

"AN INDUSTRIAL GRAPHICAL DESIGN AIDS SYSTEM"

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INTRODUCTION

This paper is intended to be in the nature of a report on the work in progress at the Bell-Northern Research Central Laboratories, to discuss the overall concepts of our design aids system, and to observe our progress to date.

Experience over the past years with the design of communications equipment at BNR has shown that a unacceptably large percentage of development cost has been associated with the traditional modes of design and documentation.

For the future generations of equipment we are attempting to adopt a system approach to the design process and to amalgamate various design phases which are traditionally separate.

To accomplish this goal we have embarked on an extensive development program to provide a design aids system which is tailored to the future needs of the BNR Laboratories.

ENVIRONMENT IN THE COMMUNICATIONS INDUSTRY

The design aids system is intended to accommodate the needs of the engineers and scientists at the Bell-Northern Research Laboratories. This covers a wide range of disciplines all of which are ultimately intended to service the communications industry.

Typical applications range from device design through circuit and logic design, to packaging and documentation.

In the selection of the system we are aiming at providing a generalized graphic problem solver¹. However, economics requires us to put a certain constraints on the design. For example, we feel it is unlikely that we will be involved in 3D applications. Therefore the cost of specialized 3D hardware is not justified.

A general design aids system of this nature must be accessible to the designer at any of the BNR Laboratory locations throughout Ontario and Quebec. Therefore, it is a requirement that graphic equipment must be ultimately relocatable at considerable distances from the main computer complex which affects the partitioning of the software load between the main machine and remote terminal.

HARDWARE SYSTEM DESCRIPTION

The layout of the system hardware is shown in Figure 1. The display unit is an IDIOM model 2 with lightpen, alphanumeric Keyboard and function Keyboard. This is serviced by a Varian Data Systems 620/f satellite computer with 32k of core storage which is connected to the IBM 360/67 at the central site via a voice grade telephone line. A disc memory provides temporary program and data storage.

The 360/67 at the central site provides access to the permanent data stored in a database and the compute power for the execution of interactive application procedures operating upon the data. Permanent hard copy output is available on an incremental drum plotter or, in the future, on a microfilm recorder.

The satellite computer can be extended with the aid of a multiplexer to drive additional display units. It is estimated that the satellite computer will drive two additional display units supporting the required design functions.

A teletype at the remote site is currently used to access the 360/67 in asynchronous mode. Eventually the function of the teletype will be amalgamated into the display unit.

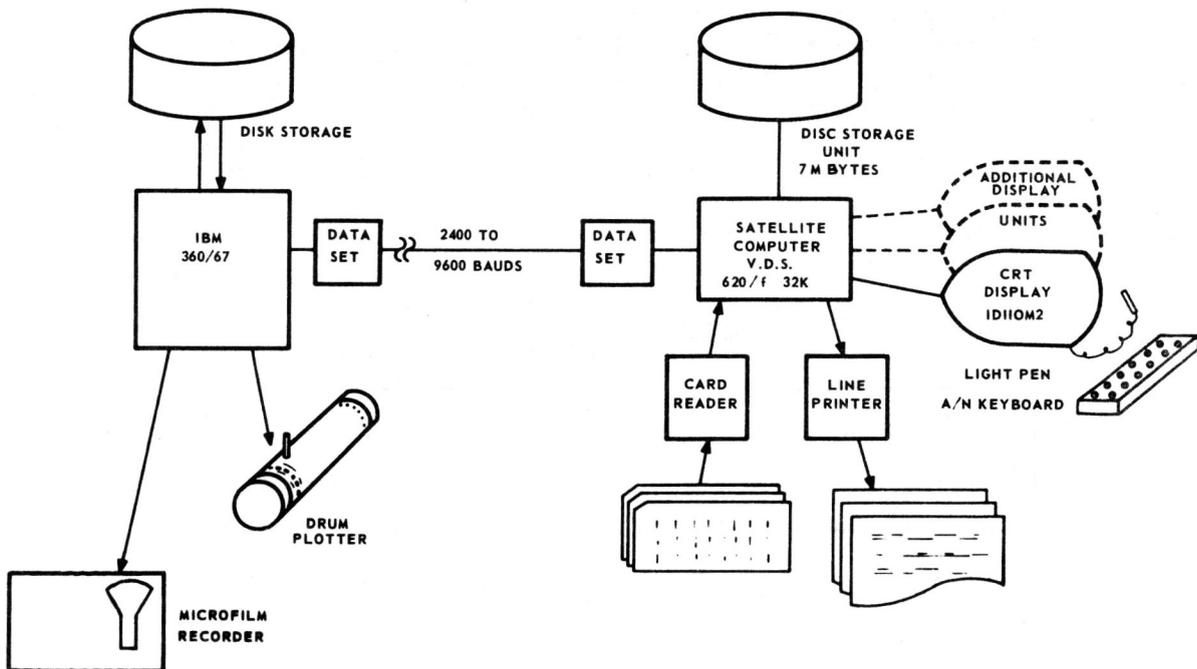


FIGURE 1

Design Aids System Hardware

GENERAL SOFTWARE SYSTEM DESCRIPTION

A general overview of the software system is shown in Figure 2. The heart of the system is a design aids database which resides in the 360/67 at the central site. The database is serviced by a procedure which is permanently activated during a user session.

Under the 360/67 monitor system CP/CMS, the user is allocated a virtual machine with virtual card reader, card punch printer etc.

The database procedure is dormant in the "wait" state until data is received from the satellite computer. On receipt of this data in the virtual card reader, the real time driver interrupts the monitor system and activates the database procedure.

The database procedure services the database and if required, calls the users applications procedures to perform an analysis on the data.

Output of a graphical nature is directed to the virtual card punch after the database procedure returns to the "wait" state.

The primary function of the software in the satellite processor is for graphical manipulation, attention handling and for servicing the communications line². During a user session the graphic handling routines are swapped in

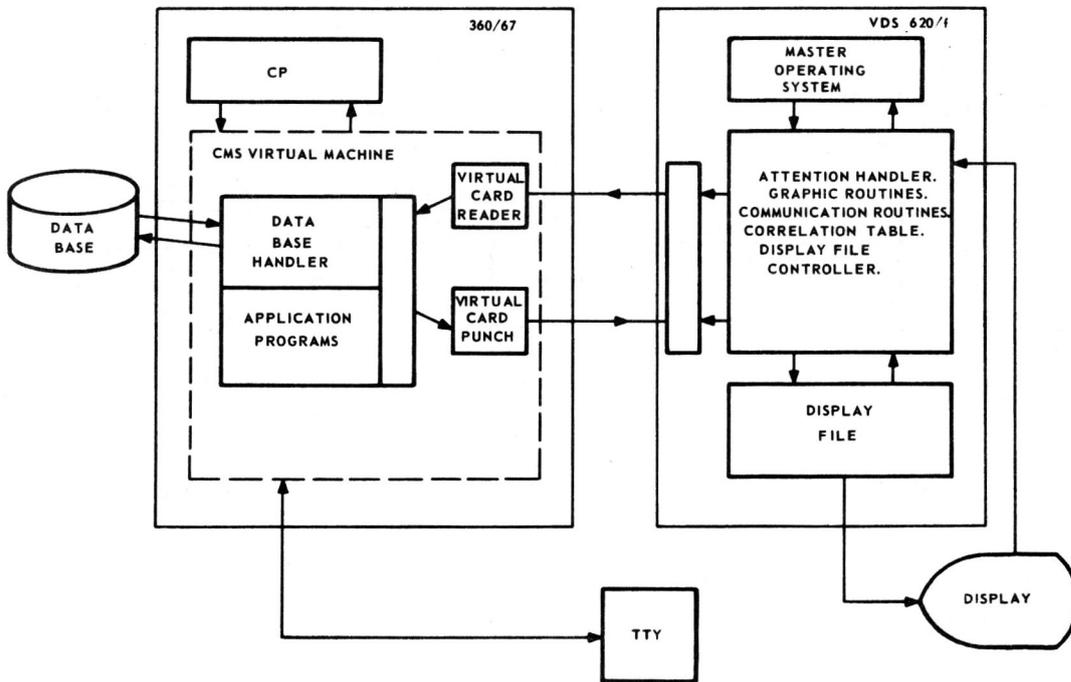


FIGURE 2

Design Aids System Software Organization

and out of core from the local disc unit which is also used for temporary data storage.

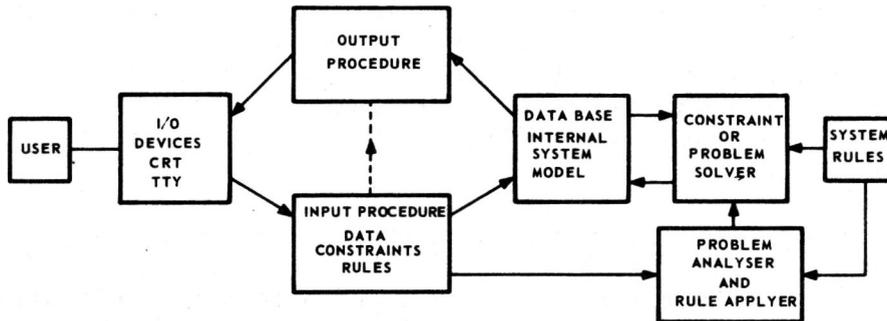


FIGURE 3

General Problem Solving Approach

As previously mentioned, we are attempting to adopt a general problem solving approach to the system design, Figure 3, without incurring excessive overhead or unreasonable economic penalties. We have already comprised the design to some extent to exclude general 3D graphics, however, we allow the concept of levels or layers to be built into the data structure. The most common application liable to be encountered, involves the construction or solution of networks, therefore the database is heavily oriented to provide a network model as well as the purely graphical information associated with the model.

Understanding of the relationship of the physical system organization to Figure 3 is complicated for there are in fact two data structures: one residing in the satellite containing only graphical information, and the other in the central site which also contains modelling information.

It is also possible under CMS to interact directly with the problem solving routines via the teletype.

PARTIONING PHILOSOPHY

With the database residing at the central site it is important to minimize the transmission time between the two processors without incurring undue penalties in core storage at the satellite processor or in compute time in either machine.

Large quantities of graphical data are most economically entered into the database from a keyboard terminal or are keypunched from card input in a graphical language which is available for this purpose. Typically, then, a user will start a session at the console with data already entered into the database. A request for a display picture will cause a large burst of data to be transmitted to the satellite processor to build the display file. Data is transmitted in a highly compressed communications language which makes use of the subroutine capability in the display processor and the database.

From then on communication is largely concerned with the transmission of commands and data to keep the database in step with the display file. The user is required to select a picture scale which then maps his data within the database to the range allowed by the IDIOM display unit. This gives a resolution of nearly one part in 10,000 which is adequate for most applications. Should the need arise for greater precision in the future it will be necessary to employ software scissoring at the 360/67.

SATELLITE COMPUTER SOFTWARE

The software in the satellite computer performs several functions including attention handling and graphical manipulation. It also contains communication drivers and routines for building and controlling the display file. The display file has a correlation table associated with it which contains a description of the display structure.

At this time the software in the satellite is written as a fixed set of routines with sufficient flexibility to service the majority of users. In the future we expect to be able to build the software for the display computer within the 360/67 and transmit it to satellite as object code for loading³.

DATABASE DESIGN

As previously mentioned the database at the central site is oriented toward network modelling and borrows heavily on the work of Evans and Katzenelson⁴.

A directory provides direct reference to the group headers of the structures in the database which are linked in a variety of ways. The graphical elements are linked in rings under a group header and may be nested. Usage or instance rings allow the repeated use of graphical structures. Graphical structures may be assigned a terminal node or pole ring with which is associated an internal node ring.

The connectivity of the individual elements is determined by their end point rings to the node records of the structure. Lastly it is possible to assign attributes to a particular structure for interpretation by the user application programs.

The structural elements of the database are accessible also from an A/N Keyboard language for direct updating.

SOFTWARE TECHNIQUES

The software is designed with machine transportability in view so that we are not inextricably locked into a particular system and can survive hardware changes with a minimum of recoding. For the most part programs are coded in high level languages. Application modules are written in PL/I on the 360/67 under the Cambridge Monitor System. User languages are analyzed by means of a syntax directed translator (NEST). This employs the standard Bacus Naur form of metalanguage and interfaces directly with a PL/I host program. Programs for execution in the satellite computer are written largely in FORTRAN IV.

Although we are attracted to the AED⁵ software engineering approach for this application, so far the practical difficulties of introducing yet another language have discouraged its introduction.

ECONOMICS

Although the design aids system is financed as an exploratory project it is expected to support a considerable quantity of productive design. It is therefore essential not to lose sight of the economics of the system.

It is estimated that on one shift basis production charges will amount to a total of \$30 to \$40 per hour. If additional display units are added the cost will decline to around \$20-30 per hour.

Long term computer graphics users have predicted that if the cost of a man sitting at terminal falls below a price threshold measured at about two to three times the regular unassisted man rate, then we can expect an enormous increase in computer graphics usage.

Clearly we have now arrived at this threshold and we can expect a further reduction in cost as the volume of terminal sales increases.

REFERENCES

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