wide variety of school environments. School applications questionnaire findings 1 to 8 and technical information questionnaire finding 2 support this conclusion. Sizes of school systems using computerized scheduling in this study varied from under 500 to over 100,000 students.

2. Computerized scheduling can be used in schools that use a wide range of procedures for organization of their scheduling process and that use scheduling packages ranging from traditional to highly innovative scheduling. School applications questionnaire findings 3 to 7, technical information questionnaire findings 1 to 4 and case study findings 3 and 4 support this conclusion. Chapter III of this study provides information about most popular scheduling packages in use. Table I (pages 64 and 65) shows several options available on four scheduling systems for possible selection of a system to meet needs of a particular school system.

3. A computerized scheduling system can be used to establish a data base for other school record keeping activities as indicated by school applications questionnaire finding 9. Grade reporting, classroom maintenance, attendance records, budget, research and curriculum development can be enhanced by the use of computerized scheduling of classes.

4. A crucial factor in successful use of computerized scheduling is the working relationship between the school administration and the data processing personnel. Case study findings 1 and 2 support the importance of a good relationship between those responsible in the school for scheduling and data processors who actually handle the hardware and software of a scheduling system.

5. Major cost factors in computerized scheduling of classes are the number of computer scheduling runs and the number of copies of output generated. Costs can be controlled by limiting these factors. Case study finding 5 indicated the limiting of the number of computer runs and the number of copies of output generated.

F. OBSERVATIONS

Some observations made by the researcher during the study do not directly relate to the questions to be answered, but could be useful to users of computerized scheduling. Written comments by respondents on the questionnaires and comments in interviews went beyond the original scope of the study. However, these comments could be valuable to users and potential users of computerized scheduling of classes.

The study did not specifically correlate the past scheduling experiences with procedures currently used in the process of scheduling; however, computerized scheduling appears to have "become of age." Many of the respondents to the questionnaires indicated that their scheduling system is an important part of their school operation. They were asked to indicate which systems they had used and were currently using. Several had tried using schedule building programs and had returned to the standard class-loading programs. At this time the trend seems to be toward using the computer to load classes but not to build the master schedule.

Declining enrollments, budget cuts, and other factors not in the original questionnaire have influenced the degree of scheduling by computer. Cost factors such as time spent in building the master schedule by school personnel also affect the willingness of a school to adopt or continue to use the computer for scheduling of classes. Principals, guidance personnel, and data processors must consider the time they must spend to develop and maintain computerized scheduling. Declining enrollment may force reduction of costs by dropping school programs or reducing the number of clerical personnel. In this case, the use of computerized scheduling could reduce costs by more efficiently allocating resources. However, schools may not be willing to move into computerized scheduling as an alternative. The willingness of the school system to fund and school personnel to develop and maintain a computerized scheduling system must be considered.

Involvement of people--students, parents, teachers, principals, and data processing personnel--can be a crucial factor in the successful use of a computerized scheduling system. This involvement may be a major reason for non-commitment or lack of interest in computer built master schedules. Teachers may desire certain rooms, students may not want certain teachers or time schedules, administrators may wish to arrange schedules of some teachers and students around non-academic activities.

Scheduling of classes by computer need not be a mysterious endeavor adaptable only to large schools with complex scheduling problems, although the computer may serve such a school very well. A traditional scheduling arrangement may be used with a computerized scheduling program or with a computer-assisted student registration system.

The preparation of computer scheduling packages for small computer systems could make scheduling available to more schools. Decreasing computer hardware costs will make computerized scheduling a viable alternative for more schools if scheduling packages are available. Computerized scheduling could provide information for curriculum development, enrollment trends, and efficiency in allocation of resources that makes it possible for schools to operate more efficiently.

G. RECOMMENDATIONS

Based on the conclusions of this study, the following recommendations are made:

1. Because many different scheduling packages are available with many options, school systems must study the software and hardware available before purchase or lease in order to select the system that is most suitable for their particular needs. Chapter II of this study provides information about the most popular scheduling packages available to those planning to adopt or to change systems. Table I (pages 64-65) shows options available on the most popular scheduling systems. This table may be used for selecting and tailoring a computer system to the needs of a particular school system.

2. Because optimal use of a computerized scheduling system depends greatly on the communication between the ultimate user and the persons assigned the major task of scheduling, school systems should provide school personnel and data processing personnel with adequate opportunity for close communication. Users and potential users should consider the use of scheduling training sessions for new principals and review sessions for experienced principals. This type of communication should also be considered when adding or changing procedures, forms, and options provided by the scheduling system.

3. Because scheduling by computer can be used by school systems of varying sizes, smaller as well as larger units should consider the advantages of computerized scheduling. The benefits of reduced clerical

time and effort and the generation of various output that can be derived from a scheduling system using the computer make a computerized scheduling system desirable for school systems of all sizes and environments.

4. Users and potential users should make efforts to control costs by limiting the number of computer runs and copies generated by computerized scheduling systems. Other cost factors, such as clerical and data processing personnel time, should be monitored to keep scheduling costs at an acceptable level.

5. Users and potential users should consider the employment of an evaluation system to measure the effectiveness and efficiency of the overall scheduling system. Periodic evaluation of the entire system will enable a user to maximize the potential of the system to meet the school system's scheduling needs.

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APPENDICES

APPENDIX A

GLOSSARY OF COMPUTERIZED SCHEDULING TERMINOLOGY

GLOSSARY OF COMPUTERIZED SCHEDULING TERMINOLOGY

- ABILITY GROUPING--the assignment of students to classes according to their abilities as determined by academic testing
- ALGORITHM--formulas or logical steps taken to solve a problem by computer
- ALTERNATIVE COURSES--courses that are scheduled in place of requested courses that do not meet the requirements of the curriculum of the school in the same manner as substitute courses
- ARENA SCHEDULING--a scheduling process where students meet in a central area to enroll in courses that have a predetermined limit of the number of students
- AUTOMATIC STUDY HALL FOR FREE PERIODS--a scheduling option that allows students to be scheduled into study halls when another course is not offered or in the student's course requests
- BLOCK COURSE--a course that meets for over two periods
- BYTE--a unit of storage made up of binary digits used when referring to the size of a computer's primary storage or memory
- CARD PULLING--same as arena scheduling
- CLASS LOADING--the process of placing students into classes or sections of classes using a predetermined algorithm--also called sectioning
- CLASS SIZE BALANCING--effort is made to schedule an equal or near equal number of students to different sections of the same course
- COLLEGE-TYPE SCHEDULING--same as arena scheduling
- COMPUTER-ASSISTED MASTER SCHEDULE BUILDING--the process of developing a master schedule using the computer to provide information to aid in the process--this information may include a conflict matrix and a tally of courses requested
- COMPUTER-ASSISTED REGISTRATION SYSTEM--the use of the computer to facilitate the placement of students into classes via a terminal--same as the arena scheduling process with the exception of the use of on-line input devices

- CONFLICT MATRIX--a computer-generated report that presents the actual number of students requesting each course offered in conjunction with other course combinations requested--major concern is given to those courses that are only offered once or twice during the scheduling time parameter (quarter or semester)
- CO-REQUISITE COURSES--courses taken at the same time that depend on each other to meet the requirements of the curriculum
- COURSE LINKAGE--combining of courses to meet the requirements of the curriculum--usually indicates the use of co-requisites or pre-requisite courses
- COURSE SEQUENCING--same as course linking
- COURSE SUBSTITUTION--allows students to be scheduled into courses other than those requested--the course that is scheduled meets the requirements of the curriculum in the same manner as the course requested
- CPU or CENTRAL PROCESSING UNIT--also called the mainframe of the computer, this part of the computer contains units that calculate, store data, and control all other parts of the computer hardware
- CPU TIME--the duration of time in which a program utilizes the central processing unit--this time determines the cost and efficiency of the scheduling program
- CRT--(cathode ray tube) the video display screen used on a computer terminal for output of data
- CYCLE--a period of time in which a complete master schedule is sequenced--usually a week
- DOUBLE PERIODS--a class meets for two periods or modules
- DOUBLETON COURSES--courses that are offered in two sections
- EDIT PROGRAM--computer instructions that check data for validity
- ETHNIC BALANCING--an attempt to allow a proportionate number of students to be scheduled into classes based on their ethnic background
- FILE--a group of related records
- FLEXIBLE MODULAR SCHEDULING--course offerings in this system are designed to meet a different times during a cycle--a cycle may be a week or other period of time
- FORMAT--the manner in which a record is uniformly structured to make it compatible to a computer program

GRADE LEVEL RESTRICTION--students are restricted from a course due to grade level

HARDWARE--the general term for computer machinery or equipment

HIPO--an acronym for Hierarchy, Input, Process and Output--a method for flowcharting of a computer system or flow of data through the system

HOMEMADE SOFTWARE OR PROGRAMS--programs developed by a user for their particular needs

"IN HOUSE" SOFTWARE--same as homemade software

K--storage units or computer bytes--usually considered a thousand words of computer storage in the primary storage area of the computer--
1024 (2) 10 Bytes

MANUALLY CONSTRUCTED MASTER SCHEDULE--the process of building a master schedule without the aid of a computer

MASTER SCHEDULE--the overall course offerings of a school with meeting time, place, and instructional information

MASTER SCHEDULE FILE--a group of records relating to the course offerings of the school

MEDIA--the means of communication with the computer (punched card, magnetic tape, magnetic disk, etc.)

MINI COURSE--a course that meets for a short duration of time--either in number of meetings (4 weeks, 6 weeks) or in the number of minutes per meeting (11, 15 minutes, etc.)

MODULE--same as period or session--usually indicates modular scheduling

MODULAR SCHEDULING--scheduling students using modules which usually means that some courses meet at different times during a cycle rather than the traditional situation where a course meets at the same time each day

OMR--optical mark recognition--a medium for the computer that reads data from marks placed on a sheet of paper

ON-LINE SYSTEM--a method of processing where terminals are directly connected and active with the central processing unit and are accessible to data files--usually used in computer assisted registration systems

ONE-TO-ONE CONFLICT--a situation where a student has requested two courses that meet at the same time

- PACKAGED PROGRAMS--a scheduling program that is generalized enough that it may be adapted to most scheduling situations--usually sold by hardware vendors or by software specialists
- PERIOD--a class session or module
- PERIPHERAL EQUIPMENT--a general term for devices found around a central processing unit--usually input or output devices
- PRE-REQUISITE COURSES--courses that must be taken to meet curriculum requirements before taking a later course that builds on the information presented in these courses
- PRODUCTION RUN--usually the final computer run of a scheduling process that produces the final output from scheduling--student schedules, class lists, etc.
- PROGRAM--a general term for instructions for the computer
- PRIMARY STORAGE--central processing unit storage which may limit the capability of a computer system--primary storage is designated in Ks or thousands of computer words of storage
- RACIAL BALANCE--an attempt to allow a proportionate number of students to be scheduled into classes based on their race
- RECORD--a unit of a file that contains information specifically related to a specific student or course
- ROOM UTILIZATION REPORT--a report generated by the computer that provides information for use of rooms--time of use, user, etc.
- ROTATING SCHEDULE--see flexible modular scheduling
- RUN--the time when a set of instructions or program interacts with the data to process desired outputs--once the program is executed, human intervention is not possible or possible on a limited basis
- RUN TIME--the duration of time taken by the computer to process data--usually designated in seconds or fractions of seconds
- SCAN SHEETS--medium used for input of data through an Optical Mark Recognition device
- SCHEDULE CYCLING--see flexible modular scheduling
- SCHEDULE LOCKING--the process of maintaining an individual student's schedule while allowing other students to schedule the same courses requested by the locked schedule

- SCHEDULING SYSTEM--a group of programs or manual tasks taken to assign students to classes
- SCHOOL SYSTEM--a group of schools unified to serve a geographic area
- SECTION BALANCING--an attempt to schedule equal or near equal number of students to different sections of the same course
- SECTIONING PROGRAM--the process of placing of students into classes or sections of classes using a computer that has been programmed to follow a predetermined algorithm
- SEX BALANCING--an attempt to schedule students to classes in a proportionate number based on their sex
- SHIFT SCHEDULING--similar to flexible modular scheduling used in schools that have limited resources where students attend school in different time periods or shifts during the school day
- SIMULATION RUN--a trial run of a scheduling program that allows the user the ability not to be committed to the results of the run
- SINGLETON COURSE--a course that meets only one time (one section course)
- SOFTWARE--programs or instructions for a computer
- SPLIT DAYS--classes that meet on different days during the scheduling cycle, usually Monday, Wednesday and Friday or Tuesday and Thursday
- STUDENT COURSE REQUESTS--a file of data relating to the desired courses of the students
- STUDENT SELF-SCHEDULING--see arena scheduling
- SUBSTITUTE COURSES--see course substitution
- TALLY REPORT--a listing of courses requested by students and the number of students requesting each course
- TEACHER UTILIZATION REPORT--computer output that aids in determining the availability of teachers and assignments given to them
- TERMINAL--an input or output device used in on-line systems--usually has a keyboard and a printer or CRT screen
- TWO-TO-ONE CONFLICT--a situation where a student has requested a two section course (doubleton) and a single section course (singleton) that have the potential of conflicting by meeting at the same time

APPENDIX B

LETTER TO STATE DEPARTMENTS OF EDUCATION,

MEMO TO AEDS MEMBER, AND ADDRESS SHEET

THE UNIVERSITY OF TENNESSEE
KNOXVILLE 37916

College of Business Administration

TO: Executive Officer
State Department of Education

FROM: George A. Wagoner, Head
Business Education and
Office Administration

DATE: February 24, 1978

For the past 15 years our department has been assisting high schools in Tennessee in the development of student schedules on the computer. We have experimented with several different systems over this period. We are now trying to obtain the experience of some high schools throughout the country in the use of computer scheduling.

Will you assist us in our efforts to collect some experiences with computer scheduling by giving us the names and addresses of up to 10 high schools in your state which have been using the computer to build class schedules in the past five years. If your office does not have such information, will you please refer this request to the proper office. Please send the list to:

George A. Wagoner, Head
Business Education and
Office Administration
The University of Tennessee
Knoxville, Tennessee 37916

A copy of our final report on this project will be sent to each state participating in the study.

dwc

TO: AEDS member

FROM: George A. Mundrake, Research Assistant
SMC 608
The University of Tennessee
Knoxville, TN 37916

SUBJECT: Computerized Scheduling in Your State

For the past 15 years under the direction of George A. Wagoner, The University of Tennessee has been assisting high schools in the development of student schedules by computer. Over this period, we have been experimenting with several scheduling systems and are currently trying to obtain some experiences of other high schools throughout the country.

We have obtained several names and addresses of high schools using computerized scheduling throughout the country from state departments of education, however some gaps exist in this effort. Will you assist us in our efforts by giving us the names and addresses of up to ten high schools in your state that have been using computerized scheduling of classes in the past five years.

An attached form and addressed envelope are provided for your convenience.

FROM: _____

HIGH SCHOOLS USING COMPUTERIZED SCHEDULING FOR THE

STATE OF _____

Contact Person

School

Street Address

State/Zip

APPENDIX C

COVER LETTER, SCHOOL APPLICATIONS QUESTIONNAIRE,

TECHNICAL INFORMATION QUESTIONNAIRE, AND

FOLLOW-UP MEMO

THE UNIVERSITY OF TENNESSEE
KNOXVILLE 37916

College of Education

Department of
Curriculum and Instruction

TO: High School and Technical Representatives

FROM: George A. Mundrake, Research Assistant *GAM*

SUBJECT: What is the current status of computerized scheduling of
classes?

DATE: October 20, 1978

The University of Tennessee, under the direction of George A. Wagoner, has aided several schools in our state in scheduling of classes by computer. For the past 15 years we have experimented with several scheduling systems and are currently trying to obtain some experiences from other high schools throughout the country.

Will you aid us in our efforts by completing the enclosed two-part questionnaire? The first part (blue form) is to be completed by the school personnel responsible for class scheduling and deals with your school's scheduling applications. The second part (yellow form) is for technical information about specific computer usage. This form may or may not be completed by the same person(s) depending upon your school's scheduling resources and procedures

The results of the study may be used to aid schools in developing or revising their scheduling system based upon descriptive data collected from this questionnaire. In addition, information for the same purposes may be obtained from four illustrative case studies of scheduling systems selected from four schools completing these forms. If you would like, a copy of the final results of the study will be made available to your school. You may indicate this desire on the consent form portion of the blue form.

Names of participants in the study will remain completely anonymous. Schools will be referred to by school A, B, C, D, etc. Descriptive data will be presented in a form that will not identify individuals or schools. Any questions regarding the procedures to be used in this study should be made to my office.

Enclosed are the two questionnaires with consent forms required for studies dealing with collection of data. Please complete the blue form (school applications) and pass the yellow form (technical information) to your technical representative for completion. Both forms may be folded and stapled for postage-free return mailing.

Your assistance shall be greatly appreciated.

Thank you.

COMPUTERIZED SCHEDULING QUESTIONNAIRE

Part I: School Applications

Name of School: _____

Address of School: _____

city state zip

Person Completing Form: _____ Title: _____

How many years has your school used computerized scheduling? _____

How many different kinds of school scheduling systems (computerized) have you used? _____

Enrollment: Number of schools in your school system using computerized scheduling: _____

Approximate number of students scheduled by computer: _____

DESCRIPTION OF COMPUTERIZED SCHEDULING AVAILABILITY: Please check all appropriate descriptor(s).

Is your computerized scheduling:

- _____ funded through a specialized budget appropriation
- _____ included as a cost of general records keeping
- _____ financed by special student fees
- _____ other (please explain): _____

Is your computerized scheduling provided through:

- _____ a private service bureau
- _____ your own school system (owned or leased)
- _____ a nearby university or college
- _____ another larger school system
- _____ an intermediate school unit, regional unit, or state owned consortium
- _____ other (please explain): _____

If your school utilizes the services of computerized scheduling outside of your school, please indicate the name and address of the person(s) who will receive the second part of the questionnaire (Part II: Technical Information):

Name: _____

Address: _____

city state zip

DESCRIPTION OF YOUR SCHEDULING ENVIRONMENT: Please check all that apply to your school.

- | | |
|-----------------------------------|---|
| _____ semester basis | _____ block courses (more than 2 periods) |
| _____ quarter basis | _____ re-enrollment each semester or quarter |
| _____ nine-week courses | _____ several scheduling runs per year (Number _____) |
| _____ six-week courses | _____ one scheduling run per year |
| _____ mini courses | _____ multi-campus school |
| _____ split days (MWF-TR classes) | _____ rotating schedules (meet different times each day for same class) |
| _____ double periods | |
| How many periods per day? _____ | Duration of periods in minutes? _____ |

OPTIONS USED IN YOUR SCHEDULING BY COMPUTER: (please check all appropriate to your school)

- | | |
|--|---|
| Types of Balancing: | Lockout of student from class due to: |
| _____ sex balancing of classes | _____ ability restrictions (ability grouping) |
| _____ class size balancing of several sections of same class | _____ grade level restrictions |
| _____ semester balancing | _____ prerequired course(s) |
| _____ racial or ethnic balancing | _____ student overload restrictions |

(OVER)

OPTIONS USED IN YOUR SCHEDULING BY COMPUTER (continued):

Options available to students:	Other options:
☐ selection of a particular teacher	☐ room restrictions for certain classes
☐ selection of a particular time or section	☐ automatic study hall for free periods
☐ course substitutions	☐ lunch period restrictions
☐ alternate courses	☐ course sequencing
☐ co-requisite courses	☐ _____

USES OF SCHEDULING OUTPUT: (please indicate all appropriate to your school)

Copies of students' schedules for:

☐ principal's office	☐ guidance office
☐ student health service (school nurse)	☐ central information desk (visitors)

Scheduling information used for:

☐ attendance records	☐ grade reporting
☐ academic records (transcripts)	☐ class rolls for teachers
☐ curriculum studies	☐ budget projection and research
☐ room utilization reports for school maintenance personnel	☐ _____

CONSENT FORM

Your decision to participate or not participate in the study will not prejudice your future relationship with The University of Tennessee. If you do desire to participate, you are free to withdraw your consent and to discontinue participating at any time without prejudice.

This certifies that the person(s) signing this form have participated of his or her own free will in the study "A Study to Assess the Current Status of Computerized Scheduling of Secondary School Classes" and is free to withdraw his or her consent and to discontinue participation in this study at any time without prejudice.

Signed: _____

Would you like a copy of the final results of the study? ☐ yes ☐ no

fold

First Class
Permit No. 414
Knoxville, TN

BUSINESS REPLY MAIL

NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY

Bureau of Educational Research
and Service
212 Claxton Education Building
The University of Tennessee
Knoxville, Tennessee 37916

Attn: George A. Mundrake

COMPUTERIZED SCHEDULING QUESTIONNAIRE

Part II: Technical Information

Name of person completing form: _____

Address of computerized scheduling service center: _____

city state zip

DESCRIPTION OF HARDWARE USED IN SCHOOL SCHEDULING: (please indicate all appropriate)

___ Burroughs	___ IBM
___ Control Data	___ NCR
___ Data General	___ UNIVAC
___ Digital Equipment Corp. (DEC)	___ Wang
___ Honeywell	___ Other (please specify: _____)

System Size:

___ Small (to 96K)	Mainframe (CPU):
___ Medium (to 256K)	_____ / _____
___ Large (over 256K)	make model

DESCRIPTIONS OF SCHEDULING SYSTEM TYPE: (please indicate all appropriate)

___ mostly computerized

___ computerized with unit record equipment (sorters, reproducers, etc.) as support devices

___ computerized with manually kept records for updating or individual schedule changes

___ computer built master schedule

___ computer-assisted master schedule building (conflict matrix, course tally, etc.) to aid in construction of the master schedule

___ manually constructed master schedule with computerized class loading

___ other (please explain): _____

DESCRIPTION OF SCHEDULING PROGRAMMING:

Have you utilized a commercially available scheduling program? ___ yes ___ no

A. If yes, have you used any of the programming packages listed below? (please check the ones you have used)

B. Please CIRCLE the scheduling program or programs you are currently using.

___ ISS MO	___ KIPAC
___ SOCRATES	___ SSSS
___ GASP	___ MENUS
___ CLASS	___ DEEC
___ STUDENT	___ other: _____

Have you undergone any changes or adaptations with your current scheduling program?

___ yes ___ no

Please indicate the type(s) of change(s) made:

___ adaptations for differing input media (card input to OMR or CME, etc.)

___ changes in output type or format

___ changes from one computer to another (equipment update)

___ other (please indicate): _____

(OVER)

METHODS OF INPUT OF STUDENT COURSE REQUESTS AND/OR MASTER SCHEDULE DATA: (please indicate all used)

☐ Optical Mark Recognition (optical scanning) ☐ Key-to-tape (magnetic tape)
☐ Key punching of data into cards _____
☐ Key-to-disk (disk files) _____
☐ Mark sensing (cards) _____

DESCRIPTION OF PROCESSING: Do you:

☐ use simulation scheduling runs, generating new schedules on each batch run until an optimal scheduling arrangement is met?
☐ allow most students to schedule and then update a disk, tape, card or printed output file without disturbing existing schedules?
☐ schedule classes by using an "arena" or "card pulling" procedure and then print out schedules by computer?
☐ other (please explain): _____

Approximately what percentage of your total students requesting schedules receive schedules generated by your scheduling process? _____%

CONSENT FORM

Your decision to participate or not participate in the study will not prejudice your future relationship with The University of Tennessee. If you do desire to participate, you are free to withdraw your consent and to discontinue participating at any time without prejudice.

This certifies that the person(s) signing this form have participated of his or her own free will in the study "A Study to Assess the Current Status of Computerized Scheduling of Secondary School Classes" and is free to withdraw his or her consent and to discontinue participation in this study at any time without prejudice.

Signed: _____

----- fold -----

Attn: George A. Mundrake

THE UNIVERSITY OF TENNESSEE
KNOXVILLE 37916

College of Education

Department of
Curriculum & Instruction

In October, I wrote to you about your scheduling system. Just in case you have misplaced the questionnaires I sent to you, I am sending you a second copy.

Would you please complete the questionnaires and return them to me? I would like very much to be able to include your school system in my survey. When the study is completed, I will send you a copy of the results if you would like a copy.

Sincerely,

/s/ George A. Mundrake

*I have received the blue form, however do not have the yellow form.
Thanks.*

GM

APPENDIX D

CODING FORMS FOR SCHOOL APPLICATIONS AND
TECHNICAL INFORMATION QUESTIONNAIRES

CODING FORM

SCHOOL APPLICATIONS

[illegible]

APPENDIX E

CASE STUDY VISITATION QUESTIONNAIRE AND CONSENT FORM

VISITATIONS QUESTIONS

School System:

Number of students in system:

Population of area served:

Scheduling System:

Approximate number of students per school:

I. BACKGROUND AND EVOLUTION:

- A. How long has the system been using the computerized class scheduling?
- B. Have you used any other packages prior to the current one?
 - 1. What were the names of these packages?
 - 2. What were some reasons for changing from these packages?
- C. What were some of the problems encountered in the changeover to the current system?
- D. What method did you use to change over?
 - 1. Point change?
 - 2. Phase in, Phase out?
 - 3. Parallel operations?
 - 4. Why did you choose this method?
- E. What hardware do you currently use for class scheduling?

II. PLANNING, ORGANIZING, AND STAFFING:

- A. Briefly describe the procedure for involving a school in your scheduling process (initial contact):
- B. In the service area, how are the personnel organized for the scheduling process?
- C. How many are involved (at the service center) in scheduling a particular school?
- D. What personnel in the schools scheduled are involved in the scheduling process? (please indicate degree of involvement)
 - 1. Principals
 - 2. Clerical or office staff
 - 3. Counselors
 - 4. Others
- E. Do you provide a training program for new personnel using the scheduling system?
- F. Which personnel are involved?
 - 1. Principals
 - 2. Clerical and office staff
 - 3. Counselors
 - 4. Teachers
 - 5. Others

G. Associated Problems:

1. Communications problems:

- a. Have you encountered communication problems among personnel from the school and the service center?
- b. What were some of the steps you take to help avoid such problems?

2. Understanding the system:

- a. What, if any, are some areas of misunderstanding of the system? (i.e., master schedule building, conflict and tally, class loading, sequence of events)?
- b. What are some steps taken to help avoid such misunderstanding?

H. What are some techniques you use to aid in planning, organizing, and staffing of your scheduling system? (seminars, organization charts, PERT, GANTT, etc.)

III. PROCESSING, DIRECTING AND CONTROL:

Please describe the general system algorithm for class scheduling of a typical school:

A. Scheduling options

1. What would you consider as the most widely used scheduling options in your system?
2. What options are used infrequently?
3. What options or center developed options do you use to tailor the scheduling to a particular school (racial balance, etc.)?
4. Have you developed any aids to meet the needs of particular schools (special forms, scheduling specifications sheets, special student schedules for mini courses, etc.)?

B. What are some steps taken to control the cost of scheduling? (limiting number of copies, number of simulation runs, forms, etc.)?

C. How are your forms provided (prefolded, special order, cost, etc.)?

- D. What are some methods used to direct and control scheduling activities? (deadlines, PERT or GANTT charts, scheduling boards, etc.)

IV. INNOVATIONS:

- A. Have you used a master schedule building program? (which one?)
- B. What was your reaction to the schedule builder?
- C. Have you developed or manipulated existing options to conform to a particular scheduling need? (i.e., learning styles, racial balance, etc.?)
- D. What plans do you have for making changes in your scheduling system in the future? (What would you like to see changed in your system?)
- F. What would you consider the strong and weak points in your system?

C O N S E N T F O R M

You are invited to participate in one of the case studies dealing with the methods and procedures you use in the computerized scheduling of classes.

The purpose of the case studies is to illustrate a computerized scheduling system in narrative and illustrative form to provide information to other schools considering a scheduling system similar to yours.

Names of participants in the case studies will remain completely anonymous. Schools will be referred to as school A, B, etc. Descriptive data, illustrations, and narrations will be presented in a form that will not identify individuals or schools.

Your decision to participate or not to participate in the case studies will not prejudice your future relationship with The University of Tennessee. If you do desire to participate, you are free to withdraw your consent and to discontinue participating at any time without prejudice.

This certifies that the person(s) signing this form have participated of his or her own free will in the case studies portion of the research entitled "A Study to Assess the Current Status of Computerized Scheduling of Secondary School Classes" and is free to withdraw his or her consent and to discontinue participation in this study at any time without prejudice.

Signed:

Date:

VITA

George Allen Mundrake was born in Scranton, Pennsylvania in 1949. He attended elementary and secondary schools in the Abington Heights School District where he graduated in 1967. He attended Lackawanna Junior College in Scranton, Pennsylvania and earned an A.S. degree in 1969, followed by a B.S. degree in 1971 from Bethel College in McKenzie, Tennessee. In the same year, he accepted a graduate teaching assistantship at The University of Tennessee, Knoxville.

Following the M.S. degree from The University of Tennessee, Knoxville in 1973, he taught two years at Lake-Sumter Community College in Leesburg, Florida. In 1975 he accepted a second graduate teaching assistantship at The University of Tennessee, Knoxville where he received the Ed.D. degree in 1980. From late 1977 to 1980 he held the position of instructor in the Computer Science and Office Administration departments at The University of Tennessee, Knoxville.

The author served two terms as Treasurer of Mu Chapter of Delta Pi Epsilon and one term as chapter President. He is also a member of Phi Delta Kappa and the Association for Educational Data Systems.