Technical Description

EDACS®
Data Gateway

ERICSSON

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PREFACE

This is one of four manuals for the Ericsson **E**DACS® **D**ata **G**ateway (**EDG™**). It contains a detailed description of the EDG capabilities, interfaces and hardware. Other relevant documents are:

EDG Installation and Maintenance (LBI-38962B)*:*
This manual contains installation and trouble shooting information. This manual also includes the boot sequence and network planning.

EDG User's Reference Manual (LBI-38963B)*:*
This manual contains information for using the EDG command shell. The command shell services the Diagnostic Terminal and Telnet logins.

EDG Configuration Reference Manual (LBI-38964B)*:*
This manual documents the commands used to configure the EDG.

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 Installation Instructions (LBI-39120):
This manual documents installation of the EDACS Network Driver product. 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.

Mobile Data Terminal Interface, Hardware and Protocol, Version 1.92
This manual documents the RDI Interface. Contact Ericsson for more information.

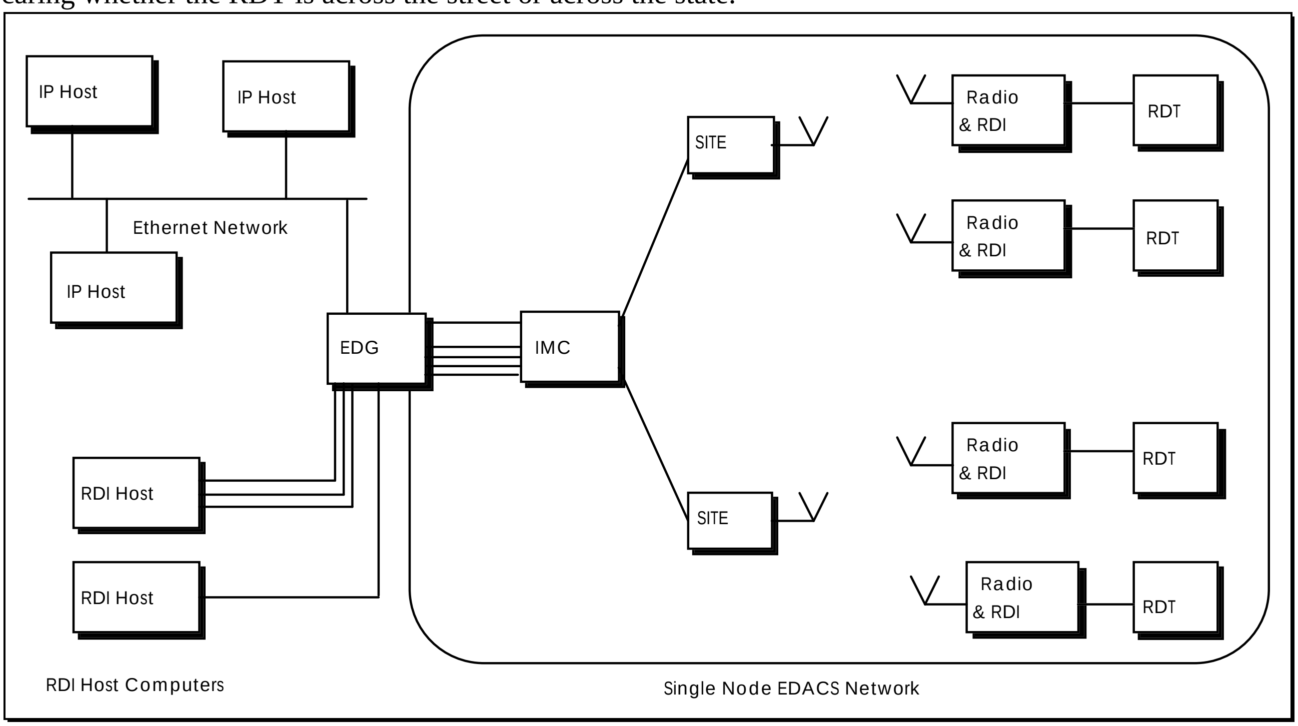
OVERVIEW

The Ericsson **E**DACS **D**ata **G**ateway (**EDG**) allows **R**adio **D**ata **T**erminals (**RDT)** to communicate with stationary host computer equipment and other RDTs through the EDACS trunked two-way radio system.

The block diagram below gives an overview of the equipment that can be used when passing data. The EDG connects to host computers using **I**nternet **P**rotocol (**IP**) over Ethernet and/or **R**adio **D**ata **I**nterface (**RDI)** protocol over RS-232 serial links. The EDG connects to the rest of the EDACS System through either an **I**ntegrated **M**ulti-site **C**oordinator (**IMC**), for multi-site systems, or a **C**onsole **E**lectronics **C**ontrol (**CEC**) for single site systems (not shown). RDTs use the 9600 bps serial interface of the RDIs to connect to radios. Depending on the radio, it can contain an internal RDI or use an external RDI.

The EDG provides the ability to send data across multiple RF sites. The EDG manages speed, addressing, and protocol differences so that IP Host Computers on a **L**ocal **A**rea **N**etwork (**LAN**) can communicate with radios on an EDACS **W**ide **A**rea **N**etwork (**WAN**). In addition, the EDG can be configured to minimize or eliminate custom communications software.

In large EDACS Networks with multiple nodes (EDGs, IMCs and Sites), EDGs can be configured to support transparent roaming. The EDGs forward radio destined messages as radios move between the nodes using tracking information supplied by the IMCs. In addition, the EDGs ensure that radios addresses remain constant regardless of location. These measures allow hosts and RDTs to communicate without knowing or caring whether the RDT is across the street or across the state.



Equipment Overview

FEATURE LIST

The Ericsson EDACS Data Gateway supports the following features:

- Call Types:
  Individual Data Call.
  Host Originated Group Data Call (Single site, Multi-site, or Multi-node).
  Radio-to-Radio Data Calls (via the EDG).

- Non-Proprietary Host Computer Interface (64K bytes per message):
  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).

- Proprietary Host Computer Interface (512 bytes per message):
  Host can receive a positive acknowledgment when the radio receives the message.

- Protocol Conversion:
  The EDG converts data messages, addresses, and error messages between the various interface types.

- Transparent Roaming:
  EDGs, in conjunction with IMCs, track radios as they move between MultiLink/StarGate nodes. EDGs automatically route Individual Data Calls to a radio, regardless of its location. Group Data Calls can be repeated on one or more nodes.

- Flow Control and Queuing:
  The EDG manages the speed differential between the various interface types. Configurable queues and message timers are available for messages destined for radios and RDI Hosts. The IP Host interface does not require queuing due to the 10MHZ speed of the interface.

- Robust Operation:
  The EDG continues call processing when an EDACS System is in Failsoft.
  The EDG helps prevent data corruption due to radio biasing.

- Flexible Configuration:
  The EDG is configured using an ASCII text file. The configuration can be verified on an MS-DOS PC.

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

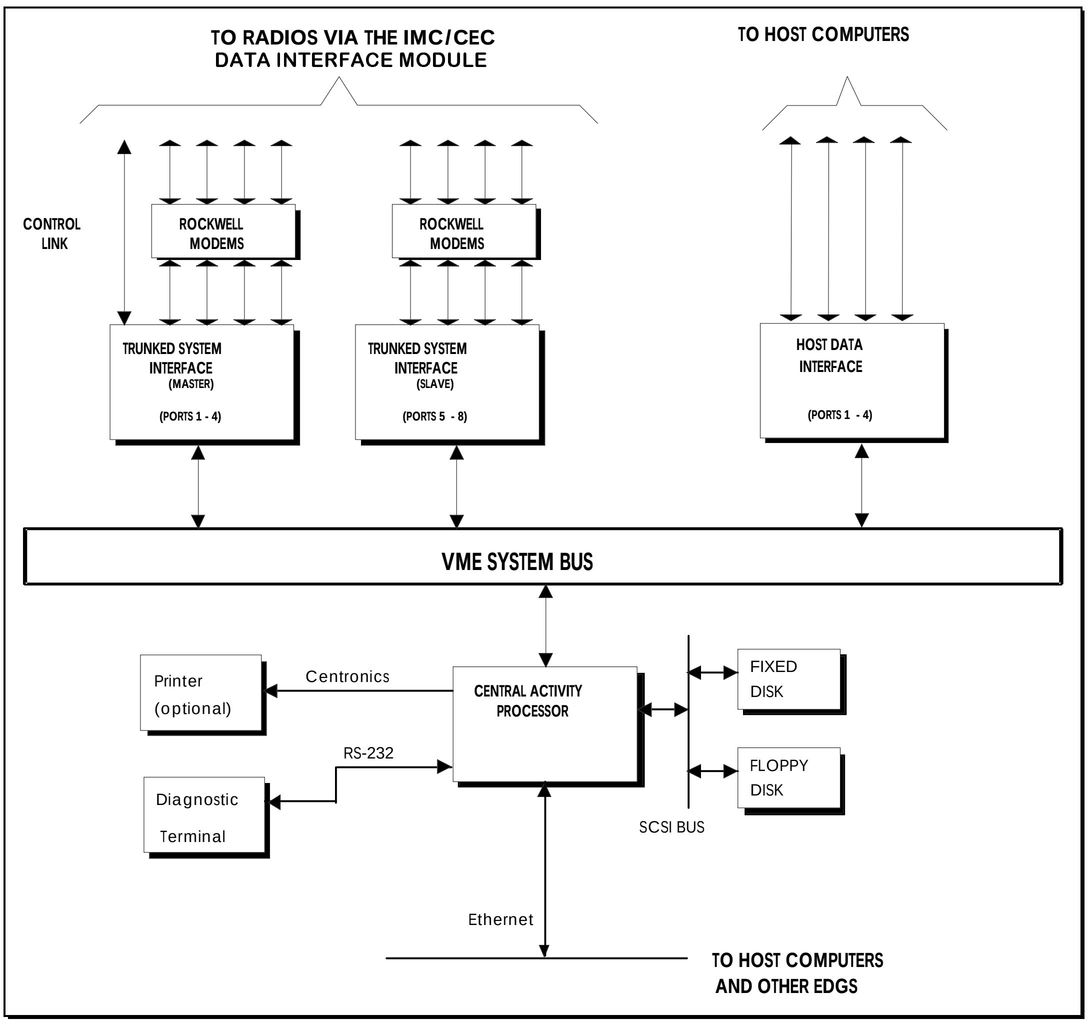
- Remote Login and File Transfer:
  The EDG can be accessed using Telnet to login or FTP for file transfer.
  Remote Software Upgrades are supported.

- Statistics Gathering and Display:
  The EDG maintains loading statistics that can be displayed and cleared as desired.

SYSTEM ARCHITECTURE

The block diagram below shows the system architecture of the EDACS Data Gateway and its external interfaces. The EDG can be configured with either an IP Host Interface, RDI Host Interfaces, or both. The TSI, HDI, and CAP boards communicate over the system bus.

One or more **T**runked **S**ystem **I**nterface (**TSI**) Boards handle all communications to the rest of the EDACS trunked radio system. The **C**entral **A**ctivity **P**rocessor (**CAP**) provides the IP Ethernet Interface to host computers and other EDGs. The CAP also provides system services such as disk I/O, printing, and the local Diagnostic Terminal interface. Optional **H**ost **D**ata **I**nterface (**HDI**) Boards provide an interface to host computers using RDI Protocol.



Internal EDG Architecture

TRUNKED SYSTEM INTERFACE (TSI)

TSIs connect to the rest of the EDACS System through one or more **D**ata **I**nterface **M**odules (**DIM**) in the IMC. The TSIs and IMCs exchange control messages over the control link at 19.2k or 9.6k bps. The TSIs and sites send data through the Rockwell Modems at 9600 bps.

Each TSI can provide up to four communication ports. Each communication port can handle one data call at a time. TSIs can be used in pairs, with one designated as the Master and providing the control link to the IMC or CEC. This allows two TSIs to share a single DIM Controller, reducing the IMC hardware required without reducing throughput. The EDG and EDACS Sites send data calls over audio lines using Rockwell Modems.

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 optional interface to host computers and other EDGs using **I**nternet **P**rotocol (**IP**) over Ethernet.

HOST DATA INTERFACE (HDI)

Each HDI Board can support up to four ports. The ports are individually assigned to hosts, allowing a single HDI to support multiple hosts, multiple HDIs to support a single host, or multiple HDIs to support multiple hosts.

EDG SIZING

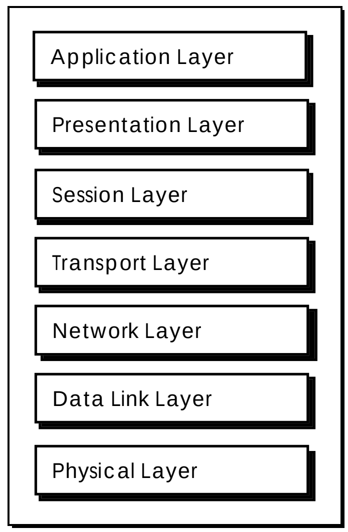
The number of TSI Boards should be selected based on the expected load. This should include expected messaging between IP Host Computers and radios, between RDI Host Computers and radios, and between radios.

While most configurations only require two or three TSI and HDI Boards, an EDG can support up to eight TSI or HDI Boards. For example, if only IP Host Computers are used, up to eight TSI Boards could be used. If RDI Host Computers are used, up to four TSI Boards and four HDI Boards could be used. If both host interfaces are used, a full EDG might consist of five TSI Boards and three HDI Boards.

NETWORKING CONCEPTS

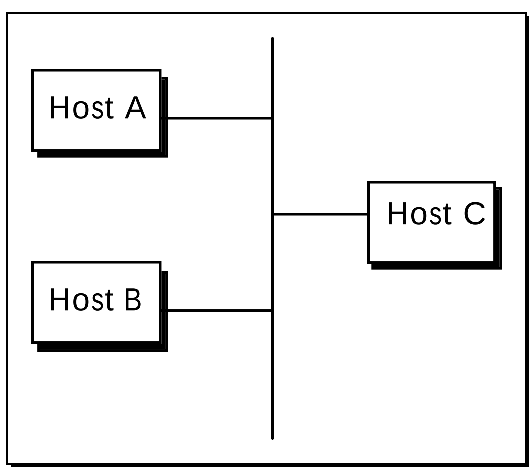
SINGLE NETWORKS

For the purposes of this discussion, a network is a physical media and protocol that allows multiple devices to communicate. In the terms of the International Standards Organization's Open System Interconnection Reference Model (OSI Model), these are the Physical and Data Link Layers.



OSI Model

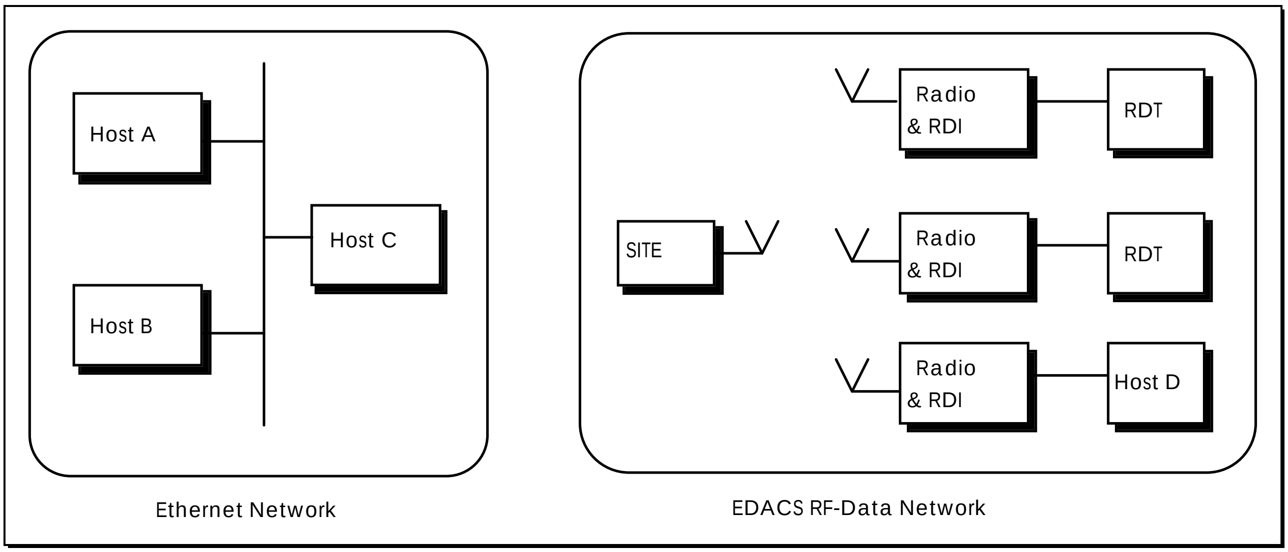
Any device wishing to communicate with devices on a network must directly connect to the network using an interface that is compatible with the network. A simple network could connect three host computers to each other using Ethernet.



Ethernet Network

Each of the devices would physically connect to the Ethernet cable. They would communicate with each other using Ethernet Addresses and 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, **R**adio **D**ata **T**erminals (**RDT**s) could not be used in mobile applications if they were connected to an Ethernet cable running through a building. This leads to multiple network types to solve different networking needs.



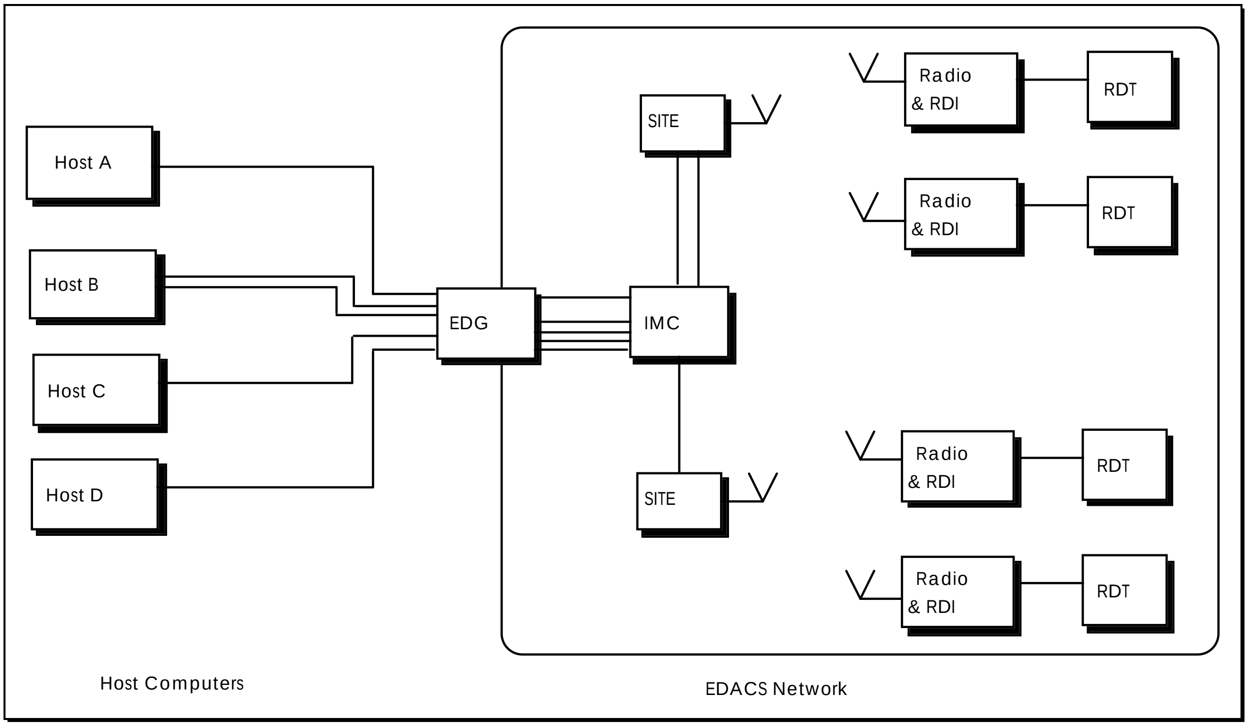
Two unconnected networks

The devices on the Ethernet Network use Ethernet cable as their physical media and use Ethernet Addresses and protocol to communicate. The devices on the EDACS RF-Data Network use radio frequencies as their physical media and use EDACS Addresses and 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. The EDG provides two solutions to this problem that can be used individually or together.

BRIDGING HOSTS AND EDACS NETWORKS

The EDG can be used as a bridge between RDTs on an EDACS Network and host computers using the RDI Host Data Interface.



Host Computers Bridged to an EDACS Network

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

1. Host computers and RDTs can communicate regardless of the RF site that the radio is logged into.

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

3. Host computers and their applications can easily be migrated from single site EDACS RF-Data Networks to bridged networks.

4. Host computers can receive a positive acknowledgment that their message has been received by the radio.

5. RDI Protocol can be implemented in RDTs with limited processing power.

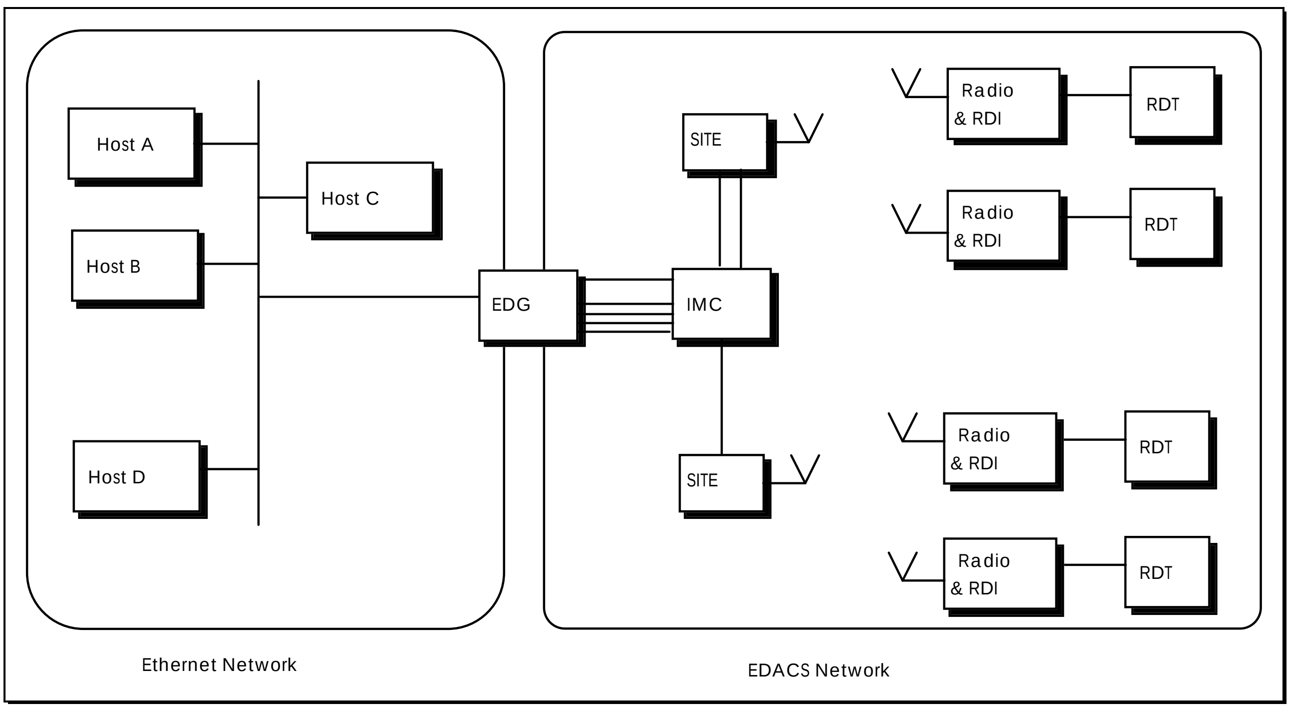
6. Several third party message switches (protocol converters) exist based on this configuration.

CONNECTING MULTIPLE NETWORKS

The EDG can also be used as a gateway between EDACS Networks and host computers on an Ethernet Network. Connecting multiple networks is known as **Internetworking,** even if the networks are the same type**.** 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 consistent addressing method, protocol, and interface across the internet.

While the network layer address provides a consistent 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.



Internetworking using an EDACS **D**ata **G**ateway (**EDG**)

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

1. Host computers and RDTs can communicate regardless of the RF site that the radio is logged into.

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

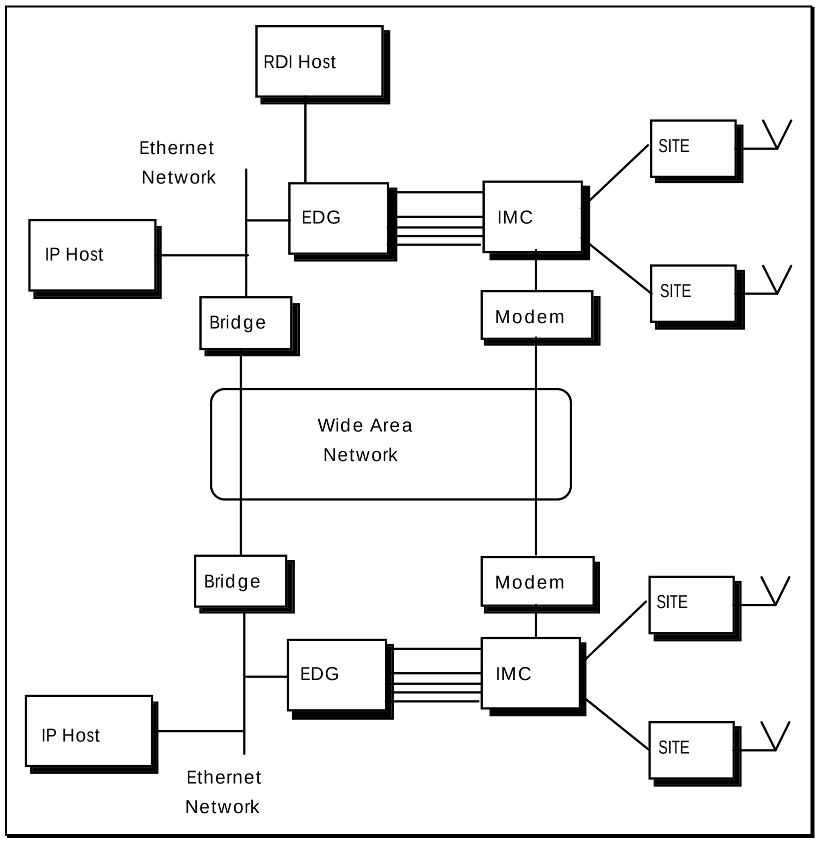
3. The EDG connects to the host computer using non-proprietary protocols. This reduces the amount of custom software required.

4. The EDG is compatible with the **E**DACS **N**etwork **D**river (**END**) software for the RDT. This allows the use of off-the-shelf IP protocol stack products. In this configuration, applications written for TCP and UDP can be used or developed.

CONNECTING MULTIPLE EDACS NODES

EDGs can be used with multiple EDACS Nodes to re-route data as radios move between them. Data is re-routed transparently to the applications on the hosts and radios. The EDGs support multiple EDACS Nodes regardless of whether the hosts are connected using Bridging or Internetworking.

When an EDG receives a message for a group of radios, the EDG forwards the message to all other known EDGs. Each EDG optionally repeats the group message on its EDACS Node based on the EDG's configuration.



Connecting Multiple EDACS Nodes using EDGs

Each EDACS Node contains Sites, an IMC, and an EDG. Typically, these nodes service different areas and are connected via routers, bridges, or modems. The EDGs use their IP Host Interfaces to re-route messages to radios. The EDGs operate independently of the throughput of the connection between them.

The IMCs are connected in a MultiLink or StarGate configuration. Control lines between IMCs are used to track radio movements. Optional audio lines can be used for voice calls. The IMCs can use modems over a separate network (as shown) or they can use the same network as the IP Hosts and EDGs using line sharers or terminal servers.

Each EDACS Node is a separate network to IP Host Computers and the Customer Network. This gives the EDACS Network consistency with Internetworking routing and addressing philosophy.

INTERFACE SPECIFICATION

RDI HOST DATA INTERFACE

Protocol Layers

RDI Hosts physically connect to EDG **H**ost **D**ata **I**nterface (**HDI**) ports using one or more 9600 bps asynchronous serial links.

The data link layer supports RDI Protocol. Version 1.92 is recommended for new applications. Versions 1.91 and 1.8a are supported for existing applications. In addition to the standard RDI Protocol features, the minimum time before retrying a message is not a fixed 45 seconds. The EDG can be configured to raise or lower this time. For more information, see the MSG_TIMEOUT command in the EDG Configuration Reference Manual (LBI 38964). If the RDI Host is using MS-DOS, the CommServ product can be used to reduce the coding effort. The *EDACS CommServ Programmers Guide* lists the minimum requirements for using CommServ.

There is no network layer on RDI Hosts. While it is doubtful that an RDI Host would be used to communicate with an RDT with a network layer, there are no restrictions to prevent this. In this case, the EDG would add the network layer for messages to the RDT and strip the network layer for messages from the RDT.

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.

Addressing

RDI Hosts and radios communicate using EDACS Addresses. EDACS Addresses can be assigned to hosts, individual radios, and to groups of radios.

Acknowledgments and Error Reporting

The RDI Host receives a positive or negative acknowledgment from the HDI when it receives a data transfer request (**XFERB**) and again when the HDI receives the message. If selected in the data transfer request, the RDI Host also receives confirmation based on the reception of the message by the radio/RDI. There is no positive or negative acknowledge back to the RDI Host after the message leaves the radio.

If the RDI Host does not request confirmation, the EDG frees the host port immediately after the data transfer between the EDG and the host is complete. If the RDI Host Computer does request confirmation, the EDG frees the host port after returning the confirmation.

If an error occurs, it may be logged at the EDG, another EDACS component, the radio, or at the RDI, depending on the type of the error.

Queuing and Flow Control

Each HDI board has approximately 300K bytes of buffer space for queuing messages to the host computer. The HDI uses this queue when all of the ports to the host are busy. Conversely, the TSIs queue messages to radios, if necessary.

If an RDI Host Computer and the EDG try to initiate a data transfer over the same port at the same time, the EDG queues its message and services the host's transfer first. When a port frees up, the EDG sends out the message that the host preempted before sending out any other queued messages.

IP HOST INTERFACE

Protocol Layers

The EDG has a DB15 AUI Ethernet Connector. A standard off-the-shelf IEEE 802.3 transceiver is used to connect the EDG to either a thick coax, thin (BNC) coax, or twisted pair (10BaseT) Ethernet. The transceiver is purchased separately based on network requirements.

The data link layer uses Ethernet II Protocol. This is also known as IEEE 802.3 DIX. The EDG does not support standard IEEE 802.3 Ethernet Protocol 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. Except for the following, the EDG fully supports the major features of the Internet Protocol:

1. Subnetting is not supported at this time.

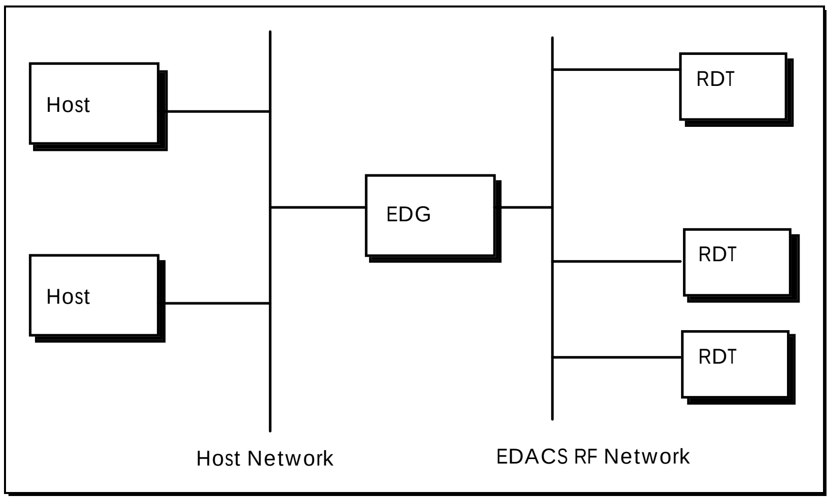
2. A Host ID of all ones does **NOT** refer to all radios on an EDACS network.

The protocols above the network layer are end-to-end conversations between the host and RDT. Any headers they use are simply passed as data through the EDACS Network. Except for the *Transport Layer Protocol* when the RDT is using a Null Network Layer, the upper protocols are of no concern to the EDACS System. The *RDT Interface* section explains this more fully.

Addressing

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

The *EDG Installation and Maintenance Manual* contains information on the format of IP Addresses and assigning them.



Simple Configuration as seen by the Host

At the data link layer, the EDG and host computers communicate using Ethernet Addresses. The host computers and the EDG 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 each radio and group. Normally, the host has a single entry added to its routing table instructing it to use the EDG's 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, the EDG 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 an error occurs after the EDG receives a message and before the radio acknowledges the receipt of the message. Unsuccessful messages may generate one of the following error indications:

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

2. **I**nternet **C**ontrol **M**essage **P**rotocol (**ICMP**) messages. The EDG or another component in the host network may return ICMP messages. If an error occurs sending an ICMP message back to the host, the ICMP message is dropped. The *EDG Installation and Maintenance Manual* contains a list of the ICMP Messages that the EDG 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 the EDG. Logging can be enabled for several levels of severity. See the log command in the *EDG User's Reference Manual* for more information.

5. Errors logged by other EDACS components such as the IMC, Site Controller or radio/RDI.

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

Queuing and Flow Control

The EDG's IP Host Interface uses several queues to send and receive IP fragments. Under normal conditions, fragments spend very little time in these queues. 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. The EDG 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.

The EDG's configuration tells it which RDTs (radios) 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 the EDG and Radio

The data link layer protocol used between the EDG and the radios is a hardened protocol designed specifically for the RF environment. If necessary, portions of the message are repeatedly transmitted in order to complete the data call. Once a call has been established (working channel assigned), the EDG and radio attempt to get the message through for up to seven seconds.

Queuing and Flow Control

Each TSI Master has approximately 300K bytes of buffer space for queuing messages to radios. Conversely, the HDIs queue messages to RDI Host Computers, if necessary.

If no working channels are available or if the radio is in a voice call, the EDG retries three times at 2 second intervals to get a channel before giving up on the call. If all four attempts fail, the EDG sends the source an ICMP Source Quench message asking it to reduce its output rate.

If the EDG is saturated, it sends the source of the message an ICMP control message asking it to reduce its output rate. The EDG 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 EDG can be configured to support **B**ias **R**eduction **En**coding (**BREN**). Before sending a message to a radio, the EDG encodes the message to balance the number of binary zeros and ones. The receiving RDI decodes the message before forwarding it to the RDT. For radio originated messages, the EDG decodes messages encoded by the RDI. This feature may increase or decrease the overall throughput, depending on the reduction in retries verses the additional BREN overhead.

RDTs without a Network Layer

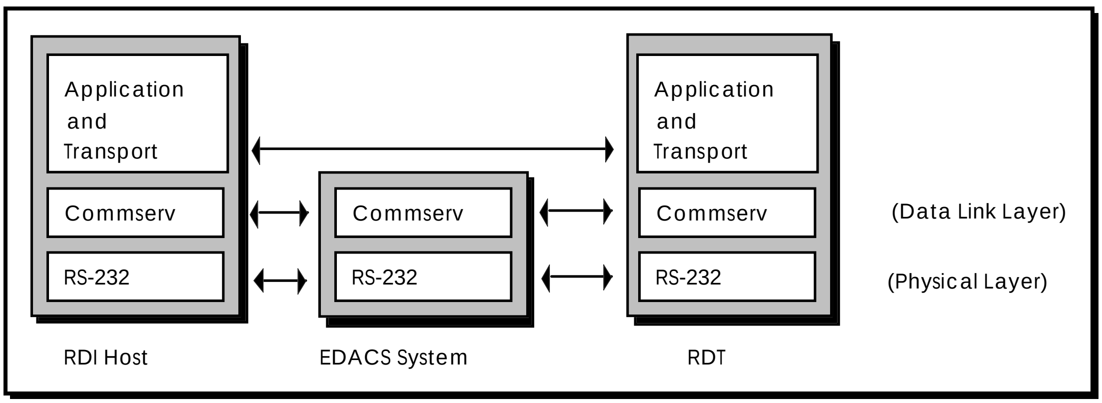
This configuration is useful when communicating with an RDI Host Computer.

Protocol Layers

RDTs physically connect to radio/RDIs using 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. 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.



Typical Protocol Stack with no Network Layer.

Addressing

RDI Hosts and radios communicate using EDACS Addresses at the data link layer. An RDT can access a maximum of sixty-three hosts. The EDG routes the messages to and from the host. The EDG is transparent to both the host and the RDTs. Since there is no network layer, there is no network layer address.

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 on to the desired radio(s).

Acknowledgments and Error Reporting

The RDT receives a positive or negative acknowledgment from the RDI when it receives a data transfer request (XFERB) and when the RDI receives the 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 the EDG. There is no positive or negative acknowledge back to the RDT after the EDG begins sending the message to the host.

If an error occurs, it may be logged at the EDG, another EDACS component, the radio, or at the RDI, depending on the error.

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

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 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 Installation Instructions* contains the correct settings for the 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.

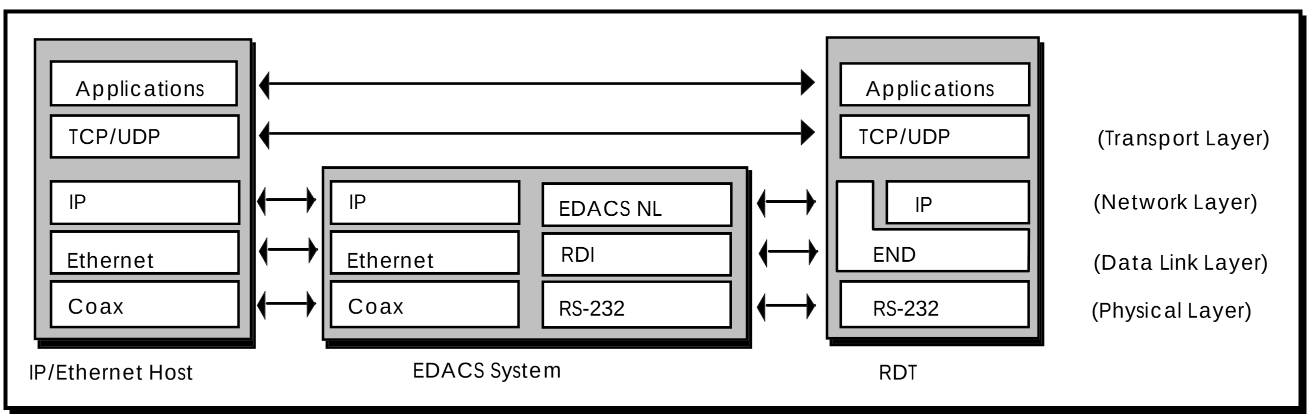
Protocol Layers

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

The data link layer uses the **E**DACS **N**etwork **D**river (**END**). END 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. END converts between IP headers and EDACS Network Layer Headers. END 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.



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, the EDG and radios communicate using EDACS Addresses. For a message to a radio or group, the EDG uses a configuration table to convert the IP Address to the EDACS Address. For messages from radios, the EDG reserves EDACS Addresses one through fifteen. END sequences through these addresses to distribute the load in case the EDG contains multiple TSI Masters. Radios send all of their messages to the EDG, even messages to another radio.

The network layer uses the IP Address to route the message to a host, another radio, or a group of radios. An RDT can access the full range of IP Addressable hosts.

Acknowledgments and Error Reporting

At the data link layer, END uses positive acknowledgment. The RDT receives a positive or negative acknowledgment from the RDI when it receives the data transfer request, when the RDI receives the data, and when the EDG receives the data. There is no positive or negative acknowledge back to the RDT after the data leaves the EDG. END returns the status to the IP product.

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, the EDG, the radio, the RDI, or another EDACS component, depending on the error.

RDTs with a Customer Supplied Network Layer

This configuration is useful if all of the following conditions are true.

1. IP host computers are being used.
2. RDTs that do not support END are being used.
3. Radio-to-radio messages, messages larger than 512 bytes, or multiple transport layer protocols are used.

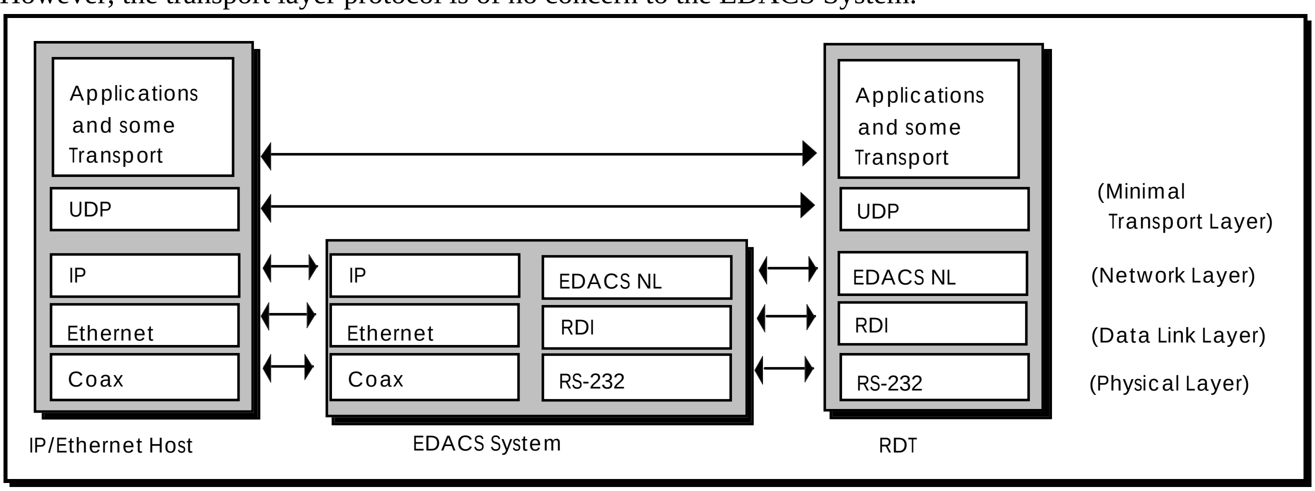
Protocol Layers

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

The data link layer uses RDI Protocol. The EDG automatically allocates EDACS Addresses one through fifteen. RDTs must originate messages to an EDACS Address allocated to the EDG. Sequencing through the addresses on subsequent messages (rotoring) distributes the load in case the EDG has multiple TSI Masters. When an EDG originates a message, it uses an EDACS address assigned to a TSI Master as the source address.

The customer supplies a network layer for the RDT that is compatible with the EDACS Network Layer. The EDACS Network Layer is similar to an IP Network Layer, but has been optimized for use with the EDACS System. A customer supplied network layer must be able to use the EDACS Network Layer Header as well as assemble and disassemble messages into message fragments. Customer Supplied Network Layers must not send ARP, RARP, or BOOTP address information requests to the EDG.

It is expected that a relatively simple transport layer protocol such as UDP would be used above the network layer and that the application would provide some transport layer services such as performing retries. However, the transport layer protocol is of no concern to the EDACS System.



Typical Protocol Stack with a Customer Supplied Network Layer

EDACS Network Layer Header

At the network layer, the EDACS Network Layer Header is the interface between the RDT and the EDG. Network Standard Byte Ordering is used (most significant byte first). The header contains the following fields:

<-------------------------------------- 16 Bits -->

<table>
<tr><td colspan="4">0</td><td colspan="4">4</td><td colspan="4">8</td><td colspan="4">12</td></tr>
<tr><td colspan="4">Vers</td><td>U</td><td>U</td><td>U</td><td>U</td><td colspan="8"></td></tr>
<tr><td colspan="16">Identification</td></tr>
<tr><td>U</td><td>U</td><td>MF</td><td colspan="13">Fragment Offset</td></tr>
<tr><td colspan="16">MSW of Expanded Address</td></tr>
<tr><td colspan="16">LSW of Expanded Address</td></tr>
<tr><td colspan="8">Protocol</td><td colspan="8"></td></tr>
</table>

Vers:

Version Number of the Header. The version number for this format header is 0.

U:

Unused Bits. These should always be set to 0.

Identification:

Number that uniquely defines all of the fragments of the same message from the same source. This field is copied directly to and from the IP Header.

MF:

More Fragments. This bit is set if there are more fragments coming in the current message. This field is used in the same manner as in the IP Header.

Fragment Offset:

This field tells where this fragment belongs in the current message. When a message is fragmented, each fragment except the last one must be a multiple of 8 bytes long. The fragment offset is multiplied by 8 to get the byte offset. The maximum message size is 64K bytes. This field is used in the same manner as in the IP Header.

Expanded Address:

For messages from the EDG, this is the Source IP Address. For messages from the RDT, this is the Destination IP Address.

Protocol:

This field specifies the transport layer on the destination that should receive the message. This field is copied directly to and from the IP Header.

Addressing

The addressing is identical to configurations with a standard network layer on the RDT.

Acknowledgments and Error Reporting

At the data link layer, the RDT receives a positive or negative acknowledgment from the RDI when it receives the data transfer request (**XFERB**), and when the RDI receives the data. The data link layer can select positive acknowledgment when the EDG receives the data.

At the network layer, the RDT 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, the EDG, the radio, the RDI, or another EDACS component, depending on the error.

RDTs with a Null Network Layer

This configuration is useful in situations similar to those where a customer supplied network layer on the RDT would be useful. Both configurations use IP host computers and neither configuration uses END. However, if radio-to-radio messages, messages larger than 512 bytes, and multiple transport layer protocols are not needed, the network layer can be omitted.

The main difference between this configuration and a configuration with RDTs without a network layer is that this is an "unbalanced configuration". The hosts use a network layer, but the RDTs do not.

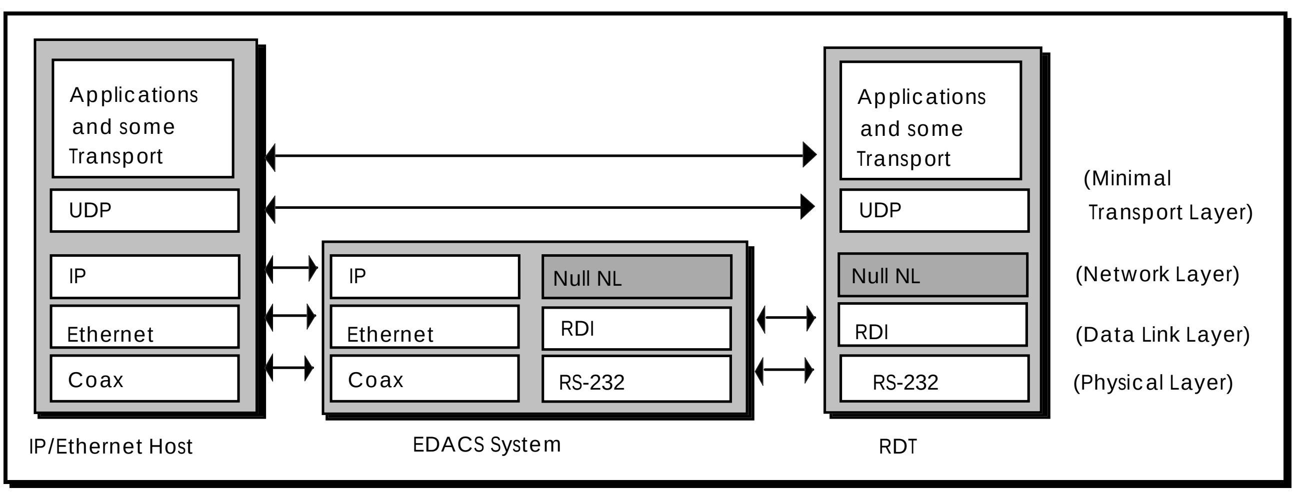
Protocol Layers

RDTs physically connect to radio/RDIs using 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. The *EDACS CommServ Programmers Guide* lists the minimum requirements for using CommServ.

There is no network layer on the RDTs. For radio originated messages, the EDG adds a network layer. For messages to the radios, the EDG strips the network layer.

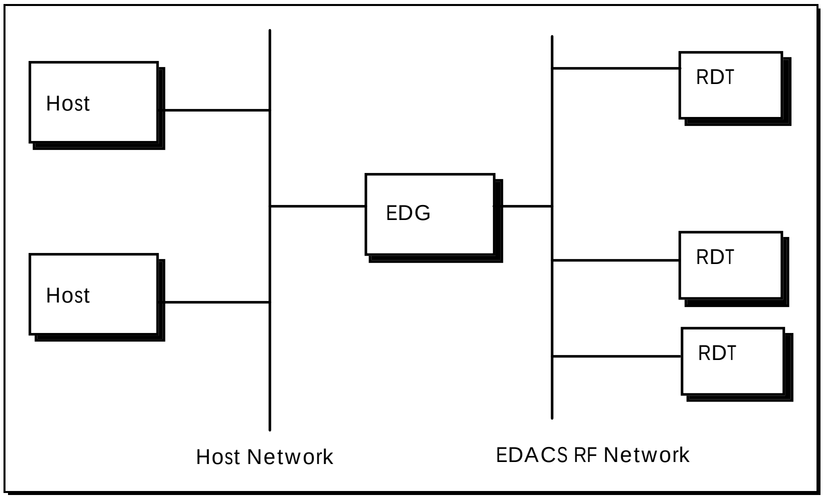
It is expected that a relatively simple transport layer protocol such as UDP would be used above the network layer and that the application would provide some transport layer services such as performing retries. Normally the transport layer protocol is of no concern to the EDACS System and there are no restrictions placed on it. However in this configuration, only one transport layer protocol can be used at a time. The IP Network Layer Header contains a *Protocol* field. This field tells the network layer on the host computer the destination transport layer. Because the EDG builds the IP Network Layer Header, the EDG must be configured with the protocol that the customer wishes to use.



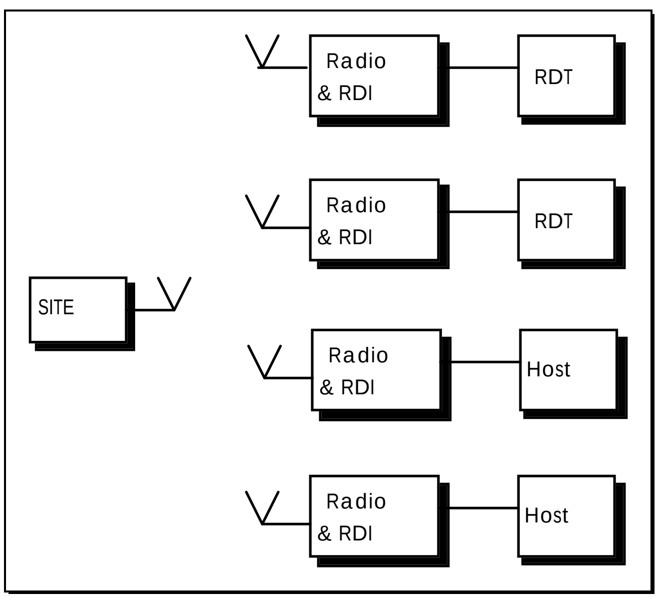
Typical Protocol Stack with a Null Network Layer

Addressing

The addressing in this situation is a hybrid of the network layer and non-network layer methods. From the host's perspective, the RDTs are peer devices on another network, just as in any network layer configuration. However, from the RDTs perspective, the host is on the EDACS Network. An RDT can access a maximum of sixty-three hosts.



Configuration as seen by the Hosts



Configuration as seen by the RDTs

The host computers send and receive messages using IP Addresses. The RDTs send and receive messages using EDACS Addresses. The EDG converts between them using a configuration table.

Acknowledgments and Error Reporting

At the data link layer, the RDT receives a positive or negative acknowledgment from the RDI when it receives the data transfer request and when the RDI receives the data. The data link layer can ask for a positive acknowledgment when the EDG receives the data.

The EDG filters outs network layer error messages to RDTs without a network layer. The EDG drops all ICMP messages except Echo Requests and Echo Replies.

If an error occurs, it may be logged at the host, other components in the Ethernet Network, the EDG, the radio, the RDI, or another EDACS component, depending on the error.

ADDRESS CONVERSIONS AND MESSAGE ROUTING

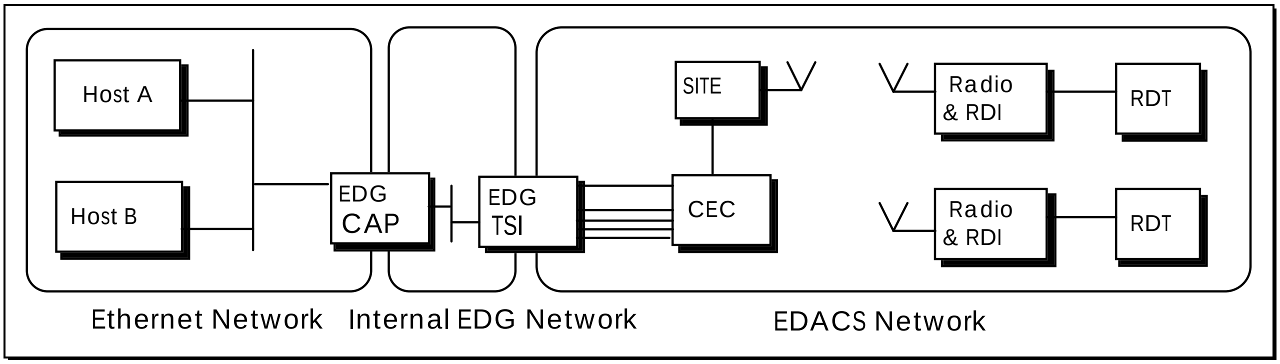
This section does not discuss possible Customer Network equipment. The *EDG Installation and Maintenance Manual* contains suggestions for configuring Customer Networks.

SINGLE NODE CONFIGURATIONS

RDI Host Computers and Non-Network Layer RDTs

RDI Hosts and radios communicate using only EDACS Addresses. The EDG serves as a transparent bridge.

IP Host computers and Network Layer RDTs



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 EDG's 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 TSI Board.

3. The TSI Board converts the destination IP Address to either an EDACS **L**ogical **ID** (**LID**) or **G**roup **ID** (**GID**). The TSI Board then sends the message to a radio or group of radios.

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 host. The TSI Board uses one of the LIDs assigned to it as the source EDACS Address in the XFERB.

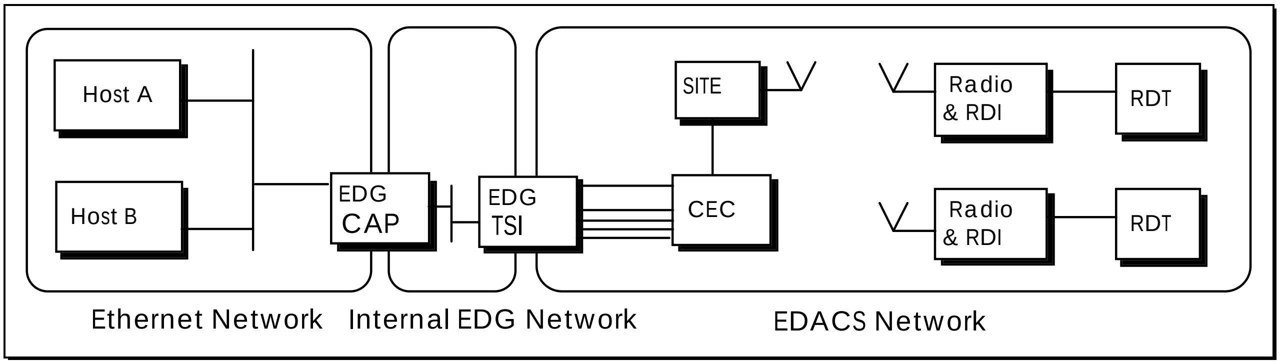
Message from RDT to Host

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 host. The destination EDACS Address in the XFERB is one of the IDs in the block assigned to the EDG.

2. One of the TSI boards receives the message from the radio. The TSI routes the message on to 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 its Ethernet Address. If the CAP does not know the host's Ethernet Address, it uses ARP to ask the host.

IP Host Computers and Non-Network Layer RDTs



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 EDG's 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 TSI Board.

3. The TSI Board converts the host's IP Address to an EDACS **L**ogical **ID** (**LID**). The TSI Board converts the destination IP Address to either an EDACS Logical ID or **G**roup **ID** (**GID**). The TSI Board then sends the message to a radio or group of radios.

4. The radio/RDI sends the message to the RDT using an XFERB command. It contains the EDACS LID of the host.

Messages from RDT to Host

1. The RDT sends a message to the radio/RDI. It contains the EDACS LID of the host.

2. The radio sends the message to a TSI board on the EDG.

3. The TSI Board converts the radio and host LIDs to IP Addresses. It then forwards 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.

MULTIPLE NODE CONFIGURATIONS

The routing described in this section is in addition to the routing description in the previous section.

Partitioning Radios Among Nodes

In a configuration with multiple nodes, each radio is assigned a Home Node. Normally, this is where the radio is expected to be located most. A given radio only has a single Home Node; all other nodes are Roam Nodes.

A radio is assigned to a node by assigning it an IP Address on the IP Network assigned to the node's IMC. Even if only RDI Hosts are used, the EDGs and the Customer Network use the IP Addresses of the radios to route messages.

Routing Messages to Radios

IP Host Computers and the Customer Network route messages to a radio's Home EDG, regardless of the radio's location. If the radio has roamed, the Home EDG forwards the messages to the Roam EDG. This places the work of re-routing for individual radios on the EDGs instead of the Host Computers and Customer Network. Placing the work on the EDGs allows large numbers of radios to roam without risk of destablizing the Host Computers or the Customer Network.

When an EDG forwards a message, it encapsulates it within an IP Datagram. To the Customer Network the IP Datagram is between two EDGs. It is unaware that the IP Datagram contains a message to a radio that has roamed.

Tracking and Error Recovery

When an EDG boots, it gets tracking information from its IMC and exchanges tracking information with other EDGs. EDGs exchange tracking information when radios move between nodes. It is possible for the Home EDG to not know the location of a radio due to network problems or during the synchronization period after an EDG reboot.

If the Home EDG loses track of a radio, the Home EDG sends any messages for the radio to all of the other EDGs defined in the configuration. The Roam EDGs send the messages out on their nodes. When the radio successfully receives a message, the Home EDG updates its tracking information. The EDGs handle future messages to the radio as described above.

MESSAGE FLOW WITHIN THE EDACS SYSTEM

RADIO ORIGINATED MESSAGE

The following provides a simplified call flow for a radio to host data message transfer.

```
RDT           RDI           Radio         Site          IMC           EDG           Host

       1 --->

                     2 --->

       <--- 3

                                   4 --->

                                   <--- 5        6 --------------------->

                                                               <--- 7

                     <--- 8

                                   9 <------------------------------------>

                     <--- 10                                                    11 --->

       <--- 12 (optional)
```

1) The Radio Data Terminal (RDT) begins transferring a message to the Radio Data Interface (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.

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

6) The site sends the call assignment to the IMC. The IMC sends it on to the EDG.

7) The EDG selects a TSI Port and informs the IMC. The IMC sets up a data path between the EDG and the working channel.

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

9) The radio breaks the message down into packets and sends the first burst of packets to the site. The site forwards the burst to the EDG as it receives it. After the EDG receives the entire burst, it sends an Ack Map back to the radio, informing it of the packets that the EDG correctly received.

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

10) The radio tells the RDI the status of the message transmission to the EDG.

11) If the EDG successfully received the message, the EDG sends the message to the destination. The message transfer from the EDG to the destination continues independently of any other signaling from the RDT.

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

RADIO DESTINED MESSAGE

The following provides a simplified call flow for an RDI Host to radio message transfer. Steps 2 and 9 do not apply to IP Host Computers and radio-to-radio messages.

```
RDT        RDI        Radio       Site       IMC        EDG        Host

                                                             <--- 1

                                                             2 --->

                                                   <--- 3

                                        <--- 4

                            <--- 5      6 ------------------------>

                            <------------------------------------------> 7

                <--- 8                                       9 --->
                                                             (optional)

                10 --->

      <--- 11
```

1) The host sends a message to the EDG.

2) The EDG sends an acknowledgment to the host after the entire message is received.

3) The EDG sends a call request to the IMC via a DIM link.

4) The IMC sends the call request to the site where the radio is located.

5) The site tells the radio to go to a working channel to receive the message.

6) The site returns the channel assignment to the IMC. The IMC connects a data path between the EDG and the working channel and notifies the EDG.

7) The EDG breaks the message down into packets and sends the first burst of packets to the site. The site forwards the burst to the radio as it receives it. After the radio receives the entire burst, it sends an ACK Map back to the EDG (through the site), informing it of the packets that the radio correctly received.

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

8) The radio sends the message to the RDI. If the message is large enough, the radio sends the initial part of the message to the RDI while the radio is still receiving the message from the EDG.

9) If requested, the EDG returns the acknowledgment to the host indicating whether the message was successfully transferred to the radio.

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

11) The RDI forwards the message to the RDT.

OPTIMIZATIONS

MAXIMIZING RF EFFICIENCY

In most configurations, the wide area 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 throughput.

1. Minimize the amount of data being sent over the air. Maintenance 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, the EDG and radio must establish a link for each individual message.

4. Split messages greater than 512 bytes on 511 byte boundaries, if possible. For example, split a 600 byte message into a 511 byte message and an 89 byte message. If the EDG 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 at the same time. If a host computer is expecting to receive a reply to a message, the host should not send another message to the same radio.

If the RDTs are using END, the *EDACS Network Driver Installation Instructions* lists the optimal configuration parameters for the recommended third party IP Products.

LOAD DISTRIBUTION FOR RADIO ORIGINATED MESSAGES

If the EDG is configured with multiple TSI Boards, throughput may be improved by rotoring radio originated calls between the available TSI Boards to distribute the load. The EDG accepts radio originated messages from the IMC using two methods, depending on whether the RDT is using a network layer.

RDTs Without a Network Layer

RDTs that do not use a network layer send messages to the EDACS Address of the host. Within the EDACS System, the EDG acts as a proxy for the hosts so that it can intercept and forward radio originated messages. This allows the EDG to be transparent to both the RDTs and the RDI Host Computers.

Rotoring can be accomplished by assigning multiple EDACS Addresses to the same RDI Host computer in the EDG. The RDTs would then sequence through the host addresses on subsequent messages. The host addresses would be spread across the TSI Masters, distributing the load.

RDTs With a Network Layer

RDTs that use a network layer send messages directly to one of the EDACS Address of the EDG. The EDG uses the IP Address in the EDACS Network Layer Header to forward the message to its destination. This allows RDTs to use the full IP Address range.

If any RDTs are configured with a network layer, the EDG automatically assigns EDACS Addresses one though fifteen to itself. If the EDG is acting as a proxy for any RDI Host computers, it will also assign those EDACS addresses to itself. If the EDACS Network Driver is being used, it sequences through addresses one through fifteen automatically. This distributes the load of radio originated calls across the available TSI Masters without requiring the RDT to have knowledge of the EDGs configuration. Customers developing their own network layer may wish to do the same thing.

COMPONENT DESCRIPTION

The EDACS Data Gateway is a multiprocessor system consisting 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 EDG also includes mass storage devices and data modems for transferring data to the EDACS System.

CENTRAL ACTIVITY PROCESSOR (CAP)

Using the 68030 microprocessor, the CAP Board is a general purpose computing board that provides typical computer peripheral interfaces for the EDG. These include disk facilities through a **S**mall **C**omputer **S**ystems **I**nterface (**SCSI**) bus; a Centronics parallel printer connection; an Ethernet connection; and a serial port interface for ASCII terminals.

In addition to providing the Ethernet/IP interface and servicing the EDG 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 the EDG. The Abort button switches the EDG to debug mode.

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.

Adapter Board

The Adapter board is a small circuit board that routes the I/O signals and grounds from its concentrated VMEbus 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 DB25 connectors for serial I/O, a 50-pin SCSI port connector, a DB15 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 the EDG's serial interfaces. The VCOM24 can be configured as a TSI Master, TSI Slave, or HDI. 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 VCOM24 also has a single full-duplex asynchronous serial port. The EDG uses this for the DIM control data link when the VCOM24 is configured as a TSI Master.

The Reset button resets the EDG. The Abort button switches the EDG to debug mode.

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 *EDG Installation and Maintenance Manual* explains the meanings of the eight small LEDs.

The EDG does not use the eight dip switches. They 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 converts serial I/O signals from TTL to RS-232 voltage levels and routes them to a DB25 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.

FIXED DISK DRIVE

The fixed disk drive has a formatted capacity of 245 megabytes. The EDG uses it to store software, configuration files, 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 1.44 megabytes. The EDG uses the floppy disk drive to transfer files to and from the hard disk.

DIAGNOSTIC TERMINAL

The EDG 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 EDG configuration and error log, shutdown and restart the EDG, or set the system time. See the *EDG User's Reference Manual* for information on the commands available from the Diagnostic Terminal.

One Diagnostic Terminal is directly connected to the EDG. The EDG can be configured to allow zero to four terminals to remotely log in at the same time using Telnet. The EDG restricts access to the Diagnostic Terminal 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.

MODEM UNIT SHELF

The Modem Unit Shelf is a rack that holds the Modem Interface Modules, Rockwell Modem Modules, and Cross Connect Panel. These modems provide the audio data path between the EDG and an EDACS System. The EDG uses one Modem Interface module and one Rockwell Modem card per TSI port. While the shelf can hold up to ten Modem Interface Modules and Modems, the EDG uses a maximum of eight per shelf to simplify the wiring.

Modem Interface Module

Each modem uses a Modem Interface Module to convert the TTL modem input and output signal levels to RS232 signal input and output levels (see LBI-38564 for more information).

Each Modem Interface Module contains 5 Status LED's. The top three are normally lit. The fourth Status LED indicates modem data from the site (through the IMC). The bottom LED indicates modem data from EDG. During a successful Individual Data Call, all of the LEDs are lit regardless of the direction of the data being transferred. During a successful Group Data Call, all of the LEDs but the fourth LED are lit. This is because radios do not acknowledge receipt of data during a Group Data Call.

Rockwell Modem

The Rockwell Modem allows full-duplex operation over 4-wire dedicated unconditioned telephone lines or half-duplex operation over the general switched telephone network at 9600 baud.

CROSS CONNECT PANEL

The Cross Connect Panel is a printed circuit board that allows cables from the VCOM24 boards with DB25 connectors to plug into the Modem Unit Shelf backplane jacks. One side of the Cross Connect Panel has connectors that mate with the Modem Unit Shelf backplane jacks. The panel routes signals off those connectors to DB25 connectors mounted on the opposite side of the panel.

POWER SUPPLY

The EDG uses a triple rail supply offering +5, +12, and -12 VDC in a single nineteen inch rack mounted chassis. The AC input circuitry is autoranging, capable of using 110 VAC at 60 Hz or 240 VAC at 50 Hz. The power supply has remote sense lines for all three voltage rails and includes an "AC POWER" solid state LED indicator.

FAN

A removable fan tray positioned directly under the card cage cools the EDG 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.

BACKPLANE

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

SPECIFICATIONS

EDACS Interface

Physical Layer	Up to 8 control lines operating at either 19,200 or 9600 bps Up to 32 data lines (minus the RDI Host Interface connections) operating at 9600 bps
Data Link Layer	EDACS Proprietary
Network Layer	EDACS Network Layer (configurable on a per unit and group basis)

RDI Protocol Host Interface

Physical Layer	Up to 16 RS-232 data lines operating at 9600 bps, using DB25 connectors
Data Link Layer	RDI Protocol, versions 1.8a, 1.91, and 1.92
Network Layer	None

Internet Protocol Host Interface

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

Inter-EDG Interface

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

General Specifications

Diagnostic Terminal	RS-232 serial interface supporting VT100 type terminals or remote access via Telnet
Printer	Centronics parallel printer interface
Drives	245 Mbyte fixed disk drive with SCSI interface 1.44 Mbyte, 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

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
Average Power Consumption	
EDG with no ports	280W
Each group of 4 TSI Ports	70W
Each group of 4 HDI Ports	40W
Fan	
Power requirements	12 VDC (from power supply)
Air flow rate	250 CFM
Filter	Removable aluminum filter
Physical (Ericsson 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
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

NOTE:
EDACS is a registered trademark of Ericsson Inc.
MS-DOS is a trademark of Microsoft Corporation.

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Printed in U.S.A.