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AN INVESTIGATION INTO THE TECHNOLOGY OF A
STATE-WIDE EDUCATIONAL ELECTRONIC DATA
PROCESSING SYSTEM DESIGN FOR MONTANA

By

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B.S., State College, Mayville, North Dakota, 1957

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requirements for the degree of

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in Business Administration

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Approved by:


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TABLE OF CONTENTS

ACKNOWLEDGEMENTS	ii
LIST OF FIGURES	iv
CHAPTER	Page
I. INTRODUCTION	1
COMPUTER IMPACT	2
STATEMENT OF THE PROBLEM	3
LIMITATIONS AND PROCEDURE OF INVESTIGATION	4
DEFINITION OF TERMS	5
II. ELECTRONIC DATA PROCESSING IN EDUCATION	7
ELECTRONIC DATA PROCESSING IN MONTANA	
EDUCATION	16
THE PROBLEM IN MONTANA	18
III. A REVIEW OF TIME-SHARING	20
DEVELOPMENT OF TIME-SHARING	20
REVIEW OF TIME-SHARING SYSTEMS	25
IV. TECHNOLOGY OF ON-LINE TIME-SHARING	39
PRINCIPLES OF DATA TRANSMISSION	40
COMMUNICATIONS FACILITIES USED IN DATA	
TRANSMISSION	47
COMPUTER REQUIREMENTS FOR ON-LINE,	
TIME-SHARING SYSTEMS	57
V. A STATE-WIDE EDUCATIONAL ELECTRONIC DATA	
PROCESSING SYSTEM	63
VI. CONCLUSIONS AND RECOMMENDATIONS	74

LIST OF FIGURES

Figure	Page
1. DATA TRANSMISSION PROCESS	41
2. TRANSMISSION LINE MODES	43
3. PARALLEL TRANSMISSION (MULTIPLE LINES)	46
4. PARALLEL TRANSMISSION BY FREQUENCIES	48
5. START-STOP TRANSMISSION	49
6. COMMUNICATION CIRCUIT ROUTES	50
7. FOREIGN EXCHANGE SERVICE	54
8. PILOT SCHOOLS TERMINAL SYSTEM	67
9. COUNTY CUPERINTENDENT OFFICE TERMINAL SYSTEM	69
10. REGIONAL COMPUTER SYSTEM	70

CHAPTER I

INTRODUCTION

Automation has been with us for only a short time, but technological change has had a long history. As each new wave of technology appeared, old skills became obsolete and workers were displaced. Because new skills were needed, the country's manpower requirements were changed, and educators had to revise their courses so that students would be equipped to meet the new job requirements.

For years, technological innovation has been America's stepping stone to economic prosperity, and it may continue to provide us with a high standard of living. Since the post-World War II boom years, even small industries have utilized automated machinery and techniques controlled by electronic computers. A major factor accounting for the rapid spread of computer utilization was the enormous amount of money spent on research and development by the Department of Defense and the National Aeronautics and Space Administration.¹

In the past decade, however, the pace of change has quickened. Those skills that have survived from yesterday's change are likely to be submerged tomorrow. New technological

¹Jerry M. Rosenberg, *Automation, Manpower, and Education*, (New York: Random House, Inc., 1966), p. 6.

changes are taking place not once in a generation, but in cycles of years or months.

Few schools now offer courses on automation. Yet, if the student is to prepare for the future, he should know what automation is all about now, what it might be a decade from now, and what changes in his training or thinking might be needed if he is to keep up with the new world of technology. He should be aware of the changes being brought by automation to business, science, and society in general.

No matter how we alter educational training and thinking, it is employment that gives us a means to enjoy our society. Students who cannot go on to college are finding that they must at least get a high school diploma with a broad base of general education to have the flexibility to adjust to the continually changing demands of the working world. We must prepare the students to face the challenges and opportunities that they will encounter in their work.

Each individual must have a fair chance to develop his abilities and to engage in productive and rewarding activity. In the Great Society, all men must have the self-respect and economic security that flow from full use of their talents.¹

COMPUTER IMPACT

Looking at the future of computers and electronic data processing, the Diebold Research Program indicates the growth

¹U. S., Department of Labor, Manpower Report of the President and a Report on Manpower Requirements, (Washington: Government Printing Office, March, 1965).

of the number of computers from 1960 to 1975 to be:¹

1960	4,500 computers in use in the USA
1965	30,000 computers in use in the USA
1970	90,000 computers in use in the USA
1975 (est.)	160,000 computers in use in the USA

Dr. G. Truman Hunter of International Business Machines Corporation has indicated that by 1975 approximately 450,000 people will be employed as computer operators and one and one-half million people will be employed as managers, programmers, and systems analysts. This does not take into consideration any of the clerical or support staff necessary to these positions. Dr. Hunter states: "Therefore it is estimated that the data processing industry will offer more new career opportunities than almost any other major field between now and 1975!"²

STATEMENT OF THE PROBLEM

Montana has 718 operating elementary schools, 27 junior high schools and 171 high schools spread across 147,138 square miles.³ The basic educational philosophy has been that of an equalization of educational opportunity for every student in the state. The impact of electronic data processing (EDP) on education has caused a problem in providing equalized opportunity

¹Diebold Research Program, "160,000 Computers in Use By 1975, Says Diebold," Administrative Management, February, 1970, p. 58.

²"The Supersonic Seventies," Business Automation, January, 1970, pp. 44-53.

³Montana, Education Directory, (Helena: Department of Public Instruction, 1970-71), p. 10.

in studying EDP. It is obvious that not every small school can afford to purchase a computer, and the majority of Montana schools are small.

This study is being conducted to investigate the design of a potential educational electronic data processing system, accessible to all schools in Montana and the Montana State Department of Public Instruction, for the purpose of providing access to electronic data processing services for all students, teachers, administrators and school managers, and the State Department of Public Instruction.

LIMITATIONS AND PROCEDURE OF INVESTIGATION

Economic feasibility is not being considered in this investigation for the fear of its inhibition in the design of the system.

The first series of resource materials read, consisted of magazine articles and theses relevant to electronic data processing in education.

The second phase of research involved the study of several articles and publications that dealt specifically with time-sharing electronic data processing systems. Communications were carried on with persons who have had experience in educational electronic data processing systems.

The third step in reviewing resource materials, was the examination of several technical books that related to system design, data transmission, telecommunication, and computer requirements for on-line, real-time, time-sharing electronic data processing systems.

The fourth aspect of the investigation was the interviewing of Mountain Bell Telephone Company officials in charge of specific services. The purpose of these interviews, was to inquire of the capabilities of the telephone facilities in the state to service a state-wide, on-line, real-time, time-sharing electronic data processing system.

The last research activity was the search for resource materials to be used in presenting workshop and in-service training to instruct teachers and administrators in the utilization of computers and electronic data processing.

DEFINITION OF TERMS

BUFFER A storage device used to compensate for a difference in rate of flow of data or time of occurrence of events, when transmitting data from one device to another.

COMMUNICATION LINK The physical means of connecting one location to another for the purpose of transmitting and receiving information.

COMPUTER A device capable of solving problems by accepting data, performing prescribed operations on the data, and supplying the results of these operations.

CONVERSATIONAL LANGUAGE A programming language which permits a user to instruct a computer via a terminal and receive an immediate response from the computer.

DATA PHONE A hardware device which provides the necessary interface between a terminal and communication link.

DATA TRANSMISSION The moving of data from one point to another point over communication links.

ELECTRONIC DATA PROCESSING (EDP) The processing of data, using predominantly electronic equipment such as an electronic digital computer.

MULTIPLEXING To interleave or simultaneously transmit two or more messages on a single communication link.

ON-LINE Pertaining to equipment or devices under direct control of the central processing unit.

REAL-TIME A real-time computer may be defined as one that controls an environment by receiving data, processing them, and returning the results sufficiently quickly to affect the functioning of the environment at that time.

TELECOMMUNICATIONS Pertaining to the transmission of signals over long distances, such as by telegraph, radio, telephone, or television.

TERMINAL A point in a system or communication network at which data can either enter or leave.

TIME-SHARING SYSTEM Characterized by multiple users working with one computer system simultaneously through remote terminals.

CHAPTER II

ELECTRONIC DATA PROCESSING IN EDUCATION

Changes occur so rapidly that it is difficult for the layman and the professional to keep their own knowledge up to date, and as companies become more and more automated, the demand for the unskilled worker shrinks as new jobs come into being. New skills are needed that emphasize the mental rather than the physical aspect of the worker. New positions are created which require a larger degree of creative intelligence. It depends upon the schools to turn out individuals who are not only capable of understanding and using the tools of an expanding technology but who will have the necessary knowledge and skill to adapt to the changes generated by current innovations. Automation and our increasing reliance on advanced technological methods present education with one of the greatest challenges of all time and promise immeasurable rewards commensurate with the investments educators are willing to make of their time and personnel to support the necessary research. Yet many are still skeptical about the possibilities of instructional technology, and education continues to lag as the most primitive sector of American technology.¹

The schools should be responsible for a student's acquaintance with automation--particularly with the computer and computer systems, by teaching them about the machinery and what computing can do.

Dr. Willard Korn has stated:

Teaching the fundamental concept of business data processing should provide a basis for further education of the individual--either in the form

¹Carlton H. Boyer, Philosophical Perspectives For Education, (Glenview: Scott, Foresman and Co., 1970), pp. 362-363.

of on-the-job training in business or for taking further coursework at the post-secondary level.

Many managers expressed the wish that our high schools would do more to introduce high school students to general electronic data processing concepts.¹

Most of the entry jobs in the electronic data processing area are open to high school graduates if they have had electronic data processing training in school.

Robert D. MacDonald has noted a growing tendency for business offices to look to secondary schools for the training in electronic data processing.²

William E. Greiner states:

High school graduates with a reasonable amount of technical training in data processing can qualify for many of the "apprentice" operator and programming positions that . . . data processing installations create . . .

Business education graduates with a knowledge of data processing will receive preferred consideration for clerical positions in the areas which prepare and edit data to be processed . . .³

Dr. Gilbert Kahn has said that no matter how small a high school business department may be, or how small its enrollment may be, or how inadequate its budget is, data

¹Willard M. Korn, "Business Data Processing for the High School," Journal of Business Education, December, 1969, p. 109.

²Robert D. MacDonald, "The Development of a Unit of Study in the Principles of Data Processing for Use in the Business Education Curriculum of Secondary Schools," The National Business Education Quarterly, 34:37, Fall, 1965.

³William E. Greiner, "Are Your Graduates Qualified to Compete in Today's Labor Market?," Business Education World, 44:9, December, 1963.

processing should be offered in the secondary school curriculum.¹

Obviously, computer facilities should not be limited to the business department of a school. Its computer power can be utilized by other departments and in the administration of the school. Mathematics and physical science departments are common users of the computer, biology classes utilize it in studies of genetics and social studies classes use it in their studies of pollution. Some schools formally incorporate the use of the computer into many courses while others require the use of the computer in a few courses and let the student apply it voluntarily on an individual basis in the rest of the courses. In either event, the computer appears to capture the imagination of most students.²

A valuable aid in a student's education is the using of computers to enable the student to deal with realistic problems rather than oversimplified models. By lessening the time spent in the drudgery of problem solving and analysis of data the student has more time for thought, insight and comprehension of the problem he is working on.

A bit of evidence on this matter was my observation of a senior student from Sentinel High School, Missoula, Montana, computing energy values used in his science experiment. It

¹Gilbert Kahn, "Take the Mystery Out of Data Processing," Business Teacher, 44:6-7, September-October, 1966.

²Richard T. Bueschel, "Time-Sharing, A Pragmatic Approach in the School," Educational Technology, March, 1970, pp. 21-23.

took the IBM 1620 computer, at the University of Montana Computer Center, two minutes and fifty-three seconds to compute the value sought of each of seven elements he was using in his experiment. Without the use of the computer to determine the value of the elements, his experiment would have been so time consuming it would have been necessary to reduce it to an unmeaningful sized model.

"Computers and computing are already invading junior high schools and elementary schools."¹

The Lebanon Elementary School in New Hampshire introduces the BASIC programming language to students at the fourth-grade level. When they reach the upper grades, these students use the computer in solving problems.²

Stanford University started a computer-assisted-instruction (CAI) drill and practice program in elementary-school mathematics in 1965. Forty-one, fourth-grade children used teletype and telephone lines to communicate with the computer.³

Additional Stanford University CAI programs are available in elementary reading, spelling and language arts for grades one through six. The purpose of these programs is to extend the learning environment of individualized instruction beyond that which the teacher has time to give each student.⁴

¹President's Science Advisory Committee, Computers in Higher Education, (Washington: Government Printing Office, 1967), p. 27.

²Bueschel, loc. cit.

³Patrick Suppes and Mona Morningstar, "Computer-Assisted Instruction," Science, October, 1969, pp. 343-347.

⁴Patrick Suppes and Max Jerman, "Computer-Assisted Instruction at Stanford," Educational Technology, January, 1969, pp. 22-24.

The New York City school system uses an RCA Spectra 70 computer for a CAI program that serves 192 student terminals in 15 elementary schools in Manhattan, Bronx, and Brooklyn. About 6,000 students in grades one through six are involved, and the curriculum used is a commercial successor of the elementary arithmetic drill and practice developed at Stanford University.¹

The Learning Research and Development Center at the University of Pittsburgh is attempting to find practical ways of providing an individualized educational environment. One of the projects, Individually Prescribed Instruction (IPI), has been under development since 1964 in the Oakleaf Elementary School near Pittsburgh.²

Computer-assisted instruction makes possible sophisticated approaches to instruction in many different fields and for students with a variety of interests or problems. "The question of whether CAI will play an increasing role in education is no longer debated. Rather, the question is 'When will CAI begin to play a more prominent role?'"³ Contrary to the understanding of many educators, CAI becomes another

¹D. Jamison, P. Suppes and C. Butler, "Estimated Costs of Computer-Assisted Instruction for Compensatory Education in Urban Areas," Educational Technology, September, 1970, pp. 49-57.

²William W. Cooley, "Computer Assistance for Individualized Education," Journal of Educational Data Processing, February, 1970, pp. 18-28.

³Patrick Suppes and Max Jerman, "Computer-Assisted Instruction," The Bulletin, (National Association of Secondary School Principals, February, 1970), p. 27.

vehicle to expand the professional capabilities of the teacher and not a substitute for him.

The question is no longer should we teach electronic data processing in the schools, it is now a question of to what extent can the school provide instruction in electronic data processing and obtain computer power adequate for the school's needs. The limits are primarily determined by the dollar cost of the computation service, the imagination of the teacher and students, and the availability of people who are able to apply these tools in new and useful ways.

The most common administrative uses of electronic data processing, at the present time, are the custodial jobs of scheduling, recordkeeping, grade reporting, general accounting, and state and federal government reporting. Unless a school district accounts for 30,000 or more students, these custodial jobs do not justify the ownership of a computer system by a single school district.¹

What can EDP do for school administration?
The uses of the computer and electronic data processing (EDP) in administration of public education are limited only by the imagination of professional administrators. The time has come to stretch this creative potential.²

It is possible for the administration, with the aid of a system simulation model builder, to develop a program by

¹A. B. Ellis, "Regional Data Processing for Schools," International Review of Education II, 1968, pp. 226-232.

²EDP and the School Administrator, American Association of School Administrators, May, 1967, p. VIII.

which the administrator could test alternatives prior to making a decision. The administrator is then able to plan in anticipation of problems rather than react to crises. The system simulation model can be for the educational administrator what the laboratory test facility is for the engineer.¹ Though expensive to construct, such simulations help to avoid costly mistakes and may result in conservation of public funds in the long run.

The Committee on Electronic Data Processing of the American Association of School Administrators recommends that each school district participate in, contribute to, or have access to a computerized educational information system or a data bank related to its needs.² The information system may contain data on professional, administrative, and supervisory staff and non-certified personnel. A second data file could contain information on students. Another data file may be developed on facilities, supplies, equipment, and financial transactions, etc. The speed with which the computer acts makes the data available almost instantaneously. The information system and speed of the computer place Planned-Program-Budgeting-System (PPBS) and program cost accounting and analysis

¹Richard W. Judy and Jack B. Levine, A New Tool for Educational Administrators, (Canada: University of Toronto Press, 1965), p. 7.

²EDP and the School Administrator. American Association of School Administrators, 1967, p. 5.

within easy reach of the administration.¹ Reports prepared by local districts for the state education department could be less burdensome, more up to date, and perhaps even fewer in number if the information system were a state-wide educational information system, utilizing a centrally located computer at the state department of public instruction. Contribution and access to the information system could be accomplished by teleprocessing operations between the state department computer and local school units. This type of system would contribute to the conformity of a uniform record system for schools state wide. It would also provide the facilities for implementation of an accounting system for state-wide financing if it materializes as predicted by some educators.

The computer, being a relatively new invention, may do more to modify the shape and destiny of our world than did any other invention. No life will be left untouched by the pace of the technological revolution. The change generated appears to feed upon itself--the greater the rate of change, the greater the pressure for more change. It would be unrealistic to assume that education will not be altered to a great extent in a society committed to radical and unending change.

Educators must be concerned about computers, must learn about them, must teach about them. They cannot ignore them. The computer is not going to go away. Its effects will not fade, its use will not

¹J. P. Maloney, Jr., "Electronic Data Processing in Education," Journal of Educational Data Processing, Fall, 1969, pp. 225-229.

decline, its influence will not disappear.¹ After a dozen years, this much is surely obvious.

The computer has had three profound impacts upon education: (1) computer appreciation (2) utilization of the computer as a learning tool and (3) use of the computer in educational administration.

Computer appreciation is more than the study of automation. It includes understanding the simplicity of the machine responsible for the computerized age. The notion that computers do not "think," but must first be instructed by a human being, is not easy for a student to understand until he tries instructing a computer himself and learns the rudimentary skills of computer technology. It is important for all students to be aware of the potential power of the computer, whether they will be affected indirectly by the computer impact on society or directly as a user of the computer. They should also learn of its effects on job opportunities and the labor market.

Utilization of the computer as a learning tool can be done in many ways. Computer-Assisted Instruction (CAI) (programmed learning, with the learning program stored in the computer is one way). Computer Based Instruction (CBI) (uses the computer as a tool in guiding learning by traditional techniques). The computer is used to test individuals, analyze their test scores and advise future direction of the student's study based on this analysis. Computer Enriched Instruction (CEI) is utilizing

¹James J. Fast, Jr., "The Inevitable Idea," Journal of Educational Data Processing, (Volume 4, No. 2, Spring, 1967).

the computer in various facets of formal learning and problem solving. A high degree of understanding is gained in developing a complete and logical program to instruct the computer in the solution of a problem. The student must thoroughly understand the concept of the problem to be successful in his efforts.

Use of the computer in educational administration for custodial processing only scratches the surface of its potential. Its real value lies in management planning and control. Through the use of information systems and the computer, future school system projections can be made. These projections can be tested by the use of simulation models. Periodic control tests can be run to determine what adjustments, if any, need to be made in the projections. School management can be alerted to potentially serious problems well before they become a reality. In this way, the seriousness of the problem can be lessened or plans changed so as to avoid the problem completely. Used in this way, the computer is a source of hope for the school system management confronted with complex problems that thus far have defied solution.

ELECTRONIC DATA PROCESSING IN MONTANA EDUCATION

Electronic data processing, is in its infancy in the schools of Montana. Fifty-six of the 171 secondary schools in the state have indicated an interest in or curiosity about the computer and its capabilities in education by having data

processing service centers prepare the academic schedules of their students for the school year 1970-71.¹

Very few schools in the state of Montana have direct access to a computer facility. One public school in the state has its own computer system. Two schools have limited access to a computer in the vocational technical schools operated in conjunction with the public school in each community. Four schools utilize batch processing on computers owned by industry in their communities. A few schools have very limited access to the computer systems on the campuses of four units of the Montana University System. Only one of these units has remote terminal, on-line, time-sharing capabilities. The State Department of Public Instruction has a Honeywell 200 computer on which it provides student scheduling and grade reporting services on a batch processing basis to schools throughout the state.²

Given present costs, most of the 916 operating schools in the state do not have enough use for a computer in the classroom and administration to justify owning or leasing one for that single school. This is a major reason why the curricula of the schools in the state do not include an extensive amount of instruction in electronic data processing, nor do these schools use a computer as a teaching tool to enrich the traditional education process.

¹Based on a telephone survey between Montana School Administrators and the writer. April, 1970.

²Ibid.

Much controversy reigns at present regarding whether or not "hands on" time should be provided to students of data processing. It is difficult to justify the expensive hardware for a high school course. Perhaps cooperation with local industry may serve as an answer for some school systems desiring to include "hands on" time or for those systems that want student programs processed.¹

The small school will have very little chance of offering hands on experience in its teaching of electronic data processing if it must wait until its school district can own or lease a computer and the software to go with it. However, some form of instruction in electronic data processing must be provided in the very near future. Each year it is delayed, means that our education system becomes one more year outdated.

Secondary-school students should be taught what computers and computing are. In addition, it may be that computers can be used to improve the teaching of many courses. Computers may be useful in stimulating the interest of students who cannot be reached in other ways.²

THE PROBLEM IN MONTANA

In keeping with the philosophy of equalization of educational opportunity in the state, every school and every student in Montana should be provided with the opportunity to have access to computer power. The problem we are confronted with is, how are we going to provide the computer power? With

¹Willard M. Korn, "Business Data Processing for the High School," Journal of Business Education, December, 1969, p. 110.

²President's Science Advisory Committee, Computer in Higher Education, (Washington: Government Printing Office, 1967), p. 26.

most of the schools in the state having a small enrollment, this implies some form of computer cooperative or time-sharing among schools. A total of 916 operating schools spread across 147,138 square miles means there is a great distance between schools; and, therefore, commuting distance to a shared computer center is unreasonable. This indicates that data transmission would be best handled by communication links and on-line terminals. Therefore, on-line, time-sharing computer systems seem to be the answer.

The next two chapters will review time-sharing systems and investigate the technology of data transmission as a basis for the development of a potential solution to the computer problem in Montana education.

CHAPTER III

REVIEW OF TIME-SHARING

DEVELOPMENT OF TIME-SHARING

Time-sharing (the almost simultaneous use of a computer facility by a number of independent users of multiple terminals)¹ can be traced back to 1940, when George Steibltitz of Bell Telephone Laboratories demonstrated the possibilities of data telecommunications to participants in the Mathematical Conference at Dartmouth College. This first demonstration link connected New Jersey to the Hanover, N. H., campus. However, it wasn't until 1952 that data retrieval systems using communication lines became operational: the first at American Airlines, and later in the year, a larger system at the Toronto Stock Exchange. Although these early systems used memory storage devices, it wasn't until IBM's RAMAC appeared in 1956 that a general purpose computer with memory capabilities became feasible. In 1958, AT&T installed its first dataphone which could enable a teletypewriter terminal to communicate with the computer. Thus, the hardware ingredients for time-sharing were assembled; a computer with memory

¹Peter F. Carr, "Time-Sharing Growth: A Communications Phenomenon," Computervorld, March 25, 1970, p. 19.

capabilities, a communication link that could handle data and input/output devices in the form of dataphones.

Many of the concepts behind time-sharing were developed at Massachusetts Institute of Technology (MIT). In 1959 and 1960 technical papers by members of the MIT faculty described the potential advantages of time-sharing.

One member of this staff, who was deeply involved in the early papers and experimentation, is J. C. R. Licklider, often called the "father of time-sharing."¹ He was instrumental in securing funds for several experimental systems including the famous Project MAC (Multiple Access Computing) at MIT.

The first truly time-shared system initiated at MIT was in 1961. It utilized an IBM 7090 computer to service eight users. This experimental project paved the way for establishment of the first prototype of a commercial system.

In 1963, Rand Corporation took a major step in developing the fourth component to a time-sharing system, a conversational language. It implemented the JOSS language which is the forerunner of many of today's conversational languages such as BASIC (a conversational programming language designed in 1964 at Dartmouth, under the direction of Professors John Kemeny and Thomas Kurtz through a National Science Foundation grant). JOSS is the first easy-to-learn conversational language

¹Peter F. Carr, "Time-Sharing Growth: A Communications Phenomenon," Computerworld, March 25, 1970, p. 19.

that attempted to place programming within the capabilities of the ultimate user.¹

Terminals for these new power tools became available at certain universities and research institutions in 1963. These remote terminals provided access for up to 30 users with the MIT developed CTSS (Compatible Time-Sharing System.)²

These developments made possible what Professor John McCarthy of MIT introduced in one of his lectures, in 1961, as the notion of a computer utility capable of supplying computer power to each customer where, when, and in the amount needed.³ He described the method of operation to be analogous to that of an electric power distribution system. In this case, the computer utility would supply logical power to aid the individual in solving his processing and computational problems.

The educational concept of time-sharing had its birth in 1964 when Dartmouth College acquired a GE-265 computer with the help of General Electric and the National Science Foundation. By the fall of 1964, 20 terminals were in use and Dartmouth students were instructed in the use of the computer as a part of the mathematics curriculum.⁴ From this time on, Dartmouth has been influential in the utilization of computers in education.

¹M. V. Wilkes, Time-Sharing Computer Systems, (New York: American Elsevier Publishing Company, Inc., 1968), p. 6.

²Carr, loc. cit.

³Edgar C. Gentle, Jr. (ed.), Data Communications In Business, (New York: Publishers Service Company, 1965), pp. 89-90.

Carr, "Time-Sharing Offers a New Tool for General Terminals March 25, 1970 p. 2

The ability to service simultaneous on-line, time-sharing users has advanced steadily since 1963. General Electric has a time-sharing system which can service up to 50 users concurrently.¹ Systems capable of supporting several hundred users are forecast for use in the near future.

In the same way that there are small and large computers, so there are also small and large time-sharing systems. A small system offers facilities of limited scope. Typically, there is only one programming language available and the size of the problem must be restricted. In the small systems there are no secondary, on-line file capabilities so each session at the terminal must begin with the loading of the program developed and at the end of the session the user must get a complete output, for nothing will remain of his work in the computer after the next user has obtained the computer for use. Small systems have great value for simple statistical calculations that are tedious to do, but small systems have very little value for administrative applications.

The larger and more sophisticated on-line, real-time, time-sharing systems attempt to give the user as unrestricted access as possible to the computer. Several high-level programming languages are often available for use, and in addition it is possible to program in machine language. Secondary storage file systems are provided with the computer; and, associated peripheral equipment enables the user to store

¹"The New 'Tailored' Business Computers," Administrative Management, October, 1970, p. 50-59.

programs, data, etc., available to the computer much the same way as data are stored in an office filing cabinet. The user may delete, update, or expand currently stored programs or data files from his terminal. It is not necessary that an entire document be re-typed to change it. The user often has access to useful programs that are already prepared and kept on file in the computer memory (program library). In addition to providing in-line (continuous) processing service to people working at remote terminals, a large real-time, time-sharing system can also provide remote batch (periodic) processing and the ordinary on-site batch processing. Remote batch processing usually consists of the program and the data on which the program will operate, all being transmitted from a remote terminal. It is received into what is known as the "background" of the central processing unit because it is processed during the delays in the in-line processing that is taking place in the time-shared (foreground) activity of the central processing unit. On-site batch processing is processed in the same manner except that it is entered into the computer by on-site input devices.

It is now possible for a user's terminal to be connected by a communication link to the most powerful computer, which may be located as close as the next room or as far away as half way around the world. All users, wherever they are, have instant access to the computer, and expect a response to their message very soon. Response time is limited only by the fact that the computer must share its time among all the users that are currently logged in. Because of the difference between human

speed and computer speed, which is on the order of 1 to 1 million, (predictions for fourth generation computers are to increase this speed by five times 1 to 5 million) the user at the terminal is under the illusion that he has exclusive possession of the system which is responding to his inputs very fast, although it is actually paying attention to him only periodically and is servicing other users in the interim.¹ This is possible, due to the various methods of multiplexing, transmission, and buffering of data.

REVIEW OF TIME-SHARING SYSTEMS

Dartmouth Time-Sharing System

The nation's schools are rapidly becoming aware of the value of time-sharing in education. For both students and teachers, time-sharing offers a new approach to learning by making available an advanced method of problem solving.

Time-sharing has become an essential part of academic life, particularly in the New England area where the innovative influence of Dartmouth College has had a marked effect on computer aided education techniques.

At present, the Dartmouth Time-Sharing System (DTSS), built around a GE-635 and a Datnet-30 computers, services over 110 terminals in use within the Dartmouth community. About 26 are in use in other institutions of higher education.

¹Joseph Orlicky, The Successful Computer System, (New York: McGraw-Hill, Inc., 1969), p. 49.

and over 35 in secondary schools.¹ Their main purpose of associating with secondary schools is to show that the computer can be a significant contribution to secondary education within the existing curriculum, without extensive teacher training. The system demonstrates that computing encourages students to think creatively. The results of this research are published to serve as guidelines to others in the utilization of computers in education.

The project findings reveal: 1. The computer is best used for exploring problems of personal interest to the user, that is, as a creative outlet for his curiosity. 2. Development of the ability to program (the process of writing instructions for the computer to follow in solving the problem) is a matter of a few hours. 3. The average student can learn to program in the seventh grade. 4. The major influence a student's ability has on using the computer is the length of time required to write the program.²

The results of the Dartmouth project so far indicate that it is quite feasible for small colleges and schools to obtain computer resources from a remote supplier. Not only are they able to obtain computing power in almost the exact quantity needed, but they are able to do so without significant investment.³

¹Peter F. Carr, "Time-Sharing Offers a New Tool for General Teaching," Computerworld, March 25, 1970, p. 2.

²Ibid., p. 18.

³Ibid.

Computer Instruction Network

Computer Instruction Network (C. I. Network) was approved in early 1967 for funding under Title III of ESEA (Elementary and Secondary Education Act of 1965). C. I. Network was proposed to operate in Marion, Polk, Lincoln, Yamhill, and portions of Clackamas and Linn counties in Oregon.

The objectives of C. I. Network were:

1. The development of awareness on the part of high school students of the impact that computers will have on their lives.

2. The development of awareness of potential job opportunities in fields related to, or which utilize computer technology.

3. The development of rudimentary skills in the use of various types of computer technology.

4. The involvement of several hundreds of high school students in activities utilizing computers to the end that these students would find opportunities to employ computers in various facets of their formal learning.

Equipment used in the project consisted of:

1. Four portable computers, rotated among the schools for periods of three weeks.

2. A computemobile, which consisted of an IBM 1130 computer and paper tape equipment, mounted in an International Harvester Metro Van truck. Power for the computer is available either from an external power source or from a self-contained generator. The van makes regularly scheduled trips to various schools in the project.

3. Teletype terminals in twenty-two schools were used for off-line tape punching, intra-C. I. Network communications, and G. E. Time-sharing.

All computers in the C. I. Network program used punched paper tape for input medium.¹

¹Don Holznagel, "1967-68 Computer Instruction Network Recap," (Salem, Oregon: C. I. Network, 1968, p. 1 (mimeographed)).

The C. I. Network project served a student population of 18,500 students in grades 7 through 12 for a period of three years. A total of 283 courses, involving computer instruction, were taught in the forty participating schools. Many of these classes consisted of integrating computer instruction and utilization into existing classes. Of the 283 courses, 177 were units integrated into existing mathematics classes, 144 into existing business classes, and 29 into existing science classes. Computer instruction courses offered in the participating schools varied from school to school. One-semester courses accounted for 38 classes and 25 were full year classes.¹

The curricula included, in most cases, a brief study of machine language programming with hands on operation of the computer by students. After each student had attained a minimum understanding of computers, a time-sharing terminal was made available and students learned to program in BASIC. The computemobile, with the IBM 1130, was used primarily to run FORTRAN programs.²

Teacher training consisted of evening courses in computer appreciation, and introduction to computers, and data processing in education. Those teachers who were to teach about

¹See End of Project Report of Computer Instruction Network, Project No. 24-000-902-0, Title III, E.S.E.A., U. S. Office of Education.

²Judith B. Edwards, Computer Instruction: Planning and Practice, (Portland: Northwest Regional Educational Laboratory, September, 1969), pp. 53-54.

computers, programming, or use the computer as a problem solver took additional courses. Teachers who wanted to use the computer for more advanced problem solving, were encouraged to take additional courses at colleges and universities. In-service teacher training programs and seminars were held for teachers in particular subject areas to provide guidance in the use of the computer in specific subjects.

Federal funding of C. I. Network ended in June 1970. At that time, sixteen of the schools had provided their own funds for hardware and others had made arrangements to continue computer instruction.¹

The evaluation by Teaching Research Division, Oregon State System of Higher Education, found that the C. I. Network project had a definite positive impact and produced significant change in its participants.²

The Oregon Total Information System

The state of Oregon, with approximately 120,000 square miles and 376 individual school districts with over 475,000 students, has faced the realization that computers are here to stay and must be used by the educational enterprise.³

¹Don Holznagel, "Computer Instruction at the Crossroads," Computalk, January, 1970, p. 3.

²End of Project Report, Computer Instruction Network.

³"OTIS Merges Management and Education," Business Automation, July, 1970, pp. 38-39, 44-45.

How many first-year teachers are on the staff? What is the account balance? What is the teacher-pupil ratio? What are the achievement test scores for arithmetic in the fifth grade at Washington Elementary School? Has John been absent an excessive number of times this quarter? How well does he read? Does he have any brothers and/or sisters? How many students for impacted area monies? How many students in South High School requested geometry on their schedules for the fall term?

This set of questions might well be heard in any superintendent's or principal's office in the nation on any random day. The usual sources for this kind of information have been inherited from the simpler past, which did not find it necessary to be involved with such large numbers of students nor with so many related agencies. As any educator knows, these sources have become burdensome to maintain, cumbersome to use, and less reliable as the need for information becomes more urgent.

Fortunately, in combination with this avalanche of data need, there is a remarkable new tool for use by society--the computer. Any school district can reasonably expect to benefit from using the computer both to store information and to provide rapid access to unlimited amounts of data. In addition, the computer can be used in an instructional mode: to learn about computers; to learn how to use the computer; or to use the computer as the vehicle for presenting materials from other fields (CAI).¹

Through the efforts of a number of capable educators, plans were laid in 1964 to develop a locally supported "cooperative" which would provide computer services for local school districts. These efforts helped to bring the problem of cost and organization clearly into focus in the minds of many Oregon superintendents and school boards. At a large gathering of superintendents in the fall of 1964, it became

¹Lowry M. Bennett, "OTIS: The Oregon Total Information System," (Mimeographed.) Received April, 1970.

apparent that local school districts could not raise the required funds to support such an effort.

Nothing more was done with the plan until after Congress passed the ESEA of 1965; then the plan was rewritten and submitted to the U. S. Office of Education, which accepted it in 1966 for a twenty-month planning grant under Title III of ESEA. The project was funded for a three-year demonstration period beginning May 1, 1968, with thirty-six districts, from all over the state of Oregon, tied directly to the OTIS (Oregon Total Information System) central computer, via leased telephone lines with seventy-five keyboard terminals. The many small school districts, spread so widely, made teleprocessing a distinct necessity. If OTIS were expecting remote districts to collect information and store it in the system, an environment was needed that would give access to data faster than the mails could provide for inquiry and updating.

Services include all normally desired management services, such as payroll, personnel accounting, grade reporting, school sectioning, modular scheduling, student programs, and others. Class instruction programs are processed in a batch environment. The System loads student programs on a tape for evening processing and returns diagnostic printouts the following morning.¹

¹Lowry M. Bennett, "Contributors to Automated Educational Information Systems in the 1980's" (Eugene, Oregon: Educational Information System Requirements: The Next Two Decades, 1967), pp. 104-112. (Mimeographed.)

Local district personnel involvement was identified as one of the most critical problems for a regional center to overcome. Numerous groups in any region will have developed techniques and procedures over the years that are nearly sacred. The pride-of-authorship syndrome elicits extremely strong defense when questions by an outside group are asked.

The OTIS staff did carry on two five-day seminars for school superintendents. During the seminars, as much information as possible was disseminated to local district superintendents to acquaint them with the OTIS effort and overcome or adjust to some of their reservations about the project. By all measurable standards the seminars were considered a success and did result in some modifications in the services offered by OTIS.

At the present, OTIS offers a wide range of services to the 22 member school districts. A district subscribing to all the services offered by OTIS pays around \$9 per month for each student in the district. This figure is expected to be substantially reduced as the system expands to more schools.

Mr. Bennett states: "Questions to be considered in the development of a regional center are for the most part political in nature." A few questions to be answered follow: Are the local boards and educators in the region willing to accept change? Able to make solid commitments? Willing to work and share with others? Capable of supporting and protecting a new supplemental staff that normally does not have

teaching credentials, but will probably receive higher average wages and increases than the certified staff?

Every school district should be making plans for increased computer use. There is no magic way to get the data-processing products needed to run a modern, responsive, educational institution. Increased needs for computer services, coupled with the complexities of current information systems and the scarcity of qualified computer personnel, makes the regional data center a must for all schools with less than 100,000 students within five years or less.¹

Computer Assisted Instruction at Stanford

Since January, 1963, the Institute for Mathematical Studies in the Social Sciences at Stanford University has been conducting a program of research and development in computer assisted instruction. Currently, both tutorial and drill-and-practice programs are in operation.²

Tutorial programs include a three-year sequence in logic and algebra offered as a supplement or enrichment for the very bright students in the regular mathematics program, beginning at grade five. Students in Kentucky, Mississippi, Tennessee, San Francisco and Ravenswood, California use teletypes, connected by telephone lines to a computer on the Stanford campus. A second course, computer based elementary

¹Lowry M. Bennett, "OTIS: The Oregon Total Information System," (Mimeographed.) Received April, 1970.

²Patrick Surpes and Max Jernan, "Computer-Assisted Instruction at Stanford," Educational Technology, January, 1969, pp. 22-24.

Russian, is offered for credit on the Stanford campus and now a second-year course is available. Two tutorial programs to teach computer programming were being developed in 1969.

Drill-and-practice programs are used for arithmetic lessons for 3,800 students enrolled in 31 elementary and junior high schools. The program is designed to supplement classroom instruction by providing individualized practice on basic skills and concepts after they have been instructed by a classroom teacher. A drill-and-practice program in elementary reading was scheduled to be started by 1970.

A special set of math lessons has been prepared at Stanford University to be used by telecommunications for the Math 111 course for entering freshmen at Tennessee A. and I. State University at Nashville, Tennessee. Math 111 is the first course of a three-course sequence for students who lack sufficient background to enter the regular calculus sections at the university.

New programs under development are an elementary math sequence. Problems are arranged sequentially by concept. Each lesson is generated according to each individual student's performance. A second new program in arithmetic is one which emphasizes problem solving. The student will be given a word-problem statement. The student commands the computer to perform operations by typing simple statements and ending the last statement with a colon which causes the computer to perform the commands. The computer will evaluate the method applied and the answer computed and will respond to the student, indicating whether or not his application was correct.

Computer Assisted Instruction in New York City

The nation's largest CAI operation in a public-school system concluded its first full year of operation in June 1969. The results indicate a very definite success for education's most closely watched use of technology.¹

The New York City School System used an RCA Spectra 70 computer for a CAI program that served 192 student terminals in 15 elementary schools in Manhattan, Bronx, and Brooklyn. About 6,000 students in grades one through six were involved and the curriculum used was a commercial successor of the elementary arithmetic drill-and-practice developed at Stanford University.² Response time to any and each terminal was kept within two seconds. The average lesson is ten minutes in length. A high degree of acceptance was indicated by the willingness of the schools to set up after-school programs from three to five p.m. The utilization rate during the after-school program was 70% of the utilization during the regular school day. An evening program was initiated, through the Bureau of Adult Education, for foreign-born students to study English.

Another activity based on CAI included a six-week CAI course in the BASIC programming language and an introduction to computer concepts given to 80 students from six Manhattan

¹Cornelius F. Butler, "CAI in New York City," Educational Technology, October, 1969, pp. 84-87.

²D. Jamison, P. Suppes and C. Butler, "Estimated Costs of Computer Assisted Instruction for Compensatory Education in the Urban Areas," Educational Technology, September, 1970, pp. 49-57.

high schools. This was accomplished by using remote terminals connected to a time-sharing system.

University of Pittsburgh's Individually Prescribed Instruction
in the Oakleaf Elementary School

The development of the Individually Prescribed Instruction (IPI) approach involves curriculum design, test development, and specification of management procedures.¹

The curriculum is defined in terms of specific objectives which are grouped into clusters called units. The units are further grouped into modules for grades one through six rather than year-long textbook courses. Each student is given placement testing to determine his competencies with respect to each curriculum area rather than achievement tests which only determine his competencies in relation to other students. The student's placement is entered into the computer based management system. The teacher, with the aid of this system, plans with each student the module he should study in the various areas of the curriculum. The student takes a pretest on the computer terminal. The results are analyzed by the computer, and it suggests the unit which the student should study. He then goes to the department in which he plans to study the unit and gets the study kit for that unit. Upon completion of the unit, the student takes a post-test to determine whether or

¹William W. Cooley, "Computer Assistance for Individualized Education." Journal of Educational Data Processing, February, 1970, pp. 18-28.

not he has achieved mastery of the materials in that unit. If so, he will be advised, by his teacher, with the aid of the management system, which unit he should go to next. If he has not mastered the material, he will be advised to study a unit that will help him overcome his difficulties..

Individually Prescribed Instruction is envisioned to ultimately be an ideal educational environment in which each student will be free to learn, to browse, and to follow his natural curiosity by avoiding the present lock-step process of fixed schedules, final examinations and grades.

SUMMARY

Articles written in the last three or four years about the impact of EDP on education, experimental projects in Computer Assisted Instruction and Computer Enriched Instruction, all indicate a wide acceptance of the computer as a teaching device and that students have profited a great deal from its use. The greatest portion of the experiences indicate that the time-sharing computer is an important teaching tool, especially with the use of multiple terminals.

South Portland, Maine, high school principal, Keith K. Thompson, makes a rather representative statement of the feelings of a lot of persons involved with a time-sharing computer system for instruction: "Students still line up to use the teletypes, and we've had to keep the building open nights, Saturdays, school holidays, and during the summer vacation to meet the demand for extra computer time. It has

been one of the single greatest motivating forces . . . that I have experienced as a high school principal."¹

¹Keith K. Thompson and Ann Waterhouse, "The Time-Sharing Computer: A Teaching Tool," The Bulletin, (National Association of Secondary School Principals, February, 1970), n. 91.

CHAPTER IV

TECHNOLOGY OF ON-LINE TIME-SHARING

With the development of electronic data-processing systems, it became apparent that existing telephone and telegraph facilities could be utilized for the purpose of sending data to a central point for processing. Large volumes of detailed information, formerly delayed by distance or weather conditions, could now be transmitted, processed, and the results returned immediately. This is data communications.

The height of technological achievement occurred when information in storage could not only be accessed randomly but also transmitted between a geographically remote terminal and a centrally located computer. This is accomplished by use of private cabling or utilizing leased or dial up lines provided by common carriers.

The on-line linkage implies direct access between the peripheral device and the central processing unit. Data transmission takes place without intermediate handling or storage of the data and is handled with a remarkable degree of accuracy. If an error is caused by communication link failure, the equipment can detect the error and retransmit that portion of the data that contained the error. The most frequent cause of error in data-communication systems is operator error at the point of input. Man is the only intellectual part of the

system and he is also the only emotional part of the system. The accuracy of the input procedure is closely related to whether the input person feels that the data is being usefully applied somewhere. The more the individual understands the system and its usefulness, the lower his error rate because of his increased interest.¹

PRINCIPLES OF DATA TRANSMISSION

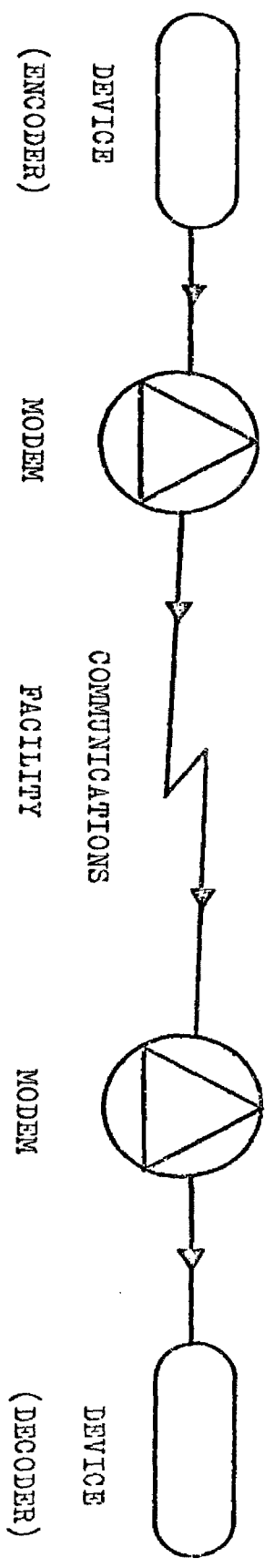
Basically, data transmission is the moving of data from one point to another. In theory, the process can be broken down into five stages, each of which can be represented by a physical component (see figure 1).

First there must be a device (encoder) which originates a bit code signal (a signal which transmits bits, the smallest unit of information in a binary system, in coded arrangement such that a controlled group of five or eight bits make up a character). The bit code scheme must be compatible with the equipment at the destination of the data. If this signal is not the same as that used by the transmission medium (e.g., the telephone system) it is necessary to utilize a modem or data set to modulate the signal to enable it to be transmitted by the common carrier facilities.

The transmission medium is a wire or wires energized by current. The process of modulating this medium is accomplished when the modem alters the current flow which creates pulses on

¹David Foster, *Automation In Practice*, (London: McGraw-Hill Publishing Company Limited, 1968), p. 120.

FIGURE 1
DATA TRANSMISSION PROCESS



the line. The rate at which binary states can be modulated to produce line signals is dependent upon the bandwidth (the range of frequencies available for sending signals, expressed in cycles per second) of the transmission facility. Roughly speaking the greater the bandwidth of a facility, the greater the potential bit-per-second transmission rate. Voice grade facilities, for example, have a range of approximately 3,000 cycles, capable of up to 4,800 bits per second transmission. To reach this upper limit rate, it is necessary to have a leased, conditioned line (conditioning is the adding of equipment to the line to bring its performance within limits for high speed data transmission). Sub-voice grade facilities have a transmission rate of up to 200 bits per second and wideband facilities have capabilities of up to 500,000 bits per second transmission.¹

To transmit data, one must decide what mode of transmission is desired or necessary for the type of components used in transmission. The mode of transmission is classified by determining if transmission is to be in one direction only or in both directions at the same time. If it is the latter, will the components transmit in both directions at the same time? The mode of transmission lines is classified as simplex, half-duplex and full-duplex (see figure 2).

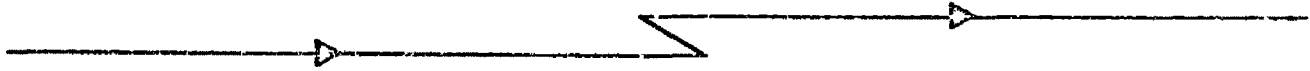
Simplex lines are capable of transmission in one direction only.

¹James Martin, Telecommunications and the Computer, (Englewood Cliffs: Prentice-Hall, Inc., 1969), p. 96.

FIGURE 2

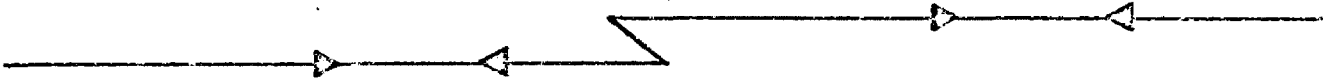
TRANSMISSION LINE MODES

SIMPLEX - HALF DUPLEX - FULL DUPLEX



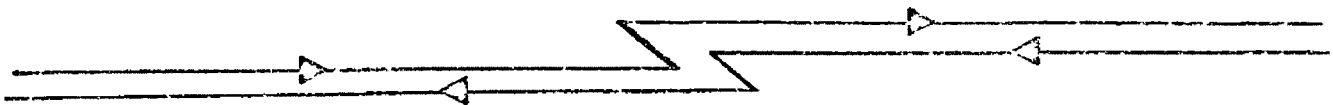
SIMPLEX

(ONE DIRECTION TRANSMISSION)



HALF DUPLEX

(TWO DIRECTIONAL TRANSMISSION--NOT SIMULTANEOUS)



FULL DUPLEX

(TWO DIRECTIONAL TRANSMISSION--SIMULTANEOUS)

Half-duplex lines can transmit in either direction, but only in one direction at one time.

Full-duplex lines can transmit in both directions concurrently. One full-duplex line is thus equivalent to two simplex or half-duplex lines used in opposite directions.¹

Simplex lines are not generally used in data transmission because, even if the data are only being sent in one direction, control signals are normally sent back to the transmitting machine to tell it that the receiving machine is ready or is receiving the data correctly. Commonly, error signals (positive or negative acknowledgment) are sent back so that there can be retransmission of messages damaged by communication line errors. Many data transmission links are half-duplex lines. This allows control signals to be sent and two-way "conversational" transmission to occur. On some systems, full-duplex lines can give more efficient use of the lines at little extra line costs. A full-duplex line often costs little more than a half-duplex line. Data transmission machines which can take full advantage of full-duplex lines are more expensive however, than those which use half-duplex lines. Half-duplex transmission is therefore more common at present, though this might well change.

The question of whether a line can support transmission in both directions at the same time or not, will depend on the speed desired and on whether it is a two-wire or four-wire line. The circuit from your telephone to the local telephone exchange

¹James Martin, Teleprocessing Network Organization, (Englewood Cliffs: Prentice-Hall, Inc., 1970), p. 8.

is usually a two-wire path, that is, only two signal-carrying wires leave your telephone. A two-wire telephone circuit can generally be used in a half-duplex fashion and a four-wire circuit can always be used in a full-duplex fashion. It is possible to use certain two-wire circuits in a full-duplex manner if they have an appropriate arrangement of amplifiers. To do so needs a special modem, and the maximum speed obtainable would be less than with a four-wire circuit. The specifications of data sets, which connect a data-handling machine to the line, state whether they operate in a half-duplex or full-duplex manner and whether they need a two-wire or four-wire circuit.

A wide variety of techniques exist for controlling the flow of characters on the line. A variety of different machines are available to connect the transmission facilities to the computer or other data processing equipment.

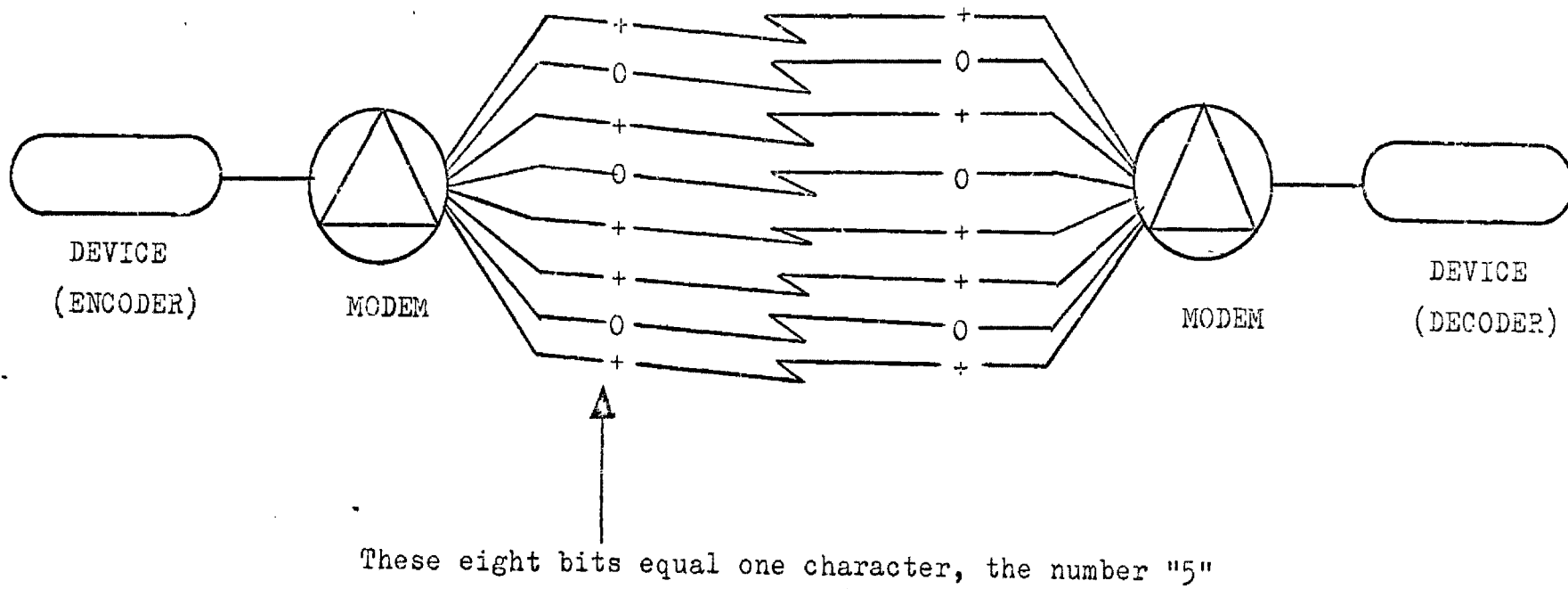
Some machines use parallel transmission, which uses eight separate paths or lines between the same locations, to convey eight-bit characters parallel by bit. This can reduce terminal time costs, but where the paths are physically separated it must be for short distances or the line costs will overshadow the savings in terminal costs (see figure 3).

Parallel transmission may be split over one physical path by using different frequencies for each transmission path. In this method, transmission is split according to the number of bits in the characters. One frequency is used for each bit. On the transmitting end, the modulating equipment must send one bit at each frequency. The receiving end requires demodulating equipment compatible with that at the transmitting end in order

FIGURE 3

PARALLEL TRANSMISSION

EIGHT LINES TO TRANSMIT AN EIGHT-BIT CHARACTER PARALLEL BY BIT



to return the bits to the original bit scheme, and reconstruct the character (see figure 4).

Start-stop transmission may transmit five bit characters or eight bit characters. In each case a character is preceded by a start bit which is a "space" that activates the clocking device in the receiver. The clocking device measures the bits in the character and is able to determine the end of the character by detecting the stop bit, which is a "mark" (usually 1.5 to 2 bits in length in order to differentiate it from a character bit) (see figure 5).

Regardless of the line type, transmission mode and coding technique, as the modulated carrier current is received at its destination, another modem must be utilized to demodulate the transmitted signal into its original bit code scheme which will be acceptable to the receiving device (decoder).

COMMUNICATION FACILITIES USED IN DATA TRANSMISSION

Generally speaking, the state of Montana is served with a vast interconnected grid of electrical channels or communication circuits over which one can send voice, data or other signals. Most any point in the state can be connected to any other point in the state by these circuits. The signal may travel the shortest distance between the two points by a very direct route or it may travel an extremely round-about route which may be many times longer. This depends on the load on the network involved when the call is dialed. (see figure 6).¹

¹William A. Gilbert, Traffic Chief, Mountain Bell Telephone Co., in telephone interview, February, 1971.

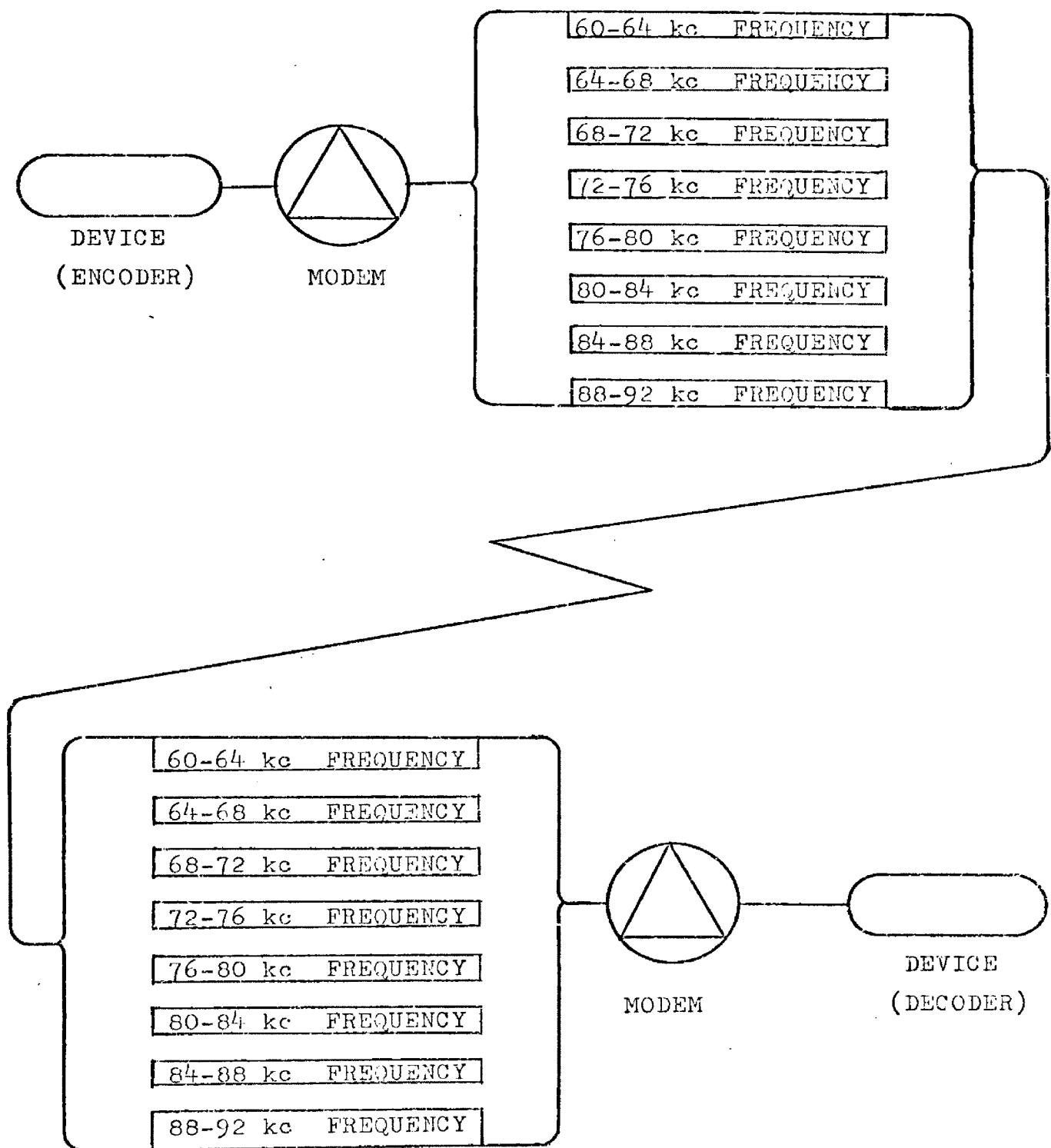
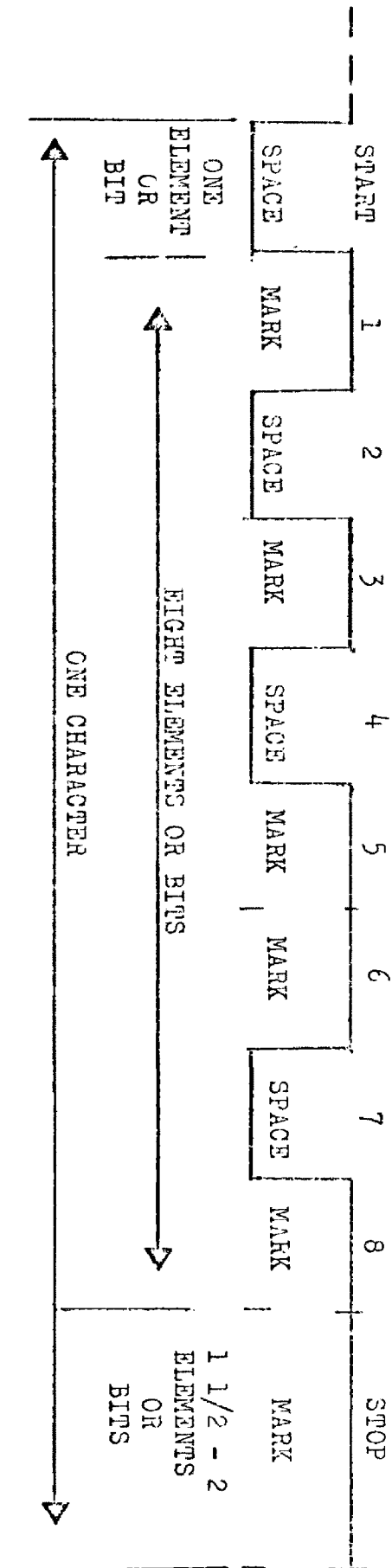


FIGURE 4

PARALLEL TRANSMISSION

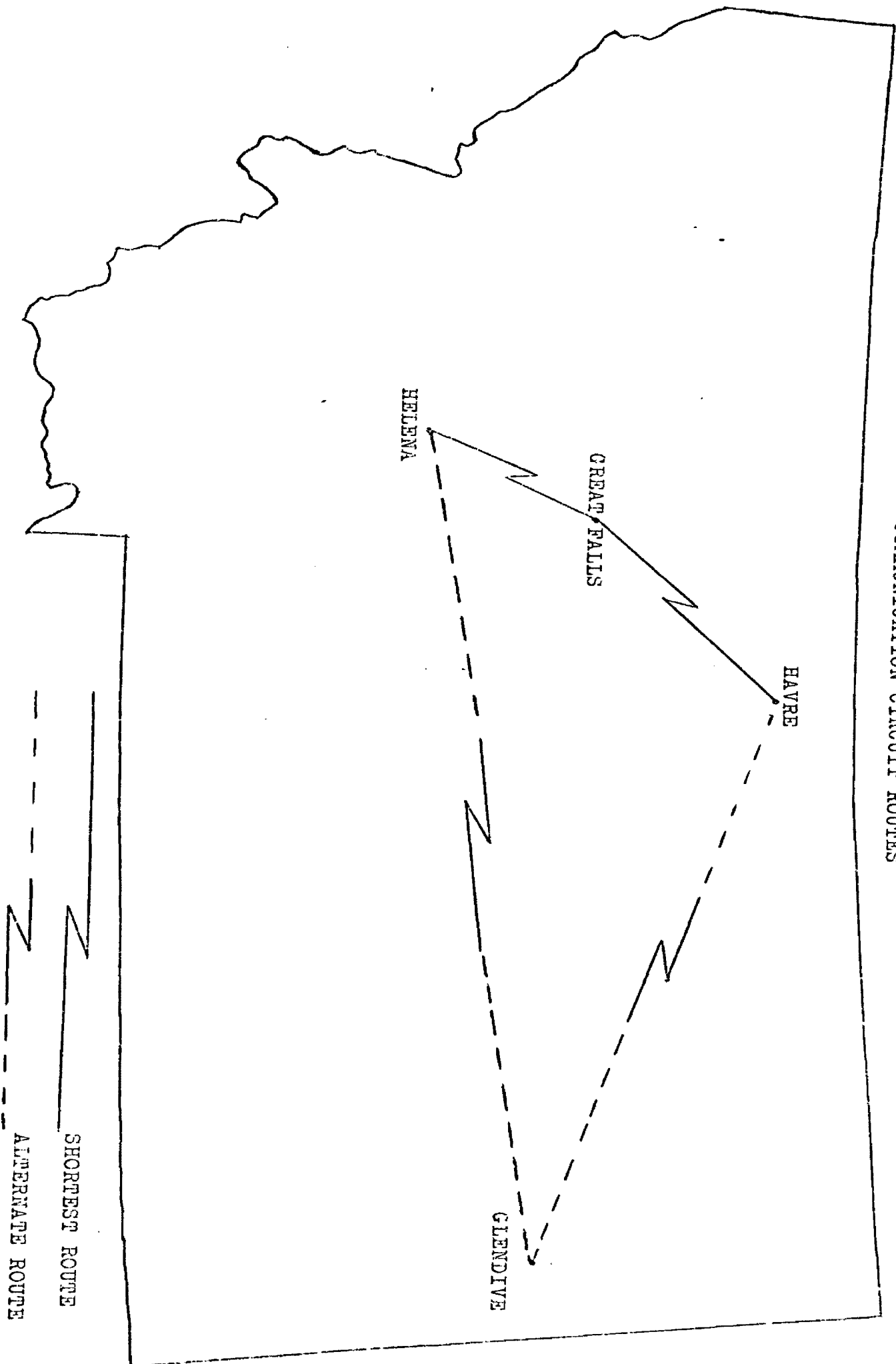
ONE PHYSICAL PATH SPLIT BY FREQUENCIES

FIGURE 5
START-STOP TRANSMISSION



THESE EIGHT BITS OF CODE EQUAL THE CHARACTER-FIGURE "5"

FIGURE 6
COMMUNICATION CIRCUIT ROUTES



The physical path over which the information flows is not a matter of concern to us as long as the voice or data arrives at its destination in good form and the cost of the transmission is no more than when it travels the shortest route possible.

There is some concern about communication facilities in the more densely populated areas such as New York; Phoenix, Arizona; Nichols, Virginia; and San Jose, California; to list a few who have indicated a shortage of communication facilities.¹ This may cause a crisis in data communications in these areas, but will not have a bearing on a sparsely populated state like Montana.²

There are two major types of facilities available to the public. The "dial-up" service which uses any available network of switching and transmission facilities in order to access the second point or number. This may be a short, direct circuit or a round-about circuit as mentioned above. The charge for the dial-up type of facilities is generally based on a charge per minute, or time used basis. The second major type of facilities is called private-line, dedicated-line, or leased-line services. This type of facility uses customer dedicated or reserved switching and transmission facilities in accessing the second point or number. In this case the circuit used between the same two points is always the same circuit, usually the shortest route possible. The

¹"Crisis in Data Communications," Computer Decisions, November, 1970, pp. CL1-CL6.

²Gilbert, op. cit.

cost of a private line is charged per month on the basis of airline mileage between points, regardless of the amount of use. Each type of facility is subdivided further into several service offerings. The services are categorized according to their speed of transmission.

Low-speed Transmission Dial-up Facilities

TWX. TWX (an acronym for Bell System Teletypewriter Exchange Network) is a dial-up service which uses the telephone exchange network, but does not utilize the higher bit rate potential of the voice-grade lines. It is a low-speed service which uses teletypewriter equipment that operates at from 45 to 150 bits per second. The teletypewriter equipment must be leased from the common carrier.

Medium-speed Transmission Dial-up Facilities

Medium-speed dial-up facilities are offered by the Bell System in the form of four packages: Direct Distance Dialing, Foreign Exchange, Inward WATS, and Outward WATS service.

Direct Distance Dialing (DDD). This is the same service used for the direct-dial voice communication, and provides half-duplex data exchange service over normal voice grade circuits. The charges are the same as for station-to-station voice transmission, and are based on a combination of call duration, distance called, and originating time of the call, with a three-minute minimum.

Foreign Exchange (FX). An FX line is one that runs from your telephone to another city and terminates in that city's

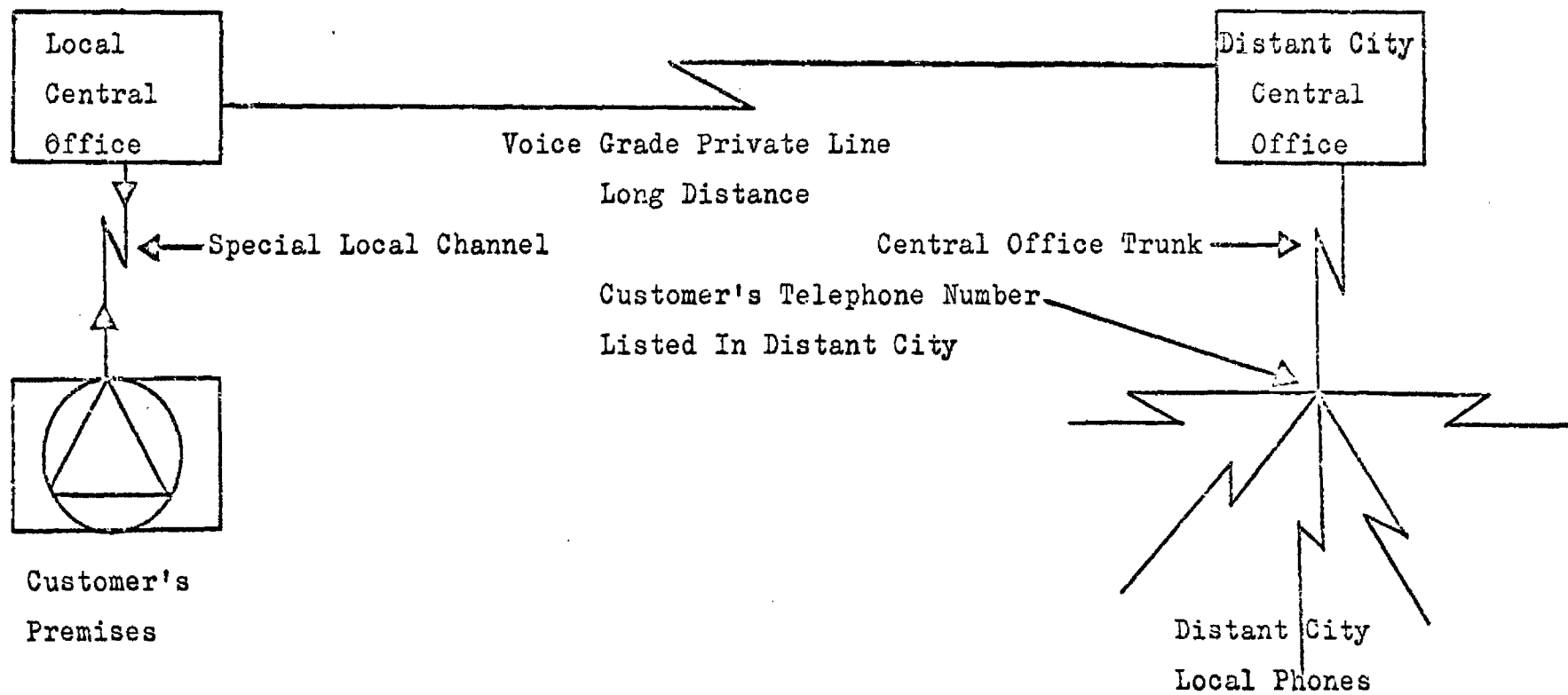
local telephone company's central office. It is connected to a local trunk line and assigned a local number for that city. You are then able to dial numbers in that city or receive calls from there as if you were within that city. The cost of FX service is the same as the cost for a private line telephone service of so much per mile, per month, plus a service charge at the customer end, and a local business line charge in the distant city. (see figure 7).

WATS (Wide Area Telephone Service). WATS is a way of obtaining DDD calls from the Bell System at a fixed monthly rate for a particular area of the country. WATS is available on both interstate and intrastate basis. A WATS line is really only a trunk line from the customer's premises to the local telephone exchange office. From the telephone exchange office, to the destination of the call, the impulse travels over regular voice grade dial-up lines. In the area covered by the WATS service, an unlimited number of long distance calls may be made, providing only one call is placed at a time. If two simultaneous calls require WATS service, two WATS lines are necessary. There are two basic forms of WATS lines called INWARD WATS and OUTWARD WATS.

Inward WATS. Inward WATS line service may be purchased monthly and used full time, 24 hours a day, or purchased monthly and used on measured time, which is $15\frac{1}{2}$ hours monthly usage service.¹ If over $15\frac{1}{2}$ hours are used, each additional

¹Berry Trent, Marketing Manager, Mountain Bell Telephone Co., in telephone interview, February, 1971.

FIGURE 7
FOREIGN EXCHANGE SERVICE



fraction of an hour over that minimum is charged for as an additional full hour. On an Inward WATS line, anyone within the geographic limits of the leased WATS area may make a call, without charge to them, to a specific WATS number at the customer's premises. The customer may only receive calls on an Inward WATS line, but once the connection is established, the flow of data or communication is in both directions.

Outward WATS. Outward WATS lines are available on the same basis as Inward WATS lines: full time, 24 hours a day service, or measured time, 15½ hours monthly usage service. Charges for Outward WATS and Inward WATS are on the same scale. The Outward WATS line can be used only to generate calls to any number in the geographic limits of the leased WATS area. Data and communications can flow in both directions once the connection is established. About the only time you can save money with a measured time WATS is if the calls are numerous and extremely short, thus circumventing the three-minute minimum charge encountered by using DDD service.

High-Speed (Wideband) Dial-up Facilities

The offering of high-speed, dial-up facilities is limited and has been inhibited in its growth because of the complex problems experienced by the common carriers in switching circuits in excess of three or four kilocycles. Also, terminal vendors are understandably unwilling to manufacture terminals for which lines are not always available. There are some

indications though, that dial-up wideband service will develop rapidly in the near future.¹

Private-Line Facilities

The bandwidths of these facilities do not vary much from those used in the dial-up facilities. Because they are "dedicated" facilities (a single common carrier customer is the sole user of the facility throughout the month) ;they are more amenable to special modification and consequently capable of higher and more accurate bit rates. Additional charges are made per month for conditioning private-line facilities.

Low-Speed Transmission Private Line Facilities

Series 1000. These services use private line tele-typewriter grade facilities. They are called the Series 1000 service in the Bell System. The higher the series number, such as Series 1006, the higher the bit per second transmission rate, up to 180 bits per second.

Medium-Speed Transmission Private Line Facilities

Series 3000. Medium-speed, private line facilities use voice grade lines dedicated to the customer. The Bell System calls these the Series 3000 service, with upper limit capability of 2400 bits per second.

¹Ernest Heau and Donald McNelis, Principles of Data Communications for Professional Programmers and Systems Analysts, (Computer Methods Corporation, 1968), p. 89.

High-Speed Transmission Private Line Facilities

Series 5000 or TELPAK C and D. Wideband facilities (greater than 2400 bits per second) are available, but are extremely expensive, with only a few terminals available on the market to use with these facilities. The Bell System calls this the Series 5000 service or TELPAK C and D. TELPAK C is capable of transferring up to 250,000 bits per second and TELPAK D is capable of transferring up to 500,000 bits per second when these facilities are widebanded.

Series 8000. The Bell System has another high-speed facility called the Series 8000 service. It is used exclusively for data transfer and is capable of a transfer rate up to 50,000 bits per second.

Dial-Up Versus Private-Line

The choice between dial-up and private-line services for data transmission, is primarily a matter of which service will do the specific task satisfactorily and at the most reasonable cost.

COMPUTER REQUIREMENTS FOR ON-LINE TIME-SHARING SYSTEMS

The general idea of an educational time-sharing system is to establish a system that can serve any educators and students and do all types of work, including accepting user supplied programs.

Just as every type of on-site input/output device needs some form of interface circuitry, (the connecting link between the input/output device and the central processor, allowing

that device to exchange data with the central processing unit) so does a data communication device require some means of interfacing with the central processor.

Data communications configurations fall into three categories, depending on the arrangement between the communications interface and the central processor.

Stand-Alone Communications Configuration

In this type of configuration the processor is usually one that was designed to handle a specific set of communication facilities and terminals. All of the interface circuitry is built directly into the computer. The computer has a stored program for communications as well as computing capabilities.¹

Front-End Configuration

In this type of configuration there is a division of services between the "front-end" or satellite computer and a host computer. Normally the front-end computer is responsible for handling the input/output activity, including data communications. In addition it serves as a buffer of data and may even be used to perform some pre-processing or post-processing while the host computer performs the major computing service. By dividing the workload between separate computers, each performing its specialty, it is hoped a more rapid response and quicker turn-around time can be achieved.

¹Ernest Heau and Donald McNelis, Principles of Data Communications for Professional Programmers and Systems Analysts, (Computer Methods Corporation, 1968), p. 135.

In a large system, a single front-end computer can host several smaller computers or some systems may involve two or more large processors which host many smaller peripheral processors.¹

General-Purpose Single-Processor Configuration

General-purpose computers normally are not designed with built-in communications interface hardware. Most general-purpose computers require the addition of a data communications interface, referred to as a communications control unit. The unit is designed by the computer manufacturer to adapt special line and terminal characteristics to the computer. The control unit performs functions for both receiving and transmitting data. On receiving, it will scan communications lines for data, assemble bits into characters, transfer data to memory, etc. On transmitting, these functions are reversed, characters are moved from the memory and serialized into bits for transmission to the output device.²

Time-sharing is a term used to describe a processing system with a number of relatively low-speed, on-line, simultaneously usable stations.³ There are two multiprogram execution techniques called Multiprogramming and Time-Sharing used to handle these on-line stations or terminals. Even though both

¹Ibid., p. 136.

²Ibid.

³Donald H. Sanders, Computers In Business, (New York: McGraw-Hill Book Company, 1963), p. 47.

techniques accomplish processing of multiprograms "simultaneously" with one central processor, there is a significant difference.

Multiprogramming

Multiprogramming is a technique of processing two or more unrelated jobs or programs "simultaneously." Actually the only simultaneity consists of the central processor unit (CPU) working on a segment of the program of highest priority until the CPU encounters a low-speed operation, such as reading in more data, then the CPU would swap this program into secondary memory. It would then swap out of secondary memory another program, of next highest priority, into the CPU and would process on this program until the low-speed operation of the first program is completed. As soon as the low-speed operation of the first program is completed, the CPU will swap the second priority program into memory and swap the first priority program back into the CPU for additional processing, until completed or until the CPU encounters another low-speed operation, at which time it would repeat the swap activities. If both first and second priority programs are involved in a low-speed operation, the CPU will swap out of memory a third program of third highest priority and process on it until one of the other two programs has completed its low-speed operation. The CPU would now swap the third priority program back to memory and swap the other program back into the CPU for processing.

A low-speed operation is performed at about one-twentieth of the speed that a third generation CPU processes. If only one program were being processed by the CPU, during a reading operation the CPU would be operating at about five percent efficiency or would be idle about ninety-five percent of the time.¹

Time-Sharing

The primary difference between time-sharing and multi-programming is that time-sharing allocates predetermined specific intervals of time for processing to the various programs in rotation, often called "Round Robin." The basis of transfer of processing from one program to the next is elapsed time rather than order of program priority. Time-sharing is characterized by multiple users working with the same computer through remote terminals simultaneously, each getting the same share of the computer's time until the individual's program is completed.

Time-sharing systems permit operation in the so-called conversational mode, that is man and machine communicating with each other at a speed set by the man. While the man is pondering or giving his reply to the computer, the computer is serving other users who are on-line.

To function in a time-sharing system, computer hardware must be fast, have a large memory and be equipped with an

¹Joseph Orlicky, The Successful Computer System, (New York: McGraw-Hill, Inc., 1969), p. 49.

interval timer capable of measuring time in very small increments such as microseconds (millionths of a second).¹

SUMMARY

Several technological points on data-communications have been considered in this chapter. There are many possible ways of designing an on-line, time-sharing computer system, using a variety of combinations of mechanical components. It is important that a person understand the expected operational requirements of the system when he proceeds to design it so that he will select the most desirable combination of components.

¹ibid., p. 49.

CHAPTER V

A STATE-WIDE EDUCATIONAL ELECTRONIC DATA PROCESSING SYSTEM

Montana schools have not invested an abundant amount of money or effort in developing Electronic Data Processing (EDP) for any phase of education. Observing the demography and geography of the state, it does not seem likely that very many of the schools will make much progress on their own to provide EDP in education.

Many authorities in business, sociology, education and other fields predict that EDP is going to have a tremendous direct or indirect effect on every person in society. They further state that any education system worth its existence will provide for EDP education. Planning now for a state-wide Educational Electronic Data Processing (EEDP) system appears to be the only likely way to prevent degradation of future education in Montana. It seems extremely important that we plan an EEDP system that currently appears to be a "pie in the sky" type vision. The ultimate goal should be an EEDP system that will provide for future expansion and accommodate Computer Assisted Instruction (CAI), Computer Based Instruction (CBI), Computer Enriched Instruction (CEI), Individually Prescribed Instruction (IPI), computer appreciation and utilization, a comprehensive total information system, research and simulation capabilities for educational administration

and management, uniform accountability, report generation, problem solving, custodial processing, and finance budgeting and accounting.

Planning one large state-wide, on-line, real-time, time-sharing EEDP system, accessible to all schools and the State Department of Public Instruction, will make it possible to develop a system that can eventually attain the ultimate goal. Experienced personnel in educational time-sharing systems state there are various problems to be considered in planning and developing a time-sharing system. Educators are typically hesitant to accept change in the traditional education system. Administrators and management are skeptical of innovations that may infringe upon the autonomy of their organization; and, especially so, if the infringement is from someone not in authority. They are reluctant to making a solid commitment of finances for such change. These attitudes have made it difficult to get cooperation for the development of some computer cooperatives. The development of local or regional installations without strict regulations of conformity end up in a conglomeration of systems that defy coordination. All of these experienced problems can be overcome by the development of the suggested EEDP system that would be located at and under the management of the Montana State Department of Public Instruction.

Development of the EEDP system should be planned for completion in phases, keeping in mind the goal of the ultimate system.

The first step in planning any system is to understand its information handling requirements. The backbone of the state-wide EEDP system will be the research and planning of the total information system. The development of data files for personnel, students, curriculum, property and fiscal records, as recommended by the U. S. Office of Education, will first require a detailed analysis of school records, reports generated, and information used in making current decisions. From this analysis will be determined the very basic data used in the operation of school systems. The next step will be to determine which of these data and any additional data will be used by the State Department of Public Instruction. When we know what data are necessary for the total information system, we must establish uniform reporting procedures. By following uniform reporting, only one record of a bit of data need be kept, regardless of the number of files or programs it may be used in, as all data files of a school system will be interactive. Each school system and the State Department of Public Instruction will be assigned a portion of the computer storage which will have file protection; limiting access to it by authorized terminals only. The school may also want to use this portion of storage for user oriented programs and any additional data storage desired by the school system. The data used by both the State Department of Public Instruction and the school will be stored so that it is accessible by both the Department and the school.

Because many of the basic operations of the schools in the state are the same, it will be possible to provide professionally prepared uniform programs for many school services. These will be stored in such a manner that they will be accessible to any terminal. Each school system will be able to do processing for itself by using a uniform program from the program library, data from the total information system and variables supplied by the local user through use of his terminal and telecommunications.

Determining the capacity and capabilities of the hardware needed is a difficult task. The central processing unit for a time-sharing system must be fast and have a large core storage with capability of utilizing a large amount of on-line storage to be added as needed to accommodate growth in the EEDP system.

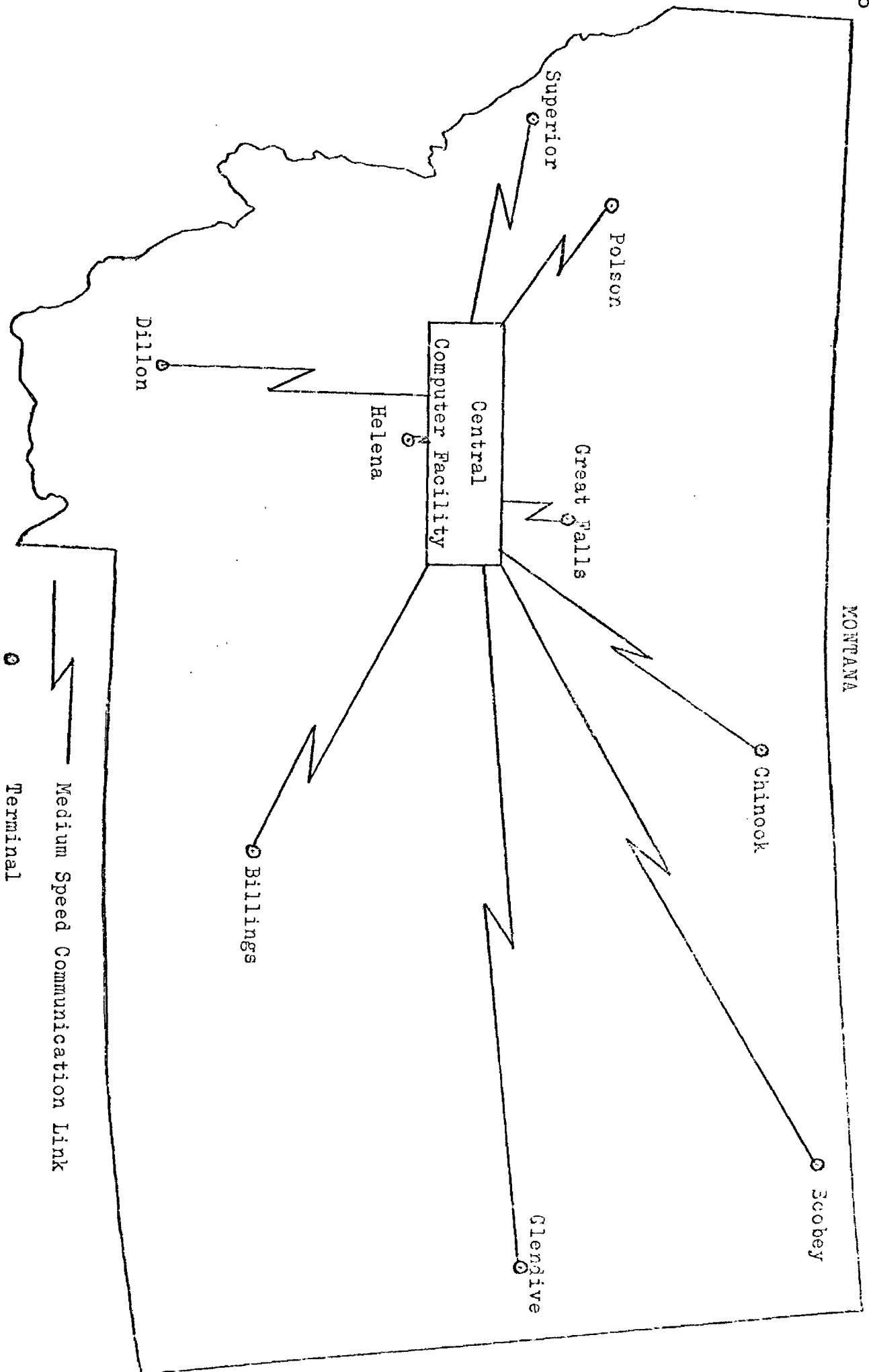
Development of the EEDP system may require several stages of expansion. This can be accomplished quite smoothly by selection of hardware that has expansion capabilities and would be compatible with larger models of central processing units. During the debugging stage of the system, it will be necessary to have a few pilot schools, from around the state, on-line in order to be sure that the system does what is intended (see figure 8).

After completing the debugging stage of the system, it will be necessary to add a considerable amount of on-line storage to be able to assign a portion of storage to each of the schools as they begin to become active in the system.

PILCE SCHOOL'S TERMINAL SYSTEM

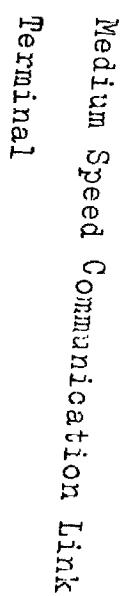
Figure 8

MONTANA



It is not anticipated that every school in the state will become actively involved in the system as soon as it is ready for operation. However, it would be desirable to have data flowing from all schools into the total information system in order to provide the State Department of Public Instruction with instant access to the information it needs for projecting and guiding the future of education in the state. To provide this information, each office of county superintendent of schools would be encouraged to install a terminal for the purpose of transmitting data to the total information system, along with having the terminal accessible to those schools in the county who do not have a terminal of their own (see figure 9).

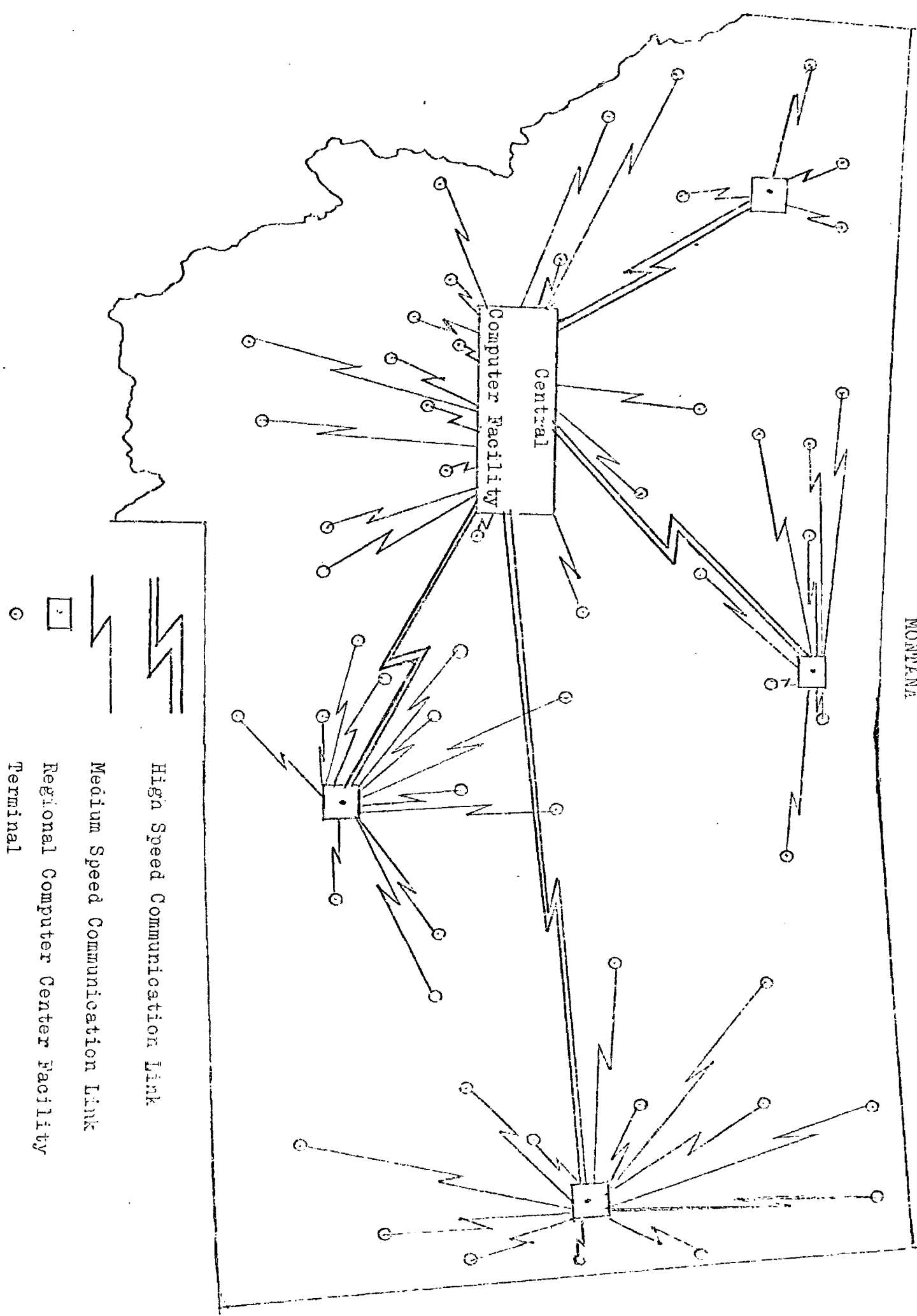
If the system reaches the point where one central computer cannot handle the demand, due to heavy usage or the addition of services such as CAI, CBI, IPI, etc., a decision will have to be made whether to add additional computers to the center or add regional computers connected to the central EEDP facility by a high-speed communication link (see figure 10). A system that would integrate regional computers into the state-wide EEDP system would connect regional computers to the EEDP system in a way that would permit schools in the region to use the regional computer for services that could be processed on the smaller regional computer. Uniform programs from the program library and data from the total information system could be accessed to the regional computer for processing. Programs and services that would be too large for the regional computer would be automatically transferred to the central



REGIONAL COMPUTER SYSTEM

Figure 10

MONTANA



EEDP facility. Data that were intended for the total information system would be transferred to the central EEDP facility as a result of a directive statement in the input format.

Regional time-sharing computer systems of similar design and service, report the cost to participating school districts to be up to nine dollars per student each month. It is estimated that the per student cost to the school district in the Montana state-wide EEDP system would be in the lower cost range, because of the participation of the State Department of Public Instruction. This savings would arise from the minimization of duplication of effort in the area of educational administration. With a regional computer system operated separately from the computer system of the State Department of Public Instruction much of the same administrative data must be handled in both systems.

In-service programs and seminars will be necessary to encourage and instruct teachers, administrators, and education managers in the utilization of the time-sharing system to satisfy their needs in a modern education program. REACT, an acronym for Relevant Educational Applications of Computer Technology, is a series of training packages developed by the Northwest Regional Educational Laboratory for the purpose of demonstrating ways the computer can be used in school administration and instruction.¹ The training packages provide hands on experience with computers by using a standard

¹"REACT," Northwest Report, (Northwest Regional Educational Laboratory, December, 1970).

telephone to connect the teletype to a computer. They will familiarize administrators and teachers with applications currently in use as well as those which are likely for the future.

The first course in the training package is an introduction to electronic data processing for administrators and teachers and covers orientation, introduction to computers, and computers in education.

The second course for administrators examines the concept of data management systems, and administrative applications are explored. There is a third course for administrators who wish to investigate implementation of computer based applications.

The second course for teachers is composed of application units for various subject areas. At the completion of course two, teachers should have developed skills for selecting and writing similar units in their subject area. Course three for teachers is intended to further refine those skills developed in course two.

The future use of REACT by the Northwest Regional Educational Laboratory fits nicely into the state-wide EEDF system. The materials will be used by laboratory staff in conducting training sessions for key personnel from state departments of public instruction and universities. They, in turn, will prepare teachers and administrators to utilize the instructional units to conduct workshops in local schools. The units are largely self-instructional.

A few Montana schools are fortunate enough to have a staff member who has a degree of expertise to direct or assist in the directing of the EEDP system in their school.

SUMMARY

A complete computerized total management information system for the State Department of Public Instruction and the schools of Montana requires that information from every school be entered into the system's files. An on-line, time-sharing computer system that will accommodate the total administrative information system can be easily expanded to provide educational services such as, attendance and grade reporting, fiscal accounting, class problem solving, etc.

Designing the EEDP system to be developed around one large central computer system is technically possible, but it may be more economical to develop regional computer centers in conjunction with a smaller central system.

A very important part of implementing the EEDP system will be the in-service training programs and seminars necessary to stimulate instructional and administrative interest in utilization of the system.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Every student, at some time between grades one and twelve, should be taught a basic understanding of electronic data processing and that every person in our society will be affected in some way by the computer.

Whether he is college bound or a terminal student, each student can best be instructed in, or made aware of, the capabilities of the computer by experiments in programming a computer. This requires accessibility to a computer by each student.

Making a computer accessible to every student and every teacher in the state of Montana can be accomplished economically only by a state-wide, on-line, real-time, time-sharing system.

Education administrators and managers of most schools in Montana could most fully utilize computer power by participating in a time-sharing, total information system and using professionally prepared programs from a time-sharing computer program library for services common to all schools in the state.

Persons who have been involved in the development of regional time-sharing educational electronic data processing

cooperatives, express as common problems: the reluctance of administrators to recognize the potential of the computer, their skepticism of innovations, and hesitancy of commitment to finance such change.

A comparison of the regional time-sharing educational electronic data processing cooperatives that have been developed independently, discloses very little conformity, coordination, or compatibility among the regional systems.

Recommendations

It is recommended that:

A definition be prepared of the present status of the data processing facilities in all the schools and the State Department of Public Instruction.

A formal study be made of the computer power requirements in all schools in the state and the State Department of Public Instruction.

A coherent plan be designed for moving toward the envisioned total system. This should include an investigation of financial sources and the economic feasibility of implementing the plan to meet the needs of students, teachers, administrators and school managers, and the State Department of Public Instruction.

The Montana State Department of Public Instruction should consider providing the leadership in organizing an EEDP advisory committee for study, development, and control of a state-wide, on-line, time-sharing EEDP system. The EEDP advisory committee should consist of representatives from the

Montana Education Association, the Montana Association of School Administrators, the Montana Association of Secondary School Principals, Montana State Department of Public Instruction, Montana School Boards Association, and every classification of Montana school districts.

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