GIGI Terminals at Caltech

Stephen Trimberger
California Institute of Technology
Pasadena, California 91125

TM 5008

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Environment

Most of the faculty and students in the Caltech Computer Science Department are concerned with integrated circuit design and large-scale processor architectures. They make heavy use of graphics equipment for plotting integrated circuits from the department's two computers, a DEC 20/60 and a VAX 11-780.

The department has three "Charles" terminals, high-resolution home-built color raster terminals, all located in one lab. The Charles terminal includes a Xerox "mouse" pointing device and may have a four-color pen plotter attached. There are also about half a dozen GIGI terminals connected to the two computers scattered around the department in offices and labs. Some GIGI terminals are equipped with a Summagraphics BitPad™ tablet for pointing, but others are used without graphic input.

A great deal of effort has been invested at Caltech to develop and maintain device independent graphics packages to handle graphic input and output. When a new device is available, an interface is written for that device, and all existing software works with the new plotter. Such plotting packages exist on both computers and can plot on the Charles, GIGI, and a wide variety of hardcopy plotting devices. Much of the software described in this article was written for the Charles terminals well before the GIGIs arrived, and was converted to plot on the GIGI with relatively little effort.

GIGI terminals are being used three ways at Caltech: as low-cost replacements for Charles terminals, as softcopy plotters to preview files before sending them to one of the hardcopy plotters, and as personal design stations.

Applications

Plotting Integrated Circuits

As was stated at the outset, integrated circuit design is a primary interest in the department. Therefore, the oldest and most widely used graphics program is CIF2OP, which plots integrated circuits defined in Caltech Intermediate Form (CIF). In CIF2OP and CIFP, the VAX version of the same program, the "cell", the part of the circuit to be plotted, is specified by typing its name. The part of the cell to be shown on the screen is set either by typing the coordinates of the bounding rectangle to be plotted or by pointing to the corners of that rectangle on the screen with the BitPad tablet. The user may select which layers of the integrated circuit to plot (shown by different colors) and may use the tablet to draw new wires to be inserted into the layout.

An important feature of CIF2OP is its ability of change the output device without modifying other plotting parameters, a result of the device independent plotting software. Although limitations of the GIGI prevent users from viewing detailed plots on the screen, users can view the chip on the GIGI, set up the plotting parameters,

and plot only the parts that are necessary on the hardcopy plotter.

Symbolic Integrated Circuit Design Software

Integrated circuits can be designed more quickly in "symbolic" or "Sticks" form, in which wires are shown as just the center path line with a color representing its wiring layer. These Stick-like wires run between symbols representing transistors and contacts between the wiring layers. This line-based type of display is more amenable to GIGI hardware than the area-based geometry in CIF2OP and several programs have been written for viewing and modifying Sticks data using the GIGI.

STKPLT is a program for plotting Sticks circuits in the same manner that CIF2OP plots CIF. STKPLT can show more of a circuit, because the Sticks form is less cluttered because sizes and spacings of interconnection in the Sticks form is much less important.

Central to the Sticks design is a powerful graphics program called REST. REST has plotting facilities similar to those in CIF2OP and STKPLT and uses a simple, externally-defined line and box editor which is built into the Charles terminal and which is implemented as a separate program, LBED, for the GIGI. LBED lets users draw vertical and horizontal lines and boxes of various sizes and colors on the GIGI screen. LBED passes the picture to REST, which interprets the lines as wiring, and the boxes as transistors, resistors, and contacts between wires. If a change must be made, REST sends the cleaned-up drawing back to the line and box editor, and the user may add to the circuit. LBED is a very simple program, but it allows users to easily input the Stick data, which is very difficult to enter without color graphics equipment.

RIOT is a graphical chip assembly program which runs on the Charles terminal and on the GIGI. RIOT reads CIF and Sticks data and shows the cells to the user as outlines with colored crosses where connections may be made. Riot allows the user to pick up the rectangular representations of cells by pointing to them. The user can then move, mirror or rotate the cells, force them to abut, or create simple wiring between them with a single command. Like Sticks, the amount of detailed information needed on the screen is slight, requiring only line drawing, usually at low resolution. Also like Sticks, this task is very tedious without graphics equipment. In this application, the GIGI terminals are adequate to assemble even fairly large chips.

GIGI as a Personal Graphic Workstation

The software described above is the basis of an integrated circuit design system in use at Caltech. Eventually, it is hoped that full use of all design facilities can be available to every member of the department in his or her own office. The Charles terminals are too expensive to dedicate one to each person. Instead, several of the GIGI terminals, which cost about a quarter of the Charles terminal, have been placed in offices rather than in a lab, giving those people instant access to color graphics. Although there is no need to constantly display color graphic information, the subjective experience of the personal graphic workstation has been positive.

Miscellaneous Plotting

The DIAG program lets users make color line drawings on the GIGI for use in theses and papers. DIAG draws a rectangle on the screen that represents a 8 1/2 by 11

inch piece of paper. The rectangle has tick marks representing a half-inch grid on the page to aid the alignment of features in the drawing. Next to the rectangle is a menu of commands which are invoked by pointing at them with the tablet. Users may draw lines and boxes by pointing at a spot on the page image and pressing a button on the BitPad cursor. Lines may be snapped to the horizontal and vertical, and they may have arrows added automatically on the tips. Text is inserted by pointing to a spot and typing the message. Existing pieces of the drawing may be moved, re-shaped or deleted. Drawings can be saved in a file and plotted on a color plotter.

Widespread use of the plotting packages has made it difficult to list all the software that has been written to use the GIGI. GIGI plotting programs include programs to plot an Applicon color raster plotter file, and to draw speech waveforms. In both cases, a considerable amount of time is saved by checking the plot before making a hardcopy.

Problems and Solutions

There are two major limitations of the GIGI for integrated circut design: too few colors and "bleeding" of colors into adjacent areas. These problems are not unique to integrated circuit design, but were addressed in that context. This section is a discussion of the problems and solutions.

The reason for plotting the circuits in an application such as CIF2OP, is to determine if wires are wide enough and spaced far enough away from one another. Many important parts of an integrated circuit plot are the overlaps between layers. Since the GIGI has only eight colors, only three layers and all their overlaps can be resolved.

A limited number of colors is a common problem in graphics programming. On the GIGI, it can be solved by re-using colors in situations where the re-use does not cause confusion, and by using line-drawing instead of area-filled drawing, so the overlaps need not be a different color. Area-filled shapes, as used on the Charles terminal, simplify identification and checking of overlaps, but since most hardcopy plotters use line drawing, the added burden for GIGI users was deemed acceptable.

The second problem has to do with the way the colors are assigned in the GIGI. Since each horizontal block of dots on the screen has the same color, any colored area in the same 12-pixel block as a new line is changed to the new color. This "bleeding" can be annoying and misleading.

The bleeding problem, which seems to be unique to the GIGI, can be limited by drawing all vertical lines of all colors before drawing any horizontal lines. This keeps colors from bleeding along horizontal pieces from vertical pieces, eliminating most of the problem. But bleeding also occurs when two features of different colors lie in the same 12-pixel block. There is no solution to this problem, which is more severe with smaller features, and it effectively limits the separation between features on the screen to about a nine pixel minimum. Users have learned to be cautious using CIF2OP on the GIGI, using it for small-scale plots only.

Conclusions

The GIGI is not perfect, especially for the task of integrated circuit plotting which the Caltech Computer Science Department does most often and for which the GIGI was not meant. However, the serious drawbacks of the GIGI are mitigated by plotting only small pieces of the chip with the GIGI, by using the GIGI as a softcopy viewer to line up the hardcopy plot which will be viewed in detail, and by using the GIGI with symbolic data which tolerates lower resolution.

The GIGI terminals remain underutilized, in favor of the more powerful Charles terminals. However, their presence in the lab and in peoples' offices is leading to increased use, and that presence could only occur because of its low cost. More powerful graphics terminals are being evaluated for integrated circuit design tasks, but there is little doubt that the GIGIs will be around for quite some time as low-cost graphic workstations.

BitPad is a trademark of the Summagraphics Corporation, Fairfield, Connecticut.