minicomputer research and applications

Proceedings of the First Conference of the HP/1000 International Users Group

Edited by
Helen K. Brown

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preface

This volume contains the invited and contributed papers presented at the HP/1000 International User's Group conference, held August 25-27, 1980, in San Jose, California. This was the first conference of the International User's Group, which was formed one year earlier, on August 23-24, 1979, in Cupertino, California. The meeting was attended by more than 300 members, including participants from many foreign countries.

The technical program included sessions on Computational Applications, Data Communications, Instrumentation, Operating Systems, Operations Management as well as seminars on HP/1000 products and subsystems. In addition there was an exhibit area in which over 15 companies exhibited products that are related to the HP/1000 computer.

The luncheon speaker was the Manager of the Data Systems Division of Hewlett-Packard, Mr. Dick Anderson. Mr. Anderson shared with us his feelings about the trends in the computer industry. He believes that computer technology, agriculture and energy are the three most important industries for the rest of this century and that these three industries will basically drive everything else. They will be the swing factors in the economic strength of nations and trading blocks. A copy of his keynote address is included in this publication.

The banquet speaker was Dr. James Blinn from the Jet Propulsion Laboratory. Dr. Blinn gave a fascinating presentation on animated computer graphics. He presented a series of slides and movies that simulated the flyby of the Voyager spacecraft past the planets of Jupiter and Saturn and their numerous moons. One of his simulations of the Jupiter flyby is on the cover of this volume. Other simulations of Dr. Blinn's can be seen on the PBS TV series, "COSMOS", produced by Professor Carl Sagan.

There are many elements which contribute to the overall success of first-of-a-kind meetings like this one. Companies dedicate large amounts of employee time in the planning and execution phases, many events are sponsored, and last but not least, attendees, speakers and seminar leaders from across the globe come together to share experiences and to learn. For the Conference Committee, the work began 8 months before the meeting and continued until about 3 months after the meeting. I would like to take this opportunity to show my appreciation to the committee members for a job well done and to thank the companies that provided the support of their activities. Many of the committee members had dual roles on the committee, in that they all assisted in the preparation of the technical program as well as performing the other duties for which they volunteered.

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I am also grateful to the companies that generously contributed to the sponsorship of the various events and functions at the meeting:

Almaden Vineyards
Hewlett-Packard Co.
San Jose Hyatt Hotel

Two members of HP/1000 International User's Group Board of Directors, Norbert Todtenkopf and Marvin McInnis, gave invaluable assistance during the meeting. Mr. Todtenkopf assisted during the very busy registration period Sunday evening and Monday morning. Mr. McInnis assisted with the registration and also helped keep track of the income and expenses from the meeting.

It may not be obvious, but one individual spent a significant amount of time preparing the manuscripts for the trip to the publisher. In our case, a very high degree of journalistic and organizational skill was demonstrated by Helen Brown in preparing these manuscripts that you see in this volume. The conference committee is very grateful for her able assistance.

I want to personally thank Intermountain Technologies Inc. and my family for enabling me to dedicate the necessary time to the conference. I am hopeful that this volume will be a valuable reference document for you, and I look forward to seeing you at the next HP/1000 International User's Group Conference.

Glen A. Mortensen

Glen A. Mortensen
Conference Chairman

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an interactive color display station for IC layout

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Abstract

A color display station is described which is used in the Hewlett Packard Interactive Graphics System (hp-IGS), an IC design system. The basic organization of the display station is described together with a summary of its capabilities. The display station is based upon an HP1000 running in an RTE environment. An intelligent display controller is employed to handle most low level graphic output functions. Communication is performed to a host HP3000 which performs all application dependent command interpretation and database management functions. Functional capabilities of the system include peripheral I/O control, coordinate transformation, a user programmable menu, and figure generation.

Introduction

This paper describes the display station for the Hewlett-Packard Interactive Graphics System (hp-IGS), a color based system for integrated circuit layout and design[1]. The system is being developed by Hewlett-Packard to supply many of the company's future LSI and VLSI design needs. An hp-IGS system consists of a central HP3000 tied to a maximum of four HP1000 based Advanced Interactive Display Stations (AIDS/1000). The HP3000 performs all command interpretation and database management functions. Details of hp-IGS operation and the HP3000 implementation will be discussed in this paper only as they relate to the operation of the HP1000 based display station.

AIDS/1000 is the primary interface between the designer and hp-IGS. The display station performs several basic functions: First, it provides an I/O interface between the HP3000 and associated graphics peripherals (e.g. color display, tablet, plotter). Second, AIDS/1000 is responsible for highly interactive operations such as cursor control and menu selection. Third, the station is an intelligent display processor performing all necessary graphics transformations including scaling, translation, mirroring, rotation, and clipping. Use of this separate, high speed processor operating concurrently with the host HP3000 off-loads I/O intensive operations and complex graphics calculations from the host and frees it for data retrieval and update.

Hardware Configuration

The hardware configuration of the display station is shown in figure 1. The system consists of the following primary components:

HP1000 F series Computer. The computer has 64Kb of memory, and interfaces to the station peripherals. It is running a memory based, unmapped version of RTE, RTE-M(II).

Color Monitor. A high resolution raster scan RGB monitor is employed for the display. The monitor screen is partitioned by software into a menu area, containing a list of names and parameters, and a graphic data display area.

Display Controller. An Intermedia Systems Model 4601 Graphic Display System (Frame Buffer) is employed by the HP1000 to interface with the color monitor. The Graphic Display System stores the video image separately from the main processor memory and provides continuous video refresh interlaced at 72 frames per second to provide a 36 frame/second refresh rate. It consists of a microprocessor-based controller board and two graphic memory boards which plug into I/O slots in the HP1000 computer. The controller board performs all vector-to-raster scan transformations and also generates the separate RGB video signals to drive the raster scan monitor. The memory boards are divided into four separate 768 x 512 bit graphics memory planes. Three memory planes, corresponding to red, green, and blue, are used for data display (for a total of six distinct colors in addition to black and white.) The fourth memory plane, always displayed in white, is used for cursor data, component highlighting, and graphic scratchpad. The Graphics Data System can respond to commands to draw vectors, generate text, clear/fill/blank specific memory planes, and send the contents of the display memory back to the HP1000.

2645 Terminal. The 2645 is used to display hp-IGS information and error messages to the user; functions as an auxillary command input device; and is used to enter local, station related commands (e.g. plotter control, RTE commands, etc.).

Tablet. The tablet is connected to the computer via the HPIB link. The tablet stylus has a pressure actuated switch which provides x,y coordinates and a two position "z-location" (on or off) for digitizing. A cross-hair cursor is shown on the display to track the position of the pen stylus on the tablet.

Hardcopy Output. Both four-color pen plotters (e.g. HP9872) and dot matrix raster printer/plotters (e.g. HP9876) are supported by the station as hardcopy devices. These are not intended as the primary hardcopy output devices of hp-IGS but rather are intended for "quick and dirty" plots of portions of devices as they are being edited. hp-IGS contains much more powerful plotting facilities when a large production plot is required.

HP3000 Link. The HP1000/HP3000 Real-Time Programmable Controller Interface[2] is used for communication between AIDS and the host HP3000. The link communicates via a 16 bit parallel format and is capable of data transfer rates in excess of 100K Baud. Within the link protocol, the HP3000 serves as master and the HP1000 serves as slave.

Software Configuration

AIDS/1000 software is composed of a main program (AIDS) and a 2645 terminal console input processor (KYBRD) which function in the RTE-M(II) environment. The software has been developed on a disc based RTE-IV system using a variety of programming languages. The input processor and about a third of the main program have been implemented in RAT-4 (a superset of FORTRAN employing many of the control structures found in structured languages like Pascal and C.) The remainder of the code is primarily FORTRAN with a sprinkling of HP1000 assembly language and SPL/2100.

The console input processor, KYBRD, is responsible for all input from this 2645 terminal. A separate program was necessary here for several reasons:

a. Input from the user may be asynchronous to the systems operation.
b. Output to the console can be sent by the host at any time; The console can not be tied up on a pending read operation unless the user actually has something to enter.
c. Local station commands (e.g. to interrupt the host during a display) must be processed when entered.

To satisfy the above requirements, the RTE-M(II) system has been configured to schedule KYBRD upon unsolicited interrupts from the terminal keyboard. Once scheduled, KYBRD issues a read request to obtain the remainder of the input (the driver is directed to use the struck character as the first character input). It then parses the input to see whether it is local or destined for the host (this is accomplished easily since local commands must be prefixed with a special character). If local, it is interpreted and executed by KYBRD (RTE commands may also be entered here, in which case KYBRD calls the RTE system message processor). For all other input, KYBRD routes the input to the main AIDS program via Class I/O.

The main program, AIDS, is responsible for all other station functions. As mentioned previously, this includes peripheral control, interactive input support, and display processing. The following sections describe these functions in more detail.

Peripheral Control

In its role as I/O controller, AIDS is used to route status information transmitted from the host to the console, and to merge tablet and keyboard inputs into a continuous stream for input to the host. AIDS will buffer up to 512 bytes of input until queried by the host for input. All input is sent back in ASCII form and data points, whether digitized on the tablet or entered from the terminal, are in user coordinates (usually microns). Whether input comes from the terminal or tablet is transparent to the host. Therefore, conversion from tablet coordinates to user coordinates must be done locally by AIDS (details of this conversion process will be described in the next section)

The AIDS user has several options when requesting hardcopy output. The user can obtain a raster dump of the screen (black and white, of course) at any time by entering a local station command of the form: 'PL,xxxx'; where xxxx may be either 2631,7310, or 9876. This command will cause the HP1000 to read the display image frame buffer, format the data appropriately, and send it to the plotter. If the user desires a four color pen plot instead, 'PL,9872' (HPIB I/F), or 'PL,7221' (RS232 I/F), may be entered. These commands enable a mode whereby graphic components sent to the station display will be duplicated on the plotter. This mode is disabled by entering 'PL'. The last local hardcopy operation supported by the station is the ability to echo host status messages sent to the console on the printer/plotter. Echoing is enabled by entering the local command 'EC,xxxx', where xxxx may be either 2631, 7310, or 9876; echoing is disabled by entering 'EC'.

Interactive Input Support

Several input related functions, though possible by the host, are performed by AIDS for reasons of performance and system integrity. The reader will recall that the display is divided into two regions: a menu area for command input, and a data area for graphic input. A sample display (produced by an HP9876 raster plotter) is shown in figure 2.

As shown, the menu region actually consists of two subregions. One of these is used as a number line. The number line is used for command parameters (e.g. counts) and to identify IC mask layers; it is not used to enter coordinate values. As the user moves the cursor up and down the number line, AIDS generates the number in green corresponding to the position of the cursor. Once the desired number is found, it is selected by pressing down on the stylus momentarily. When selected, numbers will be briefly highlighted in white, and the tablet will produce an audible tone. The second subregion is a menu for ASCII commands. Menu items are selected in a fashion similar to number line items. Users may either enter commands from the menu or enter them on the system console; AIDS sends them back to the host the same way (i.e. the particular input method is transparent to the host.) The menu is programmable in the sense that its initial contents are downloaded by the host and may be changed by the host at any time; The maximum number and size of menu items, however, is fixed. Currently, the menu is downloaded by hp-IGS when users begin their design session. It can subsequently be modified via a local AIDS command. This allows users to interactively configure the menu in a manner best suited to their design methodology and application.

One of the characteristics of all input from the graphics data region is that it is snapped to a grid. The grid is user definable and is specified in terms of a grid size (i.e. spacing in user units between grid points); a grid multiple, indicating which points should actually be displayed; and an offset, used to offset the grid from (0.0,0.0). These parameters are controlled via hp-IGS commands. In addition, grid display can be easily toggled on and off during the design session; this does not affect the snapping of tablet graphic input data to the grid. As an example of grid snapping, suppose a user defined his grid points 5.0 microns apart and centered on integral micron locations (e.g. 0.0, 5.0, 10.0, ,etc.). Inputing a point at (3.5,9.0) will cause the input to be snapped to (5.0,10.0), which is the nearest grid point. When input from the tablet, AIDS always sends the host snapped grid point. To reduce input errors, the user can specify a region between grid points in which tablet input (i.e. digitizing, not cursor tracking) is ignored. This region, known as a deadband, is specified as a percentage of the center region between grid points. For example, a deadband of 50% will cause input to be accepted from the tablet as long as it is no farther than 25% of the grid spacing from the nearest grid point. All grid related commands (including setting the deadband) are processed by the host. If acceptable, the grid parameters are then transmitted back to AIDS for their implementation.

As mentioned previously, input from the graphics data region of the display is converted by AIDS into the user's coordinate system before transmission to the host. This is made possible because AIDS can convert raw tablet data to display coordinates, using a tablet to display scaling factor (derived from device parameters); and convert display coordinates to user coordinates (using information supplied by the host).

Occasionally, the user will wish to calibrate a region on the tablet to a set of predefined user coordinates. This function is especially necessary when digitizing from drawings. Here, the drawing may be rotated and may not be perfectly square. In order to make digitizing useful in this case, the computer must compensate for the drawing as the data are being entered. AIDS performs this function by entering a calibration mode. The user enters the corner points of his drawing and the user coordinate values corresponding to each corner point.

Actually up to twenty-five subregions may be entered in this fashion. From this point on, when tracking the cursor in the graphic region of the display and processing input points, AIDS will implement a tansfer function to convert tablet coordinates (entered in four sided calibrated regions) to user coordinates (in their equivalent orthogonal regions); see figure 3. Given Xt and Yt tablet coordinates, we wânt to derive Xu and Yu user coordinates. If an imaginary line is constructed that contains point Tx,Ty and intersects both lines T1T2 and T3T4 by the same relative amount, r (expressed as a fraction between 0 and 1), then the corresponding user units for Ty can be given by: Uy = r(Uy2-Uy1)+Uy1. Similar arguments apply to the computation of Ux.

Display Processing

AIDS performs a variety of graphics related functions for the host; however, most of these functions are implemented in five basic steps:

1. Host Command Analysis.
2. Transformation To Display Coordinates.
3. Display Vector Generation.
4. Display Vector Clipping.
5. Formation and Output of Frame Buffer Commands.

The following paragraphs describe these steps in greater detail.

Host Command Analysis. AIDS commands are normally buffered in 1024 word blocks by the HP3000 before being sent over the Programmable Controller Link. All commands have basically the same format; particular fields may go unused or have specialized meanings depending on the nature of the command. Figure 4 illustrates the basic command format. The 'CODE' field is the basic command opcode; currently AIDS interprets fifteen distinct commands. The 'M' field normally controls the display mode: draw off, draw on (i.e. merge with current), complement, and jam (i.e. replace current). The 'T' field controls the type of display: outline with solid lines, outline with dotted lines, filled with solid lines, filled with dotted lines. The 'W','B','G','R' fields control output to the white, blue, green, and red display memories, respectively. The 'PARM1' and 'PARM2' fields contain additional parameters relevant to the specific function requested. 'XZERO' and 'YZERO' values are double integer coordinates which indicate the origin (in a multiple of user units) of the component to be drawn. The 'LENGTH' parameter determines the number of 'XY-COORDINATE' offsets supplied in the command buffer. A positive length indicates integers, a negative length indicates double integers. The 'XY-COORDINATE' array contains a list of vertice points for the component, or in some cases, an ASCII string. Vertice values in this array are relative to the 'XZERO' and 'YZERO' origins. This array is converted to reals before being passed to the functional processors.