

# The FDDI Ring Manager for the HP Network Advisor Protocol Analyzer

The FDDI Ring Manager application takes the knowledge burden from the user and puts it on the network management tool. It pulls ring status information from station management frames and presents it in a logically ordered display. It gathers ring topology information from neighbor information frames and status information frames and presents that information in a graphical map and a textual report.

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FDDI (Fiber Distributed Data Interface) networks offer high-speed data transfer and fault-tolerant dual-ring topology, but can add a layer of complexity to troubleshooting network problems. The dual ring can become twisted or wrapped, a serious problem that may not be immediately apparent. Interoperability issues can cause ring abnormalities between products from different vendors, but tracing these glitches to their source by looking at decodes can be intensely time-consuming. And, although the FDDI station management protocol defines a management information base (MIB) full of interesting information, it may not be convenient to access and make sense of that information. The FDDI Ring Manager application for the HP 4980 Series Network Advisor protocol analyzers<sup>1</sup> addresses these and other FDDI network management issues in one integrated network management application.

Fig. 1 shows the FDDI Ring Manager user interface. The current state of the dual ring and general network performance are reported along with other interesting network information in the top area of the window. The middle area of the window is a graphical map of the FDDI network. The nodes on the map can be opened to examine station management MIB information. The FDDI Commentator, which is automatically started when the FDDI Ring Manager application is started, reports trends, changes, and events of interest.

The design of the FDDI Ring Manager is based on customer input. Early in the investigation stages of the FDDI Ring Manager, we decided to use five customer sponsors as development partners. After the first several iterations with the five sponsors, customer requirements could be summarized as:

- Make it easy to see what's happening on the network

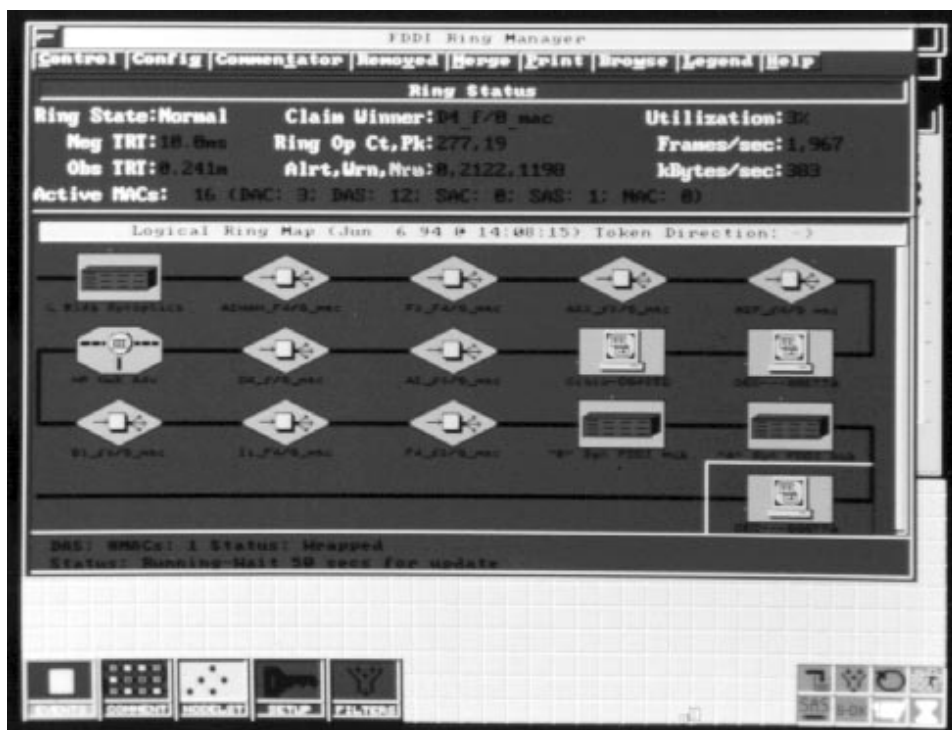
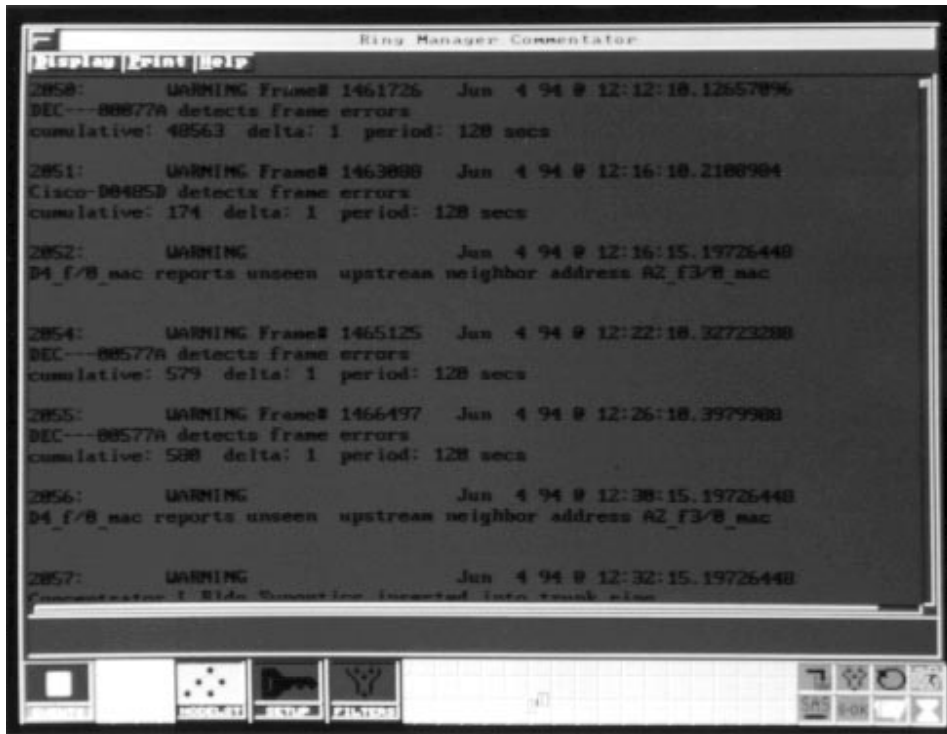


Fig. 1. FDDI Ring Manager user interface.



**Fig. 2.** FDDI Commentator window.

- Make it easy to see where network problems are
- Automate tedious tasks
- Provide a tool that does not require the user to be an expert on the Network Advisor and an expert on FDDI protocols.

As a result of ongoing customer consultations, we answered these requirements with the following FDDI Ring Manager features:

- A ring status section to give a high-level overview of the ring state
- Physical and logical ring maps to show graphical network topology
- Dynamic error indication using colors to isolate problem nodes
- Automated polling of each station management MIB for proactive indications of marginal conditions
- Station information windows to give an orderly presentation of station management MIB information
- The FDDI Commentator to provide a history of events, trends, and changes on the FDDI ring
- Ease of building a node list provided by a link from the FDDI topology maps to the node list.

The key contribution of the FDDI Ring Manager is to take the knowledge burden from the user and put it where it belongs, on the network management tool. Instead of requiring the user to sift through station management decodes looking for fields that may relate to the status of the ring, the FDDI Ring Manager pulls that information from station management frames and presents it in a logically ordered display. Rather than expect the network manager or operator to look at neighbor information frames and figure out which stations are upstream and downstream of a particular station, the FDDI Ring Manager presents that information in a graphical map and in a textual report. Why require the user to keep track of changes in link error rates for particular

stations or trends of claiming† by one or more stations? This information can be collected and synthesized into meaningful events that are logged in the FDDI Commentator. Fig. 2 shows the FDDI Commentator window.

### FDDI Ring Manager Overview

The FDDI Ring Manager window is divided into three panes: the ring status section, the ring maps or topology section, and the status bar.

**Ring Status.** The top section of the FDDI Ring Manager window is the ring status section. It provides high-level network health information. Some of the indicators in this section are:

- Ring State: Shows whether the ring is in a normal, twisted, or wrapped state.
- Observed Token Rotation Time (TRT): This is the actual time interval between successive tokens.
- Active MACs: This is a list of currently active media access control units (MACs) for each FDDI station type.
- Network Traffic: Shows the current level of network traffic displayed as a percentage of total bandwidth, and in frames per second and kilobytes per second.
- Ring Op Statistics: This is the number and peak rate of ring initializations in any five-second interval since the start of the FDDI Ring Manager measurement.
- Commentator Events: This field shows how many events of each level of severity have occurred and how many were logged to the Commentator.

**Ring Maps.** The next section of the FDDI Ring Manager window is the ring maps. The direct-manipulation graphical network map shows the token path through the ring in the logical ring map or the hierarchy of the physical connections

† Claiming is a bidding process to determine the token holding time for ring stations. The claim process is initiated when a station enters the ring (inserts) or leaves the ring (deinserts), but it can also be the result of media or configuration problems.

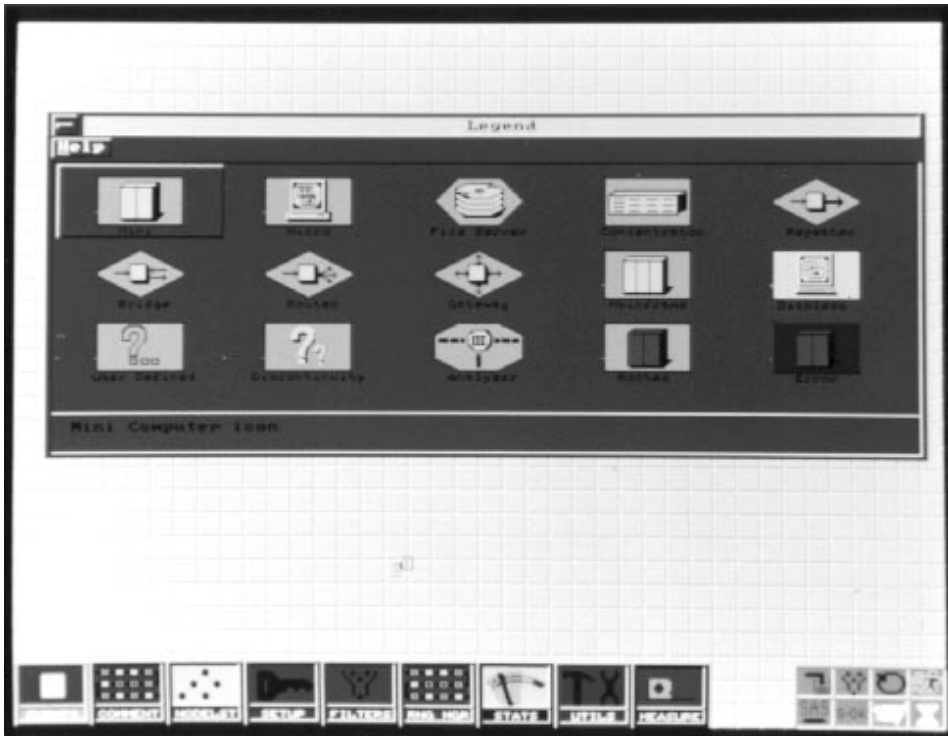


Fig. 3. Legend window.

in the physical ring map. Nodes on the graphical maps turn red or yellow to give dynamic error indication of problems. You can open or “drill down” into the problem nodes or any selected node on the map to see the current configuration and station management MIB values.

Different node icons represent the different device types on the ring and colors are used to communicate the status of each device (see Fig. 3):

- Blue: Trunk (dual-ring backbone) station
- Cyan: Node connected to the ring through a concentrator
- Yellow Concentrator: Indicates a problem in the subtree of the concentrator
- Yellow Station: Indicates that this node has detected frame errors on the ring
- Red: Indicates an alert-level problem with this station or concentrator.

**Status Bar.** The status bar is a two-line area at the bottom of the FDDI Ring Manager window. It shows the high-level status for the highlighted node. For example, the status may read “Node is wrapped on Port B.”

### Station Information

Information for every station on the network can be examined by selecting that station’s icon on the ring map. Even stations that have left the ring since the FDDI Ring Manager was started can be examined in the removed MACs window (Fig. 4). The state of a removed station’s MIB can provide valuable clues when troubleshooting a segmented ring.

When the physical ring map is displayed, concentrators can be opened to show the M-port† connections beneath them. Any concentrator connected to the M-port of another concentrator can be opened to its own M-port map, thus showing

the hierarchy of physical connections (Fig. 5). Station information windows for concentrators are accessed with a menu selection (Fig. 6).

The station information display for both stations and concentrators is composed of the following sections:

- **Station Description.** This section reports the station type, the number of MACs in the station, the number of M-ports, and the upstream and downstream neighbor addresses of the station.
- **Port Status.** This section shows the state of the connection between each local port and its remote port, the link error monitor reject count for each port, the link error estimate for each port, and the time the port connected to or disconnected from the ring.
- **Frame Statistics.** This section shows frames transmitted, received, not copied, or lost for each MAC in this station.
- **Timer Values.** This section shows the station’s requested token rotation time, the negotiated token rotation time, the valid transmission timer setting, the maximum token rotation time, and any allocated synchronous bandwidth.
- **Miscellaneous.** This section shows any user or manufacturer data for this station.

### The FDDI Commentator

The FDDI Commentator runs automatically when the FDDI Ring Manager is started. It provides a real-time commentary on all significant events occurring on the ring. These include events that lead to changes in ring topology, events that indicate a problem on the ring (or conditions that might lead to a problem), and other normal events that are likely to be of interest to a network administrator. The FDDI Commentator performs the task of combing through decoded frames for information of interest, a task usually left to the user.

The events in the FDDI Commentator window are collected over multiple runs of the FDDI Ring Manager. The contents

† Network nodes can have four types of ports: A, B, S, and M. M-ports form one end of tree mode connections, that is, they are used to expand the network tree. See article, page 97.

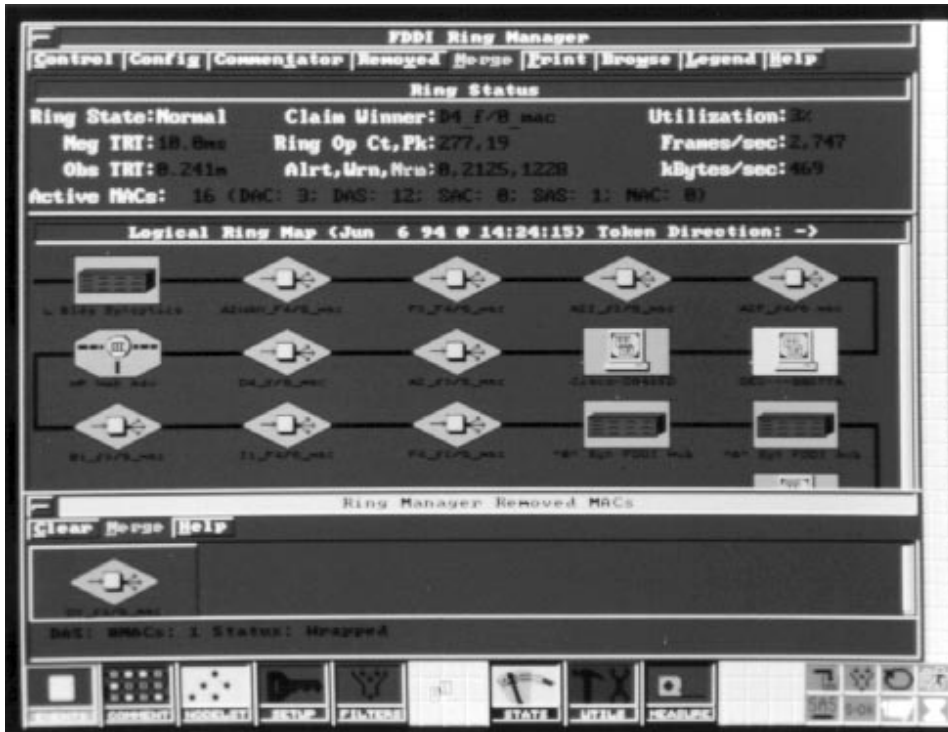


Fig. 4. Removed MACs window.

of the FDDI Commentator can be printed to a file or to the printer.

### High-Level Architecture

A quick overview of the architecture of the FDDI version of the HP Network Advisor protocol analyzer will provide a context for a discussion of the architecture of the FDDI Ring Manager. The software architecture of the FDDI Network Advisor consists of three major subsystems. Each subsystem operates on a separate hardware unit with its own processor

as shown in Fig. 7. Each subsystem constitutes a multiprocess environment that supports the execution of multiple software modules. The environments are (1) general-purpose, (2) analysis and real-time, and (3) station management.

The general-purpose environment is responsible for a Smalltalk-based windows graphical user interface and related user interface activities. It maintains and manages persistent information such as node lists and setup configuration. The general-purpose environment communicates with the analysis



Fig. 5. M-port window.

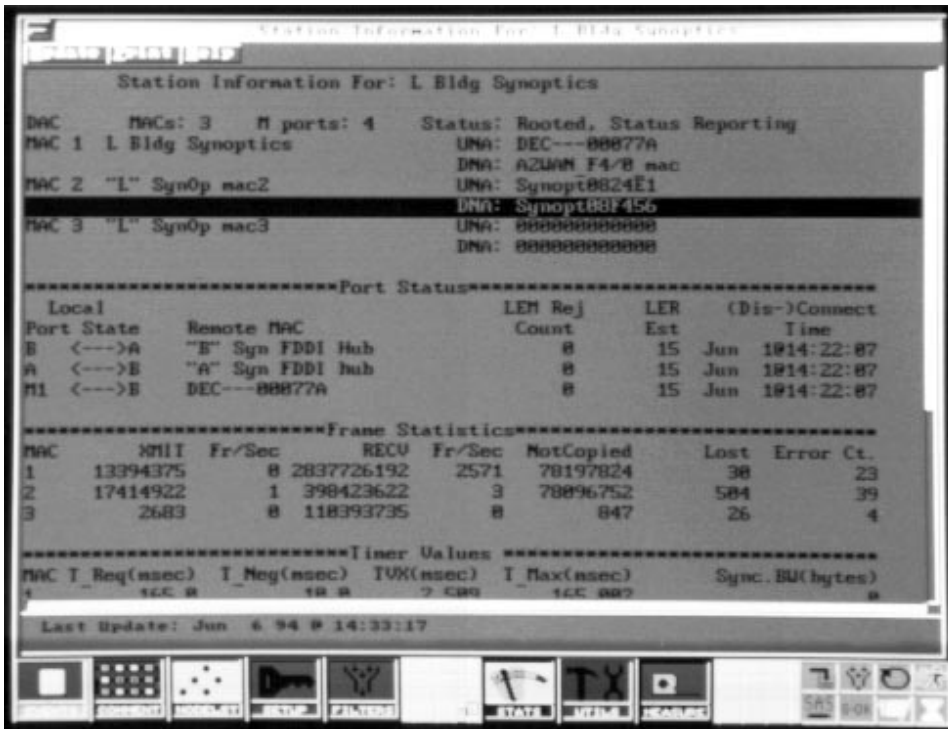


Fig. 6. Station information window.

and real-time and station management environments using commands sent via the interenvironment process communication (IEPC) channel.

The analysis and real-time environment is an event-based nonpreemptive system optimized for network protocol analysis and troubleshooting. It responds to commands from the general-purpose environment and sends back the results of its analysis in specially packaged units called analysis data units (ADUs).

The station management environment is unique to the FDDI version of the Network Advisor protocol analyzer. Its primary function is to run the station management (SMT) process required by the FDDI standard for all stations on the ring.

The implementation of the station management process was acquired from Distributed Systems, Inc. The analysis and real-time environment and the station management environment communicate via the station management interface. The FDDI Ring Manager software spans all of the above environments. It consists of software modules in the general-purpose environment that implement the user interface, and in the analysis and real-time environment that provide the basic analysis engine. The analysis engine uses ring information from the station management environment as maintained by the station management process. The data flow diagram for the entire application is shown in Fig. 8. A discussion of the FDDI Ring Manager software modules in the general-purpose environment and the analysis and real-time environment follows.

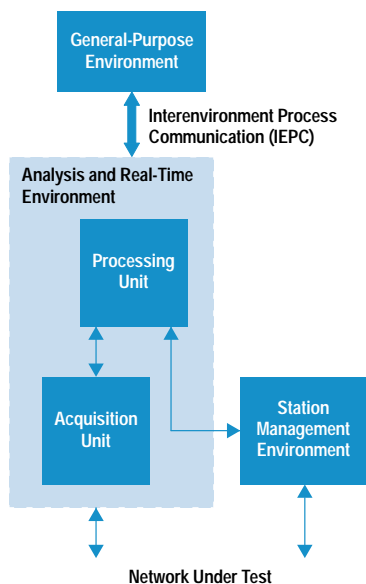


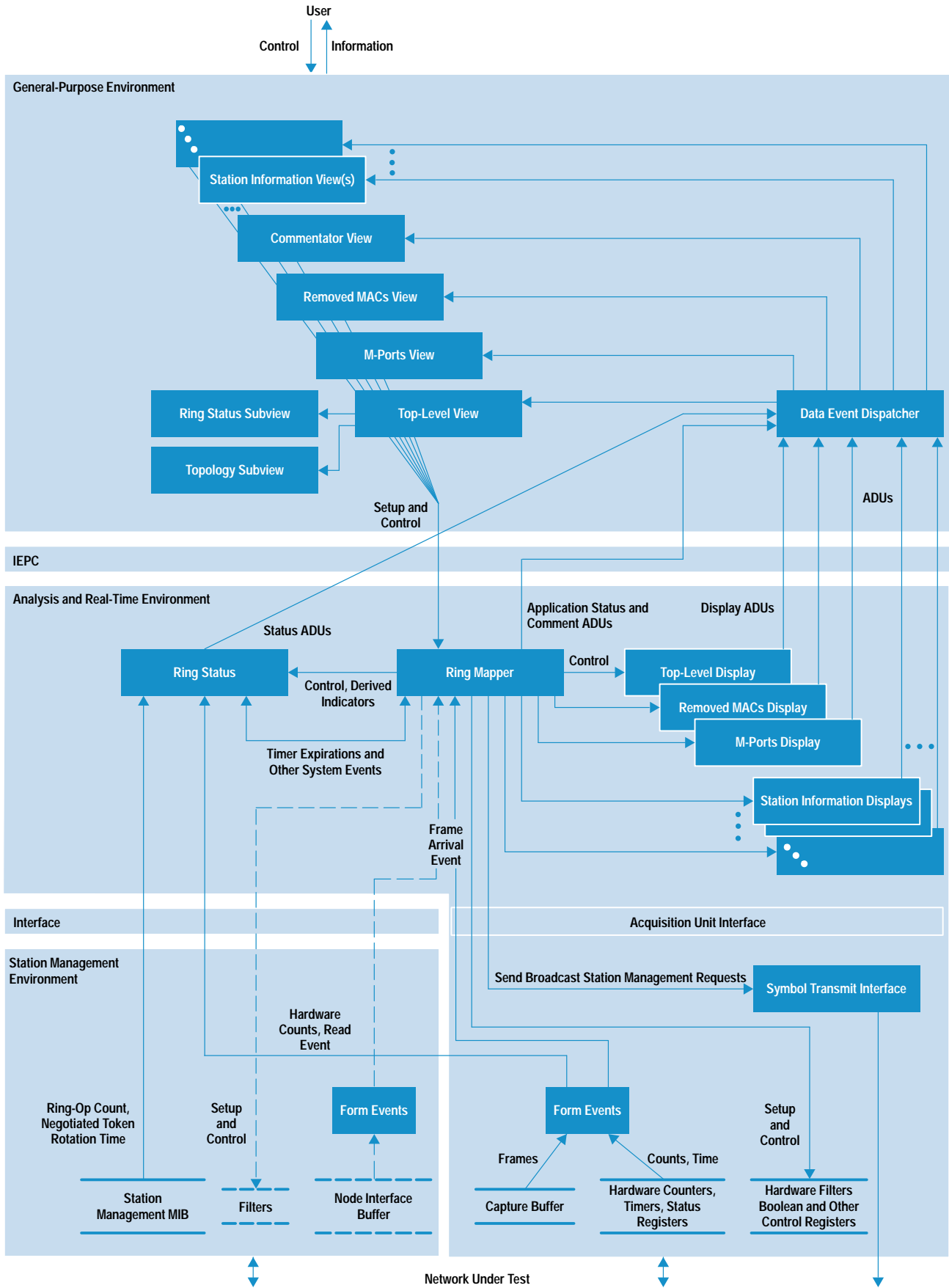
Fig. 7. FDDI Network Advisor architecture.

### General-Purpose Environment GUI Subsystem

The FDDI Ring Manager graphical user interface (GUI) subsystem is an object-oriented system written in Smalltalk. This system heavily leverages the existing HP Network Advisor software platform to provide the user interface functionality for the FDDI Ring Manager. The FDDI Ring Manager user interface subsystem is designed to process various FDDI Ring Manager analysis data units (ADUs) sent from the analysis and real-time environment and display these events appropriately. In addition, control and user commands are processed by the user interface subsystem, and if needed, they are sent to the analysis and real-time system. Fig. 8 shows the data flow diagram for the user interface subsystem.

**FDDI Ring Manager View.** The FDDI Ring Manager view controls the display of three types of data in the top-level FDDI Ring Manager window (see Fig. 1). This view contains three subviews—one for each section, or tile, of the top window. As the view receives data, it checks its type and routes the data to the appropriate subview. When a subview receives





**Fig. 8.** FDDI Ring Manager data flow diagram, including graphical user interface subsystem data flow diagram. The dashed lines indicate the node interface data path.

the data object, it is responsible for processing the data and displaying it in its tile.

The top and bottom subviews in the FDDI Ring Manager view process ring status and analysis and real-time status messages and display the data in these messages in their tiles. These tiles are read-only and require a simple translation from analysis and real-time data to ASCII data before the data is displayed. The subview that controls the middle tile, the topology subview, is discussed below.

**Ring Topology Subview.** The ring topology subview is responsible for the mapping of the ring topology data objects (representing MACs on the network) in the middle tile of the FDDI Ring Manager window. This subview also provides generic topology display functionality that is subclassed and used by the M-port connections topology subviews (see Fig. 5) and the removed MACs topology subview (see Fig. 4). Each topology subview must work closely with its corresponding display module in the analysis and real-time environment to provide user interface navigation and “drill-down” capability for the user (see below).

**Topology Mapping.** When a data ADU is sent to the topology subview, it contains the information for each MAC that must be displayed in the tile. For each MAC, the subview must determine which icon needs to be displayed based on the type of network device the MAC represents (Fig. 3 shows all of the icons used by the FDDI Ring Manager). This is done by first looking up the MAC in the node list using the MAC's address (found in the ADU). If there is a match, the node list type is used. If there is no match, the generic type (concentrator or station) found in the data ADU for the MAC is used. A lookup is then done in the FDDI Ring Manager's icon dictionary to retrieve the appropriate icon for display based on the MAC's type.

The graphical icons used in the display are prebuilt and are accessed through an FDDI Ring Manager icon dictionary. The icon dictionary contains associations of the form (type, icon) where type is the key and icon is the value. The icon dictionary is stored on disk and loaded when the FDDI Ring Manager measurement is instantiated.

Once the icon is obtained, the connecting lines are drawn to the icon based on connection information included in the ADU. If a MAC has an error or warning status, or if the MAC is rooted (on the dual ring), the icon is masked with the appropriate color (red, yellow, dark blue). After all MACs have been processed, they are painted to the screen.

**User Interface Navigation.** A topology subview controls a tile that displays icons for up to 25 MACs at any one time. If the ring has over 25 MACs (an FDDI ring can have up to 500 nodes), a different set of MACs can be displayed. This minimizes the amount of data that needs to pass through the IEPC for a topology update. The scroll bar or cursor control keys can be used to display different sections of the ring.

When the user sizes the window, thus changing the topology tile size, or navigates to inspect other MACs on the network, commands are generated for the subview's corresponding display module and sent from the subview to the view. Examples of commands are: previous page, next page, previous line, next line, home, and end. When the view receives a command, it adds its handle and sends it to the measurement.

The measurement packages it and sends it to the IEPC, destined for the subview's corresponding display module. If the display module determines that the user interface should be updated to reflect the command, it generates a display ADU for the view and sends it to the IEPC. The display ADU is routed to and displayed by the topology subview that sent the command.

**“Drill-Down” Capabilities.** The act of selecting and opening an object to get detailed information is termed “drilling down.” Each MAC icon in a topology subview is a control object that can receive and process user input. The user can move the cursor over the icons and select one by either clicking with the mouse or pressing the enter key while the MAC icon is highlighted. When a MAC icon is selected, the user interface determines if an existing window should be made the top window or a new window should be opened. In either case, the window that is displayed as a result of the icon selection displays additional information about the MAC for the user.

If the user interface determines that a new window needs to be opened it creates the view, registers it with the data event dispatcher, and sends a command to the analysis and real-time environment to create a display module of a particular type. The type of display module created depends on the type of view needed. If the selected node is a rooted concentrator and the FDDI Ring Manager is configured for physical mode operation, an M-port connections view is created and a “create M-port connections display module” command is sent to the analysis and real-time environment. In all other cases, a station information view and a station information display module are created. After the create command is sent to the analysis and real-time environment, the newly created display module sends a display ADU back to the view's subview and the data is displayed. Figs. 5 and 6 show the windows controlled by these views.

**The Ring Commentator View.** The ring commentator view controls the window that displays the commentator events sent to it by its corresponding analysis and real-time display module. The commentator view contains a subview that is responsible for the processing and display of each commentator ADU sent from the analysis and real-time environment (See Fig. 8).

Each ADU sent to a commentator view consists of a comment type, one to four line identifiers, and zero to four arguments for each line. Arguments are values used when the ADU is displayed. Examples of arguments are MAC address, port identifier, and error count. When the subview receives an event from the view, it looks up the correct ASCII string and event level for the event based on its comment type. This string contains a one-line description for the event, suitable for posting to the Network Advisor's event log. The event level determines the event severity. The severity can be either normal, warning, or alert. The file containing the event levels is ASCII and the levels can be edited by the user. Any changes to the event levels are reflected in the FDDI Ring Manager the next time it is executed.

Each line of text for the event is then found by looking it up in a file based on the line ID. The line found is an ASCII string resembling the C-language printf format string. Each line is converted to the proper display string using the format

characters to control the translation of each of the line's arguments. When each line is translated, it is displayed in the subview's tile.

### **Analysis and Real-Time Subsystem**

**Ring Status Module.** The ring status module is responsible for monitoring the key indicators of network health. It is controlled by the ring mapper module which is also the central point of control for the FDDI Ring Manager application as a whole. As described earlier, these indicators come from various sources within the analysis and real-time and station management environments.<sup>2</sup> From an implementation point of view the indicators can be categorized as basic or derived. Basic indicators are those that are either measured and maintained by hardware, such as observed token rotation time or network utilization, or available as part of the normal FDDI station management process, such as negotiated token rotation time and ring op count. Derived indicators are those that are outputs of other software modules. They tend to be inferred or derived from relevant station management frames (neighbor information frames and/or station information frame responses). Examples of this type of indicator are ring state, active MAC statistics, claim winner, and metastatistics on the commentator events.

The data flow diagram of the FDDI ring manager in Fig. 8 shows the ring status module in relation to the rest of the FDDI Ring Manager software in the analysis and real-time environment. The operation of the ring status module is driven by timers for the most part. At regular intervals (five seconds for basic indicators and longer for others), the ring status module obtains the values for these indicators, packages them in an ADU and ships it to the general-purpose environment.

Since the status consists of numerous indicators, some maintained in hardware and others in software, we faced the issue of having to combine indicators that reflect two different points in time. This is because the software takes time to process data and therefore trails the hardware by a few milliseconds. We solve this by reading the hardware-maintained indicators along with the real-time hardware clock at regular intervals. When the software finishes processing data corresponding to real time T, the hardware indicators corresponding to time T are combined with the software indicators for time T and the combined indicators are posted as the status for time T. In this way, time consistency is ensured for all ring status pane statistics.

**Ring Mapper Module.** The ring mapper module forms the core engine for the FDDI Ring Manager software in the analysis and real-time environment. It implements the algorithms for building logical and physical views of the ring. These algorithms are described in detail in the article on page 97. The ring mapper also maintains the list of removed MACs and generates event notifications for the FDDI commentator.

The ring mapper uses the front-end monitor data path to obtain neighbor information frames and station information frame responses to its broadcast configuration and operation station information frame requests. Optionally, we could

have chosen to use the node interface data path in the station management environment. This is shown in Fig. 8 using dashed lines.

Using the station management environment data path would have required Distributed Systems, Inc. to make changes to its station management software to support our requirements. Since this would add a dependency beyond our control for the project, we decided against this option. This decision was not without its downside. For performance reasons the ring mapper sets a station management filter to allow only station management frames to be saved in the capture buffer that feeds the monitor data path. This filter precludes other applications that use nonstation-management frames for their analysis from running simultaneously with the FDDI Ring Manager. However, we left open the possibility for change by implementing the ring mapper so that the source of its information is completely irrelevant to its operation.

The ring mapper compiles and organizes all necessary information from the station management frames it receives. From this information, it determines the ring maps and provides on demand detailed station information for all nodes on the ring. For the physical view of the ring, the ring mapper determines physical links between stations on the ring and to which ports that they connect.

All general-purpose commands to control the entire FDDI Ring Manager application in the analysis and real-time environment are sent to the ring mapper, which may act on a command or redirect it to the appropriate module—for example, a display module.

### **Display Modules**

A display module is responsible for supporting a virtual window in the general-purpose environment. There is a display module for each open window in the FDDI Ring Manager application. A window's display module supports standard windowing operations such as next page, previous page, next half page (for scrolling down), previous half page (for scrolling up), show page starting at specified point in virtual space (for home, end, etc.), and update page.

All display modules get their information from the ring mapper. They send their information to the general-purpose environment in the form of a display ADU. These are sent to the general-purpose environment as a result of a command from the general-purpose environment or on a periodic basis. In the latter case, the ring mapper controls the display module such that it updates the general-purpose environment with a display ADU every update interval. Finally, display modules have schemes for handling flow control and race conditions between the general-purpose environment and the analysis and real-time environment.

### **Conclusion**

The consultations with customer sponsors early in the development stages and throughout beta testing have given us a high degree of confidence in the usability of the FDDI Ring Manager. In addition to implementing the right features, we were able to address several real-life situations that would



not have occurred on the in-house test network. This collaboration with users has helped us create a product that answers the needs of our customers, the FDDI network managers and operators.

### **Acknowledgments**

The FDDI Ring Manager was truly the result of a team effort. The contributions came from far beyond the R&D team including the marketing and marcom teams and our customer sponsors. We wish to thank Bill Barkley for developing the ring status functionality and providing the basic functions for parsing station management frames. We also wish to thank Frank Actis for asking his many "What if ...?" questions to ensure that the team was clear in its objectives with regard to the target customer. Thanks also to Steve Witt, the project manager, for giving us the freedom to do whatever was

needed to realize the product. Thanks to Jim Pfaff and Mike Waughn for their marketing and support work and Aileen Johnson for coordinating other aspects of the product during its final stages. We also wish to acknowledge the contributions of a number of key individuals, too many to name here, who did intensive testing on the product in an effort to provide quality. Finally, many thanks to our customer sponsors who provided valuable input through all stages of the project.

### **Reference**

1. *Hewlett-Packard Journal*, Vol. 43, no. 5, October 1992, pp. 6-47.
2. S. Bhat, "The Network Advisor Analysis and Real-Time Environment," *Hewlett-Packard Journal*, Vol. 43, no. 5, October 1992, pp. 29-33.