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Satellite-Host Tradeoffs in Computer-Aided Design Systems

Hatvany, J.

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Introduction

Computer-aided design is the generic term for a rapidly proliferating set of techniques which have become mandatory for all who wish to maintain their competitive positions in an increasing number of industries. CAD practitioners in advanced technology industries such as aerospace and electronics are usually highly sophisticated in computer usage and therefore able to configure their own CAD environments to suit their requirements. Those, however, who are relatively new to computers, are faced with a bewildering set of choices over which they have to make decisions. Should they have a cheap terminal linked to a remote time-sharing bureau? Should they attempt to do their whole design job on a dedicated, medium-sized in-house computer? Or should they invest in a high capability, intelligent terminal backed up by access to a central (or network-distributed) number-crunching and data-bank facility? What graphic facilities should they use? A drum plotter, a storage-tube display, interactive refresh graphics unit, hardware rotation, conic generation, zooming, are all choices that are presented to them and the manufacturers' praise of their own line is often more confusing than helpful.

The International Institute for Applied Systems Analysis, IIASA, has recently embarked on a World Survey of CAD, one of whose aims has been to provide guidance to would-be users on the establishment of CAD facilities suited to their needs. In this work IIASA has relied heavily on the analysis of the activity phases in CAD, currently being conducted by W. G. 5.2 (Computer-Aided Design) of IFIP (The International Federation for Information Processing).

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**On leave from the Computer and Automation Institute, Hungarian Academy of Sciences, Budapest, Hungary; research scholar at the International Institute for Applied Systems Analysis, Laxenburg, Austria.

CAD Activity Phases

The main phases of Computer-aided Design may be grouped as follows:

Conceptual Design

In this phase the designer will wish to have quick access to such items as

- information on competitive products,
- market analyses,
- patent files,
- technical papers and reports,
- translations, and
- documentation of existing product lines.

Design Analysis

This stage of the designer's work is concerned with the use of explicit technical and cost analysis programme and the computer simulation of the object to be designed.

Detail Design

The most voluminous of the four phases, this is the phase where the checked and approved overall design goal is reduced to drawings and manufacturing information of makable parts and sub-assemblies, quality-checking, and assembly instructions. This phase will build up a set of database files on the product, which can be stored and updated with subsequent improvements.

Design Communication

Finally the CAD facility must output manufacturing, costing and accounting information in the appropriate form for the particular plant concerned. These may include:

- drawings,
- NC control tapes,
- parts lists,
- tooling lists,
- scheduling information,
- stock requirement breakdowns,
- etc.

Technique Requirements

The various phases of CAD activity will require the use of differing techniques.

Retrieval

In the conceptual stage the emphasis is on the storage and retrieval of information. The local activity at the point of design will be mainly the quick presentation of a mix of extant alphanumeric and graphic information in a passive form. The designer interacts with the system through picking large amounts of information out of background storage and occasionally he may wish to have a hard copy of something that he would like to utilize at a later stage. While techniques have been suggested for him to produce his rough sketches at this stage on some computer input medium (sketchpad, light-pen tracking), these have not been adopted in practice.

These requirements can be very well met by microfilm mass storage, retrieval, display and copy devices. The link to data stored in computer files can be provided by COM equipment. Alternatively a very low cost, entirely passive storage-tube display and hard-copy unit acting as terminal to a large computer data-base system could also be used.

Manipulation

The detail design phase, while also requiring rapid access to conceptual design drawings, other detail drawings, standards and past product files, at the same time needs a number of manipulative facilities. The designer must have the ability to use any retrieved drawing as the basis for a new one, to zoom in on any picture, select and move a window, to rotate, translate and superimpose any retrieved drawing or part of it. These are requirements that can only be efficiently met by highly interactive displays, which generally can be equated to refresh-type CRT devices.

The requirements in the analysis phase are rather similar, in design communication efficient output devices (drafting machines, plotters, COM, line-printers, tape punches) will also be needed.

Application Areas

Case studies in such widely differing areas as

- NC metalworking, machine tool programming,
- blanking-die design,
- printed circuit artwork design,
- electronic circuit design,
- building design, and
- ship design,

have shown that while in the retrieval phases there is almost constant recourse to the database; in the manipulative phases there are relatively long periods of highly intensive manipulation with low mathematical content, only occasionaly interspersed with short periods of intense computation.

In electronic circuit design, for instance, the designer will typically construct a circuit diagram on the screen by light-pen pointing, using a menu. He will allocate values, define connectivity, delete, replace, until he is satisfied that his circuit is ready for analysis. At this point he will transmit the information he has generated (preferably in the standard input format of the analysis programme he wishes to use, e.g. an admittance matrix), to the analysis programme, which will then return a set of results. He then views these in picture form, changes the original diagram and reruns. Very similar experiences have been gathered in the other areas listed.

Conclusions

It has been found that low-cost terminals can be applied economically where the size of the CAD facility is so large that a division of labour can justifiably be established between differing CAD tasks in each phase of design. For realistic industrial CAD work they have to be backed by very large time-sharing computer resources.

Sophisticated refresh-type graphic terminals with intelligent capabilities embodied in high-power local minicomputers are, perhaps surprisingly, more suitable for the medium-sized establishment, where many phases of the CAD process can advantageously be carried out on one set of equipment and only occassional remote batch entry need be used to a host computer.