Technical Description

EDACS®
Data Advantage™

ERICSSON

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Continued

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PREFACE

This is one of four manuals for **D**ata **A**dvantage™. It contains a detailed description of the capabilities, interfaces and hardware for Data Advantage. Other relevant documents are:

Data Advantage Installation and Maintenance (LBI-39190):
This manual contains installation and trouble shooting information. This manual also includes the boot sequence and network planning.

Data Advantage User's Reference Manual (LBI-39191):
This manual contains information for using Data Advantage command shell. The command shell services the Diagnostic Terminal and Telnet logins.

Data Advantage Configuration Reference Manual (LBI-39189):
This manual documents the commands used to configure Data Advantage.

Internetworking with TCP/IP, Volume I, by Douglas E. Comer:
This is an excellent (but unofficial) source of information about Internet Protocol.

EDACS Network Driver User's Manual (LBI-38961)
This manual documents how to install and use the **E**DACS **N**etwork **D**river **(END).** This product provides a **M**edium **A**ccess **C**ontrol **(MAC)** sublayer driver for use with off-the-shelf IP protocol stack products. The END product is for use with MS-DOS.

EDACS CommServ Programmers Guide (LBI-38835):
This manual documents the CommServ product. CommServ provides an application program interface that simplifies RDT programming by providing an RDI Data Link Layer. It is for use with MS-DOS and PC-DOS.

Radio Data Interface Protocol Specification, Version 1.92 (ECX 922)
This manual documents the RDI Interface.

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OVERVIEW

Ericsson Data Advantage is a mobile data gateway that connects wired computer networks with an EDACS trunked mobile radio network.

A Data Advantage is similar to EDG-IP (**E**DACS **D**ata **G**ateway), another mobile data gateway product of Ericsson. Data Advantage is distinguished from EDG-IP by the fact that it requires no connection to an IMC, and thus may be included in a single site EDACS installation, providing connectivity to an Ethernet/IP network at a reasonable cost.

Data Advantage uses RF data technology to communicate with EDACS. RF data involves the transmission of data via RF between two radios using at the same RF site. The Multi-Site function is not supported by Data Advantage.

Data Advantage provides an open system solution for mobile data applications; it uses the popular, non-proprietary IP protocol for both the host and the remote interface. The host interface provides IP connectivity over an Ethernet. At the remote interface a companion network device driver is used to interface with off-the-shelf TCP/IP protocol stack.

Figure 1 shows an overview of the equipment that is used when passing data. Data Advantage connects to host computers using **I**nternet **P**rotocol **(IP)** over an Ethernet. Data Advantage connects to the EDACS system through RF control stations housed in the Data Advantage cabinet. An RF control station is an EDACS mobile radio with a built-in **R**adio **D**ata **I**nterface **(RDI).**

A Radio Data Terminal (RDT) can be connected directly to a radio that has a built-in RDI, or indirectly to a radio through an external RDI. A radio connected to an RDT must be programmed as terminal radio with a unit ID in the range 64 - 16382. The baud rate of the serial interface between external RDI and radio is 9600 bps.

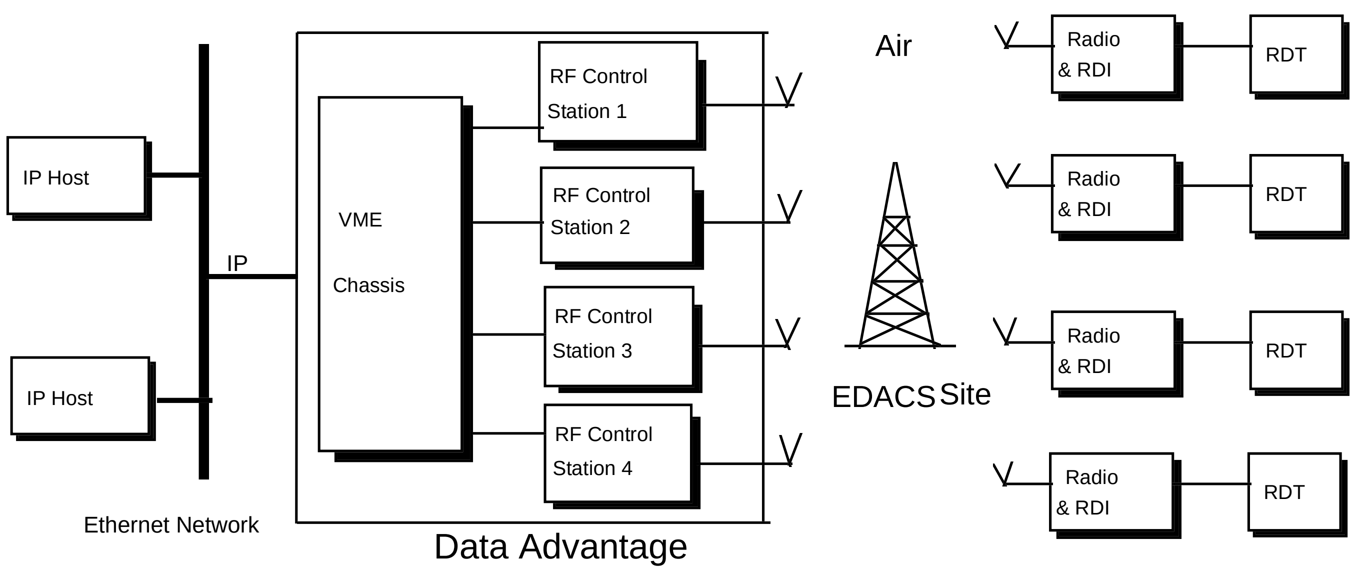

Figure 1 - Equipment Overview

FEATURE LIST

Ericsson Data Advantage supports the following features:

- Call Types:
  Individual Data Call between an IP Host and an RDT
  Individual Data Call between two RDTs
  Host Originated Group Data Call

- Non-Proprietary Host Computer Interface:
  Ethernet physical connection and Data Link Layer.
  Standard IP Network Layer supporting class A, B, or C IP addresses.
  Simultaneous use of multiple Transport Layer Protocols (TCP, UDP, or customer defined) if the RDTs support the EDACS network layer .

- Non-Proprietary Remote Interface:
  Supports Network Driver Standard Specification (NDIS)
  Transparent protocol translation between IP/DIX Ethernet and EDACS Network Protocol/RDI.

- Flow Control and Queuing:
  Data Advantage manages the speed differential between the EDACS RF interface and the Ethernet/IP Interface. Configurable queues and message timers are available for messages destined for radios. Queuing is not needed for IP Hosts due to the high network bandwidth of the Ethernet (10 Mbps).

- Robust Operation:
  Data Advantage continues call processing when an EDACS System is in Failsoft.
  Data Advantage helps prevent data corruption due to radio biasing. All radios, both RF control stations and terminal radios, have the **B**ias **R**eduction **E**ncoding **(BREN)** Anti-Biasing capability.

- Flexible Configuration
  Data Advantage is configured through an ASCII text file. The configuration can be verified on an MS-DOS PC.

- Error Logging:
  Data Advantage can log detected errors to a disk file, the Diagnostic Terminal, a remote terminal, and/or a printer, as desired. Three levels of reporting can be selected.

- Remote Login and File Transfer:
  Data Advantage can be accessed using Telnet to login or FTP for file transfer.
  Remote Software Upgrades are supported.

- Statistics Gathering and Display:
  Data Advantage maintains loading statistics that can be displayed and cleared as desired. This includes the statistics collected from the RF Control Stations in real-time.

SYSTEM ARCHITECTURE

Figure 2 shows the system architecture of Data Advantage, its interface to the EDACS System, and it's interface to Ethernet/IP network. Data Advantage is a multi-processor system with two different types of microprocessor boards: the CAP (Central Activity Processor) board and the WNI (Wireless Network Interface) board. The CAP and WNI boards communicate with each other over a VME system bus. Data Advantage has two different configurations: a four port Data Advantage or an eight port Data Advantage. A four port Data Advantage has one CAP board, one WNI board and four RF control stations. An eight port Data Advantage has one CAP board, two WNI boards and eight RF control stations.

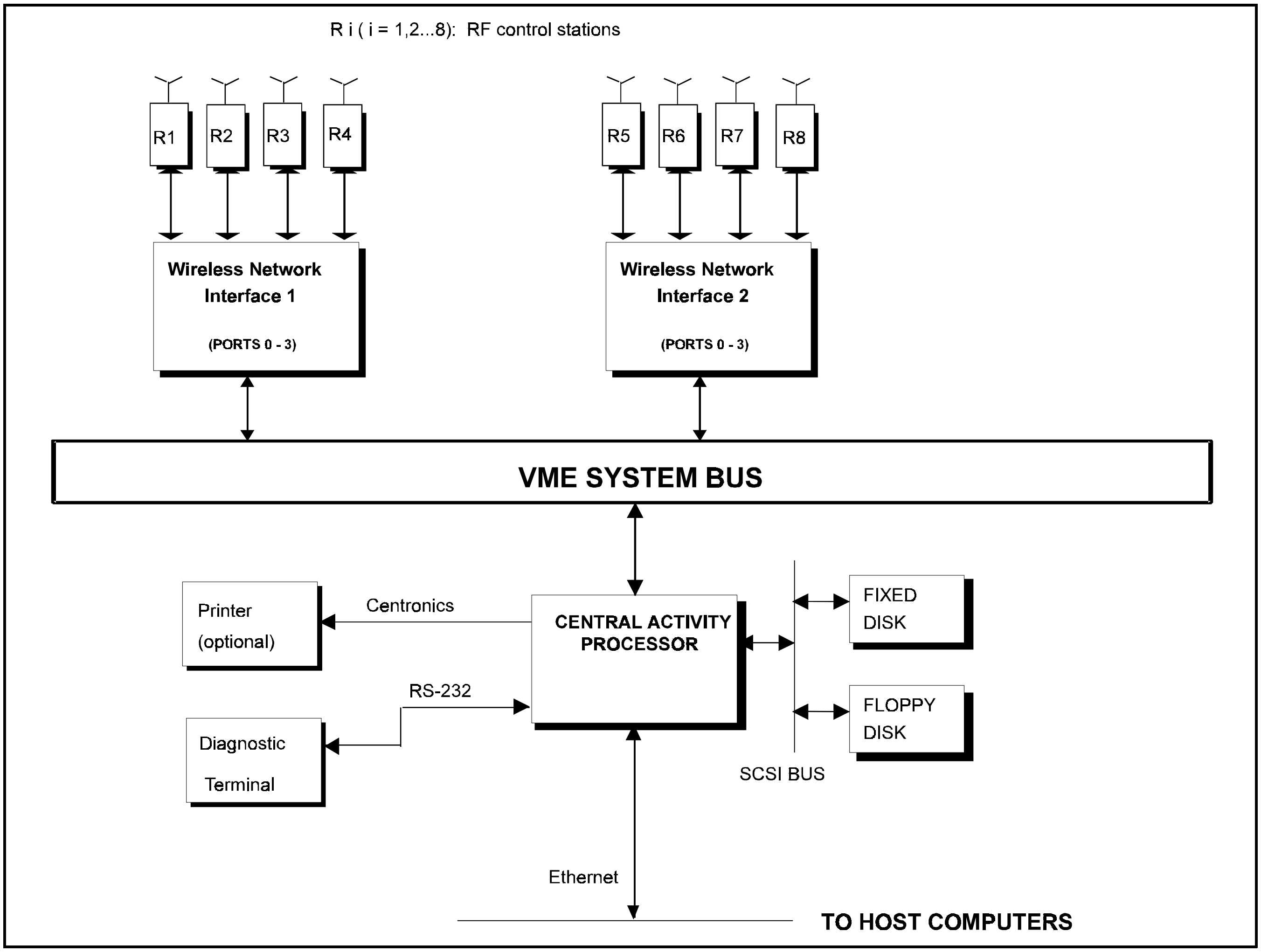

Figure 2 - VME Chassis Block Diagram

WIRELESS NETWORK INTERFACE (WNI)

The WNI boards handle the communication to and from the EDACS radio network. The WNI boards connect to the EDACS System through the RF control stations. An RF Control station is a EDACS mobile radio with a built-in Radio Data Interface. Each WNI board has four RS-232 ports with each port connecting to an RF control station.

CENTRAL ACTIVITY PROCESSOR (CAP)

The CAP board supports the disk drives, Diagnostic Terminal, and optional printer. It processes the configuration file and passes configuration information to the other boards. It also provides an Ethernet interface for the host computers, using **I**nternet **P**rotocol **(IP) .**

DATA ADVANTAGE SIZING

The number of WNI boards should be selected based on the expected load and the number of RF channels. The expected load should include expected messaging between IP Host Computers and RDTs, and between RDTs.

NETWORKING CONCEPTS

SINGLE NETWORKS

For the purposes of this discussion, a network is a physical medium and protocol that allows more than one device to communicate with each other. In the terms of the International Standards Organization's Open System Interconnection Reference Model (OSI Model), this represents the Physical and Data Link Layers of this model, as shown in Figure 3.

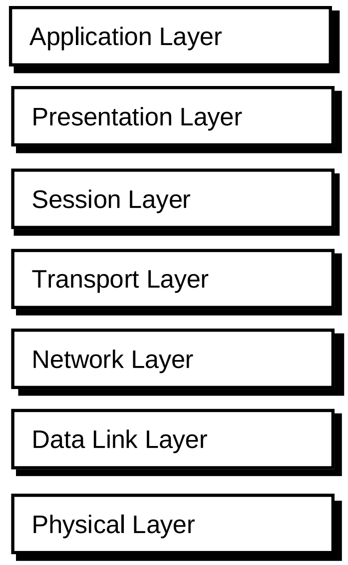

Figure 3 - OSI Model

If you want a new device to communicate with the existing devices on a network, you must connect the new device to the network using an interface that is compatible with the network. A simple network could connect three host computers to each other using an Ethernet, as shown in Figure 4.

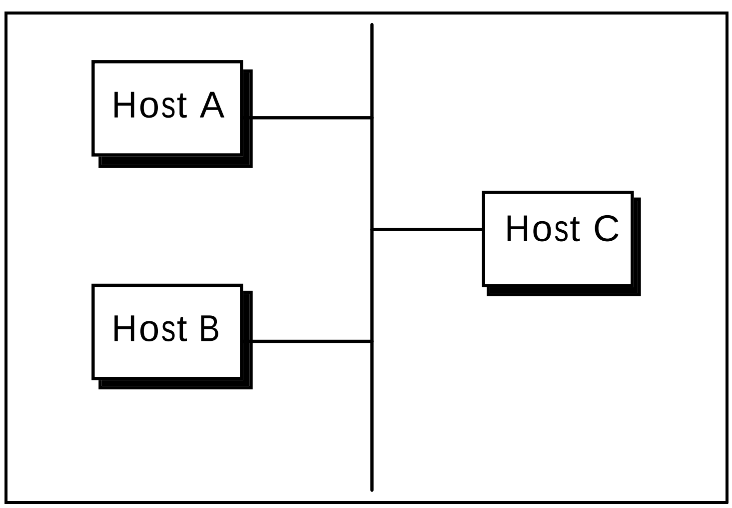

Figure 4 - Ethernet Network

Each of the devices would physically connect to the Ethernet cable. They would communicate with each other using separate Ethernet Addresses and the Ethernet Protocol.

Unfortunately, there is no single type of network that is best for all situations. Ethernet networks perform well when used to connect devices at the same location. However, Radio Data Terminals (RDTs) can not be used in mobile applications if they are connected to an Ethernet cable running through a building. This leads to multiple network types to solve different networking needs.

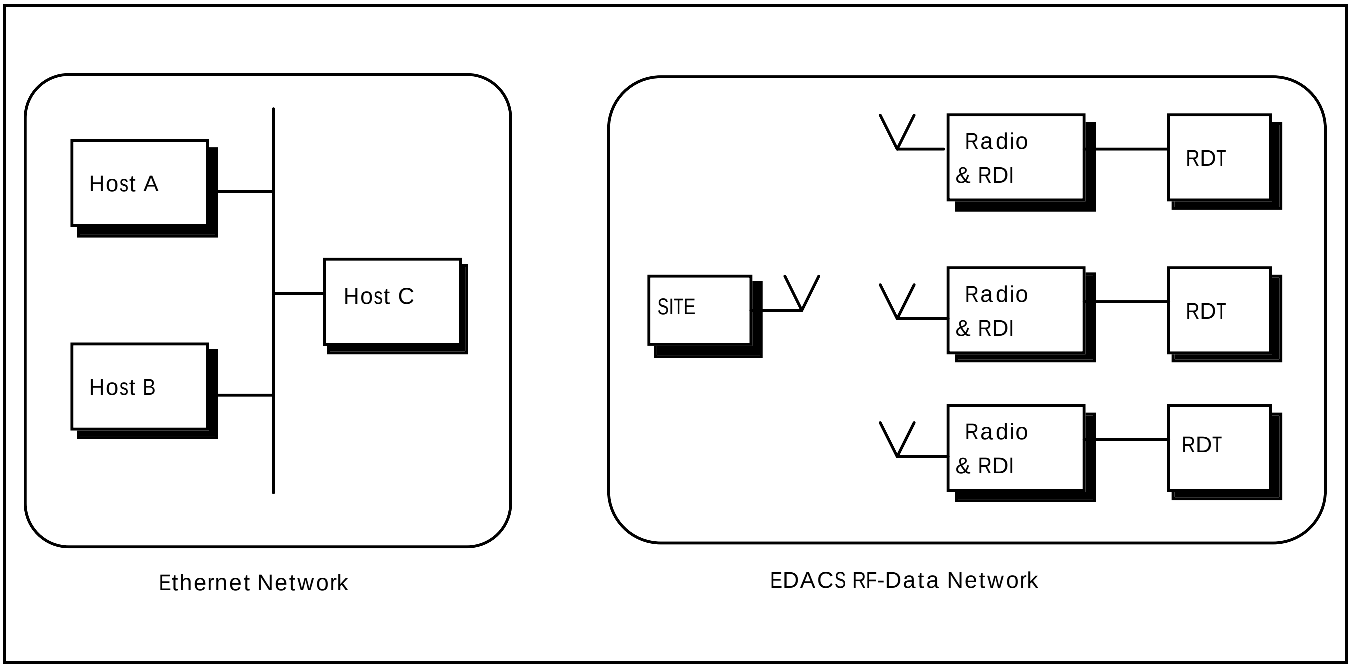

Figure 5 -Two Unconnected Networks

The devices on the Ethernet Network use the Ethernet cable as their physical medium and use separate Ethernet Addresses and the Ethernet protocol to communicate. The devices on the EDACS RF-Data Network use radio frequencies as their physical medium and use separate EDACS Addresses and the EDACS protocol to communicate.

This configuration works well until an RDT on the EDACS Network needs to communicate with a host on a different site or on the Ethernet Network. Data Advantage provides a solution to this problem that is particularly cost effective for users with a single site EDACS system.

CONNECTING MULTIPLE NETWORKS

Data Advantage is a gateway between an EDACS network and an Ethernet. Connecting networks, even if they are the same type, is known as Internetworking. The connected networks become a single internet.

Internetworking is accomplished by performing two actions. First a gateway is connected to both networks. The gateway has an interface to each network and is able to translate messages between them. Next, to simplify internetworking, a network layer is used above the data link layers. The network layer provides a universal addressing, protocol, and interface across the internet.

While the network layer address provides a universal address across an internet, it cannot be used to actually send data across a specific network. The network layer address must be converted to a data link layer address specific to the network type.

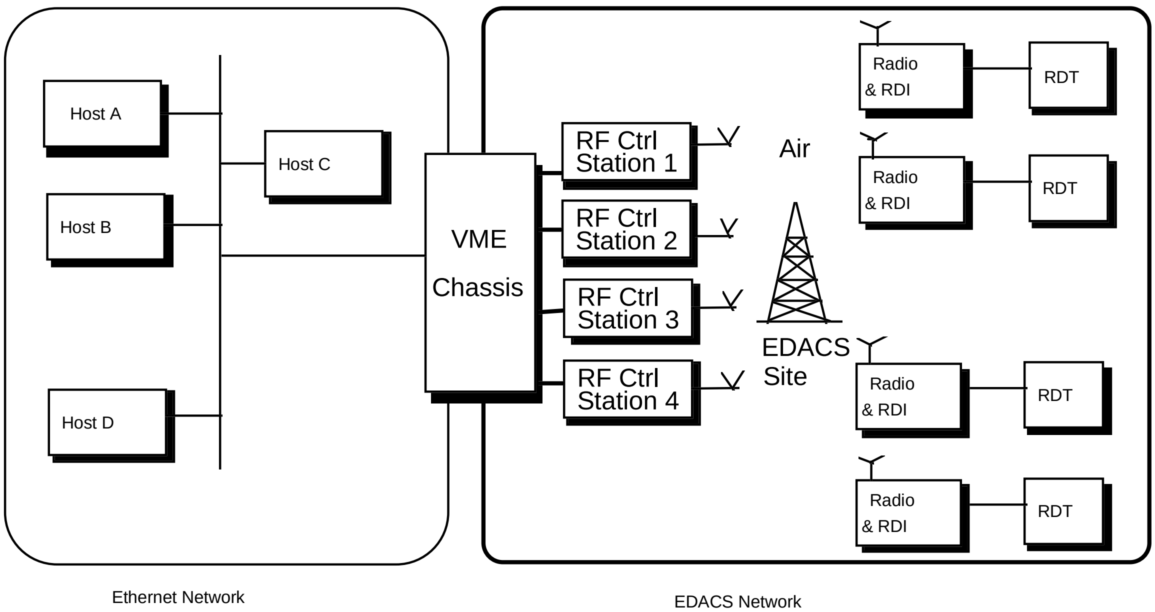

Figure 6 -Internetworking Using Data Advantage

Connecting host computers and RDTs by Internetworking has the following advantages:

1. A single host computer can communicate with multiple radios simultaneously.

2. Data Advantage connects to the host computer using non-proprietary protocols. This reduces the amount of custom software required.

3. Data Advantage is compatible with network device driver software for the RDT. This allows the use of off-the-shelf IP products for the RDT. In this configuration, applications written for TCP and UDP can be used or developed.

INTERFACE SPECIFICATION

WIRELESS NETWORK INTERFACE

Protocol Layers

The physical interface between a WNI port and an RF control station is a 19,200 bps asynchronous RS-232 link. The WNI ports are configured as DTE for communication with RF control stations which function as DCE. The protocol implemented at the Data Link Layer is the Ericsson proprietary RDI Protocol, Version 1.92.

Addressing

A WNI uses EDACS Addresses to actually send and receive messages across the EDACS network. There are two types of EDACS Addresses, **L**ogical **ID**s **(LID**s**)**, and **G**roup **ID**s **(GID**s**)**. LIDs are used to call or identify a single radio. GIDs are used to call a group of radios. LIDs and GIDs are programmed into radios and can be changed as desired.

TYPE	Range
LID	1 - 16,382
GID	1 - 2047

Table 1 - the Range of LIDs and GIDs

In Data Advantage, there are two categories of radios: Data Host Radios and RDT radios. A Data Host Radio is a fixed location radio housed in the Data Advantage cabinet called RF control station. A RDT radio is connected to a Radio Data Terminal. A Data Host Radio must be assigned a LID in the range of 1-63. The LID assigned to an RDT should be in the range of 64-16382. It is not recommended to assign a LID in the range of 1-63 to an RDT radio.

TYPE	Range
LID for Data Host Radio	1 - 63
LID for Terminal Radio	64 - 16,382

Table 2 - LIDs for Host Radios and RDT Radios

A data call involves data transmission over an RF working channel between a Data Host Radio (RF control station) and an RDT radio (or a terminal radio group). This applies also for an RDT-to-RDT call which actually consists of two data calls: one from originating RDT radio to an RF control station, and one from a RF control station to the destination RDTradio.

Note that the LID assigned to an RF control station refers to a working node on the end-to-end communication path, it does not refer to the real source and destination of a data call (IP host or RDT). There is no IP address assigned to an RF control station, whereas each RDT radio or RDT radio group must be assigned a unique IP address.

Acknowledgments and Error Reporting

The WNI port always receives acknowledgment (positive or negative) from an RF control station for an outbound message. The WNI port used for a data call is freed upon receiving the acknowledgment. A WNI never sends acknowledgment to RF control station for an inbound message.

If an error occurs, it may be logged at by Data Advantage, the RDI or radio portion of the RF control station, site controller (if present), or the RDT radio, depending on the type of error and where error occurs.

Message Retry

When an outbound message fails, the user can choose to resend the message. Both the number of retries and the delay period for resending a failed message are user configurable. When a message fails, the Data Advantage will wait for the specified delay before resending the message. If all of the attempts fail, the Data Advantage sends the source an ICMP Source Quench message asking it to reduce its output rate.

The user can also choose to resend a failed inbound message if the RDT is running the EDACS Network Driver. See *EDACS Network Driver User's Manual* for more information.

RDI statistics

Data Advantage can request basic or extended statistics from all boards used in Data Advantage. The extended statistics on a WNI also includes the statistics collected from the four RF control stations which provide both port specific and RF-channel specific information. This information can be very useful in determining the reason for call failure.

Queuing and Flow Control

Messages destined for RDTs are primarily queued at the WNI network layer. The network layer queuing guarantees that messages be sent to a specific RDT one at a time. The data link layer only queues message when all WNI ports are busy, or the destination RDT radio is involved in an incoming data call.

If a WNI port and the connected RF control station try to initiate a data transfer at the same time, the WNI will queue the outbound message to service the inbound message first. When a port frees up, the WNI will send the preempted message before any other normally queued messages.

IP HOST INTERFACE

Protocol Layers

Data Advantage physically connects to an Ethernet Network using a DB15 AUI Ethernet Connector. This can be used with thick coax, thin (BNC) coax, or twisted pair (10BaseT) using an IEEE 802.3 standard off-the-shelf transceiver. The transceiver is purchased separately based on the network requirements.

The data link layer uses Ethernet II Protocol. This is also known as IEEE 802.3 DIX. Standard IEEE 802.3 Ethernet Protocol is not supported at this time.

The network layer uses Internet Protocol (IP), version 4. The Internet Activities Board defines the official standard for the Internet Protocol. *Internetworking with TCP/IP, Volume I,* by Douglas E. Comer is an excellent, but unofficial, source of information about IP. Data Advantage fully supports the major features of the Internet Protocol (except for subnetting). The protocols that are used above the network layer are end-to-end conversations between the host and RDT. Any headers that they use are simply passed as data through the network to the RDT.

Addressing

From the host's perspective, the RDTs are peer devices on another network. In a simple configuration, Data Advantage is the next gateway to use to send data to the RDTs. In a more complex configuration, there could be multiple gateways between Data Advantage and the host. In either case, the host is only concerned with the next gateway to use, not the full topology of the internet.

Data Advantage Installation and Maintenance Manual contain information on the format and assignment of IP Addresses.

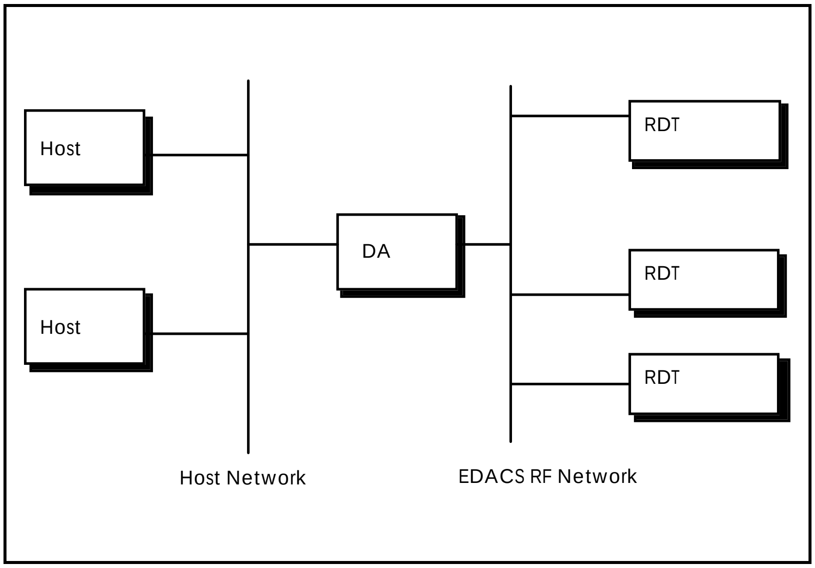

Figure 7- Simple Configuration As Seen By The Host

At the data link layer, Data Advantage and the host computers communicate using Ethernet Addresses. The host computers and Data Advantage use **A**ddress **R**esolution **P**rotocol **(ARP)** to learn each others Ethernet Addresses based on their IP Addresses.

The network layer uses the IP Address to decide where to route the message next. For host originated messages, the host addresses a radio or group of radios using the unique IP Address assigned to that radio or group. Normally, the host has a single entry added to its routing table instructing it to use the External IP Address of the CAP board as the next gateway for messages being sent to any destination on the EDACS Network. For messages from a radio to a host, Data Advantage receives the message, examines the IP Address and forwards the message on to the host computer.

Acknowledgments and Error Reporting

The IP Network Layer is a best-effort delivery system. Successful messages are not acknowledged. Typically, a positive acknowledgment is built into one of the higher protocol layers. The EDACS System generates an error indication if for some reason the destination radio fails to receive a message. Unsuccessful messages may generate one of the following error indications:

1. Error return codes on the host computer. These error codes and their meanings vary depending on the host type.

2. Internet Control Message Protocol (ICMP) messages. The Data Advantage or another component in the host network may return ICMP messages. The Data Advantage Installation and Maintenance Manual contains a list of the ICMP messages that Data Advantage returns.
   On most host computers, ICMP messages are not returned to the application program that sent the original message. If desired, a program could be written to receive all ICMP messages, filter those of interest, and return them to the application program on request.

3. Errors logged by other components in the host network.

4. Errors logged by Data Advantage. The severity of errors logged by Data Advantage is selectable. See the log command in Data Advantage User's Reference Manual for more information.

5. Errors logged by other EDACS components such as Site Controller or System Manager, if they are present.

It is also possible for a message to successfully reach the radio and the acknowledgment to fail to reach Data Advantage. In this case, the EDACS System treats the message as if it failed even though the radio, RDI, and RDT see it as a successful message. Data Advantage will send an ICMP Message back to the host computer.

Queuing and Flow Control

The Data Advantage IP Host Interface uses message queue to send and receive IP fragments. Under normal conditions, fragments spend very little time in the queue. In extreme cases, the IP Host Interface could receive messages at a faster rate than it can handle. In this situation, the interface accepts as many messages as it can and issues ICMP Source Quench messages for the rest.

RADIO DATA TERMINAL (RDT) INTERFACE

RDTs can be configured in a variety of ways. Normally, the RDT configuration is chosen for close compatibility with the type of host interface. Generally, if the host has a network layer, then the RDT should also have a network layer. If the host does not have a network layer, then the RDT should not have a network layer. However this is not required. Data Advantage compensates if an unbalanced configuration is chosen.

The network layer software on the RDT can either be provided by Ericsson or be supplied by the customer.

Data Advantage's configuration tells which RDTs (radios) use a network layer. The default setting in Data Advantage is that all RDTs use a network layer. In addition to enabling or disabling the network layer for all radios, the RDTs can be configured individually or in ranges.

Messaging Between RF control station and Radio

The over-the-air protocol used between an RF control station and a radio is a hardened protocol designed specifically for the RF environment. If necessary, portions of the message may be repeatedly transmitted in order to complete the data call. Once a call has been established (working channel assigned), the RF control station and radio attempt to get the message through for up to seven seconds (maximum time allowed on a working channel) before giving up.

Queuing and Flow Control

If Data Advantage is out of memory buffer, it sends the source of the message an ICMP control message asking it to reduce its output rate. Data Advantage also deletes messages that have been queued for the specified time and limits the number of messages queued.

Anti-Biasing Protection

Large messages that contain a disproportional amount of either binary zeros or ones can bias a radio, causing an increase in failed messages. Some radios have a greater ability to resist biasing than others, but most radios are susceptible. The Data Advantage supports **B**ias **R**eduction **En**coding **(BREN)**. All RF control stations and RDT radios should have the BREN feature enabled. Before sending a message to a radio, an RF control station encodes the message to balance the number of binary zeros and ones. The receiving radio/RDI decodes the message before forwarding it to the RDT. For radio-originated messages, the RF control station decodes messages encoded by the radio/RDI. This feature may increase or decrease the overall throughput, depending on the reduction in retries verses the additional BREN overhead.

RDTs with a Standard Network Layer

This configuration eliminates the need for custom communications software when used with an IP Host computer. Applications can be written using standard TCP or UDP transport layers. This configuration also supports radio-to-radio messages and messages larger than 512 bytes. The use of Telnet terminal emulation and FTP file transfer is not recommended at this time.

To achieve maximum performance, it is important to keep collisions to a minimum. This kind of collision occurs when a data message collides with an acknowledgment from the opposite direction on the data link. This is true for any transport layer. However, with TCP's sliding window protocol, it is especially important that protocol stacks in the RDTs and Hosts are configured correctly. The EDACS Network Driver User's Manual contains the correct settings for an RDT. In some situations, the TCP software in the Host cannot be configured to reduce collisions to an acceptable level. Using UDP may be a better solution in these situations.

Protocol Layers

RDTs physically connect to radio/RDIs via a 9600 bps asynchronous serial link.

The data link layer uses a network device driver (ex. EDACS Network Driver (END)). Network device driver software is a **M**edium **A**ccess **C**ontrol **(MAC)** sublayer driver for PCs running MS-DOS. It complies with the **N**etwork **D**river **I**nterface **S**pecification **(NDIS)** and advertises itself to off-the-shelf IP products as an Ethernet Driver.

An off-the-shelf IP product provides an IP Network Layer. Network device driver software converts between IP headers and EDACS Network Layer Headers. A network device driver also handles ARP and RARP requests locally.

The protocols used above the network layer are of no interest to the EDACS System. Any headers used by these protocols look like part of the data message to the EDACS System.

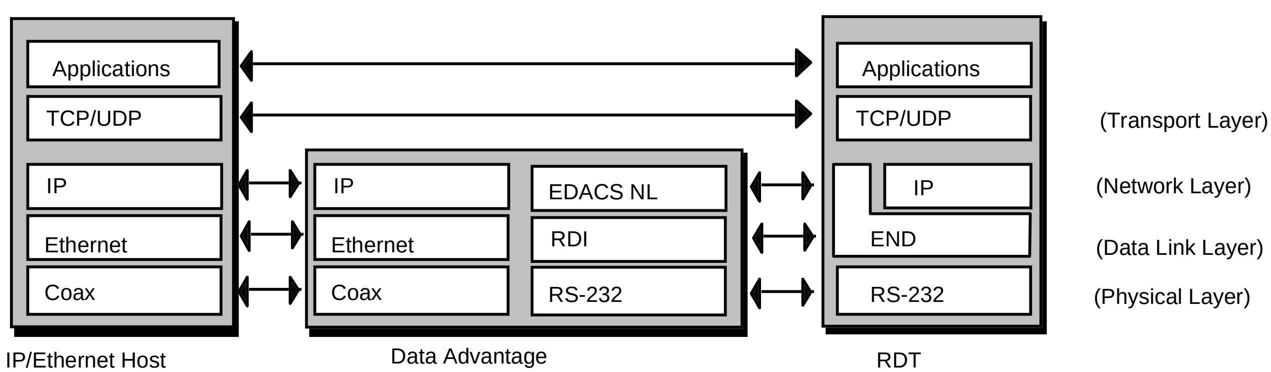

Figure 8- Typical Protocol Stack With A Standard Network Layer

Addressing

The various layers in the protocol stack use several different types of addresses to perform different functions.

At the data link layer, Data Advantage and radios communicate using EDACS Addresses. When sending a message to a radio or radio group, Data Advantage uses address-table to convert the IP Address to the corresponding EDACS Address. When receiving a message from a radio or radio group, Data Advantage extracts the destination IP address from the EDACS Network Layer Header embedded in the message. The network layer uses the IP Address to route the message to a host, another radio, or a group of radios. By using the Network Layer Header, an RDT can access the full range of IP Addressable hosts.

When sending messages through Data Advantage, network device driver software sequences through the EDACS addresses assigned to RF control stations to distribute the load among the WNI boards (eight-port Data Advantage), and among the ports within a WNI board. Note that all RDT originated messages are sent to the Data Advantage, even messages to another RDT.

Acknowledgments and Error Reporting

Using RDI protocol, the RDT receives an acknowledgment from the RDI when the RDI receives a data transfer request (XFERB), when the RDI receives the data, and when Data Advantage receives the data. If the RDT fails to send a message over the EDACS network to an RF control station, it will receive a negative acknowledgment from the RDI. Network device driver software returns the status back up to the IP product. There is no positive or negative acknowledge back to the RDT after an RF control station receives the message.

At the network layer, the IP product may receive an ICMP message as a negative acknowledgment.

If an error occurs, it may be logged at the host, other components in the Ethernet Network, Data Advantage (including RF control station), radio, the RDI, or another EDACS component, depending on the error and where the error occurs.

RDTs without a Network Layer

Data Advantage also supports data communication between a IP host and an RDT without a Network Layer.

Protocol Layers

RDTs physically connect to radio/RDIs via a 9600 bps asynchronous serial link.

The data link layer uses RDI Protocol. If the RDT is using MS-DOS, the CommServ product can be used to reduce the coding effort for application development. The *EDACS CommServ Programmers Guide* lists the minimum requirements for using CommServ.

The protocols that are used above the network layer are of no interest to the EDACS System. Any headers used by these protocols look like part of the data message to the EDACS System.

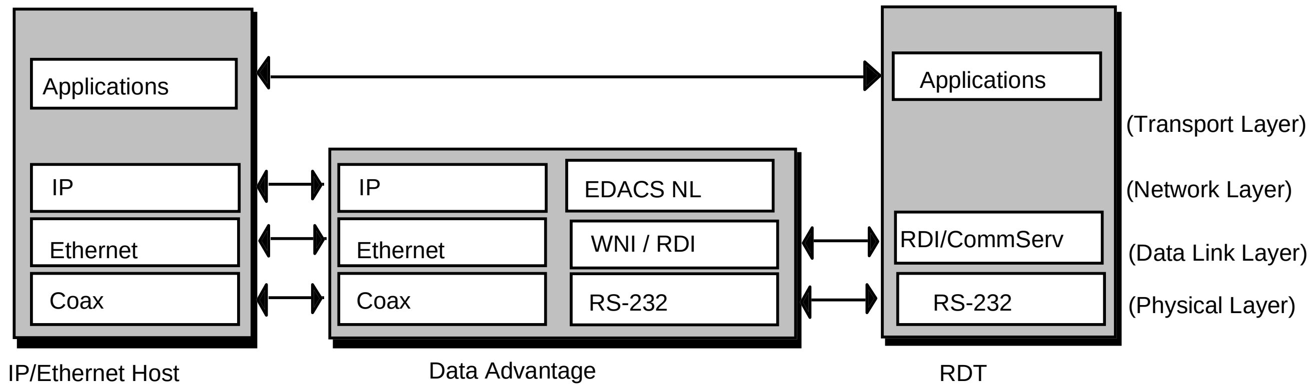

Figure 9- Typical Protocol Stack With No Network Layer

Addressing

In this unbalanced communication mode, the IP Hosts address RDTs using their IP addresses. RDTs address an IP Host through one of the EDACS Addresses assigned to RF control stations. Data Advantage uses a table to get the IP address of the host. This table maps WNI port(s) to IP Hosts. Since each WNI port is connected to an RF control station, there exists an indirect mapping between the EDACS Address assigned to an RF control station and an IP Host. Multiple ports can be mapped to a single IP host. Since there is a maximum of eight ports, the number of IP hosts that an RDT can address, is limited to eight. To enable communication between IP hosts and RDTs with no Network Layer, the user must explicitly specify the mapping between WNI port(s) and the IP host via the configuration file.

When sending a message to a radio or radio group, Data Advantage uses an address table to convert the destination IP Address to the corresponding EDACS Address. When receiving messages from radios, Data Advantage converts the EDACS Address of the RF control station that receives the message to the IP address of the host.

In this configuration, RDTs can only send individual messages to hosts. RDTs cannot send group messages or individual messages to other RDTs. If messaging between radios is desired, the originating RDTs must send the message to an application on a host computer. The host application would then send the message to the desired radio(s).

Acknowledgments and Error Reporting

The RDT receives an acknowledgment from the RDI when the RDI receives a data transfer request (XFERB) and when the RDI receives a message. If selected in the data transfer request, the RDT also receives a positive or negative acknowledgment based on the reception of the message by an RF control station. There is no positive or negative acknowledge back to the RDT after the WNI receives the message and starts sending the message to the host.

If an error occurs, it may be logged by Data Advantage (including the RF control station), another EDACS component, the radio, or at the RDI, depending on the error and where the error occurs.

ICMP messages from IP hosts are not used to return error codes to RDTs in this configuration. The Data Advantage filters out all ICMP messages to RDTs except Echo Requests and Replies.

ADDRESS CONVERSIONS AND MESSAGE ROUTING

Installations can contain additional equipment between the host computers and Data Advantage. Possible address conversions and message routing performed by additional equipment is not documented in this manual.

IP HOST COMPUTERS AND NETWORK LAYER RDTS

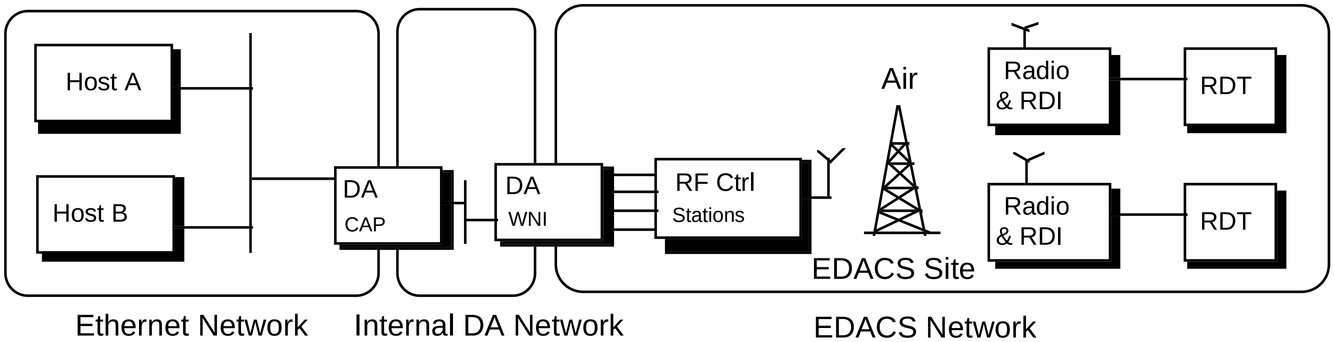

Figure 10- Communication Between IP Hosts And RDTs With A Network Layer

Message from Host to RDT

1. The host looks up the RDT's IP Address in its routing table and finds the IP Address of the Data Advantage CAP Board listed as the next gateway for the EDACS Network. The host then forwards the message to the CAP Board using its Ethernet Address. If the host does not know the CAP Board's Ethernet Address, it uses **A**ddress **R**esolution **P**rotocol **(ARP)** to ask the CAP Board.

2. The CAP Board forwards the message to a WNI Board.

3. The WNI Board converts the destination IP Address to either an EDACS **L**ogical **ID (LID)** or **G**roup **ID (GID)**. The WNI Board then sends the message to the radio or the radio group via one of the RF control stations.

4. The radio/RDI sends the message to the RDT using an XFERB command. The EDACS Network Layer Header contains the IP Address of the message originating host. The source address in the XFERB command is the LID of the sending RF control station.

Message from RDT to Host

1. The RDT sends the message to the radio/RDI using an XFERB command. The EDACS Network Layer Header contains the IP Address of the IP Host. The destination EDACS Address in the XFERB is one of LIDs assigned to the RF control stations. Using this address, the radio connected to the RDT can send the message to Data Advantage.

2. The RF control station receives the message from the radio and forwards the message to WNI. Data Advantage routes the message onto the CAP (or out to another radio) based on the IP Address in the Network Layer Header.

3. If the message is to a host, the CAP Board forwards it using the Ethernet Address of the host. If the CAP does not know the host's Ethernet Address, it uses APR to ask the host.

IP HOST COMPUTERS AND NON-NETWORK LAYER RDTS

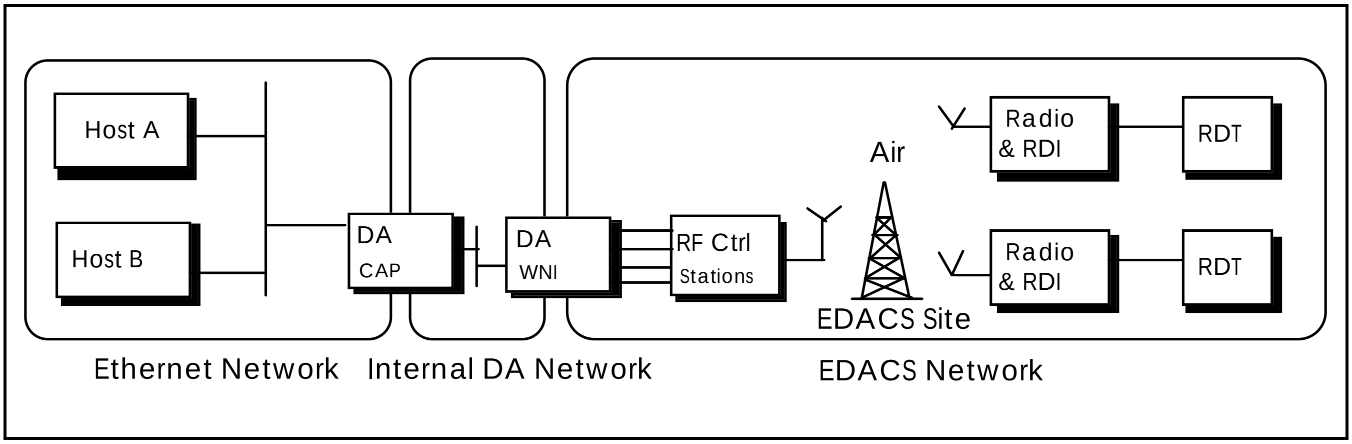

Figure 11- Communication Between IP Hosts And RDTs Without A Network Layer

Message from Host to RDT

1. The host looks up the RDT's IP Address in its routing table and finds the IP Address of the Data Advantage CAP Board listed as the next gateway for the EDACS Network. The host then forwards the message to the CAP Board using its Ethernet Address. If the host does not know the CAP Board's Ethernet Address, it uses ARP to ask the CAP Board.

2. The CAP Board forwards the message to a WNI Board.

3. The WNI Board converts the destination IP Address to either an EDACS **L**ogical **ID (LID)** or **G**roup **ID (GID)**. The WNI Board then sends the message to the radio or the radio group via one of the RF control stations.

4. The radio/RDI sends the message to the RDT using an XFERB command. The XFERB command contains the EDACS ID of the RF control station through which the message was sent.

Messages from RDT to Host

1. The RDT sends a message to the radio/RDI. It has the LID of an RF control station as destination address. It is important for a Non-Network Layer RDT to know through which RF control station the IP host can be reached.

2. The radio sends the message to the RF control station which forwards the message to WNI.

3. The message is passed to the WNI network layer along with the number of the receiving WNI port. WNI converts the port number to the IP address of the host, and routes the message to the CAP Board.

4. The CAP Board forwards the message to the host using its Ethernet Address. If the CAP Board does not know the host's Ethernet Address, it uses ARP to ask the host.

DATA COLLISIONS

A collision occurs when a data message collides with another message on the same physical data link. Depending on the timing of the two messages, the collision can happen in the RF control station or radio/RDI. Collisions waste network bandwidth and reduces the system throughput. To reduce the number of collisions, you can perform one of the following:

1. Configure the application so that it sends the next message to RDT after it receives the acknowledgment for the current pending message.

2. Partition the Data Advantage ports into inbound-only and outbound-only ports. RDTs would then send messages only through the inbound-only ports and Data Advantage would send messages only through the outbound-only ports. This avoids the collision in the RF control stations.

3. Reduce simultaneous inbound and outbound data traffic when possible.

4. Configure the Error Retry Count and Error Retry Delay parameter in Data Advantage and/or the RDT.

MESSAGE FLOW WITHIN THE EDACS SYSTEM

RADIO ORIGINATED MESSAGE

Figure 12 shows a simplified call sequence diagram for a radio-to-host data message transfer.

```
RDT        RDI        Radio      Site       RF Ctrl      WNI      Host

     1 --->

                2 --->

     <--- 3

                         4- --->

                         <----5

                        6----------->----------->
                         <----------<------------

                <--- 7

                                              8 ---------------------------->

    <--- 9
```

Figure 12 - RDT-to-Host Data Call Sequence Diagram

1) The Radio Data Terminal begins transferring a message to the RDI using RDI 1.92 protocol.

2) The RDI begins pipelining the message to the radio using Mobile Signaling Protocol.

3) The RDI acknowledges to the RDT that it has successfully received the message. This may occur earlier or later depending on the size of the message.

4) The radio informs the site that it has a message to send.

5) The site assigns a working channel and informs the radio.

6) The radio breaks the message down into packets and sends the first burst of packets to the site. The site repeats the burst to the receiving RF control station as it receives it. After the RF control station receives the entire burst, it sends an Ack Map back to the radio, informing it of the packets it correctly received.

   If necessary, the radio sends another burst containing packets that Data Advantage did not correctly receive and packets that the radio has not previously sent. This sequence continues until Data Advantage receives the entire message or until the radio exhausts its retries.

7) The radio tells the RDI the status (success or error) of the message transmission to Data Advantage across the EDACS network.

8) The RF control station forwards the message to WNI, and from there the message is routed to the host via CAP. The message transfer from Data Advantage to the destination proceeds independently of any other signaling from the RDT.

9) If requested, the RDI tells the RDT whether Data Advantage successfully received the message or not. Note that the RDT does not receive any direct confirmation that the host successfully received the message.

RADIO DESTINED MESSAGE

Figure 13 shows a simplified call sequence diagram for an IP host-to-radio message transfer. Note that for a radio destined call, Data Advantage always expects an ACK from the RF control station.

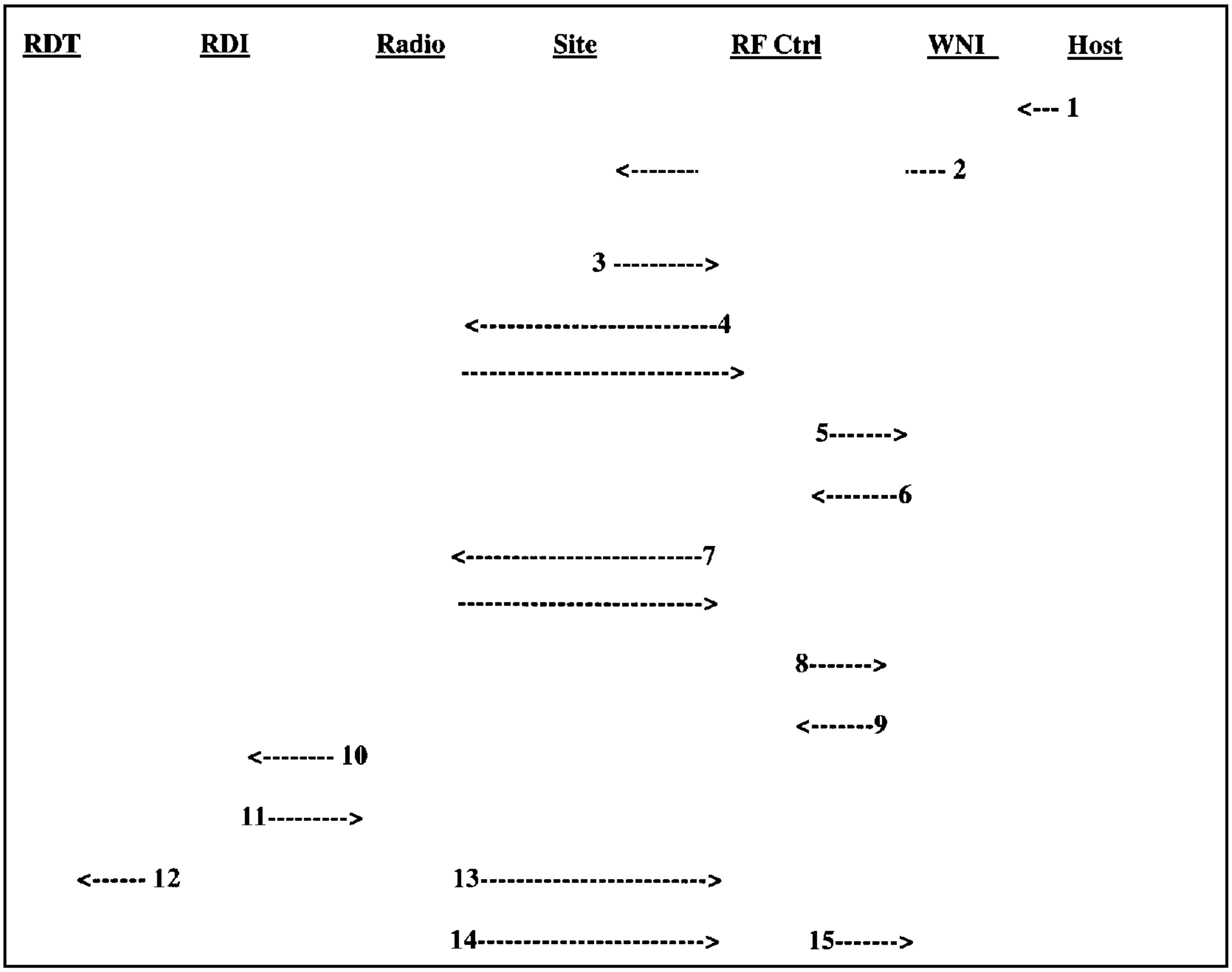

Figure 13 - Host-to-RDT Call Sequence Diagram

1) The host sends a message to Data Advantage.

2) Data Advantage allocates a WNI port for call processing and sends a call request through that port to the RF control station. The RF control station then sends a channel request to the site.

3) If a working channel is available, the site returns a channel assignment to the RF control station, and tells the RF control station to go to the working channel to transmit the message.

4) The RF control station breaks the message down into packets and sends the first burst of packets to the site. The site repeats the burst to the radio as it receives it. After the radio receives the entire burst, it sends an ACK Map back to the RF control station, informing it of the packets that the radio correctly received.

   If necessary, the RF control station sends another burst containing packets that the radio did not correctly receive and/or packets that the RF control station has not previously sent. This sequence continues until the radio receives the entire message or until the RF control station uses up the allowed number of retries.

5) If RF control station exhausts its retries, it will inform WNI that the message has failed.

6) Depending on the configuration, WNI retries the message as many times as configured, the default value is zero (no error retry).

7), 8) and 9) These steps repeat the steps 4), 5) and 6).

10) The radio sends the message to the RDI.

11) The RDI acknowledges to the radio that it has successfully received the message.

12) The RDI forwards the message to the RDT.

13) Radio sends a final ACK Map to the site which repeats the ACK Map to the RF control station.

14) Upon seeing the final ACK the site informs the RF control station of the success of the message and drops the channel.

15) The RF control station sends a positive acknowledge to the WNI to inform the WNI of the call success. The WNI can then free the port.

OPTIMIZATIONS

MAXIMIZING RF EFFICIENCY

In most configurations, the RF link has the lowest effective data transfer rate. Normally, it is also the most expensive area to add capacity. Several methods can be used to maximize through put.

1. Minimize the amount of data being sent over the air. Maintance of forms and other static information at the RDT is one method of accomplishing this.

2. Keep duplicate or unnecessary acknowledgments to a minimum.

3. If possible, send one 500 byte message instead of two 250 byte messages. Unlike systems that use dedicated resources, Data Advantage and the radio must establish a link for each individual message.

4. If messages are larger than 512 bytes, split them on 511 byte boundaries, if possible. For example, a 600 byte message would be split into a 511 byte message and an 89 byte message. If Data Advantage receives a large message from an IP Host computer, it will perform this optimization.

5. Minimize collisions caused by trying to send and receive data on a radio or RF control station at the same time. If a host computer is expecting to receive a reply to a message, no other messages should be sent to the same radio while the host is waiting on the response.

If the RDTs are using END, the EDACS Network Driver User's Manual lists the optimal configuration parameters for the recommended third party IP Products.

LOAD DISTRIBUTION FOR RADIO ORIGINATED MESSAGES

If Data Advantage is configured with two WNI Boards, throughput may be improved by rotoring radio originated calls through the available RF control stations to distribute the load. Data Advantage accepts radio originated messages using two methods, depending on whether or not the RDT is using a network layer.

RDTs With a Network Layer

RDTs that use a network layer can send messages to any one of the EDACS addresses assigned to the RF control stations. Data Advantage uses the IP Address in the EDACS Network Layer Header to forward the message to its real destination. This allows RDTs to use the full IP Address range.

If the EDACS Network Driver is being used, it sequences through a list of all, or a subset of existing RF control stations. The list should be so configured that the load of radio originated calls is distributed evenly among the available WNI boards. Note that RDTs should not send messages through the RF control stations connected to outbound-only ports to avoid collision.

RDTs Without a Network Layer

RDTs that do not use a network layer send messages to the EDACS Address of one of the RF control stations. The RDT must have the knowledge about through which RF control station(s) it can send messages to a specific host.

Rotoring can be accomplished if multiple ports are associated with a single host. The RDTs would then sequence through the corresponding RF control stations associated with that particular host.

COMPONENT DESCRIPTION

Data Advantage consists of a VME based multi-processor computer with a terminal, and four or eight RF control stations with power supplies.

The VME computer consists of a general purpose microcomputer board and multiple microprocessor-based intelligent serial communications controllers. These microcomputer boards communicate over an industry standard VMEbus backplane. The computer system also includes mass storage devices for storing system information.

The four or eight RF control stations are installed in two or four radio shelves with each radio shelf housing two RF control stations. The cables within the radio shelves connect the signal, DC power from the power supply, VME computer and RF control stations. There is a cooling fan for each RF control station.

One or two external power supplies power the RF control stations in Data Advantage cabinet. The power system performs AC/DC conversion. The main output of each power supply is connected to a power distribution panel which provides up to seven 13.6 VDC outputs to RF control stations (only four are used).

CENTRAL ACTIVITY PROCESSOR (CAP)

Using the 68030 microprocessor, the CAP Board is a general purpose computing board that provides typical computer peripheral interfaces for Data Advantage. These include disk facilities through a Small Computer Systems Interface (SCSI) bus; a Centronics parallel printer connection; an Ethernet connection; and four serial port interfaces for ASCII terminals.

In addition to providing the Ethernet/IP interface and servicing the Data Advantage peripherals, the CAP reads the configuration file and loads application software and configuration parameters onto other processor boards in the system. Finally, the CAP processes commands from the diagnostic terminal.

The Reset button resets Data Advantage. The Abort button is disabled.

During normal operation the CAP indicators display the following:

INDICATOR	Mode	INDICATES
FAIL	OFF	No board failure.
STATUS	Flickers	CPU activity.
RUN	Flickers	Local bus activity.
SCON	ON	Board is VMEbus Master.

Table 3 - LED’s On The CAP Board

Adapter Board

The Adapter board is a small circuit board that routes the I/O signals and grounds from its concentrated VME bus backplane connector (P2) to the Transition Module. The board plugs directly onto the rear of the backplane and has two mass termination connectors. Two ribbon cables carry the I/O signals from these connectors to the transition module. Also, the Adapter Board has sockets for SCSI terminating resistors if the Adapter Board's SCSI interface is at the end of the SCSI bus.

Transition Module

The Transition Module is a separate circuit board that receives the I/O lines from the P2 Adapter Assembly ribbon cables and routes them to the appropriate industry standard connector on its panel. The I/O Transition Module has four DB-25 connectors for serial I/O, a 50-pin SCSI port connector, a DB-15 connector for Ethernet, and a Centronics compatible printer connector. Jumpers on the I/O Transition Module allow the serial ports to be configured as DTE or DCE. Like the P2 Adapter Assembly, the I/O Transition Module has sockets for SCSI terminating resistors.

VCOM24 SERIAL COMMUNICATIONS CONTROLLER

The VCOM24 is a high speed serial communications controller that supports Data Advantage's serial interfaces. The Wireless Network Interface (WNI) is implemented on VCOM24 board. Powered by a 68020 microprocessor and two serial communications controllers, the VCOM24 offers four full-duplex serial ports that support asynchronous or byte-synchronous protocols.

The Reset button resets Data Advantage. The Abort button is disabled.

During normal operation the VCOM24 Status indicators display the following:

INDICATOR	Mode	INDICATES
RUN	Flickers	Local bus activity.
HALT	OFF	Board is not halted.
SYSFAIL	OFF	No board failure.

The **Boot Sequence** section of the Data Advantage Installation and Maintenance Manual explains the meanings of the eight small LEDs.

The eight dip switches are not used and can be set to any combination.

VMEADAPT Module

The VMEADAPT Module is a small circuit board that connects the I/O signals from the VCOM24's P2 connector to the SCI-232 modules (see below). The board attaches directly to the rear of the backplane and has four mass termination connectors. Four ribbon cables distribute the serial interface signals (RxD, RxC, TxD, TxC) and modem control signals (DCD, DTR, RTS, RI, CTS) from these connectors to the four SCI-232 modules.

SCI-232

An SCI-232 module converts serial I/O signals from TTL to RS-232 voltage levels and routes them to a DB-25 connector. One VCOM24 needs four SCI-232 modules to support all four ports. The SCI-232 module includes jumpers to configure the port as DCE or DTE.

Backplane

The processing cards communicate over an industry standard VME bus backplane. The backplane has slots for seven circuit boards. The first and last slot are terminated on the rear of the backplane as per the VMEbus specification.

FIXED DISK DRIVE

The fixed disk drive has a formatted capacity of 1 GB. It is used for Data Advantage software, configuration files, statistics, and activity logs. The drive has a 3.5" form factor and has an internal SCSI bus controller. The hard disk formatting is proprietary and is not compatible with MS-DOS.

FLOPPY DRIVE

The floppy disk drive has a 3.5" form factor and supports floppy disks with an MS-DOS compatible formatted capacity of 2 megabytes. The floppy disk drive is provided for transferring files to and from the hard disk.

DIAGNOSTIC TERMINAL

Data Advantage includes a VT100 compatible terminal that connects to a serial port on the CAP board. Using this terminal, the system operator can view or print the Data Advantage configuration and error log, shutdown and restart Data Advantage. See the Data Advantage User’s Reference Manual for information on the commands available from the Diagnostic Terminal.

One Diagnostic Terminal is directly connected to Data Advantage. Data Advantage can be configured to allow zero to four terminals to remotely log in at the same time using Telnet. Access to the Diagnostic Terminal is restricted by user-id and password. User-ids can be added and removed by the customer. Passwords can be changed by the customer.

Some Diagnostic Terminals do not save their tab settings between power cycles. The tab settings should be restored to the default (tab every 8 columns) after each power cycle.

Some of the Diagnostic Terminals have a Block Mode key near the enter key. Pressing this key disables the terminal until it is pressed again.

RF CONTROL STATIONS

There are two or four RF control station shelves, depending on if it is a four-port or eight-port Data Advantage. The radio shelves are rack mountable subassemblies. Each shelf houses two EDACS mobile radios with built-in Radio Data Interface (RDI). The RF control stations provide an RF data path between Data Advantage and the EDACS Network. There is one RF control station per WNI port. The RF control stations are mobile-data feature encrypted in the factory.

RF CONTROL STATION POWER SUPPLY

Data Advantage has one (four port system) or two (eight port system) dedicated power supplies to power RF control stations. Each power supply is connected to a power distribution panel that provides seven 13.2 VDC outputs to the RF control stations.

FAN

A removable fan tray positioned directly under the card cage cools Data Advantage circuit boards. The fan tray has five air movers that provide an air flow of 250 CFM and use ball bearings for high reliability. A front access filter can be removed and replaced without removing the fan tray from the rack.

SPECIFICATIONS

SYSTEM INTERFACES

WNI / EDACS Interface

Physical Layer	Up to eight RS-232 serial interfaces at 19,200 bps
Data Link Layer	RDI Protocol, version 1.92

RDT / EDACS Interface

Physical Layer	RS-232 serial interfaces at 9600 bps
Data Link Layer	RDI Protocol, version 1.92
Network Layer	EDACS Network Layer (selectable on a per unit and group basis)

Internet Protocol Host Interface

Physical Layer	DB15 AUI Ethernet Connector
Data Link Layer	Ethernet II, aka IEEE 802.3 DIX
Network Layer	Internet Protocol (IP), Version 4

VME COMPUTER SYSTEM

General Specifications

Diagnostic Terminal	RS-232 serial interface supporting VT100 type terminals or remote access via Telnet
Printer	Centronics parallel printer interface
Drives	1 GB fixed disk drive with SCSI interface 2 megabyte, 3.5" removable diskette drive with SCSI interface. MS-DOS format diskettes supported.
EMI Regulations	Conforms to FCC 20780 Part 15 Subpart J, A, and EN 55022 Class B
Safety	Conforms to EN 60950, UL 1459, and CSA 225

VME Chassis Power Supply

Input Voltage (Autosensing)	110 VAC ± 10%, 60 Hz 220 VAC ± 10%, 50 Hz single phase
Output Voltage	± 12 volts DC at 10 amps each + 5 volts DC at 100 amps
Remote Sense	For all three channels
Over Voltage Protection	120% to 130% of nominal output on all channels
Over Current Protection	On all channels
Line Regulation	0.2% of rated output
Load Regulation	0.8% of rated output
Ripple	1% peak to peak at 50 MHz
Dynamic Response	3% max. deviation to 25% - 75% step change
Filtering	Power line filter and internal filter for conducted emissions
Status Indicators	AC "POWER ON" indicator

Status Inputs and Outputs

Board LEDs	
General Purpose CPU	FAIL, STATUS, RUN, and SCON
Intelligent Serial I/O Controller	RUN, HALT, and SYSFAIL
Drive LEDs	Disk activity lamps on both drives
Fan LED	12 VDC power indicator lamp
Remote Reset Input Connector	Shorting the Remote Reset pins on front panel of CAP Board forces a system RESET

Environmental

Temperature	
Operating	0 to + 40 degrees C
Non-Operating	-20 to +85 degrees C
Humidity	to 95% noncondensating (except for removable diskette drive

Diagnostics

Error Detection	Run-time errors logged in a file for viewing or printing.
System Configuration	Configuration file can be viewed from the Diagnostic Terminal.
Controlled Shutdown	System operator can cause a graceful system shutdown so calls in progress are completed

RF CONTROL STATIONS AND POWER SUPPLIES

RF Control Station / Power Supply	
Input Voltage Range	120 VAC ± 20%
Input Frequency Range	60 ± 2 Hz
Output Voltage Range	13.2 VDC ± 0.6
Transmitter	8 Watt Output (13.6 VDC)
Power Level at Antenna Connector	6 Watt
Safety	UL 1459, CSA 225

OTHER SYSTEM DATA

Physical (EGE Standard Cabinet)

Cabinet Colors	
Housing	Light Gray
Trim	Black
Cabinet Dimensions	
Height	69 1/6" (175.5 cm)
Width	24" (61 cm)
Depth	24" (61 cm)
Material	16 gauge cold rolled steel

Regulatory Data

Radiated EMI	FCC Part 15 Class B
Conducted EMI	FCC Part15 ClassB

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