Computers: The single-user workstation – A new concept that promises to benefit the design profession

By John C. Dill and Jon H. Pittman

The single-user workstation is a micro- or minicomputer, including CAD, devoted to use by one person, that has the capability of being hooked into a much more sophisticated network of computational resources, the expenses of which are shared with other users. Thus it has the advantages of offering high performance at low cost.

Systems of most interest to architectural firms are the so-called turnkey systems that include hardware, system software, and ready-to-use application software. Since turnkey suppliers are now starting to make use of the single-user workstation in their products, an understanding of the workstation concept will aid the architect in evaluating systems now becoming available.

The new concept combines the best of previous developments

From slow early systems that could handle only one task at a time, two parallel evolutionary paths developed. On one path, computers became larger and more powerful, capable of running several programs at the same time. To justify their high expense, these systems had to be used by many people, with a resulting slowdown of efficiency.

The second path was the development of the minicomputer, small and economical enough to be owned and used by one person. The minicomputer has good interaction and response, but no means of sharing expensive resources such as disks and printers. It also has relatively low computing power and memory capacity, so large, complicated tasks cannot be done.

The single-user workstation combines these two approaches by providing the responsiveness and control of the minicomputer with the sharing of data, programs, and resources of the large time-sharing systems. The key lies in the use of another technological development—very high-speed communications networks. Now single-user systems, called workstations, could be linked to form a network, with only a few special stations having large, expensive resources such as disks, printers, and plotters. In this way, each user has at immediate disposal sufficient computing power to tackle significant problems, but can still share with other users the cost of expensive components.

This approach was not possible earlier, because the necessary technological advances have become available only recently.

The single-user workstation network consists of a collection of stations or nodes

Here's how it works:

- Each user has an individual workstation.
- All stations are connected by a very high-speed data-communication path, usually a direct wire link with a maximum separation between stations of a mile or two. Any station may transmit information to any other on the net. The combination of stations and communications path is called a local-area network (LAN).
- The network includes special stations, called "servers," to help support resources shared by all workstations: *File servers* have large disk drives for data and program storage, and may have tape drives for backup, etc. *Print servers* consist of printer(s) and plotter(s). *Gateway* is communications access to other resources, such as large central systems for very high-speed computation, very large databases, other networks, etc.

Understanding basic CAD uses helps in understanding what single-user stations can do

As outlined in "Computers: How do you jump in?" ARCHITECTURAL RECORD, August 1982, page 35, there are three categories of CAD applications: text development and production, data storage and retrieval (including analysis), and graphics development and production.

Text development and production includes specifications writing, architectural-programming documents, and feasibility reports. Data storage and retrieval includes facilities and equipment inventories, structural and environmental analysis, and cost analysis. Finally, graphics development and production includes applications such as drafting, architectural design, perspective generation, and structural and mechanical layouts.

Since the key to successful CAD systems is a central pool of data, accessible to all of these applications, it is vital to have a system that allows for sharing data, programs, and resources.

Certain computing capabilities are necessary to perform all application tasks

These capabilities include:

- A high-resolution graphic display to allow the interactive display and manipulation of design information. A fairly high resolution (the capability to display a large amount of information in a given physical space) is required to display visual images with a line quality that is acceptable to most architects. The capability to display color images may be quite useful to color-code graphic information and to generate realistic-looking images of designs.
- Graphic input devices allowing the architect to point to pieces of information or portions of drawings displayed on a screen. Such devices can be used to select a piece of information that is already being displayed or can be used to specify the location where a new piece of information is to be placed.
- Alphanumeric input capability to allow the architect to add textual information and commands to the application program and to deal with text development and production applications.
- Ability to share data with other users to allow several designers, engineers, and consultants who are working on the same project to have access to information on the current state of the project.
- A large amount of data storage since even a small architectural design project can involve large quantities of information.

The single-user workstation system offers a way to satisfy these needs

It does so with the following components:

A powerful local processor. Currently, many are of somewhat limited speed and capacity, dealing less easily with the 32-bit word-length needed for architectural applications. Processors now under development will be significantly more powerful. The processor should support virtual memory so that the programmer can work as if there were a very large memory without worrying about the size of the programs.

Large local high-speed memory. This has at least ½ megabyte, with the possibility of adding up to four megabytes, and virtual-memory support.

Local disk storage. This provides virtual-memory support and local-file support, with a capacity of five to 50 megabytes, although some designs do not require every station to have a local disk.

High-resolution raster graphics display. This has 512 x 512 pixels to 1,024 x 1,024 pixels or more. It will possibly have a specialized

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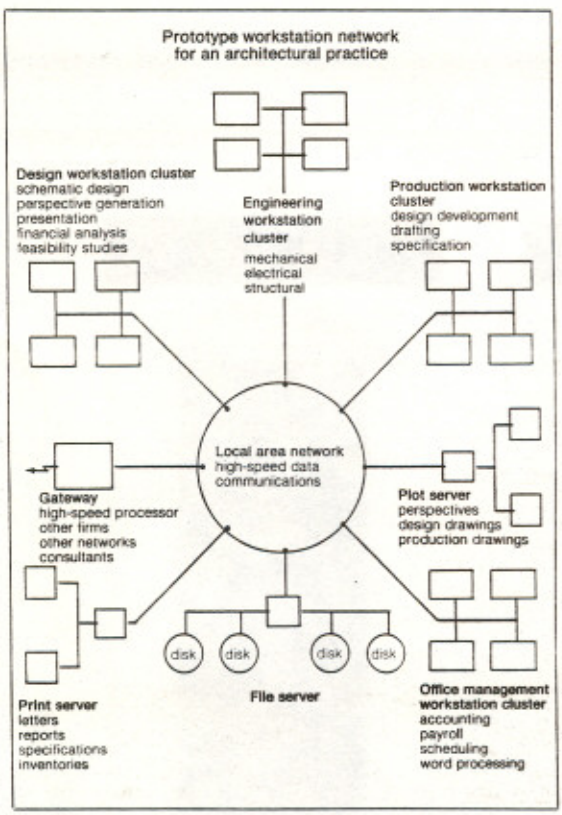


The diagram shows individual workstations for the various disciplines found in an architect's office tied by a connecting network to the required information and production resources (the servers) to complete an automated CAD system. The network in turn can be tied to other networks and more sophisticated information resources via the gateway.

display processor for very fast hidden-surface removal and/or dynamic display. It may be black-and-white or color.

Interactive input devices. These include a keyboard and a graphics input device such as a digitizing tablet and stylus, mouse, or light pen. The tablet is especially useful in architecture, due to its digitizing capability. There may be a separate alphanumeric display for textual information.

The software includes:

An operating system. This software controls the allocation of resources and the execution of programs. Many current workstations use an operating system called UNIX. The operating system should be easy to use and should allow the workstation to operate efficiently.

High-level software development tools. These may include programming languages (PL/1, Pascal, or C), editors, and debuggers.

A window manager. This allows more than one drawing to be displayed and manipulated on the screen at any given time.

A graphics-software package. Examples are those proposed by SIGGRAPH CORE or GKS.

A good database management system. This stores, retrieves, and manipulates data. This database will most likely be of the relational type. Database management systems with integral graphics capability will become common.

High-level components. These might include menu builders and spreadsheet-analysis packages with integral graphics.

The human factors should be well thought out. This means that the workstation will be quiet enough to be acceptable in a normal office environment, with no special hvac needs. It should be designed for adjustable heights, tilt-swivel display surfaces and so forth. Printers and the larger noisy (and expensive) disks may need a special environment. Hardware and software maintenance should be readily available. And the design should provide that the failure of a single station will not cause failure of the other stations.

A primary advantage is the capability for incremental expansion

From the above description, you can see that the system allows for low initial cost and low incremental expansion cost, when compared with typical larger super-mini or mainframe systems. A diagram of how this might work is shown on page 31.

Thus the smaller firm can start with a single station, some extra disk storage, and a printer/plotter. This may be easily expanded at very low incremental cost by adding stations. The larger firms, perhaps with an existing system, can also benefit by connecting a local area network into that system.

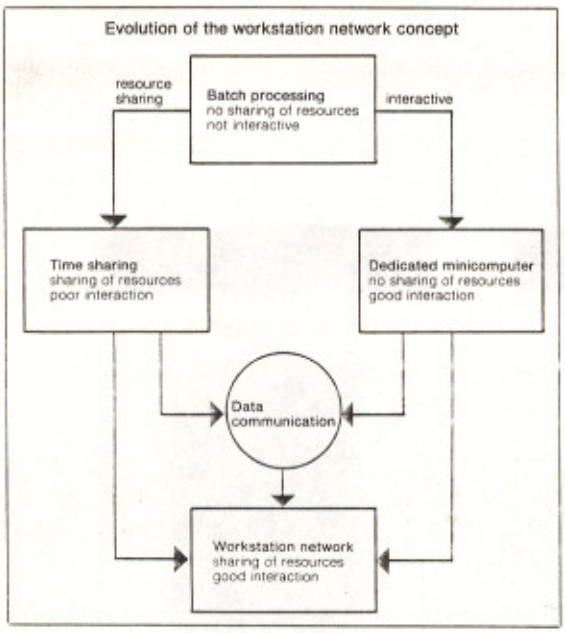
The single-user workstation, a relative newcomer in the computer-aided design marketplace, seems well suited for most architects' needs. Indeed, the specifications for a workstation could easily be developed from the requirements of an architectural application.

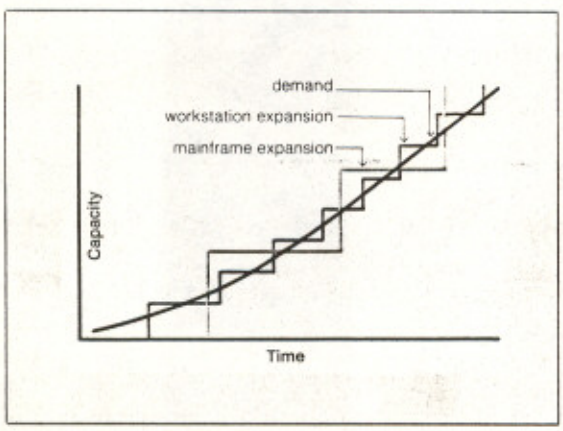
In choosing a system, consider whether it contains the latest technology

Different systems incorporate the latest technological advances to varying degrees. Among the advances that have made single-user workstation systems possible are:

- Very-large-scale integration (VLSI) that provides hundreds of thousands of components, such as transistors, on a single chip. Thus substantial computational power and memory is possible at low cost and with small space and power requirements.
- Disk technology that can now provide low-cost, high-capacity bulk memory for storing data and programs.
- High-speed data transfer. Recent developments in communication technology allow effective sharing of resources at 10 million bits per second, whereas a normal computer terminal on a time-sharing system transfers data at 1,200 bits per second.
- Reduced memory costs and new raster graphics technology to provide sufficient quality without expensive vector refresh devices. High resolution raster displays have been vital to the development of the single-user workstation.
- The capability to store data permanently and later retrieve it. This is necessary because of the large amounts of data involved in a design project and the need to occasionally refer to or revise that data. The ability to store data also allows the architect to form a permanent record of the design process that may be referred to for subsequent design work or in the event of litigation.
- Capability for hard copy output to produce documents for client presentations, contract documents, and design studies.

The diagram below shows the evolution of the timesharing workstation concept that developed from the original mainframe batch processing equipment to two initial lines sharing on the one computer and small individual computers with limited information resources.





The diagram above shows how the lower incremental expansion cost of a workstation approach means a closer match between computing capacity and demand without the extra cost of excess capacity or the lost opportunity cost of insufficient capacity.

Also consider how these capabilities are packaged

The package must be:

- Easy to use and to learn to allow architects to utilize the computer-aided design system in a natural way.
- Compatible with an office environment to minimize investment in physical facilities for the system as well as to allow the system to be in the same work space as architectural designers.
- Low in cost/performance ratio so that the average architectural firm can afford the necessary computing power.
- Capable of incremental expansion and sharing of expensive computing resources so that it becomes possible for a system to be introduced and later expanded for minimal cost.

It is clear that single-user workstations will have an effect on the system available to the architectural profession from the turnkey suppliers. And we believe that they will have a significant impact on the architectural profession in the next few years.

Glossary

Digitize. The process of converting positional information to numeric coordinate data.

Digitizing tablet. A flat surface with a stylus that can be used to enter coordinate data into the computer.

Light pen. Graphic input device that responds to light emitted from the displayed image. Produces X-Y coordinates of a location on the display screen.

Local area network. Two or more workstations connected by a high-speed communications link. A network usually includes other resources such as printers, plotters, and large-capacity disk drives. Distance between workstations varies from a few feet to one or two miles.

Megabits per second. A measure of data transfer rate. One megabit is approximately one million bits (125,000 bytes). 10 to 12 megabits per second (mbs) is the current upper limit on data transfer across a local area network. At 10 mbs, the text of a typical issue of ARCHITECTURAL RECORD would take about .2 seconds to transmit.

Megabyte. A measure of computer memory or storage. Approximately one million bytes. One character can be stored in a byte. A number may be stored in four bytes. Thus, 250,000 numbers or one million characters may be stored in one megabyte. The text (not including advertising) of a typical issue of ARCHITECTURAL RECORD would require approximately ¼ megabyte of storage.

Mouse. Small hand-held graphic input device that can be moved over any flat surface to specify a location or change in location.

Node. A workstation or peripheral device (i.e. printer, plotter, or disk drive) in the network.

Pixel. Picture element. The smallest unit of a raster display scan line which may be varied in color or brightness.

Raster graphics display. Graphics display device on which images are produced like television image, i.e. a set of horizontal lines covering the entire display surface. Varying the color or brightness along each line results in the visible image.

Vector refresh display. Graphics display device on which images are produced by regenerating (refreshing) the image 20-40 times a second. Images consist of straight line segments (vectors) and look like line drawings.

Virtual memory. Scheme whereby the amount of memory available to a program may exceed actual physical memory size. In some computers, the actual physical memory might be one megabyte, but the program would have 24 megabytes of virtual memory available.

Mr. Dill recently joined the Cornell University staff as manager of the Computer-Aided Design Instructional Facility. He has been involved in interactive computer graphics since 1964, and has an extensive industrial background, having been involved with computer-graphics research and development at General Motors Research Laboratories since 1969. At General Motors he was active in the design of graphic systems for computer-aided design applications. Among his continuing research interests are device-independent graphics, man-machine communications, color graphics in computer-aided design, and business graphics systems.

Mr. Pittman recently joined the computer group at Hellmuth, Obata, and Kassabaum. Prior to that he was an assistant professor in the Department of Architecture at Cornell University, working with the Program of Computer Graphics on the development of computer-aided design applications for architects. In the past, he has worked on the development of computer-aided design and architectural computer applications for Skidmore, Owings, and Merrill, Structural Dynamics Research Corporation, and Harvard Medical School.