# DESIGN FOR A TELIDON-BASED BUSINESS GRAPHICS PROCESSOR

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SUMMARY

This report addresses two objectives. The first objective, addressed in the first half of the report, is to describe the nature and uses of business graphics. The second objective, addressed in the second half, is to describe a Telidon-based device for producing them.

Graphics are presently used in businesses for presenting numerical data, systems descriptions and project schedules. They appear in written reports and at verbal presentations. They are characterised by a number of features including the repetitive use of images and the frequent incorporation of text.

With conventional photographic-based technology, the production and display of graphics is expensive and time-consuming. It is expected that if knowledge workers had increased access to facilities for creating business graphics they would use them even more extensively than at present.

The Telidon graphics communications protocol can be used as the basis for a business graphics processor which will provide user-friendly graphics creation terminals.

The most important part of the development of such a device is designing an appropriate user interface. The user interface can be based on the principle that a page is created by selecting pre-drawn images from an image base and electronically pasting them on a page.

A prototype of such a device has been tested at the Department of Communications. Untrained users have demonstrated that they can create business graphics with the prototype with less than 15 min training.

## A DESCRIPTION OF BUSINESS GRAPHICS

### Extent of Use of Graphics

Graphics are already very common in business communications and are becoming more common each year. In the United States before 1980, more than 20 million business slides were being produced each year at a cost of over one billion dollars per year (Paller, 1980). In 1982, over 520 million business slides were produced at a cost of $3.5 billion (Wertenberger, 1983). The production of business slides now grosses more than the feature film industry.

In the Federal Republic of Germany, Horak (1983) reported that, of 8,000,000 letters sent daily between civil authorities and industry, 37.5% contain graphic images of some sort. These graphic images include letterheads and company logos, statistical material, forms and drawings. After reviewing various organizations, Horak concluded that at least half of all office procedures involve documents containing graphic images.

Graphics are used frequenly in business applications, despite their direct and indirect costs, because they provide an

effective way to communicate ideas (for further discussion, see Mills, 1982). Communicating ideas is one of the primary functions of managers and professionals, which is why they are called "knowledge workers" (Drucker, 1968).

## Types of Business Graphics

Business graphics can be divided into five specific types according to their content and general structure.

First, graphs are required to represent numerical data. Most common are line graphs, bar graphs and pie charts. In each case, the different parts, lines, bars or sections must be drawn to a precise size, in a precise location and will be coloured or textured differently and labeled.

Second, charts are required to represent organizational structures. Most common are hierarchical organizational charts. These charts require drawing different sized elipses and rectangles which contain labels and are connected with arrows.

Third, diagrams are required to represent processes. These include flow charts, timelines and systems analysis diagrams. Again, elipses and rectangles will have to be labeled and connected with arrows.

Fourth, plans are required to represent physical relationships. The most common plans are geographical maps, blueprints and floor plans. These consist of coloured, textured, labeled polygons placed adjacent to one another.

Fifth, illustrations are required to show the appearance of objects. These illustrations consist of line drawings, cartoons and photographic images. Often these will include company logos and pictures of the company's products.

## Characteristics of Business Graphics

Graphic images for business have some characteristics that make them simpler to create and store than graphic images in general.

First, business graphics rely on a small number of generic structures (Horak, 1983). That is, the graphics are not independent, one from the other, but share a common underlying structure. In some cases, such as organizational charts, there is so much common generic structure that premade forms can be purchased. The user need only outline the parts of the chart he is using and label it.

Second, the individual graphic elements are very repetitive from one document to the next. For example, a company logo will be used over and over again. Each time, the image of the logo will be identical, but its size and location on the page will be changed. In the same way, maps, flags, company products and common ideographs are used in many different documents.

Third, business graphics rely on words and text to label the graphic image. Whereas other types of graphic art may avoid incorporating text, it is expected that text will be substituted for any part of a business graphic that would be difficult to represent with a visual image. Frequently, the graphic consists of more text than images. Many business forms, for example, are mostly text which is distributed about the page, separated by lines and borders. They are classified as graphics because it would be much easier to produce them on a business graphics processor than on a typewriter or word processor.

Finally, much of the important information on a business graphic is numeric. Thus, the relative size and placement of bars on a graph or sections of a pie chart are more important than having detailed pictures of objects.

## Conventional Graphics Technology

Currently, business graphics are created by specialized graphic artists and then reproduced photographically. Maintaining a graphic arts department is expensive for large companies and impossible for small businesses. Using existing technology, it is generally estimated that it costs between $40 and $150 to purchase a typical chart, slide or overhead graphic from an outside agency (Frost and Sullivan, 1981). The cost of producing a graphic in the graphics arts department of a large organization is slightly lower, but falls in a similar price range.

Clearly these methods are only suitable

for producing high quality graphics for presentations. The technology for producing less formal, "peer quality" graphics is much less developed than the technology for producing presentation quality graphics. At present, peer quality graphics are made with felt-pen diagrammes on flip charts for verbal presentations and pencil drawings for working reports.

## THE DEVELOPMENT OF SUITABLE TECHNOLOGY

There has been more interest in the past three years in the electronic generation of graphic images for business than previously as a result of two technical advances. The first is the development of cheaper computers and the second is the establishment of graphics encoding standards.

### More computing power per dollar

Recent developments in digital technology have made it possible to use computers to generate graphics for business at a lower overall cost than with conventional technology (Franklin, 1983). Until now, producing a graphic image incurred both a high direct cost in labor and materials and a high indirect cost in occupying the time and effort of a knowledge worker and in producing delays in the availabily of the graphic, thereby decreasing the productivity of the knowledge worker.

Now, however, the cost of computers has fallen to the point that knowledge workers are acquiring personal, dedicated micro-computers, costing between $2,000 and $10,000 each. These micro-computers can be connected to each other and to a shared midi-computer costing less than $200,000. Graphics can be stored, transmitted and displayed electronically. Those which must be produced in physical form may be converted to an 8x10 colour print, colour slide or overhead transparency for about $5.00 (Franklin, 1982).

### Development of Graphics Standards

The development of inexpensive hardware has been accompanied by the development of efficient algorithms for encoding and displaying graphic images.

A subtle, but important, consequence of the development of efficient techniques for the manipulation of electronic images is that these techniques provide the basis for widely accepted standards. As more effort is expended on develo-ing the graphics techniques, it becomes apparent which techniques are more suited for a particular application. With widespread use a techni ue eventually becomes embedded in an official standard.

The adoption of standards for graphics is critical in the development of business graphics systems. The greatest technical impediment in the development of other types of office automation is the lack of technical standards. Different companies and institutions must be able to communicate with each other in order to conduct their business, yet each supplier of office automation technology produces equipment that is incompatible with the other equipment in the market.

The most advanced standard that has been specified for the transmission of graphics is the North American Presentation Level Protocol Standard (Canadian Standards Association, 1982). This standard incorporates the Telidon Picture Descriptor Instructions (PDIs) to encode graphics. It allows graphics, intermixed with text, to be transmitted to a wide variety of terminals and display devices over low-bandwith channels, such as telephone lines. It also allows efficient storage of the graphics in a form that allows easy editing.

### Impact of Computer Technology

The impact of these technological advances are already being felt in the business graphics industry. In 1982 there was an installed base of 383,000 business graphics devices in the United States. A recent survey by the International Data Corporation projected an increase to 4.4 million devices by 1986. This represents an increase in the market from $316 million to $1.4 billion in four years (Higgins, 1983). Whether these projections turn out to be over or underestimates depends, in a large part on the ability of the business graphics industry to provide suitable, usable systems.

## GRAPHICS PROCESSOR SPECIFICATIONS

Given that both adequate technology and a suitable standard are available to satisfy an existing need, the next step is to develop specifications for a business graphics processor. This would be a machine, analogous to a word processor, which produces graphics rather than text. It allows the creation, transmission, display and reproduction of business graphics in a way that is easy for a manager or secretary to learn and use.

### The Importance of Human Factors

The first and most important issue is to design a device which can be used by knowledge workers and support staff with a minimum of training. This is critical for two reasons.

First, if the device requires too much training, the knowledge worker will not learn to use it at all. Managers and professionals are too busy to spend time learning to use a new technology unless the benefit clearly justifies the effort.

Second, the knowledge worker will be a casual user of the system. He may only use it once a week at best, and much less often at first when it is not part of his normal working routine. If it is too difficult, he will forget how to use the system between times and will not want to spend time continually re-learning the system.

Thus, the function of the system must be so obvious that the system seems "natural" to use. Then the knowledge worker and his support staff will be able to create simple, informal graphics as required. The graphics professionals would only be consulted for complex or difficult graphics that require expertise in graphics design, not expertise in using a particular type of graphics device or technology.

### The Search for an Appropriate Metaphor

The first step in producing specifications for a device which is easy to use is to search for an appropriate metaphor for the system (Carroll and Thomas, 1982). If the user can be told that the system is similar to something he already understands, much less training will be required.

Most existing graphics creation programmes are called "paint programmes" because they use drawing or painting as their metaphor. The user is told how to mix colours on an electronic pallet, how to create an electronic paint brush and how to paint on the screen.

While this is a good metaphor for artists who wish to use electronic media, it is the wrong metaphor for knowledge workers. It addresses the wrong type of graphics for business applications and requires the wrong type of skills from the knowledge worker.

Staying within the metaphor fails to address the four characteristics of business graphics.

First, it does not take into account the generic structures used in business graphics. It demands that the user redraw the general form of the graph or chart each time he wishes to create a specific example of one.

Second, it does not allow the repetitive use of a symbol or sub-picture. For example, each time a company logo is required, it would have to be redrawn.

Third, mixing words or blocks of text with the graphic is not a natural function of a paint programme. The user would have to write out the labels as though he were using a pen and paper.

Finally, representing numerical information on images would require measuring the lengths of lines on the screen.

These functions could only be incorporated into the paint programme by leaving the paint metaphor. For example, an exit to a word processing or data analysis programme could be allowed, followed by a return to the paint programme. Mixing metaphors in this way produces unsatisfactory human-machine interfaces. It adds complexity to the use of a programme which is already difficult to use because it requires adding a second or third type of training on top of the training originally required.

The other reason that painting is the wrong metaphor for the knowledge worker is that it relies on existing skills that he may not have. Clearly a meta-

phor can only save the user from learning specific things about a system if the metaphor invokes knowledge and skills that the user has already learned. It cannot be expected that a knowledge worker outside the graphics arts professions will have either talent or training in drawing and painting.

The "Cut and Paste" Metaphor

Rather than "drawing" or "painting" a page, "cutting and pasting" pieces of a page together provides a much more appropriate metaphor for business graphics. The knowledge worker would not be asked to draw a graphic image. Rather, he would be asked to name an image that he wants to add to a page. A small version of this image would be displayed in one corner of the screen. If the user confirms that this is the correct image, he would be asked to indicate the position and size of the image on the screen by using a cursor to point, first to one corner, and then to the opposite edge of the location of the image. The graphics processor will move the image to the correct location and wait for the user to name another image to paste on the page.

To do this, the graphics processor will access an image base which is a data base containing a large number of predrawn images. These could include company logos, pictures of company products, flags and generic pictures of common objects. In addition, there will be more complex pages stored such as pre-made forms, charts of parts of the organization and blueprints of equipment being manufactured.

If an image is desired which does not exist, a graphics art professional will be called to either find it somewhere else or create it. The image will then be added to the image base so that it will be available, not only to the manager who needs it immediately, but to anyone in the organization who may need it in the future.

Graceful Addition of Complex Functions

The functions described above constitute a basic business graphics processor. The use of a simple, general metaphor has implications beyond providing a way to design a programme to accomplish a restricted set of functions. The metaphor produce a software "shell" for many other programmes. Thus, the user may be given access to a number of other types of programmes within the context of the business graphics processor. As long as the programmes conform to the "cut and paste" metaphor, the user will be able to learn about them as he needs them.

Incorporating Active Functions

For example, frequently the knowledge worker will want to graph data numerical data that he has aquired. Such a graph cannot have been pre-drawn.

These graphic routines can be fit into the "cut and paste" metaphor quite readily. The difference is that, instead of giving a simple name to the object, the user must both name the object and describe some characteristics of it. In the example of a graph, he would have to type the name "line graph" and enter the data points that are to be graphed. The graphics processor would generate the graph rather than recall it from a disk. This would be transparent to the user. From his perspective the same thing is happening as for any other interaction with the system. He just selects an object and fits it on the page.

When the graphic has been created and pasted on the page, the user will be given the option of storing the image in the image base for future use. This will save both him and other users the effort of re-entering the data for graphs or charts that are going to be used more than once.

A library of data analysis routines will exist in the graphics display processor to create a number of standard functions. This will include line graphs, bar graphs, pie charts, time lines, flow charts and organizational charts.

Adding Annotations or Other Text

Another function that must exist in the business graphics machine is the ability to annotate the page by adding text. The addition of text will be the same as the addition of images to the page. The user will tell the system that he wishes to paste some text on the screen. He will be asked to select a font and colour, and then type the text. As it is typed, it will be displayed on the top of the screen in its full size. After

the line of text is entered, the user will indicate the position on the screen where the text will begin. The system will move the text into position and wait for further input. A block of text would be entered one line at a time. An alternative method of placing text on the screen would be to allow the user to indicate an area that will be filled with text and then let him type the text directly into that area. This alternative is most useful if the graphics terminal has the capacity to change the size of the text. As the user types more and more text, the existing text would get smaller in order to allow everything being typed to fit into the designated area.

Drawing on the Screen

It is interesting to note that it is only a small step from the addition of text to a page to the addition of a polygon to a page. Both may be added directly to the page at their final size. The user would specify that he would like to add a polygon of a certain colour to his image. He would then indictate the location of each vertex in turn with a cursor. The same technique would be used for lines, curves or any other fundamental shape.

At this point, the user would actually be drawing on the screen. He has reached the level of a "paint" program through small increments. There are two differences between using a drawing function within the business graphics processor and using a full-fledged "paint" programme.

First, the user would not be overwhelmed with the complexity of a "paint" program at the beginning. He can produce the graphics that he requires before he has fully learned the drawing functions.

Second, if he did not have the artistic talent or inclination to use this facility, he would not have to learn it and would still have a useful machine.

In practice, a user would produce the difficult parts of the image by pasting together pre-drawn graphics and then use one or two simple lines or polygons to add the parts that are unique to that page. If these parts are difficult to draw, the knowledge worker would use this feature to indicate their rough form and then pass the page to a graphics professional to polish.

Editing Functions

The other set of functions that may be added to a business graphics processor are editing functions for pictures that are already drawn. The user may want to modify or update an image that already exists in the image bank, or the user may discover errors in his pages and want to correct them. In order to be consistent with the metaphor, editing should be described as cutting out the part of the image which is in error, creating a correct version and pasting into the correct place.

A PROTOTYPE BUSINESS GRAPHICS PROCESSOR

A prototype of such a business graphic processor has been created and tested at the Department of Communications.

This prototype consists of an interpreted BASIC programme implemented on an Apple II Plus microcomputer equipped with an Apple Communications Card. The user interacts with the program through a Norpak Telidon decoder equiped with a keyboard.

Upon entering the program, the user is given the opportunity to view three pages of instructions which describe the metaphor and the method of moving the cursor.

In the course of creating a page of graphics, the Telidon screen is divided into four sections. Space for one row of text at the top of the screen is reserved for messages and prompts from the programme to the user (prompt area). Space for a second row of text is reserved for echoing user input (text input area). This may consist of commands to the programme, text which will be moved onto the page or a list of data for a graph.

A small area (about 1% of the total screen area) in the lower left-hand corner is reserved for displaying images before they are moved onto the page (image input area). The remainder of the screen is available to display the page being created (page creation area). The page being created may extend into the other reserved areas, even though it will be overwritten during the interac-

tions with the programme and lost from view. The input areas are separated from the page creation area by a white borderline.

At each step, the programme prompts the user for input. This input consists of "yes" or "no" answers, the names of images to be added to the page or cursor movements.

The cursor is moved by using the "i", "j", "k" and "m" keys to move the cursor up, left, right and down. These keys were chosen because they form a cluster underneath the right hand on a standard keyboard. The distance that the cursor moves with each step may be increased or decreased with the "f" or "s" keys (fast or slow) at any time. When the cursor has been placed in the correct position on the screen, the carriage return is pressed.

In addition to these standard inputs, the user may be asked to input a list of numbers (data for a graph) or a string of text (an anotation). All input must be terminated with a carriage return.

The program functions exactly as described above. The user creates a page by repeating the following steps as often as necessary. First, he names an image. The image is then displayed in the image input area. Next, he moves the cursor, first to one corner of the intended image location, then to the far edge of the intended image location. Then the image moves from the image input area and either expands or contracts to exactly fill the area that has been indicated.

Once the page has been created, the user may store it, either for viewing at another time or for making further additions to it.

## The Advantages of Telidon

Telidon Picture Descriptor Instructions (PDIs) were used to encode the graphic images in this prototype because they allow storage and communication of graphic images and allow easy editing.

First, it was necessary, in the prototype, to have an encoding which allows efficient storage for the images. Disk space was limited to the capacity of a single density 5 1/2 in floppy disk for the Apple microcomputer. Even the few images which were used for this prototype could not have been stored with a less efficient encoding method.

Second, it was necessary, in the prototype, to have an encoding which allows efficient transmission of the images at 1200 baud transmission rates. The transmission speed will generally be limited by the capability of the twisted-pair telephone lines when implementing this system in an office without a high-speed local area network. While some improvement in data transmission rates over telephone lines is possible, for the foreseeable future, the rate of data transmission will be limited.

Third, it was necessary to have an encoding method which allowed the image to be easily divided into parts which could be moved, expanded and contracted. Telidon graphics encoding allows easy segmentation of the image. In order to permit simple mathematical manipulations on the coordinates the coordinates were stored in the prototype as whole integers and converted into PDIs when they were transmitted. This made the programme somewhat slower than necessary, but much easier to write and modify.

## The Empirical Test of the Prototype

Because this is a prototype designed to be modified as it was tested, the programming was simplified at the cost of efficient execution. Thus the program is very slow to react to commands and display images. In particular, cursor movements were very slow.

Despite this, the prototype was subjected to preliminary tests with several untrained volunteers. Each volunteer was given three pages and asked to reproduce them on the terminal. The pages were graded in difficulty and used all of the features of the prototype described above. In addition to this, each volunteer was asked to create a page of his own design. After receiving feedback from each volunteer, the program was modified so that things that he had found difficult were easier for the next volunteer.

These volunteers were able to produce the required pages after less than 15 min of training.

## UNSOLVED PROBLEMS

There are two areas in which further research on a more advanced prototype is required. The first is finding techniques for managing a very large image base. The second is finding techniques for editing pages of graphics which have already been created.

### Managing a Large Image Base

The success of the "cut and paste" metaphor depends entirely on the existence of a large base of ready-made images for the user to access. An image base may contain between 1,000 and 100,000 images, depending on the application being implemented.

With image bases of this size, a method must be invented for the user to find the image that he desires. Simply attaching a name to each image will not be sufficient because most images will not have standard names. Different users will expect the same image to be found under different names or different images to be found under the same name. For example, a map of Canada may be called "National Map", "Map of Canada" or "Canadian Map" by different users. Conversely, a road map, a topological map and a geopolitical map might all be found under the heading "Map of Canada".

The problem of indexing the image base is similar to the problem of indexing a general videotex database. Recent research on this problem at the Department of Communications has found that an efficient method for indexing information on electronic databases is a keyword-menu hybrid in which the user names the image that he wishes. He is then presented with a sequence of menus from which he can make more specific choices. With practice, users become more adept at choosing more specific keywords and avoiding extensive searches through menus (Chao, 1983). A similar system could be devised for indexing images for the business graphics processor.

### Editing Images

Another area requiring further research is methods of editing images. It is important to remain in the "cut and paste" metaphor during the editing. To do this, the editing function should consist of designating parts of the screen to be cut out and specifying locations for images or parts of images to be pasted-in.

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