Development of Graphics Displays for the Integrated Traffic Data System

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The development of interactive graphics displays for the Integrated Traffic Data System (ITDS) is described, and technical details on the hardware and software considerations, which, to a large extent, influenced the end product are provided. ITDS is a user-friendly, data base–driven interface to various traffic simulation and signal timing optimization programs. Although very useful and effective, ITDS relies extensively on the user's capability to load and maintain traffic data from queueing menus. By adding the graphics display interface, users are now able to efficiently load and maintain the data base, draw schematic displays of the data stored, efficiently determine their integrity, and significantly improve the quality of the data used as input to traffic models. This paper is oriented towards individuals who are, or will be, users of ITDS and traffic models, and individuals who are involved in the development of graphics software for transportation applications.

During the past 20 years, a number of computerized traffic simulation models and network signal timing optimization programs (referred to here as traffic models) have been developed by FHWA and others. These models enable traffic engineers to efficiently design and evaluate alternative traffic control and management strategies before committing the full financial resources required to implement them in the field. However, there are three major difficulties associated with their use. First, because of the limitations and capabilities of traffic models, users developing comprehensive control strategies are often required to use more than one model. Second, these models were originally designed for use in batch-processing mode, which requires users to prepare extensive input data sets in rigid formats that differ substantially from model to model. Third, similar data items are often referred to with different terminology by different models.

In order to resolve these and other deficiencies, FHWA sponsored the development of the Integrated Traffic Data System (ITDS). ITDS is a microcomputer-based software package that enables practitioners to create, store, and maintain network traffic data in a centralized data base. This data base is, through user interaction, queried to systematically create input data sets for various traffic models.

Conceptually, ITDS was developed as a simplified representation of real-world street networks using links as streets and nodes as intersections, similar to most traffic models. All other traffic data, such as volumes, signalization, and so forth are then related to links, nodes, or both. Because only alphanumeric data can be stored in the data base and the microscopic

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nature of some traffic models requires detailed representation of the data, users often lose the intuitive physical relations of traffic-related information with respect to the actual network geometry. Traffic engineers are constantly faced with the problem of referring back and forth to street maps, network diagrams, and traffic models manuals to verify the accuracy and compatibility of the representation.

Although ITDS is a menu-driven, user-friendly, and cost-effective tool, inadequate resolution of the aforementioned problem can seriously jeopardize its usefulness. FHWA has recognized this problem and sponsored the development of interactive graphics displays for ITDS. This study has two main objectives: to provide the necessary graphics displays to resolve the problem of losing the network's physical geometry perspective; and to alleviate the cumbersome task of loading alphanumeric, network-description information by enabling users to draw the network on a CRT.

CONSIDERATIONS

System Design

The two main concerns during the concept-development stages of the study are to provide the most useful tool and to maximize the number of potential users. These concerns bring into play four important factors: (a) computer expertise of potential users; (b) system configurations available to them; (c) the current and future direction of software and hardware technology; and most important, (d) what should be graphically displayed and how.

To address Factors 1 through 3, the key is to develop a system that is user friendly (does not abort from users' mistakes), easy to use (provides on-line help), and extremely flexible from a hardware configuration standpoint. Of these three key features, hardware flexibility is the most challenging one because of the proliferation of microcomputers, graphics cards and devices, monitors, and the software to drive them. The fourth factor (in this case, the information stored in the data base) is somewhat simpler to address because the basis for the displays was a given item. The following sections address these issues in detail.

Software

The original ITDS was developed in PASCAL using a commercial data-base management package and a screen unit to enable user access through a menu-driven interface. At that time, those decisions were technically sound as they provided a user-

friendly, portable (among different machine brands) system. Because there are currently almost no graphics software packages that work in conjunction with PASCAL, it was impossible to use the Graphics Kernel System (GKS) in this study.

By searching through current available graphics software for PASCAL, it was decided that the IBM Graphics Development Toolkit should be used. This decision was based on several considerations. First, most of the potential users have access to IBM or IBM-compatible equipment. Second, IBM's endorsement of this software, its support, and licensing costs are very appealing. Third, a portable system outside the GKS standard could still be developed.

Because portability is of major concern, the use of the Toolkit graphics functions in ITDS is very limited. Functions such as scaling, transformation, window clipping, circle drawing, zooming, and three dimensional perspective viewing were developed in house. This approach was taken because the Toolkit does not conform to GKS standards and, if better graphics software becomes available in the future, conversion will be easier and relatively inexpensive.

Hardware

The graphics module takes full advantage of the interactive graphics capabilities provided by a variety of different peripheral devices such as mouse, plotter, graphics printer, and camera. It also takes the average microcomputer system into consideration in that it might not be fully equipped with these sophisticated graphics peripheral devices. Therefore, proper capability of peripheral devices selection is provided to serve a wide range of users.

The Graphics Development Toolkit was developed by Graphics Software System and uses the Virtual Device Interface (VDI) configuration. Under the VDI environment, the application program sends the graphics drawing commands to the VDI. The VDI then sends the proper actual device commands to the devices through the graphics device driver. Consequently, the graphics module developed under VDI environment can accommodate many different graphics devices. Users will only have to load the proper device drivers before the execution of the graphics module. Under the current Toolkit configuration, proper device drivers are loaded into the memory at the system start up. Although this reduces the total memory space that can be allocated for the graphics module, this has not yet created a serious adverse impact of the system.

ITDS Display Items

Maximizing the display of all data items stored in the ITDS data base is of primary concern. However, information that has no practical value for graphical representation will not be incorporated into the displays. For example, the execution information for a model, the user's name, or the title of a run are not suitable for graphics display and, therefore, will not be included in the graphics module. Among the desirable ITDS display items, the network geometry information, for example, can be displayed directly either in link-node or schematic lane-detailed diagrams.

Besides the geometry information, the rest of the ITDS display items can be divided into two major categories: link-based and node-based information. The link-based information (like speed data) then can be superimposed on the network diagram either in alphanumeric format or using width variant bars (the width of a bar is proportional to the quantity of the display item) between two nodes. The node-based information (like signal timing or turn volume) can then be displayed in reference to the intersection.

Display of Network

There are three levels of detail display for the ITDS graphics module. At Level One, the overall network is displayed in a link-node network diagram. Because of its simplicity, the link-node diagram is one of the most popular ways of representing the traffic network. The telescoping feature (zoom) is provided at this level. However, some of the microscopic computer models require a more detailed description of the network at the traffic lane level. Therefore, at Level Two, the ITDS graphics module displays the urban street in a schematic lane-detailed format. At this level, lane-based information, such as special turn pockets, signal detectors, bus stations, exclusive lane uses, and parking, is revealed. The display is schematic and, therefore, the lane-detailed network diagram will not follow the alignment of the actual streets. At Level Three, the program enables the user to display a lane-detailed intersection diagram. The lane-detailed intersection diagram is at the same level of detail as the schematic lane-detailed network display, but only one intersection will be displayed at the center of a CRT on a larger scale. The lane-detailed intersection display feature is provided because one of the most common traffic engineering problems is associated with intersections.

THE PROGRAM

The overall ITDS graphics display framework is shown in Figure 1. The graphics module, DBGraph, can be invoked either in ITDS executive program or by simply typing DBGRAPH. There are two major functions provided by the DBGraph, interactive graphics data input and static graphics display of the data base.

Interactive Graphics Data Input

In order to provide a graphics display of network-related traffic information, some basic network geometry is required. For ITDS, the only additional geometry information required are the coordinates for all node (intersection) locations. This information can be obtained by digitizing the street network from an existing map or entering the intersection coordinates information manually into the data base. However, DBGraph has the capability to allow the user to use a graphics input device (either mouse or arrow keys) to interactively identify the node location on the CRT screen.

As indicated in the ITDS Users' Manual, the initial information required by ITDS for a network data base is the node
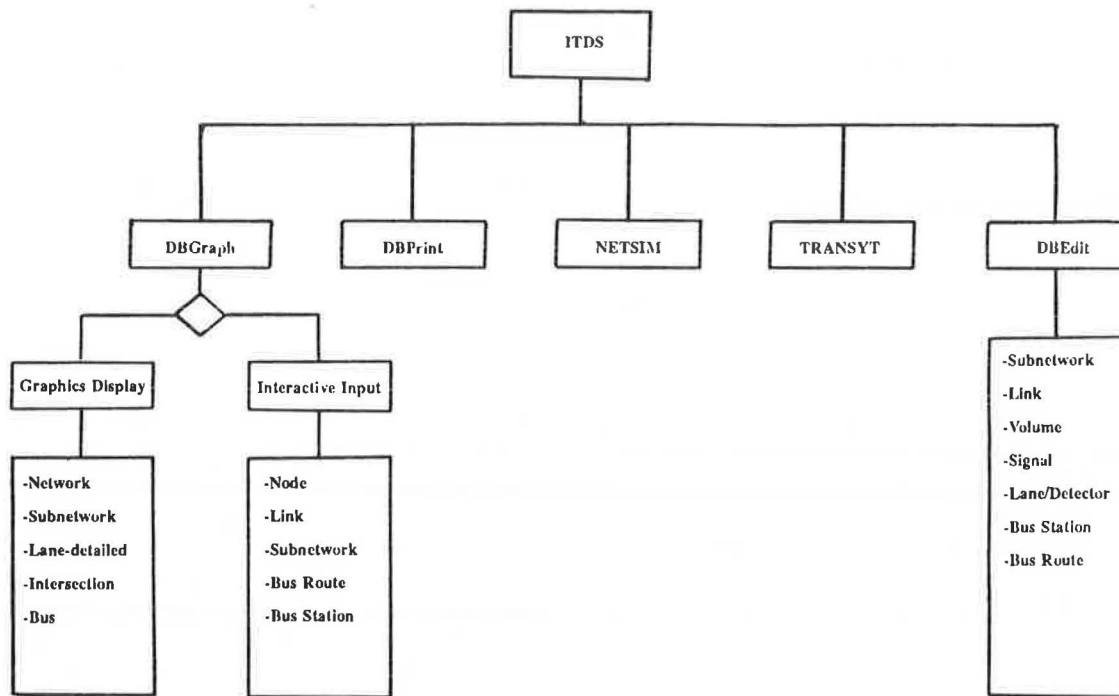
FIGURE 1 Conceptual framework of ITDS graphics displays.

information. The user has to establish the node number first in order to proceed to whatever network information the user would like to enter. DBGraph conforms to this requirement too. The user has to identify the node location first in order to proceed to specify the link information. In addition, DBGraph is designed to accommodate data bases that are generated by using DBEdit. Therefore, DBGraph constantly keeps track of nodes that do not have coordinate information.

The program will first display nodes, links, and bus stations that have the geometric information already entered. If the user starts with a new data base or a data base generated by DBEdit without node location information, the initial screen would be blank and the user could start from entering a node number and identifying the node location on the CRT using a cursor control device. The program will store the node number and the corresponding location in the data base. The user can then use the tracking capability provided by DBGraph to determine and provide the location of nodes without location information. In addition to node location input, the program also allows the user to modify the location of an existing node and delete an existing node from the data base (simple node with no other information attached to the node) by using the cursor on the CRT.

In addition to the interactive graphics node location input, similar capabilities are provided for link identification (identifying the up- and downstream nodes), subnetwork identification (identifying the link within the network), bus station identification (identifying the link where the bus station resides), and bus route identification (identifying a series of connected links). This interactive graphics input capability enables the user to enter the network geometric information in a more efficient and intuitive way.

Static Graphics Display

The other part of the DBGraph enables the user to graphically display the information in the data base. There are three levels of display with varying degrees of detail: link-node, schematic lane-detailed, and intersectional diagrams. Most network non-geometric information can be superimposed onto any of these three different display formats. For a link-node diagram, the capabilities of generating both two-dimensional and three-dimensional perspective views are also provided. For example, the grade code or right-turn-on-red code for each link can be displayed in text next to each link. However, some quantitative network information, such as travel speed, traffic volume, and so forth, can also be displayed by different width bars. The size of the bar is proportional to the magnitude of the data item for each link. Such a display provides the user with an overall understanding of the network status. The user is also furnished with the capability to produce hard copies of selected CRT screen displays. The hard copy is generated either by a printer, plotter, or camera (slides). The static graphics display is divided into five major categories: network, subnetwork, schematic lane-detailed network, intersection, and bus route or station.

Network Display (Link-Node Diagram)

The overall network is displayed in a link-node diagram. The link-node diagram is displayed in either two-dimensional or three-dimensional perspective view. The capability of generating a three-dimensional perspective view is only provided with a network display. For intersection-oriented information, the

intersection control code information is displayed under this category. In addition, many link attributes, such as actual length of the link, speed, volume, grade code, queue discharge rate, and so forth, can be selected for display. For quantitative data items, varying width bars are used to represent the magnitude of the selected data items.

Subnetwork Display (Link-Node Diagram)

ITDS is designed to accommodate a large network. However, for certain traffic engineering analyses, only a small portion of the network is needed. For example, if a data base describing an entire metropolitan area is created with DBEdit, ITDS enables the user to create a subset of it—for example, CBD area, major arterials, and so on. The subnetwork feature is furnished to enable the user to isolate a portion of the network and to create the traffic model's input data sets for the subnetwork. This option shall provide the user with a link-node network diagram with the selected subnetwork links displayed in different line style and color.

Lane-Detailed Network Display

Based on a two-point coordinate system, a schematic lane-detailed urban street network drawing algorithm is used to generate the network picture. In addition to the lane configuration, a bus station and on-street parking are also depicted. The bus station and the on-street parking space are drawn based on the geometric information stored in the data base. The size of the depicted bus station is proportioned to the capacity of the bus bay (in terms of number of buses that can be stopped simultaneously at the station). The location of the bus station and on-street parking are determined by the distance measure from the stop-line of the downstream intersection.

Intersection Display

Most of the intersection displays use the lane-detailed network display, but are limited to one intersection. The selected inter-

section is scaled so that the display can use the whole CRT screen. Link attributes, such as the actual length, travel speed, grade code, and so on, are superimposed on the lane-detailed intersection diagram in text beside each link. However, the traffic volume, traffic composition (passenger car, truck, and bus), pedestrian, and traffic signal timing information is displayed differently. For the traffic volume information, pie chart and varying width direction arrows are used. For intersection signal timing information, a common phasing diagram for each phase is used.

Bus Routes and Stations

For the bus information display, the program uses the link-node diagram as a base. Links within a specific bus route will be displayed in different line style and color. A different color is used to highlight the bus route within the link-node network diagram. However, for the monochrome monitor, the different line style will serve the same purpose. Only the bus stations associated with the selected bus route will be displayed. The bus station will be displayed according to the geometric information stored in the data base.

SUMMARY

An interactive computer graphics enhancement to ITDS is described in this paper. The graphics enhancement alleviates some of the difficulties associated with the use of ITDS in two major ways. First, incorrect information coded by users can be detected quickly through erroneous graphics display. This provides more efficient use of ITDS. Second, the interactive graphics capability provided can aid in reducing the user's problems of assimilating massive traffic information stored in ITDS. Because pictures convey more information than tables and in a more easily assimilated manner, the graphics enhancement aids immensely in comprehending massive network-related information.