COMPUTER-AIDED TRAFFIC ENGINEERING
OF THE C-1 E-A-X EXCHANGE USING A TIME-SHARED COMPUTER

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ABSTRACT
The C-1 E-A-X is a small electronic automatic exchange designed for offices up to 2400 lines and trunks. Due to the large degree of hardware standardization obtained in the design of C-1 E-A-X, it was possible to develop a computer program which determines the quantities of traffic dependent equipment from office traffic, trunking and signalling data taken from a standard data sheet filled out by the customer.

This paper describes the program philosophy, outlines the advantages of implementing the program on a time-shared computer terminal, and indicates how programs of this type might be used by operating companies and their associated manufacturing companies as part of a completely computerized engineering, ordering, pricing and manufacturing control system.

1. INTRODUCTION
C-1 E-A-X (1), (2), (3) is a small electronic automatic exchange designed for offices up to 2400 lines and trunks.

For the past several years, Automatic Electric has been using computers for the mechanized ordering of step-by-step switching equipment in order to reduce time consuming, routine engineering work, to decrease clerical errors and to allow the telephone engineer to spend a greater proportion of his time on more challenging tasks. In the present mechanized system, the engineer dimensions the switching network using traditional techniques and then uses the computer to produce orders for the necessary equipment.

The large degree of hardware standardization obtained in the design of the C-1 E-A-X made it possible to extend this mechanized approach to the computerization of the traffic engineering as well as the ordering function.

The interactive time-shared computer program which was developed determines equipment quantities from the office traffic, trunking and signalling information obtained directly from standardized data sheets filled out by the customer. With this program various alternatives in the design can be quickly evaluated and the most economical selected.

2. USE OF A TIME-SHARED COMPUTER TO IMPLEMENT THE PROGRAM
Having the choice between time sharing and batch processing, we chose to implement the program on a time-shared computer (4) for the following reasons:

- The shorter turn-around time, on-line debugging and better diagnostics would allow the program to be fully operational in at least one-quarter the elapsed time that would be required if implementation were on a batch processing computer.
- The conversational form of the program would permit engineers with little or no computer experience to use the program effectively.
- The flexibility resulting from the interaction allowed between engineer and computer would greatly increase the usefulness of the program.
- The short turn-around time on time-sharing would reduce the time interval between receipt of a customer's order and completion of the engineering.
- The debugged program with minor changes could be run on a batch processing computer.
3. DESCRIPTION OF COMPUTER-AIDED ENGINEERING PROCEDURE

After receiving the customers data sheet, the engineer enters the office data on coding forms designed for the program. It is intended that eventually the customers data sheet will record the necessary information in a form that can be directly entered into the computer.

The engineer then inputs the data into the program via the teletypewriter terminal. This input is the form of answers to conversational questions posed by the program. (See Figure 1) The interactive nature of the program allows the program to decide from previous input what data should be requested next.

FIGURE 1 - SAMPLE CONVERSATIONAL INPUT. DATA ENTERED BY THE USER IS UNDERLINED.

H ENTER TITLE (60 CHARACTER MAX.)
OFFICE: WHONOCK, B.C. JAN. 2, 1968 JHA
H ENTER FLAG DIGIT FOR DESIRED OUTPUT
H FLAG OUTPUT
H 1 TRAFFIC ENGINEERING ONLY
H 2 TRAFFIC PLUS EQUIPMENT LIST
H 3 TRAFFIC PLUS COST DATA
2/
H ARE THE STANDARD GRADES OF SERVICE DESIRED? YES OR NO
YES
H ENTER NO. OF SUBSCRIBER LINES AND DIRECTORY NUMBERS
500/625/

At this point, the engineer can visually check the entered data and if he spots an input error, he can correct the error without repeating the input process. In fact, program execution can be manually interrupted at any point if the engineer detects an error or does not wish to finish that run.

Once the input is verified, the program performs the necessary traffic calculations and outputs tables of calculated traffic quantities. Thus, if necessary the engineer can manually check the calculated values. This traffic calculation portion of the program provides great time savings since the traditional manual methods are time consuming and prone to clerical error.

After the traffic calculations are performed, the program computes the quantities of traffic dependent equipment using the appropriate probability formulas (See Figure 2). The use of traffic formulas rather than tables adds a new dimension to practical traffic engineering since it provides an accurate estimate of the actual grade of service supplied, eliminates table interpolation, and eliminates table look up errors.

This approach, while consuming more processing time, requires less computer storage space than the alternative of storing the traditional tables.

FIGURE 2 - SAMPLE TRAFFIC ENGINEERING OUTPUT

<table>
<thead>
<tr>
<th>NO. 1/C DP TRAFFIC GOS P</th>
</tr>
</thead>
<tbody>
<tr>
<td>REGISTERS TU UC</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

The program also gives the grade of service which would be supplied if less than the theoretically required equipment quantities were used. This gives the engineer sufficient information to decide the practical quantities to be supplied, and to determine what service degradation would occur if some equipment is taken out of service temporarily for maintenance purposes.

The program engineers the office for several alternate configurations. Thus, at this point the engineer can make certain "trade-off" decisions or he can allow the program to make a standard set of trade-offs. Once the trade-off decisions are completed and the program informed of the desired configuration, the program translates the gross quantities obtained thus far into equipment lists showing part number, description, quantity, and cost. Finally, the total cost of the equipment is printed out.

After engineering the office and determining its cost from the original set of data, the engineer can alter the traffic data, add or delete features and re-engineer the office without the necessity of re-entering data which remains constant. Note that because time-sharing allows on-line storage of data in the users program library, successive runs of the program on altered versions of the original data set can be separated by any time period desired. This facilitates efficient planning of the engineering study, since successive re-engineering for different office configurations or traffic requires very few instructions to the program, many practical solutions can be tried in a relatively small time period. This encourages the engineer to try a number of possible system configurations in order to find the most economical one.

4. PROGRAM PHILOSOPHY

To provide the greatest flexibility and maximum user control, a main control routine (see Figure 3) controls data input/output, The user controls the sequence in which the subroutines are called through input to the main control routine. A manual interrupt on the terminal permits the user to interrupt processing at any time and regain command control by returning to the main control routine. Intermediate results are printed out in the subroutines to avoid transferring information unnecessarily.

FIG. 3 PROGRAM FLOW CHART

MAIN ROUTINE SUBRoutines
START
READ DATA
AND CONTROL PROCESSING
NO. 1/C DP TRAFFIC GOS P
EXTEND TEMPORARY STORAGE AREA
TRAFFIC CALCULATIONS
TRAFFIC ENGINEERING
PROBABILITY MODELS
EQUIPMENT LIST AND COSTS
POWER REQUIREMENTS

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This centralized control and modular program structure offers a flexible program to which new features can be easily added to the program by adding new subroutines or altering existing routines. For example, a subroutine which calculates power requirements for C-1 E-A-X was added to the program six months after the rest of the program had been in use.

The conversational question and answer approach allows the user to specify the office characteristics in familiar terms. This is particularly important, since the user is generally not a computer professional.

The modular structure of the program permits it to be implemented on a computer with relatively small core storage capacity by employing overlaying techniques. The time-shared computer on which the program was implemented has a working core capacity of about 3500 words. Only one routine is stored in core at any instant. The others are stored temporarily on magnetic drum. A common storage area is used to transfer information from one routine to another.

5. PRESENT USE AND LONG RANGE OBJECTIVES

The computerized engineering program has been in use at Automatic Electric (Canada) Ltd. since the end of 1968 for traffic and cost studies on C-1 E-A-X in the Research and Development Department and for the traffic engineering of C-1 E-A-X orders and enquiries.

In the future, it is planned that this program will form an integral part of a highly mechanized engineering, ordering, pricing, and production control system.

The conversational program described in this paper also has many advantages for telephone operating company engineers for long range planning studies, for the initial dimensioning of offices, and engineering of additions. These studies will be facilitated by the growing use of automatic traffic data gathering systems by computer and stored images of present and proposed offices in random access computer memories. The flexibility of the conversational traffic engineering program will allow the engineer to rapidly evaluate many different trade-offs and alternate configurations in order to find the optimum system configuration before placing equipment orders. An equipment order could then be in the form of a data package sent direct to the manufacturer's computer.

6. ACKNOWLEDGEMENTS

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7. REFERENCES


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