Guest Editor's Introduction

Engineering Workstations

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As evidenced by the number of introductions at this year's major shows, the engineering workstation has become the dominant segment of the computer graphics industry. The individual engineer's access to the computing and display power now built into these systems promises to revolutionize the way industrial societies design and build all the objects of our everyday lives.

Responding to the growing interest, the Institute for Graphic Communication held its first conference on engineering workstations in June 1983, bringing together representatives of a number of major suppliers and users of these products. The success of the first conference led the IGC to hold another last January and still another this month. As conference chairman and an IEEE Computer Graphics and Applications editorial board member, I asked several of the January participants to write articles based on their conference presentations, resulting in five of the articles in this special issue. In addition to the IGC articles, we include an article on another type of workstation. Altogether, this collection of articles gives us a look at the workstation technology available now and the potential it holds for the computer-integrated design, engineering, manufacturing, and business environments of the future.

Our first article outlines developing trends in engineering workstations. Author Jon Reed emphasizes that interactive computer graphics will provide the key to a completely integrated engineering environment that supplies the tools for non-design as well as design tasks.

Lewis Brentano, also looking at the overall picture, discusses a distributed approach to computer-aided design and manufacturing, necessary if today's workstations are to significantly contribute to the envisioned "factory of the future."

For a user's viewpoint, we turn to John Fisher and Joseph Halford, who describe how their company developed an engineering workstation suited to its needs by working with a computer system vendor. Based on a desktop microcomputer and able to access all existing company computer systems, the workstation handles not only large engineering analysis programs, but certain CAD functions, office automation programs, and software development as well.

The fourth article, by Randy Nickel, describes the pipelined architecture and VLSI hardware of one of a new generation of workstations designed for demanding engineering and science applications. Nickel explains how the replacement of less efficient software by special-purpose VLSI chips improves speed, quality, and economy of workstation performance.

David Weisberg emphasizes another performance requirement of engineering workstations: reliability—that is, consistent performance. In multiuser CAD environments, Weisberg says, the most economical way to achieve predictable high performance is through intelligent, standalone stations tied together in a distributed local network.

We depart from the engineering theme in our sixth article, written by Thomas Williams for this special issue. Williams describes the development of a workstation for International Monetary Fund economists, who needed a system capable of the acquisition, analysis, and display of economic and financial data from 146 different nations. For the economists, as for engineers, the key to usability of the workstation is its graphics-oriented user interface. The rapid prototyping methodology and the interface techniques used in the IMF effort are useful models for the development of many types of professional workstations.

As mentioned earlier, a great many workstations have recently entered the marketplace. We have expanded this month's New Products department with a special section (page 70) on engineering workstations, many introduced this past spring and summer at the NCGA, Design Automation, and Siggraph exhibits. You can expect to see others, not included here because of space limitations, in the next few issues of IEEE CG&A.

I conclude my introduction to this special issue with an overview of intelligent computer graphics workstations, based on my own presentation at the IGC conference.
An overview: intelligent computer graphics workstations

One of the most exciting recent developments in computer graphics is the emergence of the microcomputer-based intelligent workstation. The sales of these stations—which include graphics capability, processing capability for more than simply display generation, communications capability, mass memory, input and output devices—are growing at a faster rate than almost any other segment of the computer graphics industry. A Frost & Sullivan market study, in which I participated, estimated that over $35 million worth of intelligent workstations were sold in 1981 and predicted the volume will grow to well over $1 billion by the end of the decade. This 46 percent growth rate is 50 percent faster than overall industry growth and higher than any other part of the market. If the workstation concept is expanded to include “dumb” and “smart” workstations, as well as turnkey systems, total sales of more than $8.5 billion by the end of the decade are forecast.

Background

Like many products that suddenly capture everyone’s attention, the origins of computer graphics workstations lie in technology and devices available years before. If we generalize the definition of workstation to include any “self-contained” unit that handles not only graphics functions but a number of application functions as well, then surely such early minicomputer-based products as the DEC 338, 339, and 340, based on the old DEC PDP eight-bit machines, and the IDI Idiom, based on the Varian 620 series of computers (both introduced in the mid-1960’s) qualify as workstations. Although the units had limited display content, computer capability (typically 12- and 16-bit words), main memory (usually 16,000 words maximum), and mass memory (one to two million bytes), they were able to handle a variety of stand-alone applications. These units were relatively expensive—typically in the $50,000 to $100,000 range.

During the late 1960’s and early 1970’s, the number of large-scale minicomputer-based systems continued to grow, and display manufacturers such as Vector General, Adage, Megatek, Imlac, and Evans & Sutherland added new minicomputer-based graphics products to their lines. These systems generally employed stroke-refresh graphics and cost from $50,000 to $100,000.

In the middle and late seventies, workstations began to appear with intelligence based on custom-designed processors rather than commercial minicomputers. Perhaps the first version of this kind of system was the storage-tube-based Tektronix 4051, which might be termed the first generation of desktop computers. The systems were equipped with up to 32K bytes of memory, various mass memory devices, and the ability to drive hard-copy output and support a variety of input devices. A flurry of new products in this category followed, including the Hewlett Packard Series 45 and the Three Rivers Perq system. In price, the Tektronix 4051 was a major breakthrough; early versions came in under $10,000.

Recent intelligent workstations are based on a wide range of commercial and custom microprocessors. Some units are built around eight-bit Z80-type processors. Newer systems include 16- and 32-bit units using microprocessors like the Motorola MC68000 and the Intel 8080 series. Others use bit-sliced microprocessor configurations. Frequently, several microprocessors are combined in the same unit, some to handle graphics, some to handle applications, and some to handle I/O (including communication and peripheral control).

Today, a wide variety of intelligent workstations is available—from systems based on personal computers, such as the Apple II and III, the TRS 80, the IBM, and the DEC, to sophisticated, high-performance, high-memory-capacity units, such as the Apollo Domain series, which was brought to market with a fully developed local area networking capability. Prices of intelligent workstations also vary widely—from under $10,000 to more than $150,000. (See the special section on page 70 for some examples.) Memory of about 4 million bytes is available and mass memories can support very large capacity hard disk.

Display characteristics

As mentioned above, the earliest workstations generally used stroke-refresh display technology. The first desktop unit, the Tektronix 4051, was based on the storage tube. Today, however, essentially all commercial intelligent workstations are raster. Both the stroke-refresh and storage tube systems were monochromatic, as were the early raster systems. Now most vendors are offering color raster systems. Earlier raster units had either personal-computer-level resolutions of about 125 x 125 pixels or commercial TV picture quality of about 500 x 500 pixels. Most of the recently introduced products offer 1024 x 1024 or higher resolution.

Intelligent workstations

The term workstation has become so widely used that it is applied to almost every kind of graphics device. The distinctions between dumb terminal, smart terminal, intelligent terminal, and workstation are blurred. The implication of the definition given earlier of an intelligent workstation is that the product has some programming capability, not just that it has a microprocessor. A number of products include microprocessors either for display generation or for I/O control; from my point of view, they should not be considered intelligent workstations because the user has no control over the characteristics of the terminal. I usually limit the term to those workstations with externally controlled programming capability.

For example, when the color raster Tektronix 4113 was introduced, it was described as having an internal microprocessor to allow local handling of picture functions such as zoom, pan, and multiple viewports. But it
was not possible for the user to add any of his own programs to the workstation. Later, however, Tektronix introduced an optional Fortran compiler board, which, in effect, gives the user access to the internal microprocessor. Thus, the unit is now an intelligent workstation.

Applications

The applications of intelligent workstations have grown enormously; they include engineering, business, science, education, art, and others. The original Tektronix 4051 was often used in stand-alone applications to solve relatively simple analysis problems and to operate as a terminal for computer-aided education. It was then occasionally linked to a central or host computer and data was transferred between the workstation and the host. Frequently, large databases or large analysis programs were in the host, and the station essentially acted as a graphics database entry device.

In engineering applications, the original purpose for intelligent workstations was to relieve the load on the host computer so that the response to an individual's actions would be much more satisfactory. By moving some drafting and design functions to the workstation, true timesharing operation (over low-grade communication lines) would be possible, and a large number of workstations could operate from the same host. Initially, it was believed that major analysis portions of the CAD function would still be resident on the host. However, in many recent implementations, essentially the entire CAD package has migrated to the station and each user has a complete software package at his disposal. A mainframe computer may still be part of the local area network but handles only very large scale analysis programs, such as finite-element analysis, rather than volumetric calculations, for example.

Future trends

There is little question that the growth of intelligent workstations will continue. Advances in VLSI technology will further increase the power available to the individual user. While the cathode ray tube will probably continue to be the dominant display device, flat-panel displays based on plasma, LCD, and other technologies, are beginning to appear. As physical portability of terminals becomes an issue, flat-panel displays can be expected to become more common. Workstations with multiple display heads are also becoming available.

As time goes by, engineering and business users will need to make a decision about "footprint" issues. That is, now most engineering and office systems are viewed as isolated elements: word processing is one function, performed by one terminal; CAD is performed by another terminal; and business graphics by a third terminal. As the power of the workstation increases, it is very possible that all these functions will be funneled into a single workstation, which will become the user's window on his professional world. This is becoming increasingly feasible in terms of the power capability, responsiveness, display clarity, multiple-window capability, and so forth that are currently available in hardware. Much work still needs to be done in software.

The final issue is how the user responds to the workstation environment. Keyboards are still widely used. As we bring these workstations to a wider population, however, we must pay more attention to operator interfaces. One can expect to see growing use of voice input and various kinds of touch-sensitive devices. Ergonomic considerations will continue to grow in importance. European users have been much more aggressive than American users in imposing ergonomic constraints on workstation suppliers. However, US suppliers are becoming increasingly sensitive to this issue, and a number of them have built product lines that successfully address ergonomic requirements.

And, of course, pushing the traditional workstation suppliers are the myriad personal computers, with increasing power and decreasing costs. While a conventional workstation vendor might measure sales in thousands or tens of thousands of units, the PC vendors foresee sales in hundreds of thousands and millions of units. When we consider that today we carry on our wrists computers with power equivalent to a room full of computers two decades ago, we realize that the potential for this technology is staggering.

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