16. Handheld PC Applications - An Integrated Computer-Based Cruising System for Appalachian Hardwoods

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Introduction

During the winter of 2002, we began a cooperative project with the West Virginia Division of Forestry that included the re-inventory of the forest resources on state forests in West Virginia. This was a rather large undertaking, with approximately 70,000 acres needing to be inventoried. Because the fieldwork on this type of project is a large undertaking that cannot be avoided, we wanted to make certain that the data handling aspects of the project would be especially efficient. We were looking for a robust system that would allow for easy field data collection, but also incorporate a powerful backend system for data storage, retrieval and analysis.

Computer programs have been developed for many applications in forestry from the development of species-specific optimal thinning schedules to stand generation and harvesting simulations (Farrar 1981, Brooks and Vodak 1986, Reisinger et al. 1988, Rose and Chen 1995). Computer simulation has proven to be sufficiently comprehensive to handle the various types of problems envisioned in forest operations and has been used for linking the variable components into production and cost analysis (Goulet et al. 1979, Stuart 1981). Simulation also provides an accepted method of evaluating a wide range of system configurations, operating environments, and timber utilizations. The use of computer programs in the forest industry can reduce costs, save time, and aid extensively in the practice of processing timber inventory data (Rennie 1991). Timber cruising and forest inventory are two very important aspects of forestry, and using a computer program to determine timber cruise and forest inventory design and plot layout can minimize time in the field and result in considerable savings in time and money (Wiant and Gambill 1985). A computer-based timber cruising and forest inventory system could help landowners and resource managers protect forest resources and might assist in the management of timberlands (Blinn and Vandenberg-Daves 1993).

Several programs have been developed in the area of timber cruising from the simple calculator-assisted procedures for marking stands and rapid sawtimber/pulpwood estimates to relatively complicated handheld- or PC-based programs for yield curve design and cruising data collection and analysis (Moser and Raney 1990, Wiant 1990, MacLean et al. 1998). Wiant and Gambill (1985) developed a program to minimize timber cruise field time by determining the optimal basal area factor or plot size. This package was written with BASIC and run under DOS environment. Rennie (1991) showed new uses of Statistical Analysis System (SAS) for processing timber inventory data. The SAS routines would allow the forester to write a program that would enable

the efficient design of a forest inventory to meet specified objectives. The Private Lands Information System (PLIS) was developed to provide field foresters with access to a map-based inventory of nonindustrial private forest landowners' timber lands in Minnesota (Blinn and Vandenberg-Daves 1993). The PLIS included three basic components - a database, software, and hardware. The database held not only data for individual timber stands but also spatial data for stand or property boundaries. A timber cruise and forest inventory program named CRUISE was recently developed by Wiant to process cruise data into meaningful cruise statistics in the field (www.geocities.com/harryvwiant/). The CRUISE was programmed with HotPaw™ Basic and is used on the Palm OS handheld. The CRUISE99 was accordingly developed for PC environment.

Reports need to be generated once cruising/inventory data were processed. Using a database management system such as dBASE could fulfill the needs of generating forest inventory reports (Belli et al. 1987). Belli et al. (1987) stored tabular data such as site descriptions, plot-level data and tree-level data in a database. Reports generated by the database management system included stand/stock tables, land use summaries and recalculation of individual tree volume estimates from specified input file (Belli et al. 1987).

Information on timber cruising programs is also available on the Internet. The USDA Forest Service provides four Window-based generic programs – Check Cruise, Cruise Design, Timber Theft/Local Volume Table, and Traverse. (http://www.fs.fed.us/fmsc/measure/cruising/othersoftware.php). The Check Cruise program is used to compare measurements and volumes between an original cruise and a check cruise while the Cruise Design program was developed to help cruisers design timber cruises and meet predetermined sampling errors. The Timber Theft/Local Volume program is used to not only determine the volume of a tree but also estimate the removed volume in a theft case. The Traverse program uses distances and compass bearing to construct maps and determine the acreage within the traversed area. Canal Forest Resources has developed Cypress^{TM}, an advanced timberland inventory and investment management system (http://www.canalforest.com/software.htm). It offers silvicultural, land management and investment information to timberland investors through secure, web-based technology. Another forest inventory software program named TwoDog has been developed and provided by Foresters Incorporated (http://foresters-inc.com/). It is a comprehensive forest inventory application for field and desktop computers. Sampling options are also provided in the package.

Although there were many systems that could have been used for this project, we did not feel that any of the options fit our situation. Due to the specific requirements needed and the sheer size of the inventory, the development of an integrated timber cruising system for the state forests in West Virginia was necessary. This paper discusses the development of the cruising package with reference to object-oriented system design and entity-relationship (ER) data modeling techniques.

Objectives

The objectives of this project were to:

(1) develop a handheld system with MS Windows CE based graphical user interface (GUI) for timber cruising in the field,

(2) adapt a relational data model to hold cruising data on both handheld and desktop PC,

(3) implement data transfer component on desktop PC to synchronize cruising data using ActiveX Data Object (ADO), and

(4) provide a data analysis component to summarize cruising data and generate cruising reports and integrate the system using Component Object Model (COM).

System Structure

This timber cruising system consists of three major components: a handheld data collection system, data transfer, and data analysis components (Figure 1). The handheld system is used to collect cruising data including forest, plot, and tree measurements. Understory vegetation and wildlife data collection (referred to as transect data) were also implemented with the handheld system. Data transfer is an interface for communicating between handheld PC (HPC) and desktop PC, which is used to synchronize data on the desktop PC. Data analysis is a component that is used to analyze and summarize the cruise data and generate desired reports. These components can be run as an integrated system, or on a stand-alone basis.

The handheld system was written with Microsoft VB CE, which is run under Microsoft Windows CE environment. It contains two main modules: collect and edit (Figure 2). The collect module is designed to allow a user to collect plot, tree, and transect data associated with each cruise point while the edit module is designed to permit field editing of tree data. Retrieval and storage of cruising data is accomplished with a MS Access database.

Both transfer and data analysis components were programmed with MS VB V6.0, which reside on desktop PC under MS Windows environment (Figure 2). The data transfer provides two major functionalities, it allows for the transfer of cruising data from HPC to desktop PC and accommodates updates of data tables on the desktop PC as well as readying the database for the next cruise transfer. The edition of species, cruise data backups, and exportation of data (into ASCII text and MS Excel) are also provided in the data transfer component. ADO CE application programming interface (API) was employed to conduct data transfer via a dynamic link library (DLL) – adofiltr.dll (Roof 1998). The adofiltr.dll, a MS pocket Access file converter and synchronizer, is a part of

the ADO 2.0 Solution Development Kit (SDK) for Windows CE. It allows programmatic transfer of database tables between the host desktop computer and the remote device. This DLL contains two functions, DesktopToDevice(parameters) and DeviceToDesktop(parameters), which are used to transfer data or copy tables. It runs on the desktop PC, not the handheld. The desktop initiates and controls the transfer process. The key requirement for this transfer process is the presence of the same table schemas on both desktop and handheld. The ADO CE data transfer feature has a solid set of tools for transferring data. While the manual method for copying tables does not offer the control needed by most applications, the programmatic method does. This feature allows the transfer of complete tables between devices rather than requiring the synchronization of individual records.

The data analysis was organized in a modular way, in which modules were designed as independently as possible (Figure 2). A module, or self-contained unit of code, could be a single function or act as several functions. Data Access Object (DAO) was used to load the cruising data from the database into this component. This allows tree form class and cruise information to be edited for summaries and reports. In the cruise summary module of this component, stand/stock table, point/plot, and cruising statistics are provided by business functions built in the component. All end user reports were developed using an ActiveX component of MS Access object, which is a reusable piece of programming code and data. It allows the user to call MS Access reports directly from VB application without the use of complicated coding.

A relational database model was used for holding cruising data on both the handheld system and data transfer component, which was implemented based on the entity-relationship (ER) model (Figure 3). The relational database model presents the data as a collection of tables. Instead of modeling the relationships in the data according to the way that it is physically stored, the structure is defined by establishing relationships between data entities. An entity represents a data table in the ER model and has attributes (fields) that are the descriptive properties of the entity. Primary key refers to one or more fields that make a record unique in a data table. The field or fields used to link to a primary key in another data table are known as foreign keys and a foreign key is any field(s) used in a relationship.

There are four data entities – *Plot, Tree, Transect, and Species* in the model. Each entity has its own attributes. For example, the *Plot* entity has forest, crew, plotNo, plotType, and other attributes. Entities are related using relationships such as "contains," and "associates" in the model. The relationship between plot and tree or transect is one-to-many and simply means that the plot "contains" many trees or transects. One-to-one relationship is applied between tree and species entities, which implies each tree is "associated" with a specific species. Attributes belonging to a key are underlined for an entity set. For example, forest, crew, and plotNo together is a primary key of entity plot while forest, crew, plotNo, treeNo is a primary key of entity tree. Foreign key of forest, crew, and plotNo for entity tree and transect represented the one-to-many relationships.

System Implementation

Handheld System

The main method of user interface with the handheld system is accomplished through the use of a "stylus". The stylus is included with the handheld systems and is used in much the same way the user would use a mouse to navigate and select objects on a desktop computer screen. The user can also use a fingertip to tap the touch screen, however, the stylus provides the greatest accuracy.

Two modules were implemented in the handheld system to collect cruising data (Figure 4). Forest and plot information is entered first and the user then selects the "Add Plot" button. The tree data frame is then enabled accordingly (Figure 4a). For the West Virginia state forest inventory, there were three types of plots – intensive, DBH only, and DBH and merchantable height. Text boxes on the tree data frame are enabled and disabled depending on the type of plot being selected. A function is also implemented to calculate the cull percent of a tree. Once trees are entered, a VB list box control is used to display the tree attributes found on a plot. Three elemental times are collected at each plot, IP_Time, DP_Time and HP_Time. The IP_Time is the time interval from the time the "Add Plot" button is pressed to the time the "Start Transect" (understory vegetation data collection) button is pressed. The DP_Time is the time interval from the time the "Add Plot" button is pressed to the time the "In-Trees" box is checked and the HP_Time is the time element from the time the "Add Plot" is pressed to the time the "In-Logs" box is checked. These time values can be used to examine the cruising efficiency of the field users. A list of convenient VB list controls were implemented for adding or removing single or multiple items for transect data collection (Figure 4b).

Field transcription mistakes are common; therefore the handheld system provided functionality that allowed the user to edit tree data in the field (Figure 4c). Trees sampled on a plot can be retrieved based on forest, crew number and/or plot number. Once trees are retrieved for a plot, the user can navigate the selected record set and modify the data for that tree and then move to the next tree or on to another plot.

Data Transfer

The data transfer component was implemented on the desktop PC, which provides two basic functions: the transfer of cruise data from the HPC to PC, and updating and clearing data tables on the HPC (Figure 5a). For the sake of data security, this component was designed to run these events separately. The system is designed to first update the species table and then empties temporary tables on HPC before the cruise data can be entered in the field. Once users collect the cruising data, the data tables on the handheld PCs are copied and synchronized to a temporary database on the PC. The tables in the temporary database are then appended to the related tables in the main database. Finally, the system again needs to empty the data tables on the handheld in preparation for the next timber cruise.

The other major function provided is for editing cruising data (Figure 5b). A VB tab strip control was used to implement three tabs for plot, tree, and transect. A VB DB

gird on each tab associated with a record set defined in the database. The plot tab is first displayed. Structured Query Language (SQL) was used for retrieving trees and transects associated with the plot the user selects. Once the user selects a record from plot tab, they can select either the tree tab or the transect tab to continue the editing process.

Data Analysis

The DAO was implemented to connect the database and a VB flex grid control was used to display the data. Once the cruising data were loaded into computer memory, a cruise design window is then popped out (Figure 6). The user can browse the data loaded and invoke another dialog box to view species and grade codes used in the system. In this design window, the user can design and save cruising information for a report header. The user simply enters data into the required text boxes and then selects the "Save Cruise Info" button. To modify form class for a specific species, the user needs to simply click "Girard Form Class" button. A form is displayed using a DB grid control associated with a form class table in the database. This allows the user to modify the form class data.

Cruise type selections can also be made during the cruise design process. The user can choose fixed area, variable radius plot (VRP), or 100% tally by checking VB radio buttons. If a plot type of fixed area is chosen, plot size must be entered while basal area factor should be given if VRP is checked. Four types of summaries are provided depending on the user's requirements. Volume summaries can be done on both per acre basis and per tract basis. Stand/stock tables are further summarized by DBH class, species and DBH, and by species, grade, and DBH. Cruise statistics are provided for volume per acre in cubic feet (CFV), International board feet (1/4) (IBFV), Doyle (DBFV), trees per acre (TPA), and basal area per acre (BA/A). Statistics include the mean, standard deviation, standard error, variance, coefficient of variance (CV), confidence interval at 95% level, percent of error, and sample size.

Once the cruising data were summarized, the results are stored in the database for report generation. A total of seven reports can be generated in the data analysis component of this system.

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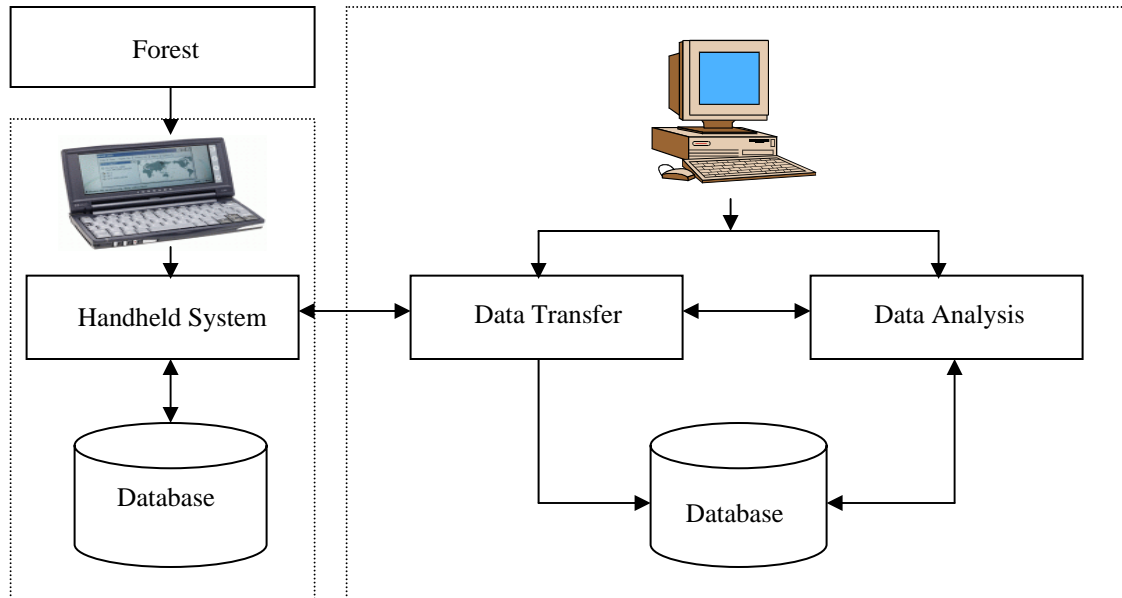
Figure 1. Structure of the integrated timber cruising system.
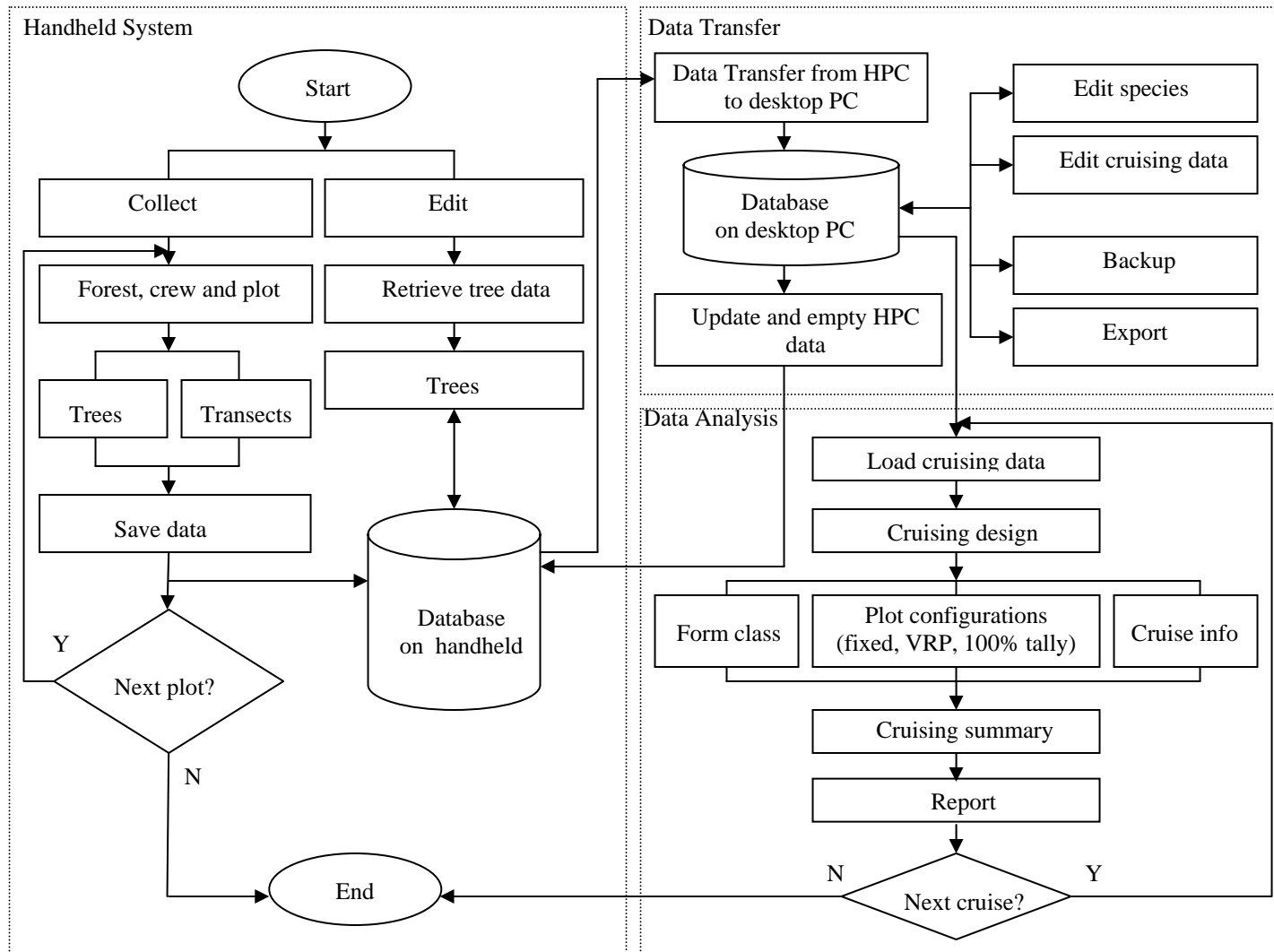
Figure 2. Flowchart of the integrated timber cruising system.
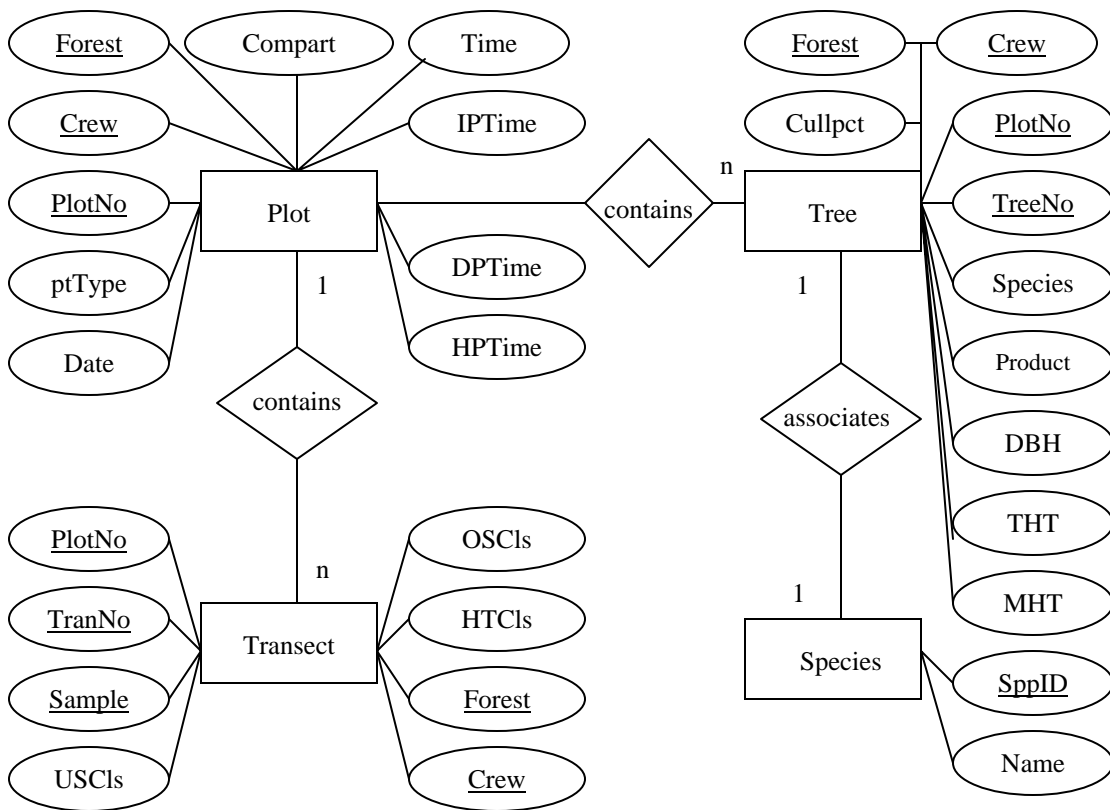
Figure 3. ER data model of the integrated timber cruising system.

(a)

(b)

(c)

Figure 4. Main forms in the handheld system.
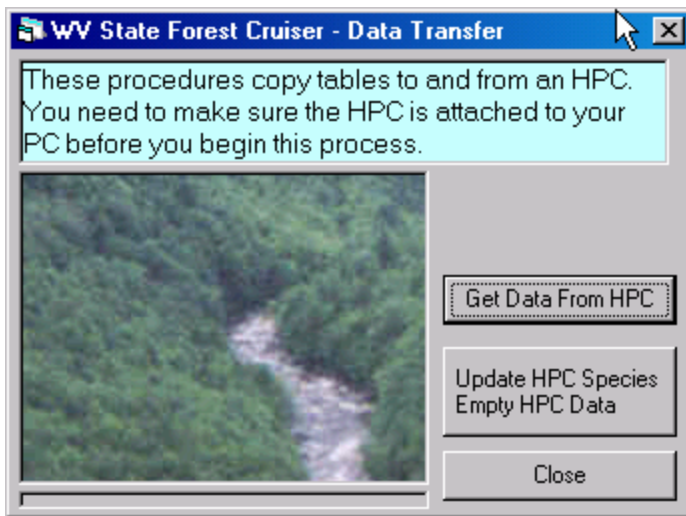
(a)
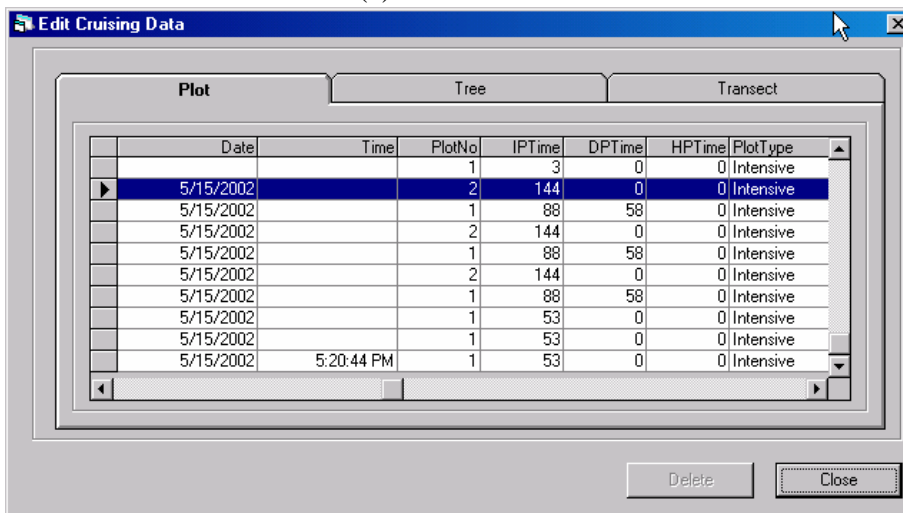
(b)

Figure 5. Major functions of data transfer component.

Figure 6. A major form in the data analysis component.