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PC Graphics Generation and Management Tool for Real-Time Applications

Long V. Truong
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio

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Because of the considerable effort required to generate these real-time graphics applications in the past, the need for an easy graphics generation and management tool became apparent. Although there are many sophisticated commercial graphics tools such as Freelance [3] and Quattro Pro [4], none support run-time software for graphics manipulations, or disclose their graphics file formats for user implementations of real-time applications. Because such a tool is not available for PC use, we designed a tool to eliminate custom graphics programming and to simplify the development of our application software.

This paper describes the tool's features and usage, and presents examples of real-time graphics applications in the area of monitoring and diagnosis (M&D) for a distributed electrical power system (EPS).

FEATURES OF THE TOOL

The system is user friendly with graphical interfaces, is menu-driven, and provides on-line help instructions at every step. A popular "rubber" drawing method, found in many commercial graphics tools [3-4], was applied for drawing convenience. All options are executed using mouse commands [5] and are displayed on a single menu for fast and easy operation (Fig. 2). The basic drawing elements, drawing styles, and graphics file format for real-time graphics applications are described as follows:

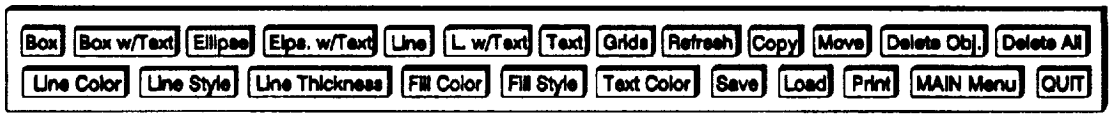

Figure 2. - The tool's menu.

Basic Drawing Elements

The basic drawing elements, sometimes referred to as objects or images, are box, circle, ellipse, polygon, line, poly-line, and text (Fig. 3). A description of their unique characteristics follows.

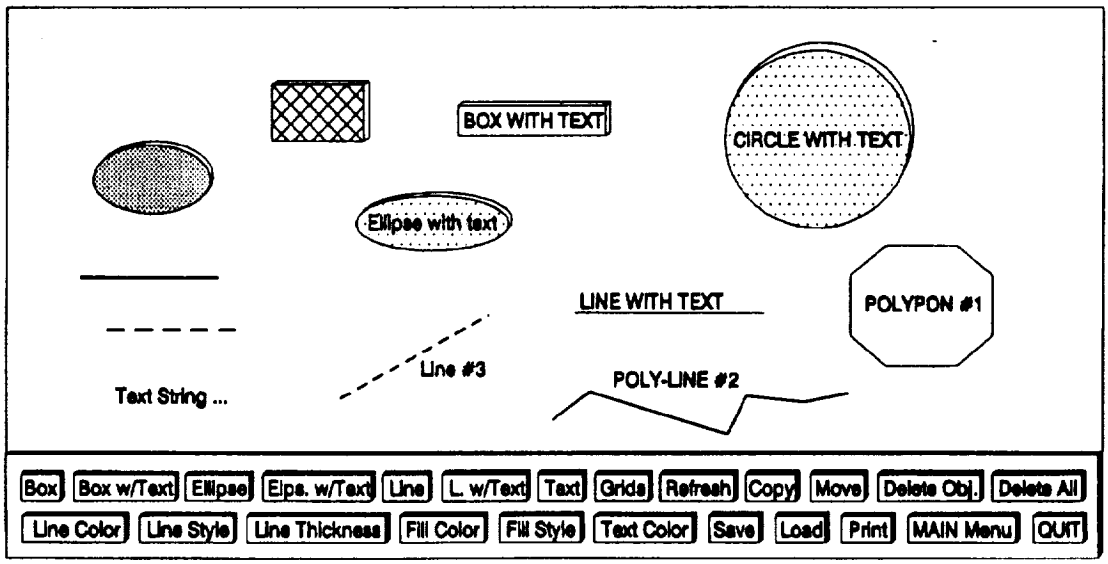

Figure 3. - Samples of the basic drawing elements.

Box, Ellipse, and Line

The box, ellipse, and line can be drawn with or without the option for attaching a text string or label. To draw a box or ellipse with the text option attached, the object is calculated automatically to contain the given text string. To draw a line with the text option attached, the text string is placed automatically at a proper location (predetermined) next to the line. In addition, boxes and ellipses are drawn in three-dimensional images.

Circle, Polygon, and Poly-line

Note that circles, polygons, and poly-lines are not listed as menu items (Fig. 2). However, they can be generated from the Ellipse and Line options.

Text

Input text is an alphanumeric string of up to 80 characters (including white spaces). Presently, only one font (with a fixed size) is being used.

Modifications of these drawing elements are done easily by mouse commands through three convenient functions: Copy, Move, and Delete Object.

Drawing Styles

The drawing images can be selected from 16 standard colors (Fig. 4(a)), 2 sizes of line thickness (Fig. 4(b)), 4 types of line styles (Fig. 4(c)), and 12 distinctive filled patterns (Fig. 4(d)).

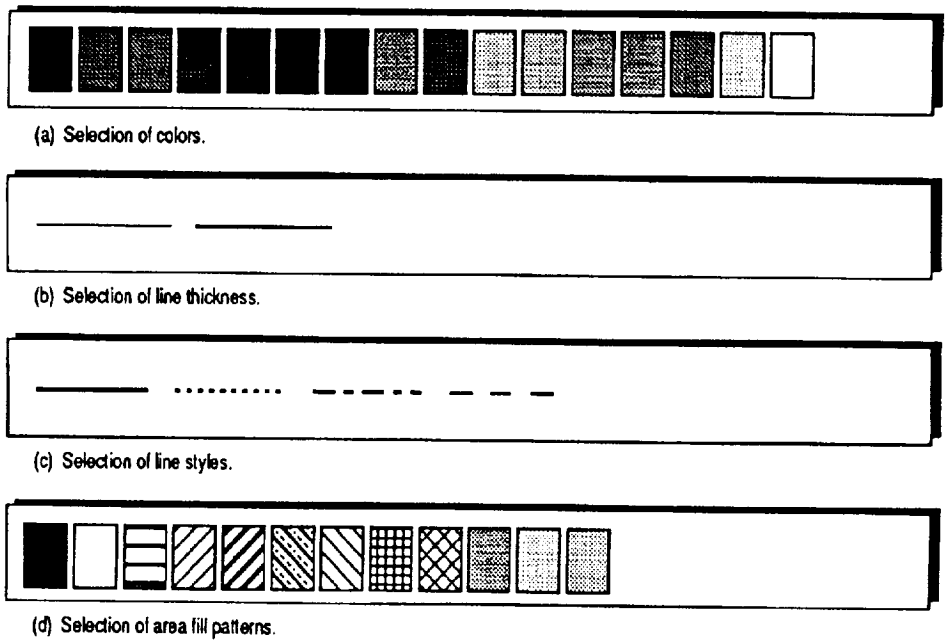

Figure 4. - Samples of the basic drawing styles (using mouse).

Graphics File Format

A custom graphics file format was designed for solving real-time graphics application problems. Unknown graphics file formats and the lack of software support in many commercial graphics tools make it difficult or impossible to access the graphics knowledge base from user programs in many typical real-time applications.

Figure 5 shows a typical listing of the saved graphics file which allows easy access and tremendous saving of computer memory in both run-time (RAM) and storage (hard disk). Each drawing object is saved as a record (116 bytes max), including 12 fields and 11 bytes of spaces as field separators. Descriptions of individual fields (from left to right) are explained as follows:

```
B 112 060 199 080 15 00 01 01 00 15 BOX WITH TEXT
E 472 099 060 039 15 00 01 00 00 15 noname
T 424 107 000 000 15 00 01 00 00 15 CIRCLE WITH TEXT
L 302 187 424 232 15 00 01 00 00 15 LINE #3
```

Figure 5. - A typical listing of a saved graphics files.

Field #1 contains the object type (1 byte), coded with letters B (for Box), C (for Circle), E (for Ellipse), L (for Line), and T (for Text).

Field #2 contains the horizontal location (3 bytes) of
- the top left corner of a box
- the center of ellipse or circle
- one end of a line, or
- the bottom left corner of a text string.

Field #3 is the same as Field #2, but for vertical location.

Field #4 has 3 bytes and contains
- the horizontal length of a box, line, or text string
- the radius of a circle, or
- the horizontal radius of an ellipse.

Field #5 is the same as Field #4, but for vertical length.

Field #6 contains the line color (2 bytes).

Field #7 contains the line style (2 bytes).

Field #8 contains the line thickness (2 bytes).

Field #9 contains the fill style (2 bytes).

Field #10 contains the fill color (2 bytes).

Field #11 contains the text color (2 bytes).

Field #12 contains the text string (80 bytes).

File management functions such as Save, Retrieve, and Print File are also provided.

USAGE

Because all options are displayed in a single menu and are executed by mouse, the tool is extremely easy to use. It operates on any IBM or compatible PC. A color monitor (EGA, VGA, or super VGA) is highly recommended. If modifications of the tool's software are necessary for user applications, a Turbo C++ [6] compiler is also needed.

To start the tool, type the command "FRAMEMKR" at the DOS prompt [7] and hit the Enter key. After successful completion of the command, the computer screen should appear as in Fig. 2. For best performance, the tool's software should be loaded and executed from the hard disk.

To select an option move the mouse cursor over the desired menu item and click (press and release) the left mouse button. After each selection, operators will be assisted with the on-line instructions for completion of the process. Operations are very easy with custom on-line help; thus, illustration of step-by-step instructions for each option is not necessary here.

REAL-TIME GRAPHICS APPLICATION EXAMPLES

As previously mentioned, the application examples given pertain to the area of monitoring and diagnosis (M&D) of a distributed electrical power system (EPS). A top-level diagram of the EPS is shown in Fig. 6.

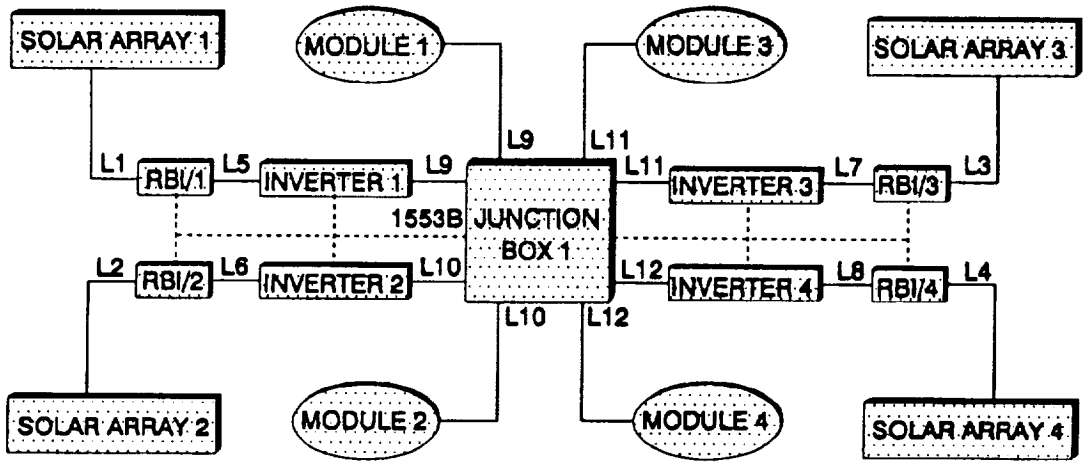

Figure 6. - Example of a normal display for the simulated electrical power system (top level diagram.)

Because of the nature of the EPS, electricians normally use hardware schematics as "road-maps" for troubleshooting problems. What could be better than having "live" schematics on the computer screen for M&D? An essentially live schematic can be achieved by using computer images with designated colors, video intensity, and sound to symbolize the component hardware status (real-time feedback from sensors), and therefore, status of the system itself. Table 1 defines these image representations or models for the following examples. Notice that only black-and-white shadings are shown to represent the actual colors in illustrated figures.

Table 1. - Designated Image Representations of Colors, Video Intensity, and Sound of System Status.

Image Representations	Status of Hardware Components/Modules
Green	ON or present of electricity in the circuits
Red	OFF or absence of electricity in the circuits
Yellow	WARNING, a "side-effect" or minor failure, temporary or permanent, diagnosed (usually requires attention)
Flashing & beeping	ALARM, a "hard" or serious failure diagnosed (requires immediate attention)

Example 1: M&D Display of a *Normal* Condition.

Figure 6 shows a simulated typical EPS displaying the normal status for the system. Notice that green images and steady video intensity were used to indicate the "ON" status of the hardware components and the flow of electricity in the connected wires or cables (Table 1).

The second-level detail of JUNCTION BOX 1 can be accessed also (with the zoom-in feature) and examined as shown in Fig. 7. Note the normally "OFF" status (Table 1) of the RBI/5 (space Remote Bus Isolator #5,) [1] for comparison in example 3 (alarm condition).

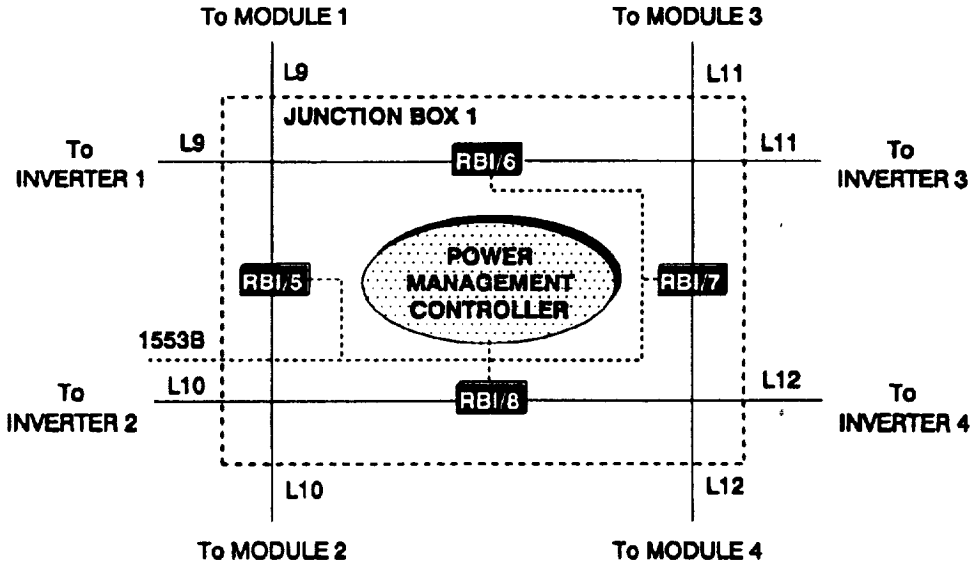

Figure 7. - Example of a normal display for the second level detail of JUNCTION BOX 1.

Example 2: M&D Display of a *Warning* Condition.

Figure 8 displays an example of a warning condition (conclusion from the diagnostic software module) for the component RBI/2 that is due to invalid feedback data caused by bad sensors or electrical noise in data transmission networks. Its image is highlighted in yellow according to the model in Table 1. The nature of the warning condition is then explained or displayed at more detailed levels when requested.

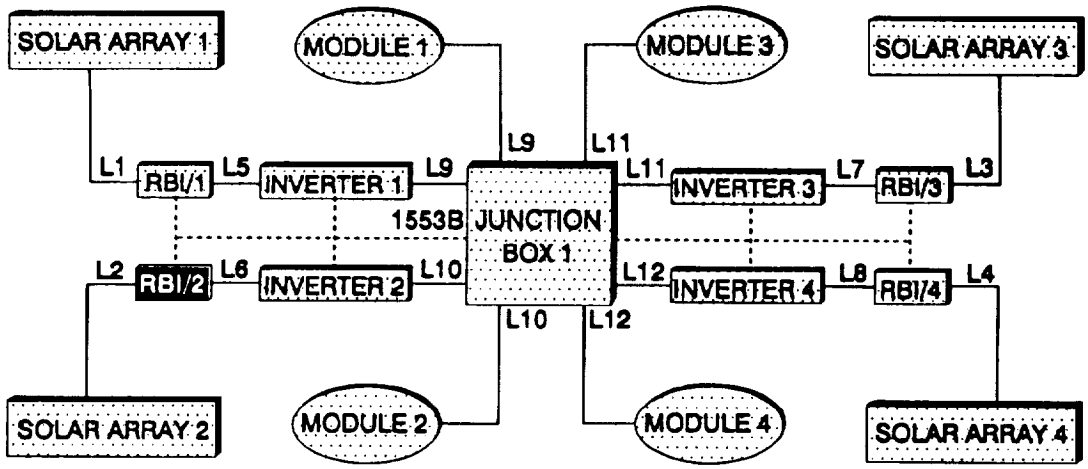

Figure 8. - Example of a warning display for the RBI/2 (Remote Bus Isolator #2).

Example 3: M&D Display of an *Alarm* Condition.

Figure 1 displays an example of an alarm condition (conclusion from the diagnostic software module) for the INVERTER 1 that is due to an internal hardware failure of the component. Its image is highlighted in red with flashing and beeping (Table 1).

At this time the second-level detail of JUNCTION BOX 1 can be accessed and examined for comparison, as mentioned previously. Notice the status of RBI/5 is now ON (Table 1), as shown in Fig. 9. For the sake of our discussion, RBI/5 changed status as a result of a system reconfiguration (shedding or rescheduling electrical loads) to provide an alternate source of power (SOLAR ARRAY 2) to MODULE 1 (where electrical loads are located).

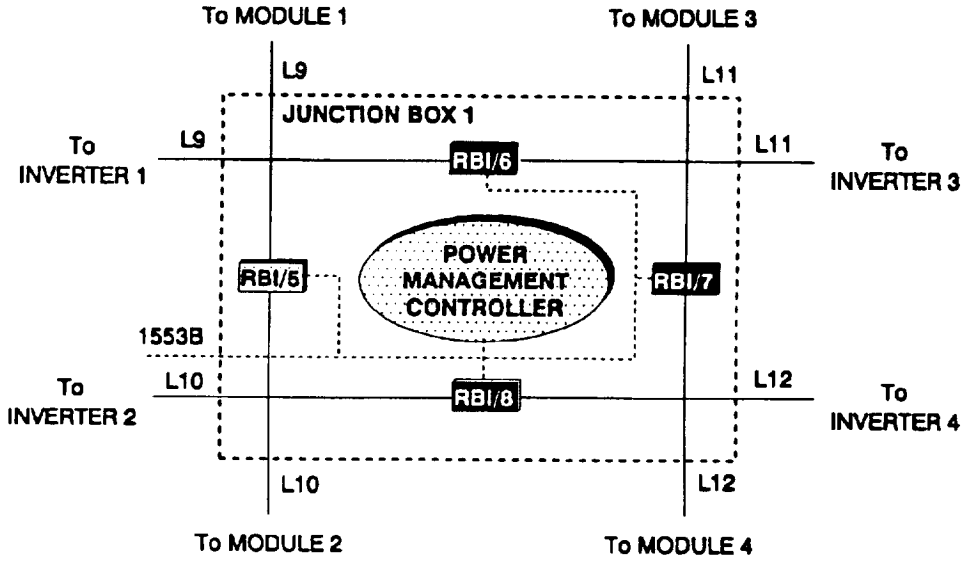

Figure 9. - Example of a re-configuration display for the second level detail of JUNCTION BOX 1.

Color images and various video intensity levels are essential to visualize the flow of electricity and to highlight the problem areas. Real-time visualization and highlighting are key contributions of these new graphics tools.

SUMMARY AND CONCLUSION

With new graphics generation and real-time graphics management tools, graphics programming is largely eliminated and applications are handled with ease. The tools are very easy to use. Aside from the normal benefits for fast and easy graphics generation and modification, the open structure of the saved graphics files and with the available software for run-time graphics manipulation suggest new possibilities for commercial markets in real-time graphics applications.

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2. Walters, J., et al., Autonomous Power Expert System. Goddard Conference on Space Applications of Artificial Intelligence, NASA Goddard Space Flight Center, Greenbelt, Maryland, May 1-2, 1990 (NASA E-221).

3. Lotus Freelance Plus, trademark of Lotus Development Corp.

4. Quattro Pro, trademark of Borland International Inc.

5. Microsoft Mouse Programmer's Reference, copyright 1989 by Microsoft Press, A Division of Microsoft Corporation, 16011 NE 36th Way, Box 97017, Redmond, Washington 98073-9717.

6. Turbo C++ Version 1.0, copyright 1990 by Borland International Inc., 1800 Green Hills Road, P. O. Box 660001, Scotts Valley, CA 9067-0001.

7. Microsoft MS-DOS Version 5.0, User's Guide and Reference, copyright 1985-1991 by Microsoft Corp.

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Long V. Truong

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Lewis Research Center
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A graphics tool was designed and developed for easy generation and management of personal computer graphics. It also provides methods and "run-time" software for many common artificial intelligence (AI) or expert system (ES) applications.

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