Protocol Software Toolkit Programmer Guide

DC 900-1338I

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Preface

Purpose of Document

This document describes the protocol software toolkit for the Freeway server and embedded intelligent communications processor (ICP) environments, and discusses the issues involved in developing software that executes in either of these environments. It also provides information on client application programs and the host/ICP interface.

Note

The Protocol Toolkit is designed to be used either with a Freeway server or an embedded ICP using DLITE. For the embedded ICP, also refer to the user guide for your ICP and operating system (for example, the *ICP2432 User Guide for Windows NT*).

Intended Audience

This document should be read by programmers who are developing code to be downloaded to the ICP2424, ICP2432, or ICP6000. You should be familiar with your client system's operating system and with program development in a real-time environment. Familiarity with the C programming language and Motorola 68*xxx* assembly language is helpful.

Required Equipment

You must have the following equipment to use the protocol software toolkit to develop and test communications applications:

- a client computer that runs the following:
    - TCP/IP (for a Freeway server)
    - Freeway data link interface (DLI) or embedded DLITE interface
- An ICP2424, ICP2432, or ICP6000 installed in the Freeway server's backplane or embedded in your client computer system
- A console cable and an ASCII terminal or terminal emulator (running at 9600 b/s) for access to the ICP console port
- A programmer's module for the ICP2432 or ICP6000
- A set of software development tools for the Motorola 68*xxx* processor
- If you plan to use the sample protocol software (SPS) test program as a basis for your client application code, you will need a C compiler for your client system

Organization of Document

Chapter 1 is an overview of the Freeway server and embedded products and the protocol software toolkit.

Chapter 2 describes the issues involved in ICP software development, including software-development tools, the various interfaces, and how to program the hardware devices.

Chapter 3 describes local memory address allocation on the ICPs.

Chapter 4 describes system download, configuration, and initialization.

Chapter 5 describes the ICP debugging tools and techniques.

Chapter 6 describes the ICP software.

Chapter 7 gives an overview of the interface between the ICP's host processor and an ICP. It also describes the interface between the ICP's driver, XIO, and OS/Impact application tasks.

Chapter 8 gives an overview of DLI concepts relating to client applications.

Chapter 9 describes the messages exchanged between the client and the ICP.

Appendix A clarifies some points made in the technical manuals and describes some peculiarities of the devices and the ICP6000 hardware.

Appendix B provides some commonly used data rate time constants for SCC programming on the ICP6000.

Appendix C describes error codes.

Protogate References

The following general product documentation list is to familiarize you with the available Protogate Freeway and embedded ICP products. The applicable product-specific reference documents are mentioned throughout each document (also refer to the "readme" file shipped with each product). Most documents are available on-line at Protogate's web site, www.protogate.com.

General Product Overviews

• *Freeway 1100 Technical Overview*	25-000-0419
• *Freeway 2000/4000/8800 Technical Overview*	25-000-0374
• *ICP2432 Technical Overview*	25-000-0420
• *ICP6000X Technical Overview*	25-000-0522

Hardware Support

• *Freeway 1100/1150 Hardware Installation Guide*	DC-900-1370
• *Freeway 1200/1300 Hardware Installation Guide*	DC-900-1537
• *Freeway 2000/4000 Hardware Installation Guide*	DC-900-1331

• *Freeway 8800 Hardware Installation Guide*	DC-900-1553
• *Freeway ICP6000R/ICP6000X Hardware Description*	DC-900-1020
• *ICP6000(X)/ICP9000(X) Hardware Description and Theory of Operation*	DC-900-0408
• *ICP2424 Hardware Description and Theory of Operation*	DC-900-1328
• *ICP2432 Hardware Description and Theory of Operation*	DC-900-1501
• *ICP2432 Electrical Interfaces (Addendum to DC-900-1501)*	DC-900-1566
• *ICP2432 Hardware Installation Guide*	DC-900-1502

Freeway Software Installation and Configuration Support

• *Freeway Message Switch User Guide*	DC-900-1588
• *Freeway Release Addendum: Client Platforms*	DC-900-1555
• *Freeway User Guide*	DC-900-1333
• *Freeway Loopback Test Procedures*	DC-900-1533

Embedded ICP Software Installation and Programming Support

• *ICP2432 User Guide for Digital UNIX*	DC-900-1513
• *ICP2432 User Guide for OpenVMS Alpha*	DC-900-1511
• *ICP2432 User Guide for OpenVMS Alpha (DLITE Interface)*	DC-900-1516
• *ICP2432 User Guide for Solaris STREAMS*	DC-900-1512
• *ICP2432 User Guide for Windows NT*	DC-900-1510
• *ICP2432 User Guide for Windows NT (DLITE Interface)*	DC-900-1514

Application Program Interface (API) Programming Support

• *Freeway Data Link Interface Reference Guide*	DC-900-1385
• *Freeway Transport Subsystem Interface Reference Guide*	DC-900-1386
• *QIO/SQIO API Reference Guide*	DC-900-1355

Socket Interface Programming Support

• *Freeway Client-Server Interface Control Document*	DC-900-1303

Toolkit Programming Support

• *Freeway Server-Resident Application and Server Toolkit Programmer Guide*	DC-900-1325

OS/Impact Programmer Guide	DC-900-1030
Protocol Software Toolkit Programmer Guide	DC-900-1338

Protocol Support

ADCCP NRM Programmer Guide	DC-900-1317
Asynchronous Wire Service (AWS) Programmer Guide	DC-900-1324
AUTODIN Programmer Guide	DC-908-1558
Bit-Stream Protocol Programmer Guide	DC-900-1574
BSC Programmer Guide	DC-900-1340
BSCDEMO User Guide	DC-900-1349
BSCTRAN Programmer Guide	DC-900-1406
DDCMP Programmer Guide	DC-900-1343
FMP Programmer Guide	DC-900-1339
Military/Government Protocols Programmer Guide	DC-900-1602
N/SP-STD-1200B Programmer Guide	DC-908-1359
SIO STD-1300 Programmer Guide	DC-908-1559
X.25 Call Service API Guide	DC-900-1392
X.25/HDLC Configuration Guide	DC-900-1345
X.25 Low-Level Interface	DC-900-1307

Other Documents (Available from Protogate)	Protogate Order #
MC68000 Family Reference Manual (Motorola)	DC 900-0698
MC68901 Multi-function Peripheral (Motorola)	DC MC68901/D
PTBUG Debug and Utility Program Reference Manual (PTI)	DC 900-0424
Serial Communications Controller User's Manual (Zilog)	DC 00-2057-05

Other Documents (Available from Vendor)	Vendor
MC68340 Integrated Processor with DMA User's Manual	Motorola, MC 68340UM/AD
MC68349 High Performance Integrated Processor User's Manual	Motorola, MC 68349UM/AD
User's Manual, PT-VME340, High Speed Synchronous Communications Controller	Performance Technologies, Inc. (PTI), 126A0137

• *Z16C32 IUSC Integrated Universal Serial Controller Technical Manual*	Zilog, DC8292-01

Other Documents (Development Tools and Environment)	Vendor
• *CrossCodeC for the 68000 Microprocessor Family*	Wind River
• *M68000 Family Resident Structured Assembler Reference Manual*	Motorola
• *PTBUG Debug and Utility Program, Model PT-VME800-10393, Reference Manual for VME 340*	PTI, 811A017910
• *SingleStep Debugger for the 68000 Microprocessor Family*	Wind River

Document Conventions

This document follows the most significant byte first (MSB) and most significant word first (MSW) conventions for bit-numbering and byte-ordering. In all packet transfers between the client applications and the ICPs, the ordering of the byte stream is preserved.

The term “Freeway” refers to any of the Freeway server models (for example, Freeway 500/3100/3200/3400 PCI-bus servers, Freeway 1000 ISA-bus servers, or Freeway 2000/4000/8800 VME-bus servers). References to “Freeway” also may apply to an embedded ICP product using DLITE (for example, the embedded ICP2432 using DLITE on a Windows NT system).

Physical “ports” on the ICPs are logically referred to as “links.” However, since port and link numbers are usually identical (that is, port 0 is the same as link 0), this document uses the term “link.”

Program code samples are written in the “C” programming language.

Revision History

The revision history of the *Protocol Software Toolkit Programmer Guide*, Protogate document DC 900-1338I, is recorded below:

Revision	Release Date	Description
DC 900-1338A	November 4, 1994	Original release
DC 900-1338B	November 22, 1994	Update file names for Release 2.1 Add “Loopback Test Program” appendix
DC 900-1338C	July 1995	Update file names Add ICP2424 information
DC 900-1338D	February 1996	Minor modifications throughout Add ICP6030 information Add new dlControl function to Table 8–5 on page 156 Add Windows NT to Loopback Test Program appendix Delete HIO task information
DC 900-1338E	November 1997	Add embedded ICP product information Add ICP2432 information Document changes in directory structure
DC 900-1338F	December 1998	Minor modifications throughout. Chapter 8 is now a programming overview, and Chapter 9 contains all the command and response formats. Add command/response summary (Table 9–2 on page 161) Add electrical interface values (Section 9.2.7.1 on page 175)
DC 900-1338G	April 1999	Minor modifications throughout for embedded ICP users Update electrical interface information (Table 2–4 on page 44) Remove appendix for the loopback test. This information is included in the *Freeway Loopback Test Procedures* document (for a Freeway server) or the user guide for your embedded ICP and operating system (for example, the *ICP2432 User Guide for Windows NT*).
DC 900-1338H	December 1999	Protocol Toolkit no longer supports the ICP6030 Modify Section 4.1.1.1 on page 59 Add Section 4.1.3 on page 64, “ICP Buffer Size” Add Section 9.2.5.1 on page 171, “X21bis Line Status Reports” Modify Section 9.2.7.1 on page 175 & Section 9.2.7.3 on page 182 Add new error codes to Table C–1 on page 196
DC 900-1338I	January 2002	Update Document for Protogate, Inc. Add new Freeway model numbers

Customer Support

If you are having trouble with any Protogate product, call us at (858) 451-0865 Monday through Friday between 8 a.m. and 5 p.m. Pacific time.

You can also fax your questions to us at (877) 473-0190 any time. Please include a cover sheet addressed to “Customer Service.”

We are always interested in suggestions for improving our products. You can use the report form in the back of this manual to send us your recommendations.

Chapter 1 Introduction

1.1 Product Overview

Protogate provides a variety of wide-area network (WAN) connectivity solutions for real-time financial, defense, telecommunications, and process-control applications. Protogate's Freeway server offers flexibility and ease of programming using a variety of LAN-based server hardware platforms. Now a consistent and compatible embedded intelligent communications processor (ICP) product offers the same functionality as the Freeway server, allowing individual client computers to connect directly to the WAN.

Both Freeway and the embedded ICP use the same data link interface (DLI for Freeway, DLITE for embedded ICP). Therefore, migration between the two environments simply requires linking your client application with the proper library. The DLI library is supported on various client operating systems (for example, UNIX, VMS, and Windows NT). The DLITE library requires a compatible ICP device driver to operate and is currently available on Windows NT/2000 and VMS (AXP systems only).

Protogate protocols that run on the ICPs are independent of the client operating system and the hardware platform (Freeway or embedded ICP).

1.1.1 Freeway Server

Protogate's Freeway communications servers enable client applications on a local-area network (LAN) to access specialized WANs through the DLI. The Freeway server can be any of several models that use the ICP2432, ICP2424, or ICP6000 products. The Freeway server is user programmable and communicates in real time. It provides multiple data links and a variety of network services to LAN-based clients. Figure 1–1 shows the Freeway configuration.

To maintain high data throughput, Freeway uses a multi-processor architecture to support the LAN and WAN services. The LAN interface is managed by a single-board computer, called the server processor. It uses commercially available operating systems such as VxWorks or BSD Unix to provide a full-featured base for the LAN interface and layered services needed by Freeway.

Freeway can be configured with multiple WAN interface processor boards, each of which is a Protogate ICP. Each ICP runs the communication protocol software using OS/Impact, Protogate's real-time operating system.

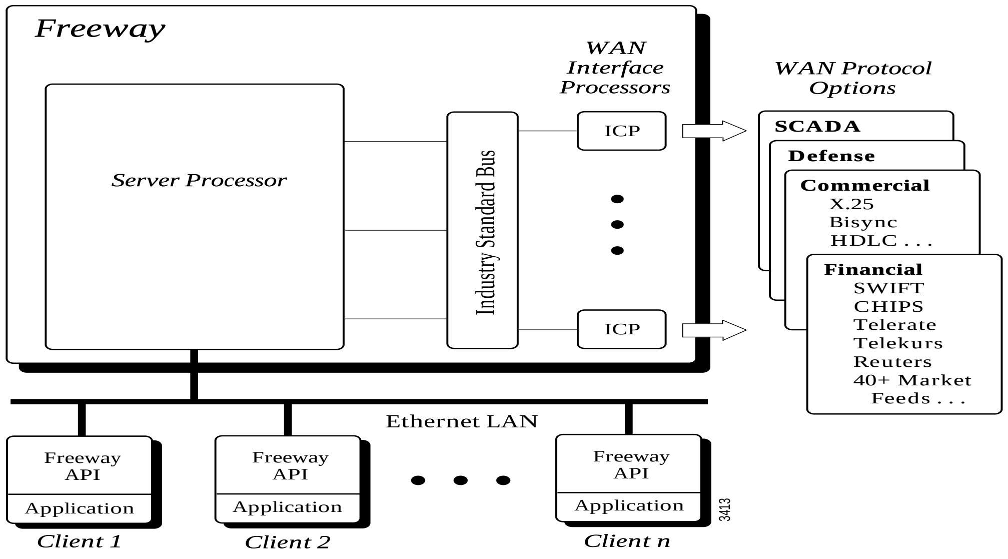


Figure 1–1: Freeway Configuration

1.1.2 Embedded ICP

The embedded ICP connects your client computer directly to the WAN (for example, using Protogate's ICP2432 PCIbus board). The embedded ICP provides client applications with the same WAN connectivity as the Freeway server, using the same data link interface (via the DLITE embedded interface). The ICP runs the communication protocol software using Protogate's real-time operating system. Figure 1–2 shows the embedded ICP configuration.

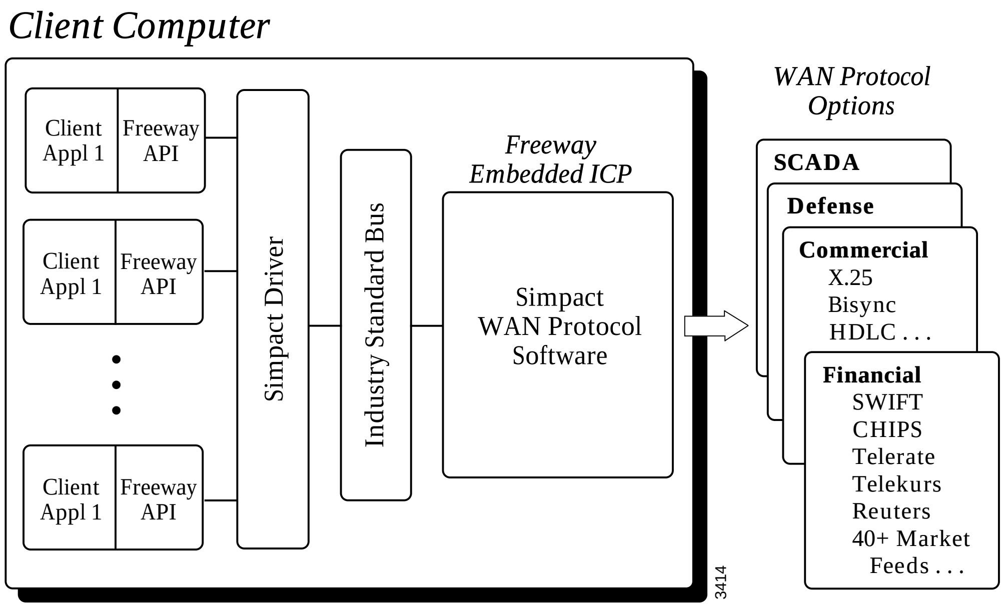


Figure 1–2: Embedded ICP Configuration

Summary of product features:

- Provision of WAN connectivity either through a LAN-based Freeway server or directly using an embedded ICP
- Elimination of difficult LAN and WAN programming and systems integration by providing a powerful and consistent data link interface
- Variety of off-the-shelf communication protocols available from Protogate which are independent of the client operating system and hardware platform
- Support for multiple WAN communication protocols simultaneously
- Support for multiple ICPs (two, four, eight, or sixteen communication lines per ICP)
- Wide selection of electrical interfaces including EIA-232, EIA-449, EIA-530, and V.35
- Creation of customized server-resident and ICP-resident software, using Protogate's software development toolkits
- Freeway server standard support for Ethernet and Fast Ethernet LANs running the transmission control protocol/internet protocol (TCP/IP)
- Freeway server standard support for FDDI LANs running the transmission control protocol/ internet protocol (TCP/IP)
- Freeway server management and performance monitoring with the simple network management protocol (SNMP), as well as interactive menus available through a local console, telnet, or rlogin

1.2 Freeway Client-Server Environment

The Freeway server acts as a gateway that connects a client on a local-area network to a wide-area network. Through Freeway, a client application can exchange data with a remote data link application. Your client application must interact with the Freeway server and its resident ICPs before exchanging data with the remote data link application.

One of the major Freeway server components is the message multiplexor (MsgMux) that manages the data traffic between the LAN and the WAN environments. The client application typically interacts with the Freeway MsgMux through a TCP/IP BSD-style socket interface (or a shared-memory interface if it is a server-resident application (SRA)). The ICPs interact with the MsgMux through the DMA and/or shared-memory interface of the industry-standard bus to exchange WAN data. From the client application's point of view, these complexities are handled through a simple and consistent data link interface (DLI), which provides dlOpen, dlWrite, dlRead, and dlClose functions.

Figure 1–3 shows a typical Freeway connected to a locally attached client by a TCP/IP network across an Ethernet LAN interface. Running a client application in the Freeway client-server environment requires the basic steps described in Section 1.2.1 and Section 1.4.

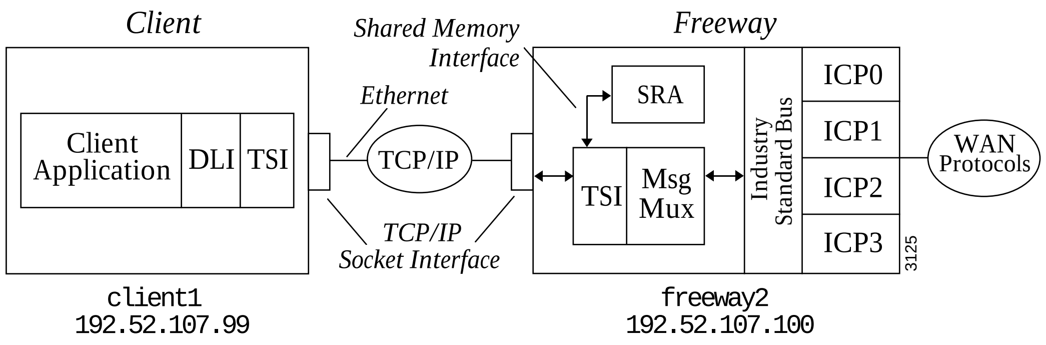


Figure 1–3: A Typical Freeway Server Environment

1.2.1 Establishing Freeway Server Internet Addresses

The Freeway server must be addressable in order for a client application to communicate with it. In the Figure 1–3 example, the TCP/IP Freeway server name is freeway2, and its unique Internet address is 192.52.107.100. The client machine where the client application resides is client1, and its unique Internet address is 192.52.107.99. Refer to the *Freeway Server User's Guide* to initially set up your Freeway and download the operating system, server, and protocol software.

1.3 Embedded ICP Environment

Refer to the user guide for your embedded ICP and operating system (for example, the *Freeway Embedded ICP2432 User's Guide for Windows NT*) for software installation and setup instructions. The user guide also gives additional information regarding the data link interface (DLI) and embedded programming interface descriptions for your specific embedded environment. Refer back to Figure 1–2 on page 23 for a diagram of the embedded ICP environment. Running a client application in the embedded ICP environment requires the basic steps described in Section 1.4

1.4 Client Operations

1.4.1 Defining the DLI and TSI Configuration

In order for your client application to communicate with the ICP's protocol software, you must define the DLI sessions and the transport subsystem interface (TSI) connections. You have the option of also defining the protocol-specific ICP link parameters. To accomplish this, you first define the configuration parameters in DLI and TSI ASCII configuration files, and then you run two preprocessor programs, dlicfg and tsicfg, to create binary configuration files. The dlInit function uses the binary configuration files to initialize the DLI environment.

1.4.2 Opening a Session

After the DLI and TSI configurations are properly defined, your client application uses the dlOpen function to establish a DLI session with an ICP link. As part of the session establishment process, the DLI establishes a TSI connection with the Freeway MsgMux through the TCP/IP BSD-style socket interface for the Freeway server, or directly to the ICP driver for the embedded ICP environment.

1.4.3 Exchanging Data with the Remote Application

After the link is enabled, the client application can exchange data with the remote application using the dlWrite and dlRead functions.

1.4.4 Closing a Session

When your application finishes exchanging data with the remote application, it calls the dlClose function to disable the ICP link, close the session with the ICP, and disconnect from the Freeway server or the embedded ICP driver.

1.5 Protocol Toolkit Overview

The protocol software toolkit helps you develop serial protocol applications for execution on Protogate's intelligent communications processors. Many of the software modules required to build a complete system are provided with the toolkit or reside in the ICP's PROM, including download facilities, operating system, and the PTBUG (ICP6000) or Peeker (ICP2424 and ICP2432) debugging tool. The toolkit also includes a debug monitor program for use with Software Development Systems' SingleStep debugger. (The SingleStep debugger must be purchased directly from Software Development Systems.) All you have to provide is your application code, which you can build using the toolkit's sample protocol software as a model. Chapter 2, Chapter 4, and Chapter 5 give more information on software development, configuration, and debugging.

The toolkit includes software, provided on the distribution media, and complete documentation (see the document "References" section in the *Preface*). Some of the toolkit's software components, such as the SingleStep monitor, are provided only in executable object format. All other components are provided in both source and executable form so that they can be modified, used as coding examples, or linked with user applications. Figure 1–4 shows a block diagram of the ICP's PROM and the toolkit's software components for the Freeway server. Figure 1–5 shows the same information for the embedded ICP products.

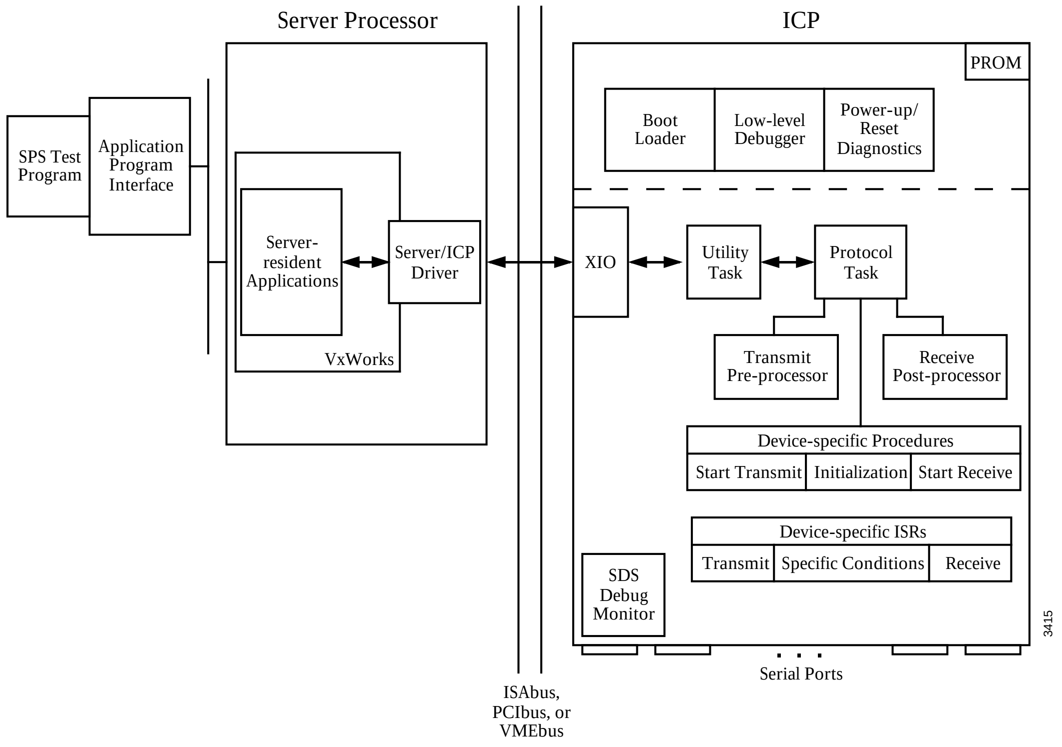


Figure 1–4: ICP PROM and Toolkit Software Components — Freeway Server

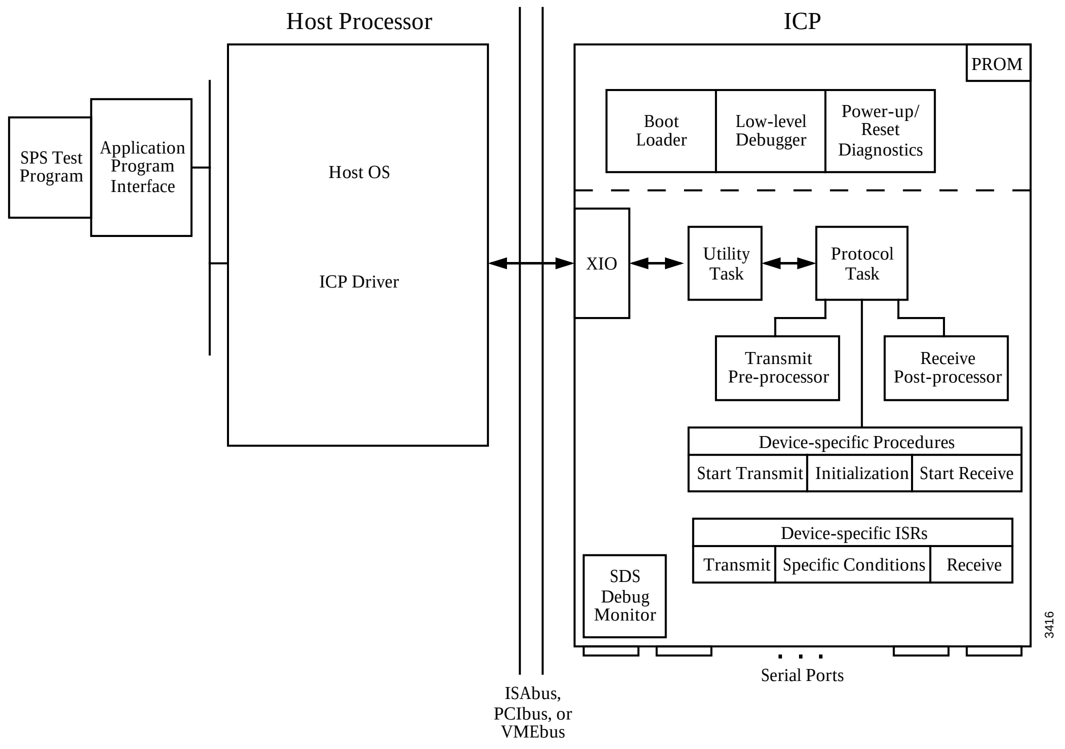


Figure 1–5: ICP PROM and Toolkit Software Components — Embedded ICP

1.5.1 Toolkit Software Components

The toolkit loopback test program (spsalp.c) is provided in source form and, when compiled, executes in the client application program's system environment. For the test procedures, see the "Protocol Toolkit Test Procedure" section in the *Freeway Loopback Test Procedures* document or the appropriate embedded ICP user guide.

The following programs execute on the ICP:

- System-services module containing the OS/Impact operating system and the XIO ICP-side driver (sources provided)
- Sample protocol software (source provided)
- Sample host interface I/O utility (source provided)
- Debug monitor; must be used with the Software Development Systems' SingleStep monitor package (executable code only)

The following source files aid in ICP software development:

- Subroutine library for C interface to OS/Impact
- Macro library for assembly interface to OS/Impact
- Header files with OS/Impact and XIO definitions and equates
- Make files for supplied source files
- *.spc files for linking and address resolution of the executable images

Chapter 2 Software Development for the ICP

This chapter describes the issues involved in developing software for the Protogate ICPs, including software-development tools, the client application program interfaces, and the hardware devices. The application program interface between the client and ICP protocol tasks are described in the *Freeway Transport Subsystem Interface Reference Guide* and *Freeway Data Link Interface Reference Guide*. The interface between the ICP and the server (for Freeway server systems) or remote (for embedded ICP systems) is described in Chapter 7 of this manual.

2.1 Board-level Protocol-executable Modules

An ICP board-level protocol-executable module is an absolute image file containing Motorola 68*xxx* code and data developed on a CrossCodeC development system and subsequently downloaded to the ICP. Any division of code and data among modules is entirely arbitrary. For example, Protogate's protocol software toolkit includes the following modules:

- A system-services module containing the OS/Impact operating system kernel, timer task, and XIO for the ICP2424 (xio_2424.mem), ICP2432 (xio_2432.mem), or ICP6000 (xio_6000.mem)

- A module comprising the sample protocol application for the ICP2424 (sps_fw_2424.mem), ICP2432 (sps_fw_2432.mem), or ICP6000 (sps_fw_6000.mem)

- A module containing the source-level debug monitor for the ICP2424 (icp2424c.mem), ICP2432 (icp2432c.mem), or ICP6000 (icp6000c.mem), used only with the Software Development Systems' SingleStep debugger

In general, the toolkit programmer develops or modifies one or more application modules or tasks that run with Protogate's system-services module. Application tasks can run concurrently.

Modules are downloaded to the ICP as individual entities as described in Chapter 4. They are not linked with one another. Any shared information must be made available to a module when it is created (in other words, during compilation or assembly) or must be obtained by the module at the time of execution. Modules designed to execute in the OS/Impact environment access system services through the use of software traps and, in general, communicate with other tasks through OS/Impact services, using public task and queue IDs.

For these reasons, and because there are no provisions in the OS/Impact environment for memory protection, it is essential to document the system resources required by a module if it is to execute in combination with other modules. The following information is provided for each module developed by Protogate and defined in the *.spc files:

- Reserved areas of memory for code, data, and stack space
- Reserved exception vector table entries
- Dependencies on, or conflicts with, other modules
- Configuration requirements (number of tasks, priorities, queues, alarms, resources, and partitions for the configuration table parameter list)
- Task initialization structures to be included in the configuration table
- Reserved task, queue, alarm, resource, and partition IDs (to avoid conflict with user-added modules and as public information for intertask communication)

During the design and development of your application, you can use this information to build a complete system composed of compatible and cooperating modules. In addition, your application code must provide a system configuration that is adequate for the combined needs of all the modules in the system, and it must include the required task initialization structures.

2.2 Development Tools

Modules are developed at Protogate using Wind River's CrossCodeC cross-compiler, assembler, and linker, and the SingleStep debugger. These tools were formerly available from Software Development Systems (SDS) and later DIAB before Wind River took over the product line. Note that most sections of this document still refer to these as SDS tools instead of Wind River tools. This section describes the issues related to the development of download modules from the perspective of these specific tools that Protogate has chosen.

2.2.1 SDS Compiler/Assembler/Linker

The Protocol Toolkit includes modules developed by Software Development Systems (SDS) for source-level debugging using the SDS SingleStep debugger for the 68000 microprocessor family. To use the SingleStep debugger, see Chapter 5.

The SDS tools are available on SUN4 UNIX workstations and PCs running DOS or Windows NT. The CrossCodeC cross-compiler and SingleStep debugger must be purchased directly from Wind River.

The following SDS documents apply to these development tools:

- *CrossCodeC for the 68000 Microprocessor Family*
- *SingleStep Debugger for the 68000 Microprocessor Family*

The CrossCodeC package is designed specifically for the Motorola 68000 family and includes a complete development system with a C compiler, a Motorola-standard

68000 assembler, a linker, and a downloader. The SDS assembler allows you to define up to 250 relocatable regions, identified by region names. These regions are mapped into the target memory structure by the linker using a linker specification file. This file allows you to map various regions to particular addresses and position them in ROM or RAM as needed. The C compiler automatically splits output into five standard regions for code, strings, constant data, initialized data, and uninitialized data which are named code, string, const, data, and ram, respectively. The freeway/icpcode/proto_kit/icp*nnnn*[1] directory contains a sample make file (makefile) and a sample linker specification file (sps_2424.spc, sps_2432.spc, or sps_6000.spc) which can be used to build the sps_fw_*nnnn*.mem image.

2.3 Interfacing to the Operating System

The assembly and C language interfaces to OS/Impact are described in the *OS/Impact Programmer Guide*. The freeway/icpcode/proto_kit/src directory contains source code for a C interface library (oscif.h and oscif.asm). The routines in this library are written according to the subroutine calling conventions of the CrossCodeC compiler and can be easily modified for most other C compilers or high-level language compilers.

The interface routines are necessary when accessing OS/Impact from C language routines for two reasons. First, OS/Impact's system calls are accessed through a software trap instruction, which cannot be generated directly from C. Second, the subroutine calling conventions of the CrossCodeC compiler (where parameters are passed mainly on the stack) differ from those of the OS/Impact system calls (where parameters are passed in registers). The interface routines must perform the necessary translations before and after OS/Impact system calls.

The oscif.h file contains C structure definitions for all relevant operating system data structures.

1. icp*nnnn* refers to the icp2424, icp2432, or icp6000 directory.

For programs written in assembly language, the freeway/icpcode/proto_kit/src directory includes the files sysequ.asm, with OS/Impact system call macros, and oscif.asm, with assembly language definitions of OS/Impact data structures. These files are in a format compatible with the CrossCodeC assembler, but can also be modified for use by other assemblers.

2.4 Motorola 68*xxx* Programming Environment

The Motorola 68*xxx* CPU is a 32-bit microprocessor with 32-bit registers, internal data paths, and addresses that provides a four-gigabyte direct addressing range. If your application code will be written in assembly language, you will find the *MC68000 Family Reference Manual (Motorola)* indispensable. It contains information on the general-purpose and special registers, addressing modes, instruction set, and exception processing. When programming in a higher-level language, most aspects of the processor are relatively transparent. The following sections present some general information to help you understand the 68*xxx* programming environment.

2.4.1 Processor Privilege States

The 68*xxx* supports two privilege levels: user and supervisor. On the ICP, OS/Impact operates in supervisor state, as do all interrupt service routines and certain sections of the application code. All tasks (including the system-level timer) operate in user state, where certain operations are not allowed. See the *MC68000 Family Reference Manual (Motorola)* for additional information.

2.4.2 Stack Pointers

The 68*xxx* special registers include three stack pointers: user (USP), master (MSP), and interrupt (ISP). When the M-bit in the status register is set to zero, only the USP and ISP are used. The ICP always operates in this mode, and user code must never set the M-bit to one.

In user state, the USP is the current stack pointer. In supervisor state, the ISP (usually called the system stack pointer, or SSP) is current. The current stack pointer is swapped automatically by the processor into general register A7 when the privilege level changes, so that register A7 is always used as the stack pointer, regardless of the processor's state.

A stack pointer is pre-decremented when an element is added to the stack (pushed) and post-incremented when an element is removed (popped). Stacks therefore grow from higher to lower memory addresses, and the stack pointer always contains the address of the element currently at the top of the stack.

During its initialization, OS/Impact allocates space for the system stack and initializes the SSP. The system stack is used whenever the processor is in supervisor state. This includes system calls and all interrupt service routines, including those associated with user applications.

You must allocate stack space for each application task you create and specify the initial stack pointer in the task initialization structure (see Section 4.2.2 on page 72). The initial stack pointer should be specified as the ending address of the stack space plus one. For example, if a task's stack space is 0x40016000 through 0x400163FF, the initial stack pointer should be specified as 0x40016400. OS/Impact saves this initial value in the task control block as the current stack pointer. When the task is dispatched, OS/Impact initializes the USP to the stack address saved in the task control block. When the task is preempted, the task's state (the contents of the general registers) is saved on its stack and the current USP is again saved in the task control block.

When allocating a task's stack, you must consider the space required at the deepest level of nested subroutine calls, and allow 66 bytes for the registers saved when the task is preempted. You need not allocate additional stack space for interrupt service routines, as the USP is not used for interrupt processing.

Note

The stack spaces are defined in the linker specification file freeway/icpcode/proto_kit/icp*nnnn*[1]/sps_*nnnn*.spc.

2.4.3 Exception Vector Table

On the 68*xxx*, interrupts and traps are processed through an exception vector table. The 68*xxx* vector base register points to the exception vector table, which contains 256 long-word (four-byte) vectors. The vector base register is not accessible in user state, so OS/Impact provides the base address of the exception vector table in its system address table. (See the *OS/Impact Programmer Guide*.)

The *MC68000 Family Reference Manual (Motorola)* lists vector assignments as defined by the 68*xxx* CPU. Table 2–1 lists the vectors that are reserved for use by Protogate's system software.

To install an interrupt service routine (ISR) for a particular device, multiply the vector number by four to obtain the vector offset, add the offset to the base address of the exception vector table, and store your ISR entry point at the resulting address.

When the device generates an interrupt, it supplies the 68*xxx* CPU with the eight-bit vector number, which the CPU multiplies by four to obtain a vector offset, then adds the contents of the vector base register to obtain the vector address at which your ISR entry point is stored. When interrupt servicing is complete, the ISR must terminate with a "return from ISR" (s_iret) system call (described in the *OS/Impact Programmer Guide*) if the interrupt requires that system services be invoked. Otherwise, a return from exception (RTE) is sufficient.

1. *nnnn* stands for 2424, 2432, or 6000.

Table 2–1: Vectors Reserved for System Software

Vector Number (Decimal)	Vector Offset (Hexadecimal)	Function
25	64	Auto vector level 1
26	68	Auto vector level 2
27	6C	Auto vector level 3
28	70	Auto vector level 4
32	80	TRAP # 0
33	84	TRAP # 1
34	88	TRAP # 2
35	8C	TRAP # 3
36	90	TRAP # 4
37	94	TRAP # 5
47	BC	TRAP # 15

When programming interrupt service routines in a high-level language, it is usually necessary to provide an assembly language “shell” for the ISR in order to save certain registers.

For example, the CrossCodeC compiler saves on entry and restores on exit all registers used in a subroutine except D0, D1, A0, and A1, which are considered working registers. The calling code must save these registers, if necessary, before making a subroutine call. These calling conventions, however, are not sufficient for ISRs. An ISR is not “called” in the ordinary sense; it interrupts code that might currently be using the working registers. The ISR must, therefore, save those registers as well.

Because many compilers cannot distinguish between an ordinary subroutine and an interrupt service routine, the programmer must provide an assembly language shell to save the working registers on entry and restore them at completion of the ISR. (Note that it is the address of the shell rather than the high-level language routine that must be stored in the appropriate vector of the exception vector table.) Figure 2–1 shows a sample assembly language shell.

```
      SECTION       9
      XREF      _Cisr                      external reference to C isr
      XDEF      _isr_shell                 external definition for C code
*                                          which stores this address
*                                          in the exception vector table
_isr_shell
      movem.l   d0/d1/a0/a1,-(sp)          save registers not saved by C
      jsr       _Cisr                      call C routine for interrupt
*                                          processing
      movem.l   (sp)+,d0/d1/a0/a1          restore registers
      s_iret                               return from isr (system call)
```

Figure 2–1: Assembly Language Shell

2.4.4 Interrupt Priority Levels

The Motorola 68*xxx* supports seven levels of prioritized interrupts, with level 7 being the highest priority. Any number of devices can be chained to interrupt at the same priority. Table 2–2 shows the interrupt priorities for the various ICP's hardware devices.

When an interrupt occurs at a particular priority, the interrupt mask field in the 68*xxx*'s status register is set to the priority level of that interrupt, causing other interrupts at the same or lower priorities to be ignored. When interrupt servicing is complete, the interrupt mask level in the status register is returned to its previous value, at which time pending interrupts at lower priorities can be serviced.

The interrupt priority level can be changed by directly modifying the mask field in the status register, but this is possible only in supervisor state. OS/Impact includes a system call that can be called from the task level to modify the interrupt priority level.

The *MC68000 Family Reference Manual (Motorola)* contains important information that should be studied before implementing interrupt-level code.

Table 2–2: ICP Interrupt Priority Assignments

Device(s)	Level
ICP2424	
Integrated Universal Serial Controllers (IUSC)	6
68340 periodic timer interrupt	5
ISAbus	5
ICP2432	
Integrated Universal Serial Controllers (IUSC)	6
68349 periodic timer interrupt	5
PCIbus	5
ICP6000	
Direct memory access controller	6
Serial communications controllers	5
Multi-function peripheral timer	5
VMEbus slave interface device	2

2.5 ICP2424 and ICP2432 Hardware Device Programming

The ICP2424 uses the Motorola 68340 CPU, an integrated processor. The ICP2432 uses the Motorola 68349 CPU. The 6834*x* includes:

- a CP32 CPU
- a two-channel DMA controller
- a two-channel universal synchronous/asynchronous receiver/transmitter (USART)
- a periodic interrupt timer
- two counter/timers

In addition to the Motorola 6834*x*, the ICP2424 and ICP2432's programmable devices include:

- two, four, or eight Z16C32 integrated universal serial controllers (IUSCs) with integral DMA for the ICP2432 or four IUSCs for the ICP2424
- Sipex's SP502 (ICP2424) or SP504 (ICP2432) multi-mode serial transceivers
- a test mode register
- an LED register

Note

The 8-port ICP2432 only supports EIA-232.

2.5.1 Programming the 68340/68349

The ICP2424 does not use the 68040's two-channel DMA controller. The ICP2432 uses the 68349's two-channel DMA controller for PCIbus transfers.

The 6834*x*'s serial port A is used as a console port. The SingleStep debugger uses vector 0x4c for serial port A interrupts. Serial port B's control signals are used to control the red and green LEDs on the mounting bracket. Table 2–3 contains the information needed to turn the green and red LEDs on and off.

Table 2–3: LED Control Information

Address	Value	Operation
0xee00f71e	0x40	Green LED on
0xee00f71e	0x10	Red LED on
0xee00f71f	0x40	Green LED off
0xee00f71f	0x10	Red LED off

Timer 1 of the two 8-bit timers is used by the ICP to support DRAM/Refresh. Timer 2 is not used. OS/Impact uses the periodic interrupt timer, which uses vector 0x40.

2.5.2 Programming the Integrated Universal Serial Controllers

The Z16C32 IUSCs are used to control the ICP's serial ports. Each IUSC controls transmit and receive operations for one port. The IUSC also includes a DMA facility. Refer to the *Z16C32 IUSC Integrated Universal Serial Controller Technical Manual*, for IUSC programming instructions. The sample protocol software package includes examples of IUSC programming for asynchronous, byte synchronous and bit synchronous communications. See Chapter 6 for more information.

2.5.3 Programming Sipex's Multi-Mode Serial Transceivers

The ICP2424 uses the SP502 and the ICP2432 uses the SP504 multi-mode serial transceiver. These transceivers allow software to select the electrical protocol to be used while communicating on the serial line. Table 2–4 gives the value to be written into the transceiver to select the corresponding electrical interface. See Chapter 3 for the addresses of the transceivers.

Table 2–4: SP502 or SP504 Electrical Interface Values

Interface	Value
RS-232	0x02
RS-449	0x0c
EIA-530	0x0d
V.35	0x0e

2.5.4 Programming the Test Mode Register

All modem control signals except Test Mode are handled directly by the IUSC associated with the port. The Test Mode input status for all supported ports is through the Test Mode register located at 0x1808000 for the ICP2424 or 0x1810000 for the ICP2432. When a bit is set to one, the Test Mode signal is asserted on the serial line. See Figure 2–2 for the ICP2424 or Figure 2–3 for the ICP2432.

Address = 0x1808000, byte wide, read only

Reserved	3	2	1	0

Figure 2–2: Test Mode Register, ICP2424

Address = 0x1810000, byte wide, read only

7	6	5	4	3	2	1	0

Figure 2–3: Test Mode Register, ICP2432

2.5.5 Programming the LED Register (ICP2424 only)

The byte-wide write-only LED register resides at address 0x410000. The LED register is used to control the eight LEDs on the ICP2424 board's edge. The LEDs are illuminated when the register bit is 0 and off when the bit is 1.

2.6 ICP6000 Hardware Device Programming

In addition to the Motorola 68020 CPU, the ICP6000's programmable devices include the following:

- a MC68901 multi-function peripheral (MFP) with four timers, interrupt control logic, and a single-channel universal synchronous/asynchronous receiver/transmitter (USART) which is used to support the ICP's console
- four or eight two-channel Z8530 serial communications controllers (SCCs)
- a 32-channel DMA transfer controller

Refer to the *MC68901 Multi-function Peripheral (Motorola)* and the *Serial Communications Controller User's Manual (Zilog)*.

The following sections describe how to program these devices as related specifically to their implementation on the ICP. More information can be found in the *Freeway ICP6000R/ICP6000X Hardware Description*. Appendix A of this manual provides some important application notes correcting errors and omissions in the technical manuals and describing some peculiarities of the devices and the ICP hardware.

The ICP hardware also includes a VMEbus slave interface device that controls the ICP's interface to the Freeway server or the embedded ICP's client machine. This device is under the control of XIO and does not normally require programming at the application level. All data transfers to and from the client machine are performed by the ICP through the VMEbus master interface. Programming parameters for the master interface are provided to the ICP by the client-side driver prior to download. Refer to the *Freeway ICP6000R/ICP6000X Hardware Description* for more information.

2.6.1 Programming the Multi-function Peripheral

The MC68901 multi-function peripheral (MFP) requires 16 interrupt vectors. The starting vector number is programmed using the MFP's vector register and must be an even multiple of 16. The In-service Register Enable bit in the vector register must be set (that is, OR the vector number with 8 before storing it in the vector register). OS/Impact uses MFP timer channel A. The PTBUG debugging tool uses channel D as the baud rate generator for the MFP's serial port and uses the MFP's USART to control the console port. Timer channels B and C are dedicated to hardware functions. Do not change the configuration of the timer channels.

The MFP contains 24 byte-wide registers beginning at the MFP base address (0x20000000). The MFP's eight channels of external interrupt control are used to provide SCC interrupts. The MFP must be initialized appropriately before using SCC interrupts.Table 2–5 shows the recommended setup.

Table 2–5: Setup for MFP Initialization

Register	Value (Hexadecimal)
VR	48
DDR	00
AER	00
IPRA	00
IPRB	00
IERA	C0
IERB	CF
IMRA	C0
IMRB	CF

With the MFP vector register set to 0x48, the MFP's base vector is 0x40 and the eight SCCs interrupt at the vector numbers shown in Table 2–6.

Refer to the *MC68901 Multi-function Peripheral (Motorola)* for MFP programming instructions. The sample protocol software package includes code to perform MFP initialization and handle MFP control of SCC interrupts.

Table 2–6: Vector Numbers for SCC Interrupts

Channels	Vector (Hexadecimal)
0 and 1	40
2 and 3	41
4 and 5	42
6 and 7	43
8 and 9	46
10 and 11	47
12 and 13	4E
14 and 15	4F

2.6.2 Programming the Serial Communications Controllers

Four or eight Z8530 or Z85230 serial communications controllers (SCCs) are used to control the ICP6000's eight or sixteen ports. Each SCC has two channels, A and B, and each channel controls transmit and receive operations for one port. For example, SCC01 controls port 0 on channel A and port 1 on channel B, SCC23 controls port 2 on channel A and port 3 on channel B, and so on. Table 3–4 on page 55 lists the SCC base addresses. Each SCC is accessed through the eight-bit registers shown in Table 2–7.

Table 2–7: SCC Access Registers

Register	Offset from SCC Base Address
Channel A Data	0
Channel A Control	1
Channel B Data	2
Channel B Control	3

Each channel of the SCC contains 16 eight-bit write registers, numbered 0 through 15, and nine eight-bit read registers, numbered 0, 1, 2, 3, 8, 10, 12, 13, and 15. Write register

8 and read register 8 (the transmit and receive data buffers) are accessed directly through the channel's data register. All other registers except Read and Write registers (RRO and WRO) are accessed through the channel's control register in two steps: a write to select the actual register number, followed by a read or write to transfer the data. RRO and WRO are accessible with a single transfer.

Note

These two steps must be done at CPU level 6 to lock out any ISRs that might need to access the SCCs.

Refer to the *Serial Communications Controller User's Manual (Zilog)* for SCC programming instructions. The sample protocol software package includes examples of SCC programming for asynchronous, byte synchronous, and bit synchronous communications. See Chapter 6 for more information. Also see pointer array Z8530 *scc[] in freeway/icpcode/proto_kit/src/spsstructs.h.

2.6.3 Programming the DMA Controller

The 32-channel direct memory access (DMA) controller is programmed using a single byte-wide command register and, for each channel, a 32-bit memory address register and a 32-bit terminal count register. Channels 0 through 15 are dedicated to receive operations on serial ports 0 through 15, and channels 16 through 31 are likewise dedicated to transmit operations.

The command register is located at address 0x10000000. The memory address registers begin at address 0x400FFF00. The terminal count registers begin at address 0x40*x*FFF80. (*x* is 0 for a 1 MB ICP, 3 for a 4 MB ICP, or 7 for a 8 MB ICP.) Only the low-order 20 bits of the memory address and terminal count registers are valid, allowing an address range of 1 megabyte beginning at the base address of RAM (0x40000000). Also see pointer array IO_DMA io_dma[3] in freeway/icpcode/proto_kit/src/spsstructs.h.

Vector numbers 224–255 (0xE0–0xFF) are dedicated to DMA controller channels 0–31, respectively.

Refer to the *Freeway ICP6000R/ICP6000X Hardware Description* for DMA programming instructions. The sample protocol software package includes examples of DMA programming for transmit and receive operations.

Chapter 3 Memory Organization

This chapter describes the memory maps for the ICP2424, ICP2432, and ICP6000.

3.1 ICP2424

The 128-kilobyte EPROM on the ICP2424 is located at address 0x0000. The EPROM contains the diagnostics, Peeker debugging tool, and boot loader.

One megabyte of dynamic random access memory (DRAM) starts at 0x00800000. This DRAM is only accessible to the MC68340 and is used for program and private data space that does not need to be accessed by any of the devices in the Z-bus space. The Z-bus space contains one megabyte of DRAM as shared memory. The shared memory starts at 0x01000000 as seen from the MC68340. The shared memory is to buffer data between the ISAbus and the IUSCs. The ISAbus has access to that memory at the locations defined in Table 3–1. The IUSCs' DMA controllers see the shared memory at 0x00000000.

Addresses 0x00800000 to 0x00801200 of the private memory are reserved. The system services module (containing the operating systems and XIO) is loaded beginning at address 0x00801200. As described in Section 4.3.1 on page 75, the fixed memory requirements for a particular version of the system services module are specified in the spsdefs.h file, and additional memory required for the OS/Impact's configurable data section depends on the system configuration. The rest of the DRAM is available for user applications.

The *ICP2424 Hardware Description and Theory of Operation* provides a complete memory map. Table 3–2 summarizes the hardware device and register addresses.

Table 3–1: ICP2424 Memory Address Registers Base Address

Physical Device ID	Address (Hexadecimal)
0	00080000
1	00090000
2	000A0000
3[1]	000B0000
4[a]	000C0000
5[a]	000D0000
6[a]	000E0000
7[2]	000F0000

[1] Physical device IDs 4, 5, 6, and 3 are preferred for logical ICPs 0, 1, 2, and 3, respectively.

[2] Physical device ID 7 cannot be used in Freeway 1100 because of a motherboard device conflict.

Table 3–2: ICP2424 Device and Register Addresses

Device or Register	Base Address (Hexadecimal)
LED on board edge	00410000
Base address of IUSC for Port 0	01800000
Base address of IUSC for Port 1	01801000
Base address of IUSC for Port 2	01802000
Base address of IUSC for Port 3	01803000
SP502 for Port 0	01804000
SP502 for Port 1	01805000
SP502 for Port 2	01806000
SP502 for Port 3	01807000

3.2 ICP2432

The 128-kilobyte EPROM on the ICP2432 is located at address 0x0000. The EPROM contains the diagnostics, Peeker debugging tool, and boot loader.

Two or eight megabytes of dynamic random access memory (DRAM) start at 0x00800000. Memory addresses 0x00800000 to 0x00801200 are reserved. The system services module (containing the operating systems and XIO) is loaded beginning at address 0x00801200. As described in Section 4.3.1 on page 75, the fixed memory requirements for a particular version of the system services module are specified in the spsdefs.h file, and additional memory required for the OS/Impact's configurable data section depends on the system configuration. The rest of the DRAM is available for user applications.

The *ICP2432 Hardware Description and Theory of Operation* provides a complete memory map. Table 3–3 summarizes the hardware device and register addresses.

Table 3–3: ICP2432 Device and Register Addresses

Device or Register	Base Address (Hexadecimal)
Base address of IUSC for Port 0	01800000
Base address of IUSC for Port 1	01810000
Base address of IUSC for Port 2	01820000
Base address of IUSC for Port 3	01830000
Base address of IUSC for Port 4	01840000
Base address of IUSC for Port 5	01850000
Base address of IUSC for Port 6	01860000
Base address of IUSC for Port 7	01870000
SP504 for Port 0	01880000
SP504 for Port 1	01890000
SP504 for Port 2	018A0000
SP504 for Port 3	018B0000

3.3 ICP6000

The 64-kilobyte PROM on the ICP6000 is located at address 0x0000. The PROM contains the diagnostics, PTBUG debugging tool, and boot loader.

Socket U19 on the ICP is available for a user-added PROM of up to 256 kilobytes. If installed, this PROM is addressed beginning at 0x20000.

One, four, or eight megabytes of dynamic random access memory (DRAM) starts at 0x40000000. Addresses 0x40000000 to 0x40001200 are reserved for PTBUG's data area. The system services module (containing the operating system and XIO) is loaded beginning at address 0x40001200. As described in Section 4.3.1 on page 75, the fixed-memory requirements for a particular version of the system services module are specified in the spsdefs.h file, and the additional memory required for OS/Impact's configurable data section depends on the system configuration. The rest of the RAM is available for user applications.

The *Freeway ICP6000R/ICP6000X Hardware Description* provides a complete memory map. Table 3–4 in this chapter summarizes the addresses of hardware registers and the base addresses of hardware devices.

The Freeway server communicates with the ICP6000 via 16 mailbox registers. Table 3–5 defines the base of these registers as seen on the VMEbus.

Table 3–4: ICP6000 Device and Register Addresses

Device or Register	Base Address (Hexadecimal)
DMA command register	10000000
General control register 0	10000001
General control register 1	10000002
General status register 0	10000003
Multi-function peripheral base address	20000000
VMEbus slave interface base address	30000000
Base of DMA memory address registers	400FFF00 (for 1 MB DRAM system) 403FFF00 (for 4 MB DRAM system) 407FFF00 (for 8 MB DRAM system)
Base of DMA terminal count registers	400FFF80 (for 1 MB DRAM system) 403FFF80 (for 4 MB DRAM system) 407FFF80 (for 8 MB DRAM system)
Base address of SCC01	60000000
Base address of SCC23	60000004
Base address of SCC45	60000008
Base address of SCC67	6000000C
Base address of SCC89	60000010 (for a 16-port ICP6000)
Base address of SCCAB	60000014 (for a 16-port ICP6000)
Base address of SCCCD	60000018 (for a 16-port ICP6000)
Base address of SCCEF	6000001C (for a 16-port ICP6000)

Table 3–5: ICP6000 VME Slave Address Registers Base Address

Physical Device ID	Address (Hexadecimal)
0	F000[1]
1[2]	F200
2[b]	F400
3[b]	F600
4[b]	F800
5	FA00
6	FC00
7	FE00

[1] VME short address space.

[2] Physical device IDs 1, 2, 3, and 4 are preferred for logical ICPs 0, 1, 2, and 3, respectively.

Chapter

4 ICP Download, Configuration, and Initialization

Section 4.1 of this chapter describes additional download considerations not covered in the *Freeway User Guide* or the embedded ICP user guide so you can download the toolkit protocol software with or without the Software Development Systems (SDS) debug monitor. Section 4.2 describes configuration and initialization issues. Section 4.3 describes the relationship between the system configuration and OS/Impact's memory requirements and performance.

4.1 Download Procedures

4.1.1 Freeway Server Download Procedure

The protocol software toolkit installation procedure is described in the *Freeway User Guide*. On UNIX systems, all subdirectories are installed by default under the directory named /usr/local/freeway. On VMS systems, all subdirectories are installed by default under the directory named SYS$SYSDEVICE:[FREEWAY]. On Windows NT systems, all subdirectories are installed by default under the directory named c:\freeway. ***It is highly recommended that you use these default directories.***

During the software installation, boot, and test procedures described in the *Freeway User Guide*, the non-debug version of the toolkit software is downloaded to the ICP. However, during toolkit application development, you must modify your Freeway server boot configuration file and then reboot the Freeway server to download and start the debug monitor module. Section 4.1.1.1 and Section 4.1.1.2 describe the files and modifications required to download with or without the Software Development Systems (SDS) debug monitor.

The Freeway server boot configuration file, used to control the download procedure, is covered in detail in the *Freeway User Guide*. The boot configuration file is located in the freeway/boot directory (for example, bootcfg.vme for a Freeway 2000/4000/8800). The download script file parameter (download_script) in the boot configuration file specifies the modules to be downloaded to the ICP and the memory location for each module. You must modify the download_script parameter as described in Section 4.1.1.2 when you need to change between debug and non-debug operation.

When you reboot the Freeway server, the modules are downloaded to the ICP in two stages. First, the server software uses a file transfer program to download the modules to the server's local memory. The modules are then transferred across the ISAbus, PCIbus, or VMEbus to the ICP.

PCIbus and VMEbus transfers are handled by the ICP's CPU. The server software provides the location and size of the binary images and the address in the ICP's RAM at which the modules should be loaded, and then signals the ICP to begin the download process.

ISAbus transfers are handled by the server's CPU. The entire image is placed in shared memory, then the ICP moves the image to private memory.

4.1.1.1 Downloading Without the Debug Monitor

Under normal operations you download the toolkit software without the debug monitor. The following files are required:

spsload	This is the download script file. You must specify this file name for the download_script parameter in your boot configuration file. The file is in the freeway/boot directory.
xio_2424.mem, xio_2432.mem, or xio_6000.mem	This is the system-services module containing the OS/Impact operating system kernel, timer task, and XIO. This file is in the freeway/boot directory.
sps_fw_2424.mem, sps_fw_2432.mem, or sps_fw_6000.mem,	This is the toolkit sample protocol software (SPS) module. This file is in the freeway/icpcode/proto_kit/icp*nnnn*[1] and freeway/boot directories. Source files are in the freeway/icpcode/proto_kit/src directory. If you make changes to the source files, you must rebuild the sps_fw_*nnnn*.mem module before downloading. The makefile is in the freeway/icpcode/proto_kit/icp*nnnn* directory.

The protocol toolkit developer may wish to change the download script file to download the sps_fw_*nnnn*[2].mem file directly from freeway/icpcode/proto_kit/icp*nnnn;* otherwise, you must copy any new versions of the protocol sps_fw_*nnnn*.mem file after each rebuild.

Figure 4–1 shows the spsload download script file that downloads the toolkit software when you reboot the Freeway server. Uncomment the “normal” lines associated with the type of ICP you are using and modify path names as needed. Do not change the memory locations (such as 40001200) for the LOAD commands.

1. icp*nnnn* refers to the icp2424, icp2432, or icp6000 directory.
2. *nnnn* refers to the icp2424, icp2432, or icp6000.

Note

Do not remove the comment indicator (#) from the “LOAD buffer.size” statement if the buffer size is to be the default (Section 4.1.3 on page 64).

```
#---------------------------------------------------------------------------#
#
# spsload - Protocol load file to be used to load the SPS toolkit protocol
#           onto an ICP.
#
# Protocol load files are referenced from the server boot configuration file
#
# load files contain LOAD and INIT commands.
#    LOAD <fully qualified path name to the .mem file> <load address>
#    INIT <initialization address>
#
# If no path name is provided for the .mem files to be loaded, Freeway
# searches the System Boot Directory specified in the Freeway System
# Boot Parameters for the file.  A fully qualified path name to
# each file may be used if desired.  e.g.
#
#   LOAD /usr/local/freeway/boot/sps_fw_2424.mem   818000
#
# for the "sps_fw_2424.mem" file in the "/usr/local/freeway/boot"
# directory on a UNIX host.  (see the bootcfg example
# file for example path syntax for various host machines)
#
# Each sps load file must contain an osimpact (xio) .mem file
# and an sps .mem file
#
# Uncomment the ICP load/init section below for your ICP model.
#
#---------------------------------------------------------------------------#
```

Figure 4–1: Protocol Toolkit Download Script File (spsload)

```
#
# SNMP support notes for SPS toolkit protocol software product SP-000-6013:
#
# When using Freeway server SP-000-6055 Rev M (or later revision)
# LOAD the appropriate snmp .mem file show in the samples below.
#
# When using Freeway server SP-000-6055 Rev L (or prior revision)
# DO NOT load the appropriate snmp .mem file show in the samples below.
#
#--------------------------------------------------------------------------#
#
#
# the example below is for icp2424 normal operation
#
#LOAD xio_2424.mem        801200
#LOAD snmp2424.mem        810000
#LOAD sps_fw_2424.mem     818000
#LOAD buffer.size         1001000
#INIT                     818000
#
# the example below is for icp2424 debug operation
# (SNMP support is not recommended for debug operation)
#
#LOAD xio_2424.mem        801200
#LOAD icp2424c.mem        812000
#LOAD sps_fw_2424.mem     818000
#LOAD buffer.size         1001000
#INIT                     812000
#
# the example below is for icp2432 normal operation
#
#LOAD xio_2432.mem        801200
#LOAD snmp2432.mem        810000
#LOAD sps_fw_2432.mem     818000
#LOAD buffer.size         9d0000
#INIT                     818000
#
# the example below is for icp2432 debug operation
# (SNMP support is not recommended for debug operation)
#
#LOAD xio_2432.mem        801200
#LOAD icp2432c.mem        812000
#LOAD sps_fw_2432.mem     818000
#LOAD buffer.size         9d0000
#INIT                     812000
#
```

Figure 4–1: Protocol Toolkit Download Script File (spsload) (*Cont'd*)

```
# the example below is for icp6000 normal operation
#
#LOAD xio_6000.mem      40001200
#LOAD snmp6000.mem      40010000
#LOAD sps_fw_6000.mem   40018000
#LOAD buffer.size       400d0000
#INIT                   40018000
#
# the example below is for icp6000 debug operation
# (SNMP support is not recommended for debug operation)
#
#LOAD xio_6000.mem      40001200
#LOAD icp6000c.mem      40012000
#LOAD sps_fw_6000.mem   40018000
#LOAD buffer.size       400d0000
#INIT                   40012000
#
```

Figure 4–1: Protocol Toolkit Download Script File (spsload) (*Cont'd*)

4.1.1.2 Downloading With the Debug Monitor

During application development you must download the toolkit software with the debug monitor. The SDS tools are not compatible with VMS platforms, but UNIX, DOS and Windows versions are available. If you are a VMS user, you can develop and debug your software with these tools using a PC running under DOS or Windows and a utility to transport files from the PC to the VMS system. Chapter 5 explains how to use the SDS debug tools.

The following files are required:

spsload	This is the download script file. You must specify this file name for the download_script parameter in your boot configuration file. The file is in the freeway/boot directory.
icp2424c.mem, icp2432c.mem or icp6000c.mem	This module contains the source-level debug monitor. This file is in the freeway/icpcode/proto_kit/icp*nnnn*[1] directory.
sps_fw_2424.mem, sps_fw_2432.mem, or sps_fw_6000.mem	This is the toolkit sample protocol software (SPS) module. This file is in the freeway/icpcode/proto_kit/icp*nnnn*[1] directory. Source files are in the freeway/icpcode/proto_kit/src directory. If you make changes to the source files, you must rebuild the sps_fw_*nnnn*.mem module before downloading. The makefile is in the freeway/icpcode/proto_kit/icp*nnnn* directory.

Figure 4–1 on page 60 shows the spsload download script file that downloads the toolkit software when you reboot the Freeway server. Uncomment the "debug" lines associated with the type of ICP you are using and modify path names as needed. Do not change the memory locations (such as 40001200) for the LOAD commands.

1. icp*nnnn* refers to the icp2424, icp2432, or icp6000 directory.

When the SDS debug monitor is downloaded along with other executable image files, the placement and order of execution of the downloaded code is different. The download addresses of the modules can differ, and the debug module will be first to execute. Note that the monitor must use RAM from 0x812000 to 0x818000 on the ICP2424 or ICP2432, and from 0x40012000 to 0x40018000 on the ICP6000.

4.1.2 Embedded ICP Download Procedure

As with the Freeway server environment described in Section 4.1.1, the freeway/boot/spsload file defines the files to be downloaded to the embedded ICP. Uncomment the lines associated with the type of ICP you are using and modify path names as needed. Do not change the memory locations (such as 40001200) for the LOAD commands.

The ICPs are loaded by the program icpload (a Windows NT service) which is normally executed during the start up of the client machine. During development, the ICPs may be loaded or reloaded by running spsload.

4.1.3 ICP Buffer Size

The maximum ICP buffer size can be set at ICP download time by downloading a “buffer size” file. A default buffer.size file is provided in the freeway/boot directory and can be downloaded at the following addresses (as shown in Figure 4–1 on page 60):

ICP2424	0x01001000
ICP2432	0x009D0000
ICP6000	0x400D0000

To create your own buffer.size file:

1. Set your default directory to freeway/icpcode/proto_kit/buffer_size.

2. Compile and link the make_size utility program:

on Windows NT:	**nmake -f makefile.nt**
on UNIX:	**make -f makefile.unix**
on VMS:	**@makefile**

3. Run the make_size utility program, specifying the desired buffer size when prompted.

4. Copy the new buffer.size file to the freeway/boot directory for subsequent downloads.

However, since in most cases the maximum buffer size is not changed, it is suggested that the #define variable DEFAULT_FNAME be changed if the default size of 1024 is not acceptable.

4.2 OS/Impact Configuration and Initialization

A complete ICP run-time system is composed of a system-services module and one or more user-application modules. One of the user-application modules must include a configuration table and a system task initialization routine. For example, the system-services module provided with toolkit is the binary image file (xio_2424.mem, xio_2432.mem, or xio_6000.mem), and the sample user-application modules are the sample protocol software binary image (sps_fw_2424.mem, sps_fw_2432.mem, or sps_fw_6000.mem).

The last step of the download script file specifies an entry point or start-up address for execution of the downloaded code (see the INIT command in Figure 4–1). This entry point must be the address of your system task initialization routine (or the address of the icp*nnnn*c.mem debug module if you are running with the SDS debug monitor).

After download completes and control has been transferred to your task initialization routine, system configuration and initialization begin as described in the remainder of this section.

Figure 4–2 shows a sample memory layout that specifies the download and start-up locations in the ICP2424's RAM for the system-services module and sample protocol application.

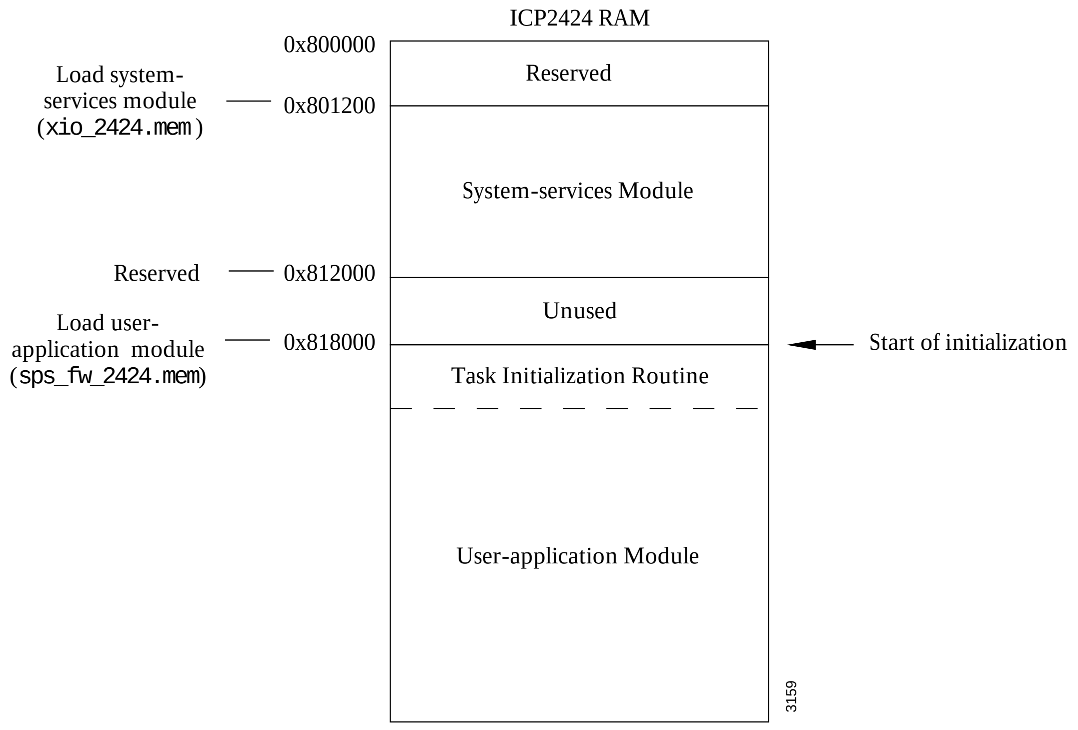


Figure 4–2: ICP2424 Memory Layout with Application Only

Figure 4–3 shows a similar ICP2424 configuration consisting of the system-services module, SDS debug monitor, and sample protocol application.

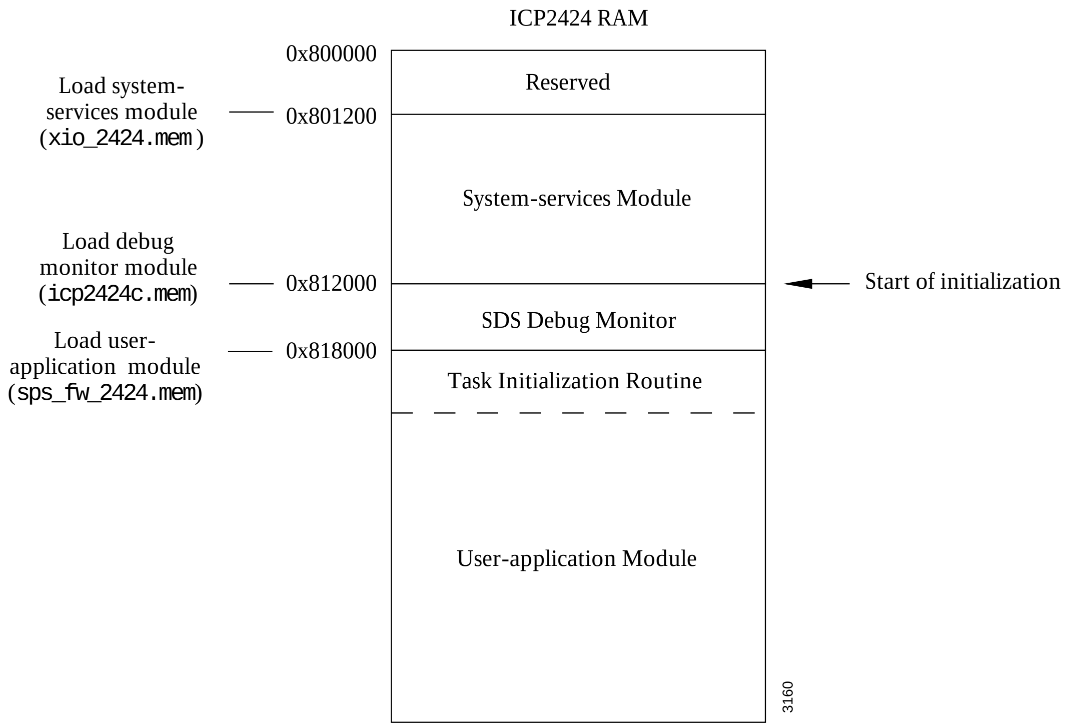

ICP2424 RAM
0x800000
Reserved
Load system-services module (xio_2424.mem)
0x801200
System-services Module
Load debug monitor module (icp2424c.mem)
0x812000
Start of initialization
SDS Debug Monitor
Load user-application module (sps_fw_2424.mem)
0x818000
Task Initialization Routine
User-application Module
3160

Figure 4–3: ICP2424 Memory Layout with Application and SDS Debug Monitor

Figure 4–4 shows a sample memory layout that specifies the download and start-up locations in the ICP2432's RAM for the system-services module and sample protocol application.

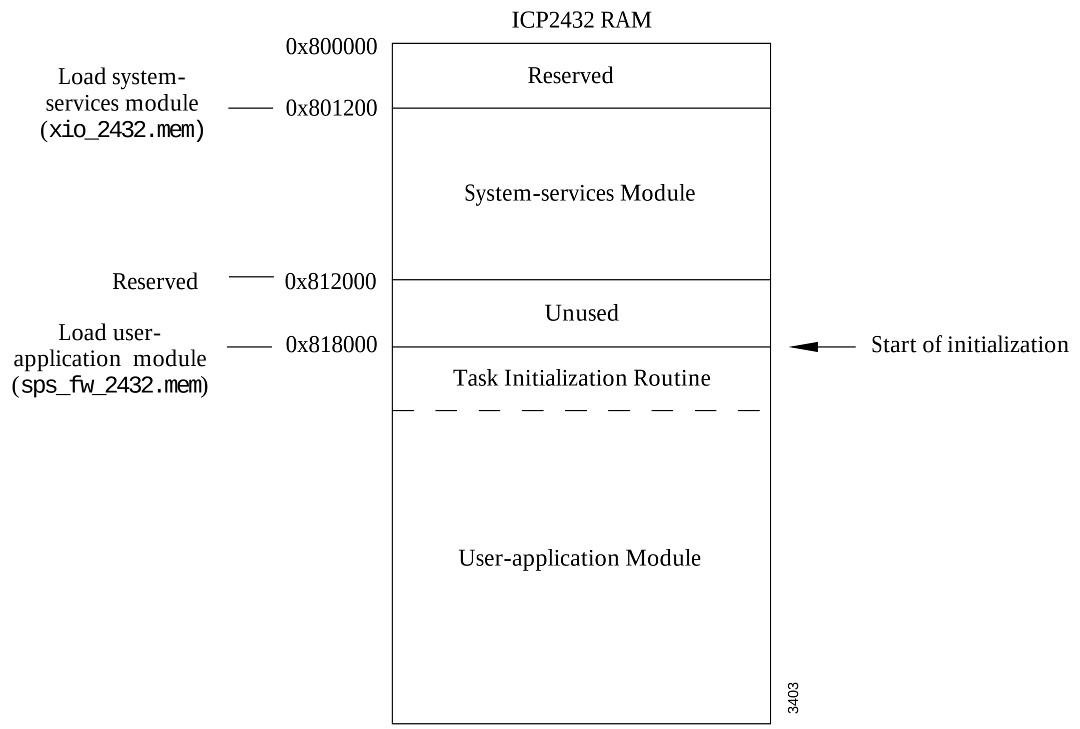


Figure 4–4: ICP2432 Memory Layout with Application Only

Figure 4–5 shows a similar ICP2432 configuration consisting of the system-services module, SDS debug monitor, and sample protocol application.

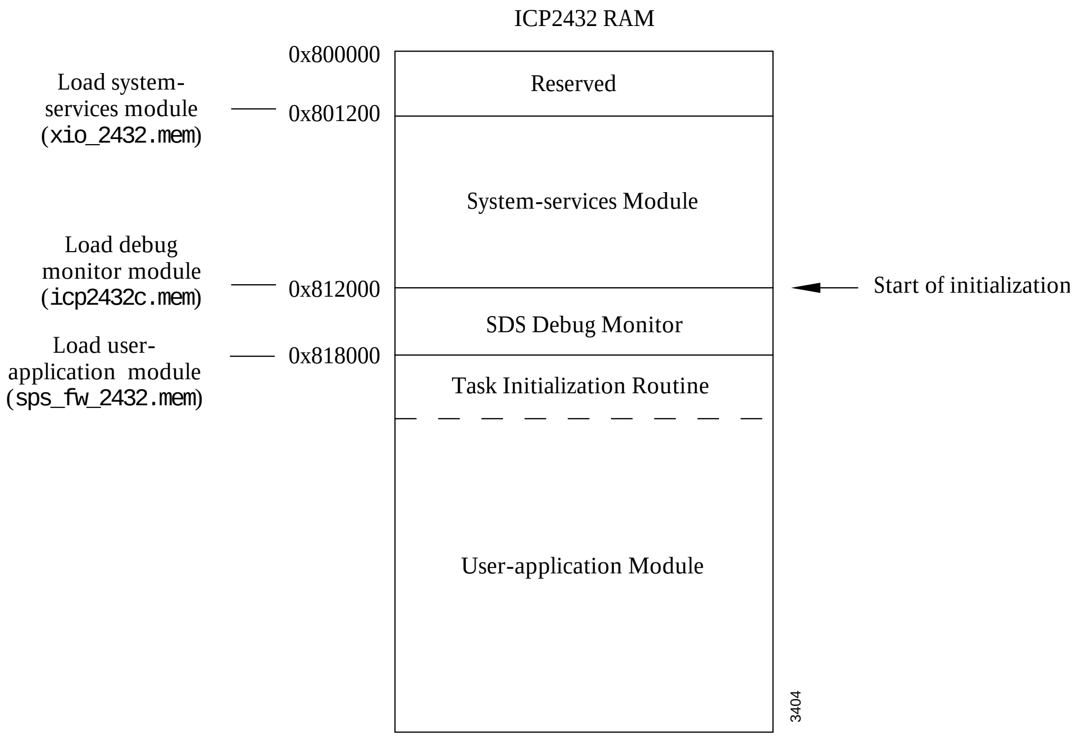

ICP2432 RAM
0x800000
Load system-services module (xio_2432.mem)
0x801200
Reserved
System-services Module
Load debug monitor module (icp2432c.mem)
0x812000
Start of initialization
SDS Debug Monitor
Load user-application module (sps_fw_2432.mem)
0x818000
Task Initialization Routine
User-application Module
3404

Figure 4–5: ICP2432 Memory Layout with Application and SDS Debug Monitor

Figure 4–6 shows a sample memory layout that specifies the download and start-up locations in the ICP6000’s RAM for the system-services module and sample protocol application.

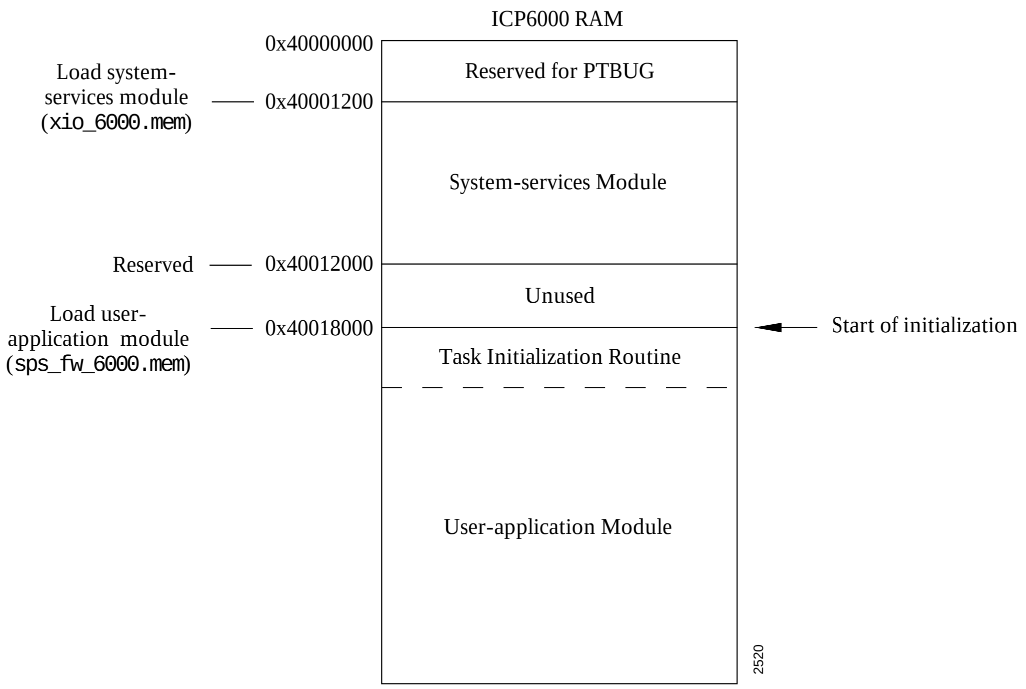


Figure 4–6: ICP6000 Memory Layout with Application Only

Figure 4–7 shows a similar ICP6000 configuration consisting of the system-services module, SDS debug monitor, and sample protocol application.

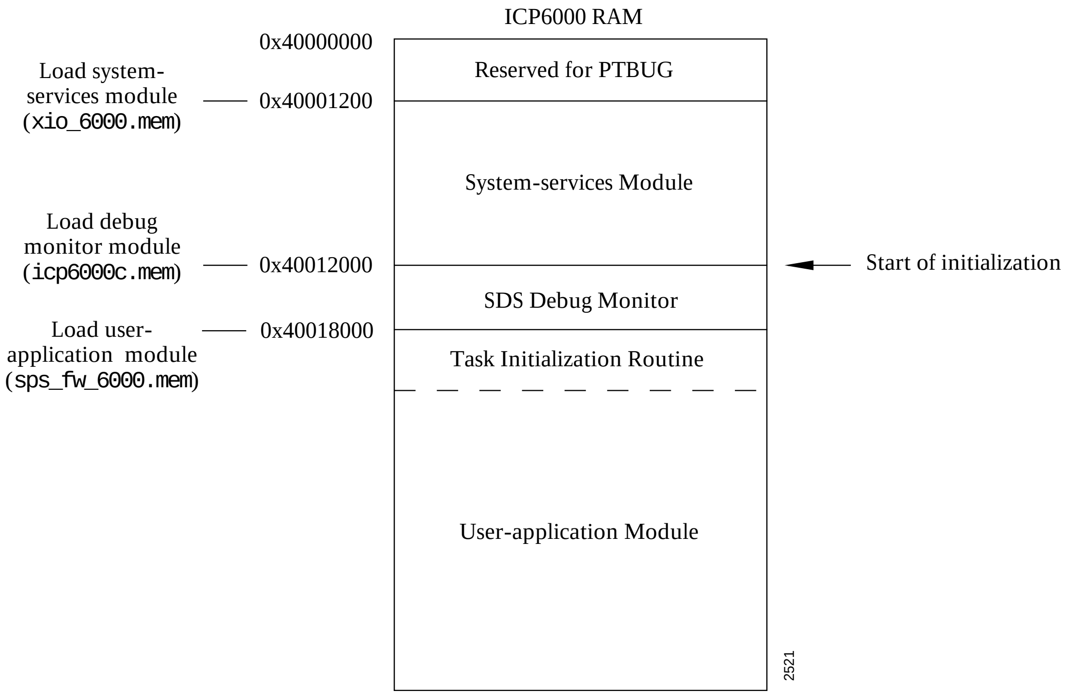


Figure 4–7: ICP6000 Memory Layout with Application and SDS Debug Monitor

4.2.1 Configuration Table

The format of the configuration table is defined in the *OS/Impact Programmer Guide* and consists of a list of configurable parameters and a list of task initialization structures.

OS/Impact creates its data structures based on the values of the parameters, then creates a task for each task initialization structure.

Section 4.3 discusses the selection of appropriate configuration parameters. Figure 4–8 gives an example of a configuration table (not including the task initialization structures).

```
spscon
        DC.W          8          number of tasks
        DC.W          8          number of priorities
        DC.W        164          number of queues
        DC.W         10          number of alarms
        DC.W          8          number of partitions
        DC.W          0          number of resources
        DC.W        100          tick length (milliseconds)
        DC.W          8          ticks for time slice
        DC.L          0          no user clock isr
```

Figure 4–8: Sample Configuration Table

4.2.2 Task Initialization Structures

A list of task initialization structures must follow the configuration table. The sample configuration table shown previously in Figure 4–8 is repeated in Figure 4–9 with task initialization structures for a sample task.

```
*
* Configuration Table
*
        SECTION 14

        XDEF    spscon

spscon
        DC.W    8       number of tasks
        DC.W    8       number of priorities
        DC.W    164     number of queues
        DC.W    10      number of alarms
        DC.W    8       number of partitions
        DC.W    0       number of resources
        DC.W    100     tick length
        DC.W    8       ticks for time slice
        DC.L    0       no user clock isr


* Task Initialization Structure for the sample protocol task

        DC.W    SPSTSK_ID       task ID
        DC.W    2               task priority
        DC.L    _spstsk         entry point address
        DC.L    RAM+$f8000      initial stack pointer
        DC.W    0               time slice enabled
        DC.W    0               filler (not used)


* Task Initialization Structure for the spshio (utility) task

        DC.W    SPSHIO_ID       task ID
        DC.W    2               task priority
        DC.L    _spshio         entry point address
        DC.L    RAM+$fe000      initial stack pointer
        DC.W    0               time slice enabled
        DC.W    0               filler (not used)

* end of list
        DC.W    0               end of list marker
```

Figure 4–9: Sample Configuration Table with Task Initialization Structures

4.2.3 Task Initialization Routine

You must supply a task initialization routine in one of the downloaded modules to be used at the start-up of the ICP. The task initialization routine is executed at the completion of the download sequence and must perform the following functions:

1. Load the configuration table address into register A0.

2. Obtain the operating system initialization entry point address from the global system table at fixed address 0x801600 for the ICP2424 or ICP2432, or 0x40001600 for the ICP6000. Load this address into register A1.

3. Jump to the operating system initialization entry point “osinit.”

Figure 4–10 shows a sample task initialization routine associated with the configuration table shown previously in Figure 4–9.

```
            XDEF      _sysinit
_sysinit
            move.l    #spscon,a0          address of config table
            move.l    RAM+$1600,a1        address of OS/Impact init
            jmp       (a1)                jump to OS/Impact's init
```

Figure 4–10: Sample Task Initialization Routine

4.2.4 OS/Impact Initialization

After your task initialization routine passes control to OS/Impact’s system initialization entry point with the address of the configuration table in register A0, the “osinit” routine performs the following operations:

1. Initialize system stack pointer, exception vector table, and clock interrupts (using the tick length specified in the configuration table).

2. Build data structures (task control blocks, queue control blocks, and so on) according to parameters specified in the configuration table.

3. Allocate space for the timer task's stack and create the task.

4. Use the task initialization structures included in the configuration table to create one or more application tasks.

5. Transfer control to the kernel's dispatcher to begin normal run-time operations.

The timer task is the highest priority in the system and is dispatched first. It performs certain initialization procedures and then stops, after which the other tasks that were created are dispatched in order of priority.

4.3 Determining Configuration Parameters

Although the design of a system should never be constrained by its configuration, when available memory is extremely limited or system performance is critical, it might be wise to consider the relationship between the system configuration and OS/Impact's memory requirements and performance. These relationships are discussed in the following sections.

4.3.1 OS/Impact Memory Requirements

OS/Impact requires memory space for code, system data, stacks, and the exception vector table. Some data requirements are fixed, and some are dependent on the system configuration. The space required for the exception vector table, code, and fixed data for a particular version of the operating system can be found in xio_*nnnn*.xrf for xio_*nnnn*.mem. The number of bytes required for the system stacks and configurable data structures can be calculated as shown in Table 4–1.

Table 4–2, which is based on the configuration shown previously in Figure 4–8 on page 72, shows a sample calculation used to determine the total number of system data bytes required. The total memory requirements for the system are calculated by adding the total number of system bytes required to the ending address of the system services module and rounding up, if necessary, to an even multiple of four bytes.

Table 4–1: System Data Requirements

Stack	Bytes Required
Supervisor stack	1024
Timer task’s stack	512
Task control blocks	Number of tasks x 24
Queue control blocks	Number of queues x 20
Partition control blocks	Number of partitions x 28
Resource control blocks	Number of resources x 16
Alarm control blocks	Number of alarms x 28
Task alarm control blocks	Number of tasks x 28
Dispatch queues	((Number of priorities + 1) x 8) + 4

Table 4–2: Sample Calculation of System Data Requirements

Stack	Bytes Required		
Supervisor stack			1024
Timer task’s stack			512
Task control blocks	8 x 24	=	192
Queue control blocks	30 x 20	=	600
Partition control blocks	4 x 28	=	112
Resource control blocks	0 x 16	=	0
Alarm control blocks	10 x 28	=	280
Task alarm control blocks	8 x 28	=	224
Dispatch queues	((5 + 1) x 8) + 4	=	52

			2996
			or
			0xBB4

Continuing this example, assume that the xio_6000.xrf file shows 0x400045BE as the system services module ending address. When the module is downloaded, the exception vector table, fixed data, and code occupy 0x33BE bytes at memory locations 0x40001200 (starting load address) through 0x400045BE. After operating system initialization is finished using the configuration table in our example, an additional 0xBB4 bytes is used for system stacks and configurable variables. The first free byte following system memory is then 0x400045BE + 0xBB4 + 2 (for an even multiple of four), or 0x40005174. This address can be verified by checking the gs_ramend field of the global system table after the system has been downloaded and initialized. The global system table is defined in the *OS/Impact Programmer Guide*.

4.3.2 Configuration and System Performance

The following fields of the configuration table define the number of control structures to be allocated during system initialization:

cf_ntask	Task control blocks and task alarm control blocks
cf_nque	Queue control blocks
cf_nalarm	Alarm control blocks
cf_npart	Partition control blocks
cf_nresrc	Resource control blocks

As described in Section 4.3.2.1, the values of these fields, no matter how large, have no effect on system performance. The cf_nprior field determines the number of task priorities in the system and affects performance as described in Section 4.3.2.2. The cf_ltick field determines the length of a “tick” and the cf_lslice field determines the length of a time slice. The relationships of these fields to system performance are discussed in Section 4.3.2.3.

4.3.2.1 Number of Configured Task Control Structures

The cf_ntask field of the configuration table defines the number of task control blocks to be allocated in the system. Task control blocks are allocated sequentially, forming an array of structures. The task ID is used as an index into the array to locate a particular task control block. Therefore, the processing time required to access any task control block is fixed and is not dependent on the number of task control blocks in the system. Likewise, and for the same reason, the number of queue control blocks, alarm control blocks, partition control blocks, and resource control blocks has no effect on system performance.

4.3.2.2 Number of Configured Priorities

The cf_nprior field of the configuration table determines the number of task priorities to be defined. A dispatch queue is created for each priority. When the head pointer for a particular dispatch queue is zero, the queue is empty (in other words, no task is scheduled for execution at that priority). When the head pointer is non-zero, it contains the address of a task control block corresponding to a task that is scheduled for execution at that priority. Whenever a task switch occurs, the system dispatcher tests the head pointer of each dispatch queue, in order of priority, until a non-zero value is encountered, then dispatches the task indicated by the task control block address. Because the dispatch queues are searched sequentially, a large number of priorities can adversely affect system performance. There is no benefit to configuring more priorities than required by the system design.

For example, suppose that a particular system consists of the following tasks:

Task ID	Priority
1	0 (timer task)
2	1 (reserved)
3	2
4	2
5	3

The operation of that system is no different than the operation of a system with the same tasks at the following priorities:

Task ID	Priority
1	0 (timer task)
2	50 (reserved)
3	75
4	75
5	200

The priority of task 5 is no lower in the second system than in the first. The difference between the priorities of tasks 1 and 2 is no greater in the second system than in the first. However, the first system executes more efficiently because it requires the configuration of only three priorities (priority 0 is added automatically for the timer task), and the dispatcher must search a maximum of only four dispatch queues at each task switch, rather than the 201 required by the second system.

4.3.2.3 Tick and Time Slice Lengths

Ticks measure the duration of alarms and the system's time slice period. The cf_ltick field of the configuration table specifies the length of a tick (1 to 222 milliseconds).

The length of a tick should be set to the smallest of the following values:

- The minimum duration of any alarm in the system
- The maximum acceptable error in an alarm duration
- The desired time slice duration

Because each tick corresponds to a clock interrupt and involves processing by the clock interrupt service routine, setting the tick length to a smaller value than is actually required results in increased overhead and a degradation in system performance.

The cf_lslice field of the configuration table specifies the number of ticks for each time slice. The time slice should be long enough to allow each task adequate processing time before being preempted (in other words, to avoid "thrashing"), but not so long that any task is able to prevent other tasks from executing in a timely fashion. (If no tasks in the system are created with time slicing enabled, the length of the time slice is immaterial.)

Chapter 5

Debugging

The debugging facilities available depend on whether Software Development Systems' or some other cross development environment is being used. This chapter describes the debugging facilities provided.

5.1 PEEKER Debugging Tool

PEEKER is a low-level peek and poke routine stored in the ICP2424 or ICP2432 PROM. To use PEEKER, attach a 9600 b/s terminal directly to the ICP's console port with the console cable (and programmer's module for the ICP2432) provided. To enter PEEKER, type Control-C on the ICP's console device, depress the black NMI switch on the ICP2424's card edge or the ICP2432's programmer's module, or execute a branch or jump subroutine.

On entry, PEEKER displays the current values of the MC6834*x*'s register set.

PEEKER allows you to examine and modify locations in the ICP's memory space by bytes, words, or longwords.

In response to PEEKER's prompt (pk>), enter Control-X to return to PEEKER's caller or to examine or modify a location.

To examine a location, enter:

- the location's address in hexadecimal

- the access width (preceded by a semicolon):
  - b for byte
  - w for word
  - l for a longword
- an equal sign

PEEKER then displays the address and contents of the given address in the form specified. The data may be modified by entering the new hexadecimal value followed by “^”, “=”, a space, or a return as listed below.

^	Close current location, open previous location (in address space), and display contents
=	Close current location, open current location (in address space), and display contents
space	Close current location, open next location (in address space), and display contents
return	Close current location and return PEEKER to its initial state, waiting for a new address or Control-X

The following is a typical example:

```
pk> **1000;b=**
0000_1000 01 n **<return>**
0000_1001 10 p **<return>**
0000_1000 01 **<return>**
pk>
```

PEEKER uses the following special characters to navigate and/or process inputs:

b	Open by byte
circumflex (^)	Close current location, open previous location (in address space), and display contents
comma	Field delimiter between address and data
Control-X (exit)	Return to whomever called PEEKER

delete	Return PEEKER to its initial state
equal sign	Close current location, open current location (in address space), and display contents
l	Open by longword
linefeed Control-J	Close current location, open next location (in address space), and display contents
space	Close current location, open next location (in address space), and display contents
n (next)	Close current location, open next location (in address space), and display contents
p	Close current location, open previous location (in address space), and display contents
period	Ignore, but echo
r or R	Publish registers and return PEEKER to initial state
<return> <esc>	Close and return to initial state
tab	Field delimiter between address and data
u (up)	Close current location, open previous location (in address space), and display contents
underscore	Ignore, but echo
w	Open by word (default)

When PEEKER is entered, a brief summary of the special characters is published after the register dump:

```
Peek & Poke <address>[,<data>][;<b, w or l>]<p, =, n, or <return>>
R/r = dump registers
ctrl/x = return to caller
```

The ICP2424 has “reset” and “abort” (NMI) pushbuttons on its circuit board. Pushing the NMI button allows you to break out of loops and gain control even if the CPU is at level seven.

Note

If the vector table entry for Autovector 7 or the vector base register has been corrupted, the result of pushing the NMI button is indeterminate.

5.2 PTBUG Debugging Tool

The PTBUG debugging tool is available on the ICP6000. The *PTBUG Debug and Utility Program Reference Manual (PTI)* (for the ICP6000) describes how to use the PTBUG debugging tool included in PROM on every ICP.

To use PTBUG, attach a 9600 b/s terminal directly to the ICP's console port with the console cable provided. After the ICP has completed its power-on/reset diagnostics or after the protocol application has been loaded, type Control-C to enter PTBUG. To generate a breakpoint or "panic" trap from user applications, execute the 68020 assembly language instruction ILLEGAL to generate an illegal instruction trap or execute a TRAP #15. The TRAP #15 can be continued by entering "go".

For the ICP6000, an alternative is to connect the console via the programmer's module assembly (Protogate part number 10-000-0105). This device includes a circuit board that supports reset and abort (NMI) signals. If your ICP software enters an endless loop, the abort button can be used to force control to the PTBUG program. This allows you to determine the location of the loop as well as the register contents, the memory contents, and so on.

Note

If the vector table entry for Autovector 7 or the vector base register has been corrupted, the result of pushing the NMI button is indeterminate.

5.3 SingleStep Debugging Tool

The *SingleStep Debugger for the 68000 Microprocessor Family* manual describes how to use the SingleStep debugging tool provided by Software Development Systems (SDS). SingleStep is a symbolic debugger that allows developers to debug optimized C code for 68000-based target systems. VMS users must have a PC running DOS and a utility to transport files from the PC to the VMS system.

Modules built with SDS development tools can be downloaded to the ICP along with the SDS RAM-based debug monitor. This monitor runs on the ICP and communicates with SingleStep through the 68901 MFP's USART for the ICP6000 or the 6834*x* serial port A for the ICP2424 and ICP2432. You must connect the USART by a cable from the ICP's console port to a serial port on the SingleStep client machine. SingleStep instructs the monitor to set breakpoints, dump memory, view registers, and so on.

You must perform the following basic operations to use SingleStep:

1. In the spsload file, uncomment (remove the pound sign) the LOAD command for the debug monitor, uncomment the INIT ...12000 command, and comment out the INIT ...18000 command.

2. Install cables that connect the serial port on the SingleStep client machine with the console port on the ICP.

3. Reboot the Freeway server or rerun icpload on the embedded product to download the SPS software and debug monitor to the ICP.

After the cables have been properly installed, you can test the configuration from SingleStep. If the software was successfully downloaded, you can invoke SingleStep by typing fm68k at the client machine's prompt.

From the SingleStep prompt you can enter a transparent mode that echoes what the monitor is transmitting. At the SingleStep prompt on a UNIX system, type the following command. (This option is not available in the DOS or Windows NT environment.)

```
SingleStep> debug -p /dev/ttya=9600 -T -
```

This tells SingleStep to use port /dev/ttya and to set the baud rate to 9600. The "-T" parameter puts SingleStep into debug mode. At this point, the pattern "{#@<cr><lf>" should appear. If this pattern does not appear, make sure the cables are connected correctly, then type the command again. To verify the data path to the ICP, enter {#}. The ICP should then respond with {#+.

Press <ctrl>C to exit this mode.

Type one of the following commands, depending on which ICP you are using. SingleStep displays a few messages, followed by “Reset complete.”

```
SingleStep> debug -p /dev/ttya=9600 -N sps24.lo
SingleStep> debug -p /dev/ttya=9600 -N sps32.lo
SingleStep> debug -p /dev/ttya=9600 -N sps60.lo
```

If you are working on a PC, type one of the following commands, depending on which ICP you are using:

```
SingleStep> debug -p com1=9600 -N sps24.lo
SingleStep> debug -p com1=9600 -N sps32.lo
SingleStep> debug -p com1=9600 -N sps60.lo
```

(You must have a terminal emulation program in order to have I/O through the serial port.)

After “Reset complete” has been displayed, all SingleStep commands can be used. For example, type the following command at the SingleStep prompt to show the source for start.s:

```
SingleStep> where
```

Consult the *SingleStep Debugger for the 68000 Microprocessor Family* manual for complete instructions on commands, aliases, and so on.

5.4 System Panic Codes

The OS/Impact system software generates an illegal instruction trap (using the ILLEGAL instruction) when it encounters a non-recoverable error condition. Before executing the ILLEGAL instruction, the operating system stores a “panic code” in the gs_panic field of the global system table. The format and location of the global system table is described in the *OS/Impact Programmer Guide*, and Appendix A in that document describes the OS/Impact panic codes.

XIO pushes its panic code onto the stack and calls hio_panic, which executes an illegal instruction. The illegal instruction will then trap to PTBUG or the debug monitor. User applications can handle error conditions in the same manner to their own assembly language panic routine.

Chapter 6 ICP Software

Note

From the ICP's perspective, the "host processor" can be either the server processor of the Freeway in which the ICP resides, or the processor of the client computer in which the ICP is embedded. In this chapter, the term "ICP's host" reflects this perspective.

6.1 ICP-resident Modules

The ICP-resident sample protocol software (SPS) is downloaded in addition to the system services module. The sps_fw_2424.mem, sps_fw_2432.mem, or sps_fw_6000.mem module contains the task-level code and interrupt service routines. Figure 6–1, Figure 6–2, and Figure 6–3 show the SPS memory layout for the ICP2424, ICP2432, and ICP6000, respectively.

Functionally, the sample protocol software is composed of the protocol and utility tasks and a group of interrupt service routines. Figure 6–4 shows a block diagram of the Freeway server and Figure 6–5 shows a block diagram of the embedded ICP product.

6.1.1 System Initialization

As the last step of the SPS download (Section 4.1 on page 57), the system is initialized at the address of a system task initialization routine that is part of the SPS module (sps_fw_2424.mem, sps_fw_2432.mem, or sps_fw_6000.mem). The task initialization routine loads the address of the system configuration table into register A0 and jumps to OS/Impact's initialization entry point (osinit). The SPS task initialization routine and configuration table, described in Section 4.2 on page 65, are located in the spsasm.asm file located in the freeway/icpcode/proto_kit/src directory.

OS/Impact's osinit routine initializes the operating system variables and data structures, then creates the timer task and the tasks specified in the configuration table. These are the protocol task (spstsk) and the utility task (spshio). Section 4.2.4 describes the osinit procedure in more detail.

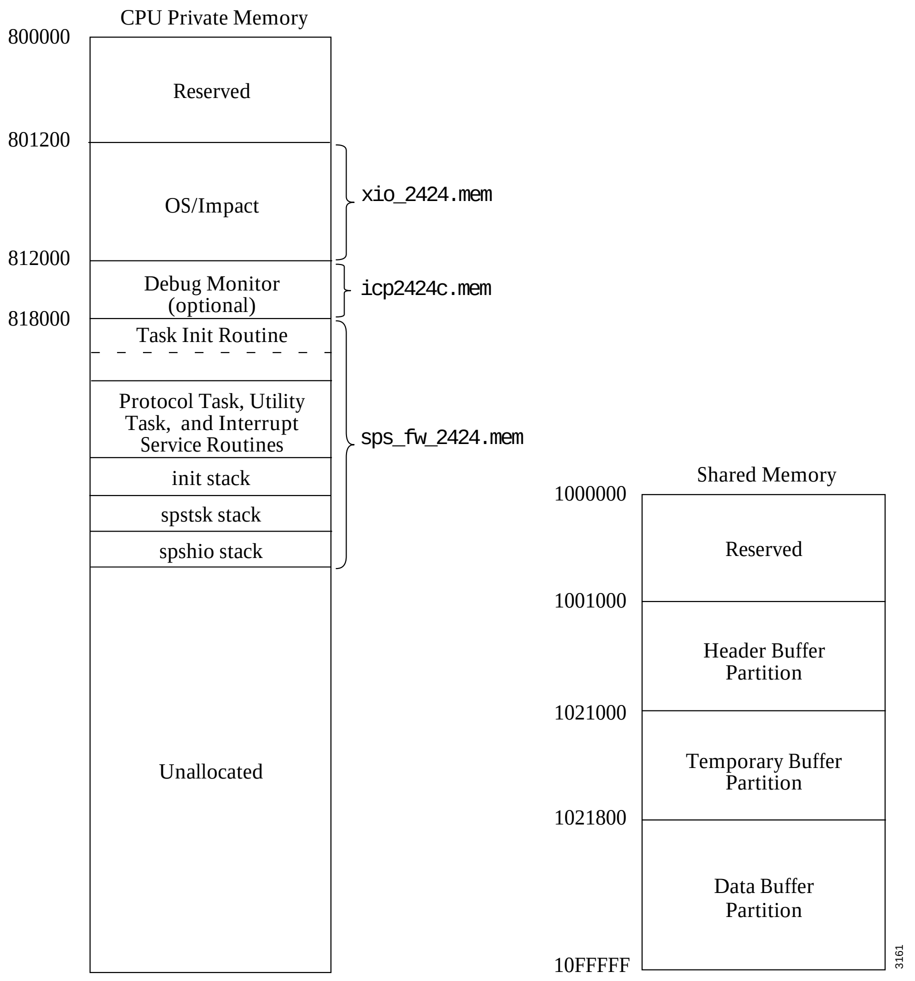


Figure 6–1: Sample ICP2424 Protocol Software Memory Layout

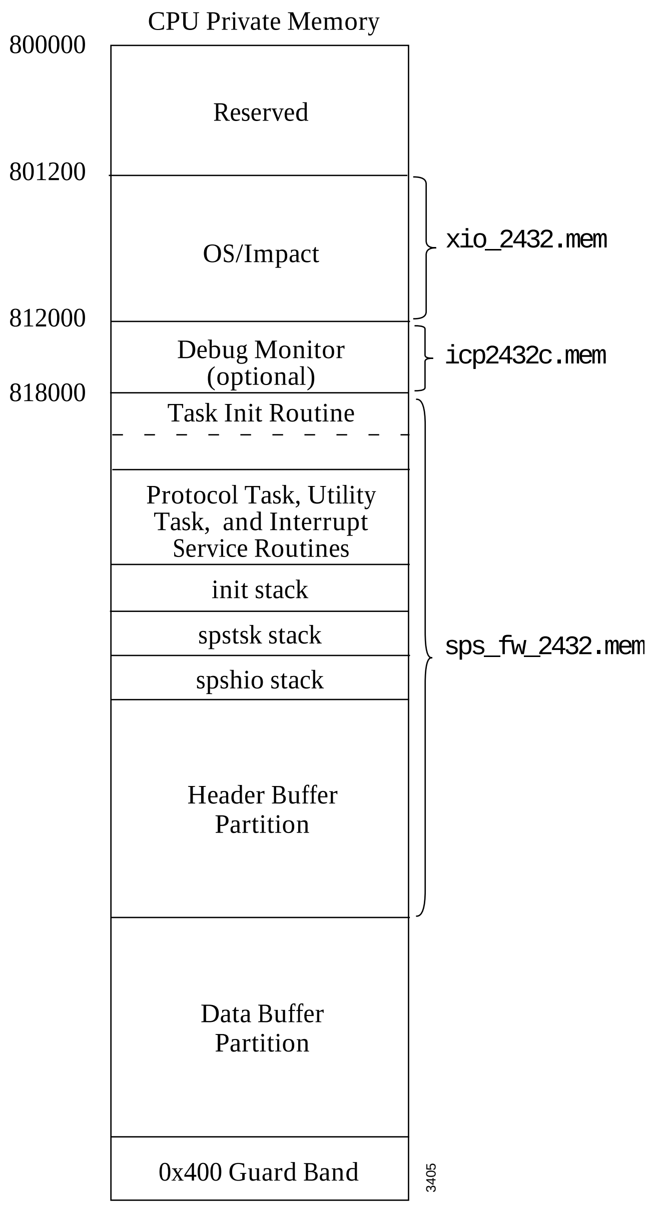


Figure 6–2: Sample ICP2432 Protocol Software Memory Layout

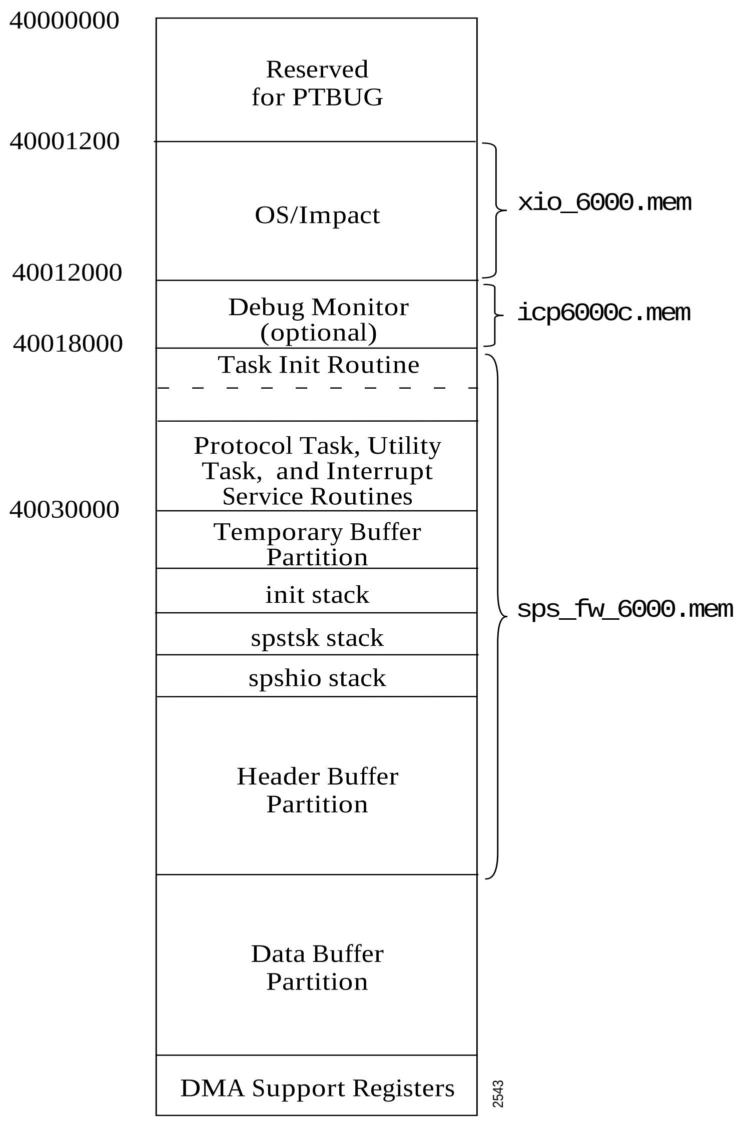


Figure 6–3: Sample ICP6000 Protocol Software Memory Layout

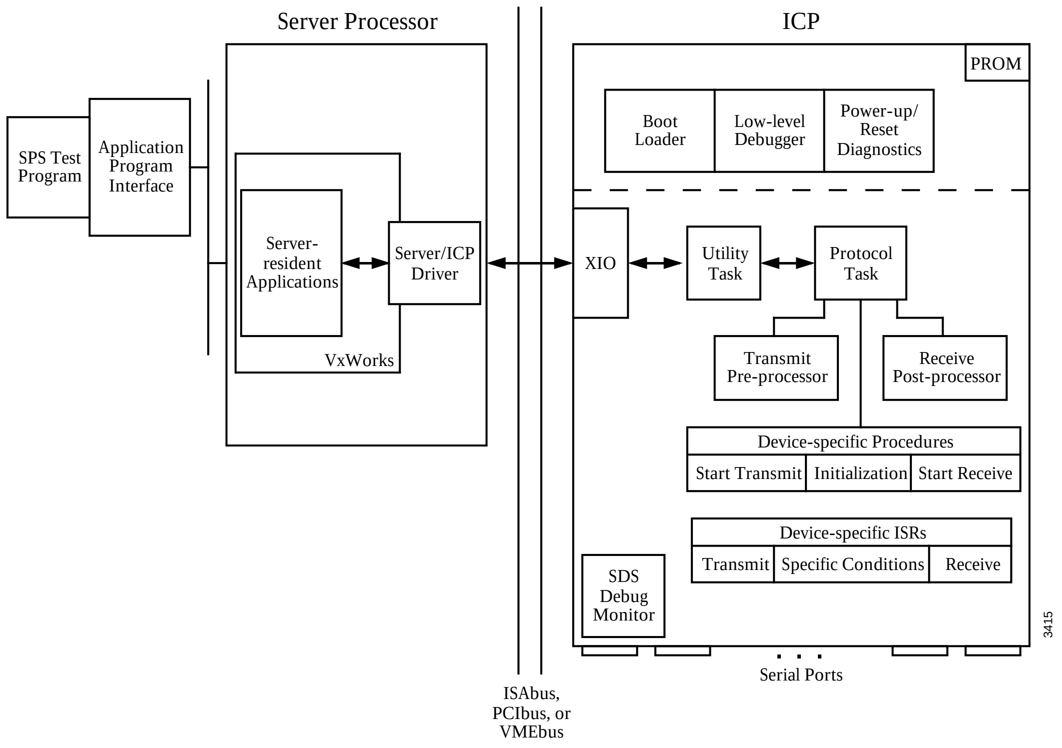


Figure 6–4: Block Diagram of the Sample Protocol Software — Freeway Server

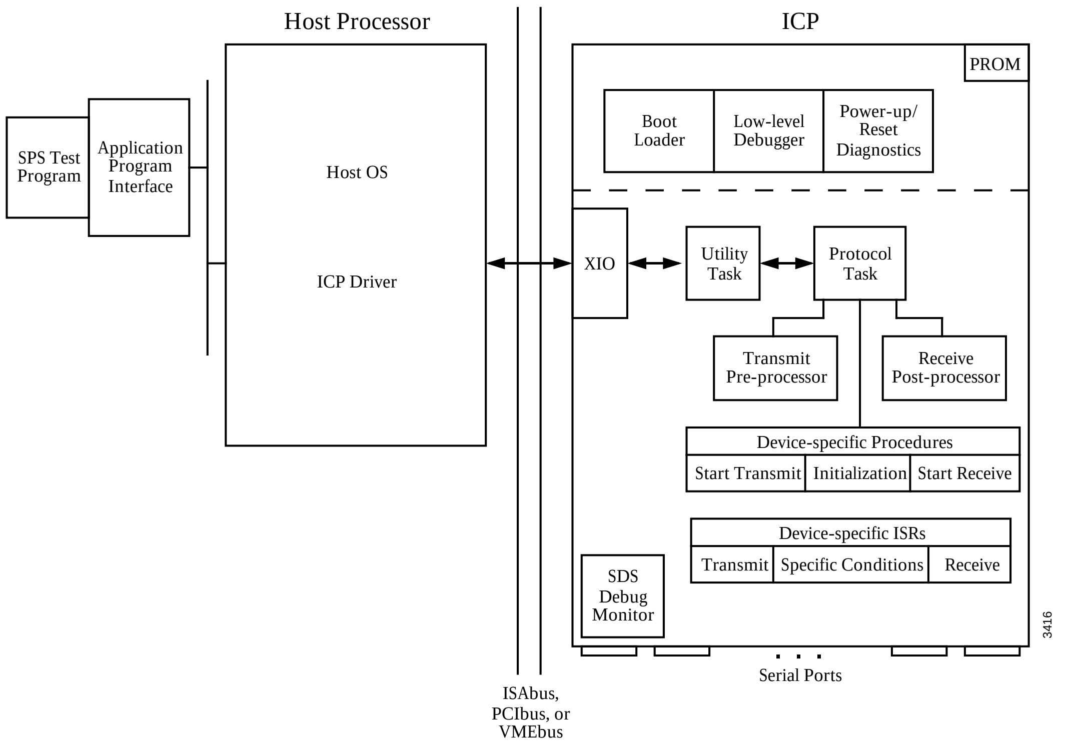


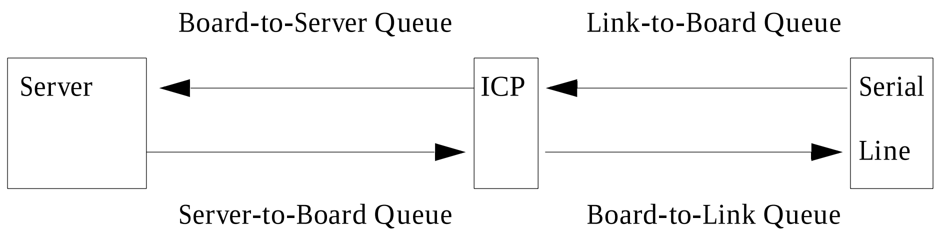
Figure 6–5: Block Diagram of the Sample Protocol Software — Embedded ICP

6.1.2 Protocol Task

This section explains the buffer management method for writing to or reading from the ICP's host. The eXecutive Input/Output (XIO) interface is a collection of function calls that are executed in the context of the user's application tasks. XIO uses queues that are declared by the utility task.

XIO consists of simple function calls. Section 7.4 on page 135 gives details of XIO.

During its initialization, the protocol task creates queues for each link, which relate to the stages and direction of data flow as follows:



After initialization completes, the protocol task operates in a loop. Within the loop, it makes a series of subroutine calls for each link. In the chkhio subroutine, the protocol task checks for messages from the ICP's host that have been routed to the individual queues by the utility task; these messages are then processed according to command type. For a transmit data block command, the message is not processed immediately, but is transferred to the link's board-to-link queue, where it is later processed in the chkloq subroutine.

In the chkloq subroutine, which is called only for active links, the protocol task sends data buffers associated with completed transmit messages back to the application program as write acknowledgments and checks the board-to-link queue for transmissions that are ready to be started.

In the chkliq subroutine, also called only for active links, the protocol task checks the link-to-board queue for buffers that have been filled with received data at the interrupt level. Completed received data messages are sent to the link's board-to-server queue to await processing by the utility task.

When all links have been processed, the protocol task suspends. It continues when a message is posted to any of its queues or when an interrupt service routine notifies it that a transmit or receive operation has completed. The interface between the protocol task and its interrupt service routines is described in Section 6.2.

The SPS utility task, spshio, sets up an interface to XIO during its initialization, then enters a loop. Within the loop, it checks its input queue for returned header buffers as well as messages from the ICP's host that have arrived on node 1 and node 2. It also checks the protocol task's board-to-server queues for messages to be sent to the host. It then suspends, and will be unsuspended by the protocol task or when a message is posted to its input queue. The operation of the utility task is described more completely in Section 6.1.3.

6.1.3 Utility Task (spshio)

The ICP-resident software communicates indirectly with the ICP's host through the part of the system services module called the XIO interface. The utility task, spshio, handles the interface between the protocol task, spstsk, and XIO. This section describes the utility task and its relationship with the protocol task. Chapter 7 provides a more detailed explanation of the ICP/host protocol used for communication between the utility task and XIO.

As described in Section 6.1.2, the protocol task, spstsk, creates an board-to-server queue and a server-to-board queue for each link during its initialization. These queues hold messages to be transferred to and from the ICP's host by the utility task. (Section 7.2.3 on page 124 describes the node declaration queues.) The protocol task is also responsible for creating the buffer partition that contains data buffers to be used for passing data to and from the ICP's host. The size of the buffers created for this partition depends on the value of the buffer.size file which is downloaded with the application. (See the /freeway/boot/spsload file.)

During initialization, the utility task creates the header buffer partition and posts node declaration queue requests to XIO to establish nodes to be used by the ICP for reading from, and writing to, the ICP's host. As requested by the utility task, XIO creates read and/or write request queues for each node. Node 1 (the main node) and node 2 (the priority node) are special insofar as all information coming to the ICP from the ICP's host arrives through these nodes. These nodes do have write queues, and in rare cases (such as rejecting an erroneous attach request) are used to pass information back to the ICP's host, but for the most part they are a one-way path for messages coming from the ICP's host. These messages are then de-multiplexed to the various links. The remaining nodes are used strictly by the ICP for writing to the ICP's host.

The utility task begins by creating all the nodes as well as the queues for the system header and data buffers. After this initialization, the utility task operates in a loop and performs the following functions:

1. Keeps reads posted on the main and priority nodes
2. Distributes incoming buffers to the correct server-to-board queues
3. Posts buffers from the board-to-server queues to the appropriate nodes

The utility task is also responsible for the verification of session and link IDs, and for swapping bytes within words (to allow for differences in word ordering for Big Endian (Motorola) and Little Endian (Intel and VAX)), both for messages coming from and messages going to the ICP's host. When no message processing is required, the utility task suspends and will be unsuspended by the protocol task or when a message is posted to its input queue.

The following sections provide detailed examples of read and write processing by the utility task. Figure 6–6 shows the SPS message format.

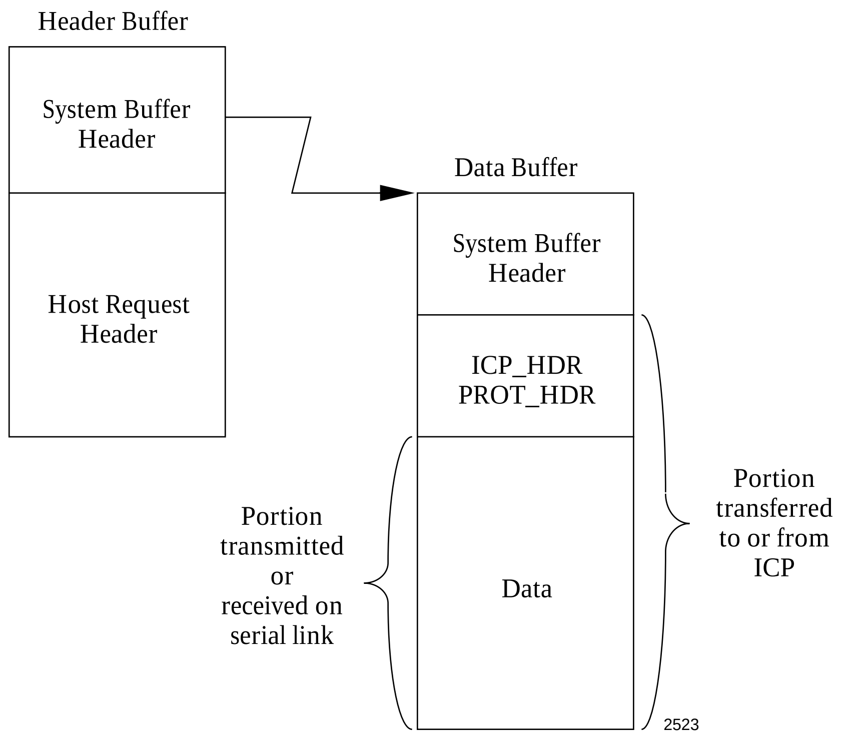


Figure 6–6: Sample Protocol Software Message Format

6.1.3.1 Read Request Processing

The utility task, spshio, issues read requests to XIO to obtain messages from the ICP's host, which could be either data or control messages. A message from the ICP's host contains one of the command codes described in Chapter 9. The DLI_PROT_SEND_NORM_DATA command code is used as an example in this section to describe the steps involved in processing read requests. Figure 6–7 illustrates these steps.

1. To obtain messages from the ICP's host, the utility task creates read request queue elements composed of headers from partition H and data buffers from partition D. The utility task sets the disposition flags in the system buffer headers to inform XIO of the action it should take when the request is complete. It also sets the node number in the host request header for XIO to use in communicating with the host. Sixteen queue elements are created for node 1 and sixteen for node 2. These are the only nodes to which the host can write.

2. The utility task issues read requests to XIO for each queue element created in Step 1.

3. For each read request, XIO posts a read to the Read Request Queue associated with the node identified in the host request header.

4. When the ICP's host sends a write request to its driver, XIO transfers the message to the data buffer, and the ICP read request issued in step 2 is complete.

5. XIO posts the header and the data buffer to the utility task's data and header input queues for node 1 or 2.

6. The protocol and utility tasks then do the following:

   a. Based on the session or link field of the ICP header, the utility task multiplexes and transfers the data buffers from its data input queue to the appropriate server-to-board queue.

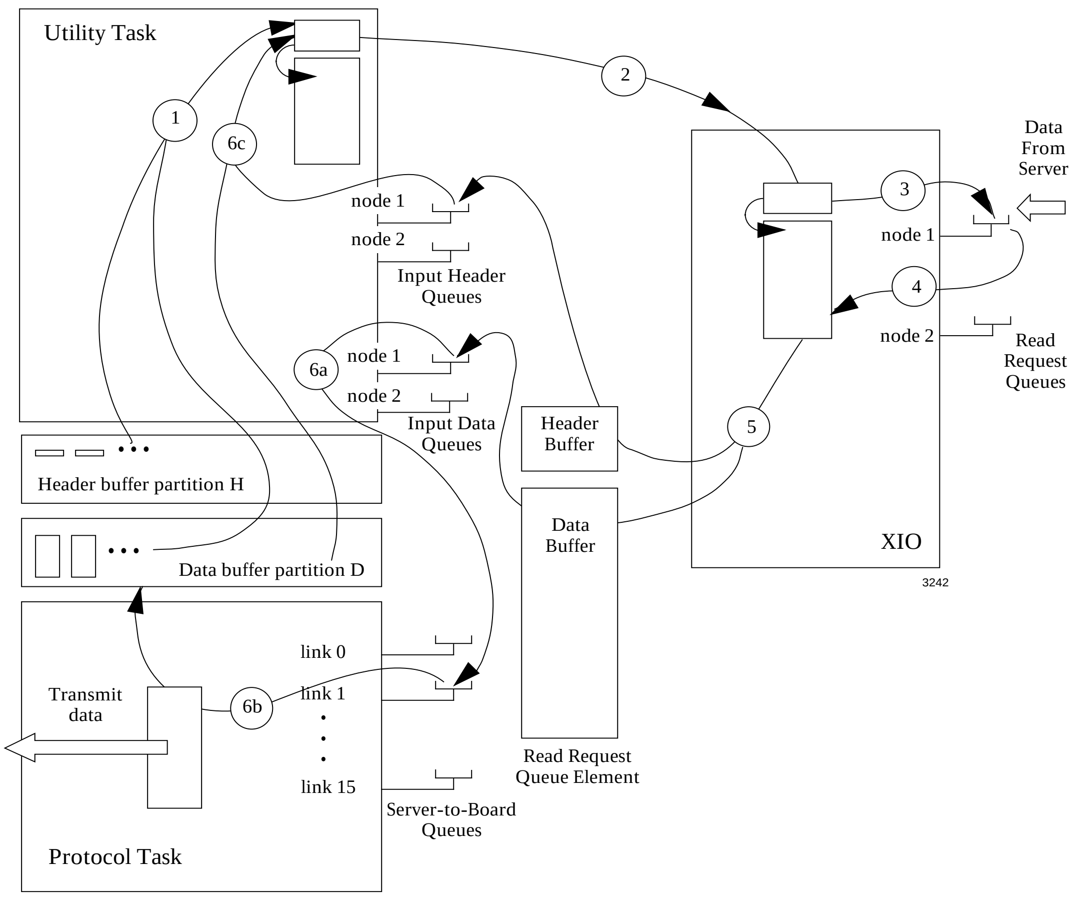


Figure 6–7: ICP Read Request (Transmit Data) Processing

b. The protocol task removes data buffers from the server-to-board queue, processes the requests, then releases the buffers to partition D or uses them to send acknowledgments back to the application program.

c. The utility task obtains additional data buffers from partition D and links them to header buffers that were returned to its header input queue. It then issues new read request to XIO for node 1 or 2 (depending on the node from which the header buffers were returned). In this way, the utility task attempts to keep at least one read request pending at all times.

6.1.3.2 Write Request Processing

The utility task issues write requests to XIO when data is received on a serial line or in response to other requests from the ICP's host. A message to the ICP's host can contain a received data block, a statistics report, an error message, or some other acknowledgment to a client application program. A received data block is used as an example in this section to describe the steps involved in processing write requests. Figure 6–8 illustrates these steps.

1. The protocol task obtains a data buffer from partition D, to be filled with data received on a particular link. When a block of data has been received, the protocol task posts the buffer to the link's board-to-server queue.

2. When the utility task finds the data buffer on the board-to-server queue, it links the buffer to a header buffer obtained from partition H, creating a write request queue element. The utility task sets the disposition flags in the system buffer headers to inform XIO of the action it should take when the request is complete. It also sets the link's previously assigned node number in the host request header for XIO to use in communicating with the host.

3. After filling out the data length and session fields of the ICP and PROT headers, the utility task issues the write request to XIO.

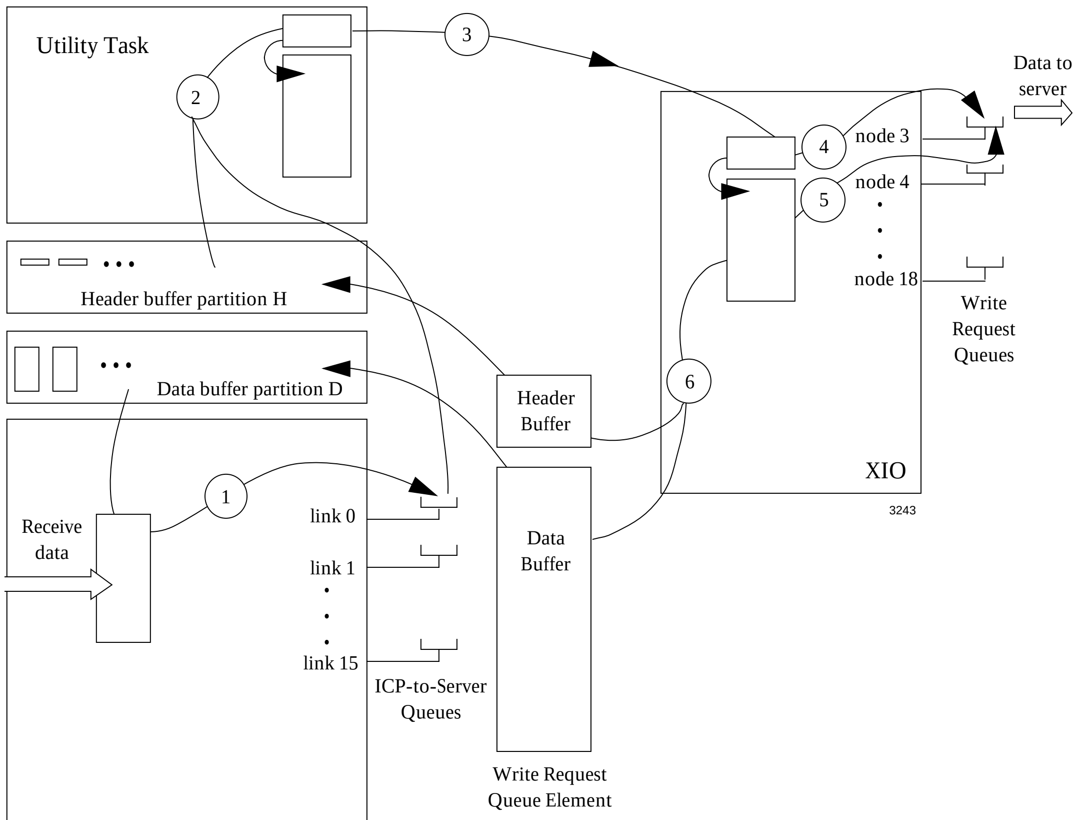


Figure 6–8: ICP Write Request (Receive Data) Processing

4. XIO posts a write to the Write Request Queue associated with the node identified in the host request header.

5. When the ICP's host sends a read request to its driver with a matching node number, XIO transfers the message from the data buffer to the ICP's host memory and the ICP write request issued in step 3 is complete.

6. As instructed by the disposition flags, XIO releases the header and data buffers to their respective partitions.

6.2 Control of Transmit and Receive Operations

Various techniques are available for coordinating transmit and receive operations at the task and interrupt level. The simplest method is to start every operation from the task level. In this case, a signal of some kind must be sent from the interrupt service routine to the task level at completion, at which time the task can start the next operation. This is the method used by the SPS for data transmissions.

Another option is to maintain a queue of messages. To save time in the interrupt service routine, messages can be added to the tail and removed from the head of the queue at the task level, with the interrupt service routine moving from message to message within the queue using a link field in the buffer headers. An example of this technique is provided by the SPS receive operations.

The following sections describe the task/interrupt-service-routine interface used to control transmit and receive operations for the SPS.

6.2.1 Link Control Tables

The protocol and utility tasks and the interrupt service routines communicate and coordinate their operations for each link by means of a global link control table. One link control table is allocated for each link. The link control table contains state information, queue IDs, configuration parameters, SCC or IUSC register values and/or addresses, transmit and receive control parameters, configuration-specific subroutine addresses, statistics information, and so on. The link control table is defined in /freeway/icpcode/proto_kit/src/spsstructs.h as follows:

```
/*   LINK CONTROL TABLE (LCT) */

struct lct
{
   bit16   lct_id;             /* Link number                        */
   bit8    lct_lact;           /* Link active flag                   */
   bit8    lct_flags;          /* Flag bits byte                     */

   bit16   lct_baud;           /* baud rate constant                 */

   bit8    lct_clkext;         /* internal(1)/external(0) clock      */
   bit8    filler0;

   bit16   lct_s_id;           /* link control table session number  */
   bit16   filler1;

   struct QCB_TYPE *lct_s2bq;  /* SERVER-TO-BOARD BUFFER QUEUE       */
   struct QCB_TYPE *lct_b2sq;  /* BOARD-TO-SERVER BUFFER QUEUE       */
   struct QCB_TYPE *lct_l2bq;  /* LINK-TO-BOARD BUFFER QUEUE         */
   struct QCB_TYPE *lct_b2lq;  /* BOARD-TO-LINK BUFFER QUEUE         */
   bit16   lct_s2bqid;         /* SERVER-TO-BOARD BUFFER QUEUE ID    */
   bit16   lct_b2sqid;         /* BOARD-TO-SERVER BUFFER QUEUE ID    */
   bit16   lct_l2bqid;         /* LINK-TO-BOARD BUFFER QUEUE ID      */
   bit16   lct_b2lqid;         /* BOARD-TO-LINK BUFFER QUEUE ID      */

   bit16   lct_hio_read_id;    /* hio read queue's id                */
   bit16   lct_hio_write_id;   /* hio write queue's id               */

#if defined(ICP2424) || defined(ICP2432)
   IUSC    *lct_iusc ;         /* pointer to serial controller       */
#else
   Z8530   *lct_scc ;          /* pointer to serial controller       */
```

```
    bit32   *lct_dma_rda;       /* pointer to dma rcv address   icp6000 */
    bit32   *lct_dma_rtc;       /* pointer to dma rcv count     icp6000 */
    bit32   *lct_dma_xda;       /* pointer to xmit address      icp6000 */
    bit32   *lct_dma_xtc;       /* pointer to dma xmit count    icp6000 */
#endif
    bit8    lct_prot;           /* protocol type                       */
    bit8    lct_syncs;          /* number of leading sync chars (BSC)   */
    bit8    lct_bits;           /* 0 = 8 bits, 1 = 7 bits (asynch)      */
    bit8    lct_crc;            /* CRC on/off (1=on)                    */

    bit8    lct_parity;         /* Parity, stop bits & wr4 image holder */
    bit8    lct_start;          /* start char for BSC & asynch          */
    bit8    lct_stop;           /* stop char for asynch                 */

    bit8    lct_rcvie;          /* Copy of rcv int enable byte (WR1)    */
    bit8    lct_xmtie;          /* Copy of xmt int enable byte (WR1)    */
    bit8    lct_idle;           /* WR10 - idle flags                    */

    bit8    lct_zrof;           /* Copy of WR3 for BSC--rcv disabled    */
    bit8    lct_zron;           /* Copy of WR3 for BSC--rcv enabled     */
    bit8    lct_zxof;           /* Copy of WR5 for BSC--xmt disabled    */
    bit8    lct_zxon;           /* Copy of WR5 for BSC--xmt enabled     */

    bit8    lct_zwr1;           /* Copy of WR1 for BSC                  */
    bit8    lct_elect;          /* Electrical Interface ICP24xx         */
    bit8    lct_exstat;         /* External status record               */
    bit8    filler3;
    bit16   filler3a;

    bit8    lct_rstate;         /* receive state                        */
    bit8    lct_rlact;          /* count of receive lists active        */
    bit8    lct_xstate;         /* transmit state                       */
    bit8    lct_xlact;          /* count of transmit lists active       */

    bit16   lct_xbc;            /* xmt byte counter                     */
    bit16   lct_rbc;            /* rcv byte counter                     */
    bit8    *lct_xptr;          /* xmt char ptr (asynch)                */
    bit8    *lct_rptr;          /* rcv char ptr (asynch)                */

    bit16   lct_write_num;      /* Write buffer number                  */
    bit16   lct_read_num;       /* Write buffer number                  */

    DATA_BUFFER *lct_ftbuf;     /* Transmit frame buffer                */
    DATA_BUFFER *lct_tprebuf;   /* Transmit's previous frame buffer     */
    DATA_BUFFER *lct_frbuf;     /* Receive frame buffer                */
    DATA_BUFFER *lct_rprebuf;   /* Receive's previous frame buffer      */

    void (*lct_rcvstr)();       /* Start receive routine address        */
    void (*lct_xmton)();        /* Start transmit routine address       */
    void (*lct_devoff)();       /* Device off routine address           */

    int  (*lct_postr)();        /* Post process rcv buffer routine addr */
    void (*lct_prepx)();        /* Pre-process xmt buffer routine addr  */

#if defined(ICP2424) || defined(ICP2432)
    int  (*lct_dbase)();        /* dma base isr routine address         */
    int  (*lct_resv)();         /* dma reserved isr routine address     */
#endif
    int  (*lct_dxmt)();         /* dma xmt isr routine address          */
    int  (*lct_drcv)();         /* dma rdata isr routine address        */

#if defined(ICP2424) || defined(ICP2432)
    int (*lct_sbase)();         /* serial base isr routine address      */
    int (*lct_misc)();          /* serial misc isr routine address      */
    int (*lct_io_pin)();        /* serial io_pin isr routine address    */
    int (*lct_xdata)();         /* serial xdata isr routine address     */
    int (*lct_xstat)();         /* serial xstat isr routine address     */
    int (*lct_rdata)();         /* serial rdata isr routine address     */
    int (*lct_rstat)();         /* serial rstatus isr routine address   */
    int (*lct_illeg)();         /* serial illegal isr routine address   */
#else
    int (*lct_xdata)();         /* serial xdata isr routine address     */
    int (*lct_extern)();        /* serial external status isr address   */
    int (*lct_rdata)();         /* serial rdata isr routine address     */
    int (*lct_rspc)();          /* serial special receive condition isr */
#endif

    STATA lct_stats;
};
typedef struct lct LCT;
```

6.2.2 SPS/ISR Interface for Transmit Messages

When the protocol task receives a transmit data block message on a link's server-to-board queue, it moves the message to the link's board-to-link queue to await transmission. The board-to-link queue is processed in the chkloq subroutine according to the mode of communication.

The lct_flags field in the link control table is cleared by the protocol task when it initiates a transmission and is set by the interrupt service routine when the transmission is finished. A transmission can be initiated only when the link is in the IDLE state. The protocol task points the transmit data block message on the head of the board-to-link queue, calls the appropriate preprocess routine for the protocol to prepare the data for transmission, and calls the subroutine xmton to set up the hardware devices for transmission of the data. Xmton clears the flags field in the buffer's headers and clears the lct_flags and states in the link control table. When the transmit completes, the interrupt service routine sets flags in the buffer's headers, initializes the lct_flags and states in the link control table, and resumes the protocol task. The protocol task releases the completed buffer and starts the transmission of the next message on the queue.

6.2.3 SPS/ISR Interface for Received Messages

When a link is enabled, the rcvstr subroutine for the requested protocol (located in asydev.c, bscdev.c, and sdlcdev.c) is called, which calls "restock" to obtain PREALLOCATE data buffers from the data buffer partition and posts them to the link-to-board queue. The lct_frbuf field in the link control table is set to the address of the first buffer on the queue.

When a frame is received, the buffer is filled, and the interrupt service routine updates lct_frbuf to the next buffer on the queue using the sb_nxte field in the system buffer header. (The interrupt service routine does not unlink the filled buffer from the queue).

In the chkliq subroutine, the protocol task determines whether the buffer at the head of the queue has been completed (a block has been received). If the receive is finished, and the protocol task removes the buffer from the link-to-board queue, calls the appropriate postprocessor to process the data before passing it to the application program, posts it to the board-to-server queue, and resumes the utility task which passes the message to the host.

Whenever the protocol task removes a buffer from the head of the link-to-board queue, it restocks the queue. In this way, the protocol task maintains several available buffers for received messages.

Figure 6–9 shows a link-to-board queue containing four buffers. Two are filled and waiting for removal by the protocol task. The third buffer is set up for the current receive.

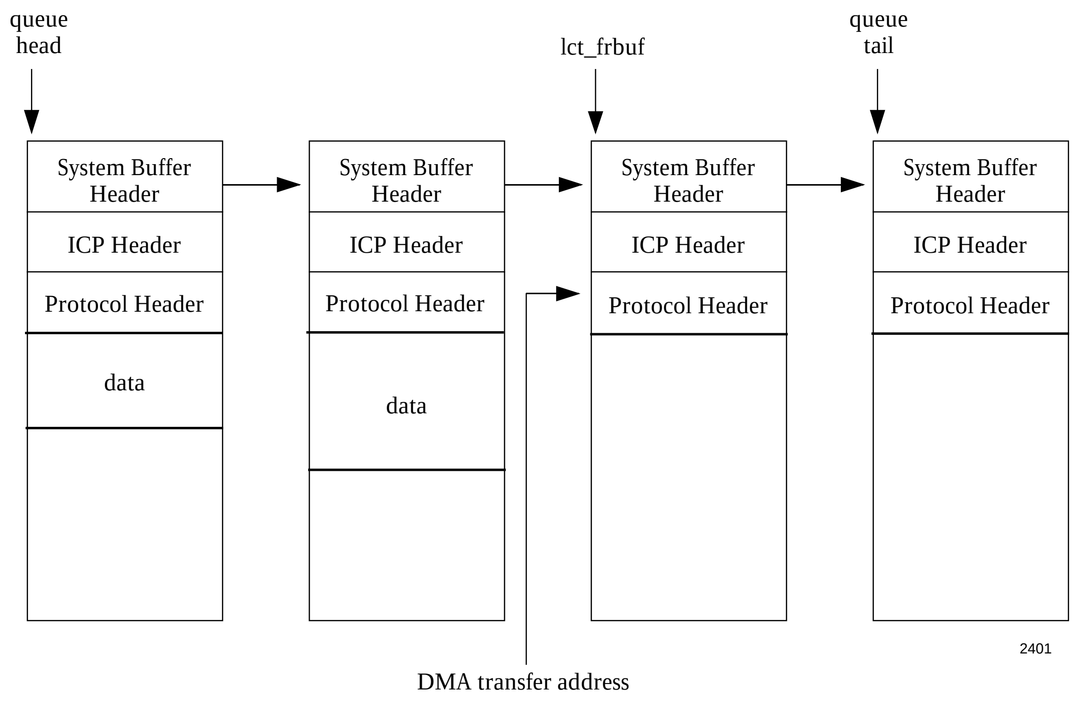


Figure 6–9: Sample Link-to-Board Queue

6.3 Interrupt Service

At the interrupt level, the SPS provides specific examples of SCC and IUSC programming for asynchronous (ASYNC), byte synchronous (BSC), and bit synchronous (HDLC/SDLC) modes of operation. At the same time, examples are provided for:

- operation with and without the use of DMA
- C and assembly language programming
- CRC calculation in hardware (by the SCC or IUSC) or in software

Table 6–1 summarizes these features for each mode of operation.

Table 6–1: Summary of Communication Modes

	Asynchronous	BSC	HDLC/SDLC
SCC or IUSC mode	Asynchronous	Byte synchronous	Bit synchronous
Data transfer method	Character interrupts	Character interrupts/DMA	DMA
Start block detection (receive)	ISR search for start character	SCC or IUSC detects SYNC character	SCC or IUSC detects opening flag
End block detection (receive)	ISR search for end character	Byte count in header	SCC or IUSC detects closing flag
CRC calculation	Software	Software	SCC or IUSC
ISR programming language	C	Assembly/C	C

6.3.1 ISR Operation in HDLC/SDLC Mode

In HDLC/SDLC mode, DMA is used for both transmit and receive. The SCC or IUSC automatically provides the opening and closing flags on transmit. The DMA transfer count is set to the number of bytes in the frame, not including CRC and flags. The SCC or IUSC is set to calculate the CRC during transmission of the frame and to send the CRC when it detects a transmit underrun. When the DMA reaches terminal count (and no longer transfers characters to the SCC or IUSC), a transmit underrun is generated. The SCC or IUSC transmits the two-byte CRC followed by a closing flag to terminate the frame.

To receive, the DMA transfer count is set to the maximum block size and will not normally reach terminal count. The SCC or IUSC automatically calculates CRC during the received frame and generates an end-of-frame (special receive condition) interrupt when the closing flag is detected. The interrupt service routine reads an SCC register to determine whether the CRC that the SCC calculated matched the CRC bytes received at the end of the frame. The IUSC posts the status of the reception in the linked list header record (located at the end of the data buffer) which is then examined by the ISR.

The following interrupts are processed in HDLC/SDLC mode:

SCC DMA Receive Terminal Count or IUSC End of Buffer If terminal count is reached before end-of-frame, the received message is too long (receiving more data would overrun the receive buffer). In this case, the interrupt service routine increments an error count and restarts the receiver using the current receive buffer.

SCC Special Receive Condition or IUSC RDMA Complete This interrupt is generated at the end of a received frame. If the SCC or IUSC indicates a CRC error, an error count is incremented, and the receiver is restarted using the current buffer. If the CRC is good, the receiver is restarted using the next buffer in the link-to-board queue.

SCC Transmit Buffer Empty or IUSC End of Buffer This interrupt is enabled only by the external or transmit status interrupt service routine when a transmit underrun occurs while the transmit buffer is not yet empty. The end of the transmission is processed.

SCC External/Status (ICP6000 only) This interrupt is generated under any of the following conditions:

Loss of DCD An error count is incremented and the receiver is restarted using the current receive buffer.

Abort An error count is incremented and the receiver is restarted using the current receive buffer.

Transmit Underrun If the DMA has reached terminal count, transmit underrun can cause an external/status interrupt. This indicates end-of-frame on transmit, although the final character of the frame might not yet be completely sent. If the SCC transmit buffer is empty, the end of the transmission is processed. Otherwise, the SCC's transmit interrupt is enabled, so the end of the transmission can be processed when the transmit buffer becomes empty. If a transmit underrun interrupt is generated when the DMA has not reached terminal count, an actual underrun has occurred. An error count is incremented, but the transmission is allowed to continue. (The receiving link detects a CRC error on the frame.)

6.3.2 ISR Operation in Asynchronous Mode

For asynchronous mode, DMA (conditional compile option for the IUSC) is not used for either transmit or receive. Rather, the SCC or IUSC is set up to generate interrupts on every character received and transmitted. On transmit, a count is decremented as each character is written to the SCC's or IUSC's transmit buffer, and the block is complete when the count reaches zero. On receive, user-configured start and end characters are used to delimit a block. CRC, if enabled, is calculated and compared at the task level.

The following interrupts are serviced in asynchronous mode:

SCC or IUSC Receive Character Available This interrupt is generated on every received character. The receive interrupt service routine is state-driven. After transferring the received character from the SCC or IUSC receiver to the receive data buffer, the interrupt service routine processes the character according to the current state:

State 0 Search for start character. If the start character is found, move to state 1; otherwise, take no action and ignore the current character (it will be overwritten by the next character).

State 1 Receive frame. Check for stop character. If the stop character is found and CRC is enabled, move to state 2. If the stop character is found and CRC is not enabled, process the end of received block and restart the receiver at state 0 using the next buffer in the link-to-board queue. If the stop character is not found, store the character and increment the count.

State 2 First CRC byte. Move to state 3.

State 3 Second CRC byte. Process the end of received block and restart the receiver at state 0 using the next buffer in the link-to-board queue.

SCC Special Receive Condition or IUSC Receive Status This interrupt is generated on receiver overrun, parity error, or framing error. The appropriate error count is incremented, but the receive is not aborted.

SCC or IUSC Transmit Buffer Empty This interrupt is generated on every transmitted character. The transmit byte count is decremented, and the end of the transmission is processed if the count has reached zero. (The next transmission is started at the task level.) The IUSC is set up to interrupt when there are 16 bytes free in its transmit FIFO and up to 16 bytes are loaded during each interrupt.

6.3.3 ISR Operation in BSC Mode

In BSC mode, a simple header is prepended to the start of the data block, containing a user-configured start character and a byte count. For transmit, the DMA transfer count is set to the number of bytes in the block, including the header and the two-byte CRC, if enabled. The CRC is calculated and appended to the data at the task level.

For receive, the SCC or IUSC is initially set up to generate interrupts on every character received. Each character is compared to the configured start character. After the start character has been found, the remainder of the BSC header can be received. The DMA transfer count is set to the value specified in the BSC header, SCC or IUSC receive interrupts are disabled, and DMA is used to receive the remainder of the message.

The following interrupts are processed in BSC mode:

SCC or IUSC Receive Character Available While enabled, this interrupt is generated on every received character. No data is transferred to the receive buffer until the data count is received. When the entire three-byte header has been received, the interrupt service routine disables receive and special receive condition interrupts, sets the DMA transfer count according to the count field of the BSC header (plus two if CRC is enabled), and initiates DMA transfer.

SCC or IUSC Special Receive Condition While enabled (before and during reception of the BSC header), this interrupt is generated on receiver overrun errors. An error count is incremented and the receive is aborted.

SCC DMA Receive Terminal Count or IUSC End of Buffer This interrupt is generated when the data portion of a BSC message has been received. The interrupt service routine re-enables SCC or IUSC receive and special receive condition interrupts and restarts the receiver using the next buffer in the link-to-board queue. CRC, if enabled, is checked at the task level.

SCC DMA Transmit Terminal Count or IUSC End of Buffer This interrupt is generated at the end of a transmitted frame. The interrupt service routine processes the end of the transmission. (The next transmission is started at the task level.)

Chapter 7

Host/ICP Interface

Note

From the ICP's perspective, the "host processor" can be either the server processor of the Freeway in which the ICP resides, or the processor of the client computer in which the ICP is embedded. In this chapter, the terms "ICP host processor," "ICP's host," and "host/ICP interface" reflect this perspective.

This chapter describes the interface between the ICP's host processor and an ICP. This interface will be referred to as the "host/ICP interface." It is managed by an XIO interface which runs on the ICP, in the OS/Impact environment, and provides a queue-driven, non-blocking interface to the host processor. Section 7.4 on page 135 gives details of XIO.

7.1 ICP's Host Interface Protocol

Communications between the ICP's host and the ICPs is performed by the host's driver, icp.c, and the ICP's driver, XIO. Information concerning any data transfers between the two is passed through a Protocol eXchange Region (PXR).

The PXR for the ICP6000 is implemented via a hardware device that has 16 byte wide registers called mailboxes. The ICP's host sees these registers as bytes on word boundaries, while the ICP sees them as consecutive bytes. One of these registers is used for host-to-ICP commands; when the host writes to this register, an interrupt is generated to the ICP in order to gain service. Another register is used for ICP-to-host commands, but another device's registers must be set up to generate the interrupt to the host.

ICP2424s use a region of shared memory to support the PXR. The ICP2424 PXR is the first 16 bytes of the shared memory. These are consecutive bytes addressable as bytes, words, or longwords as long as the proper boundaries are observed.

The PXR for the ICP2432 is implemented via mailboxes within the PCI interface chip. They are accessed as 32-bit entities.

The host driver and the ICP driver have a master/slave relationship. The master is the driver that actually moves the data between the host and the ICP. For the ICP2432 and ICP6000, the ICP is the master. For the ICP2424, the host is the master.

When the slave has a buffer into which data may be transferred, it issues a "read" request to the master along with the address of the buffer and the maximum amount of data it can hold. When the master receives a matching request from its application program and moves the data into the buffer, it signals the slave that the "read" is complete.

When the slave has a buffer of data ready to transfer to the master, it issues a "write" request to the master with the address of the data's buffer and the amount of data in it. When the master receives a matching request from its application program, it transfers the data and signals the slave with a "write" complete.

As the protocol is asynchronous, the slave can send any number of requests to the master without waiting for completions on previous requests, and the master can process requests and return completions in any order.

The ICP driver and the host driver coordinate the information flowing between the ICP and the host processor by means of node numbers. Each node can have one read and one write queue. At startup, the utility task creates the nodes it will be using, up to the maximum number of nodes allowed by the configuration parameters of the two drivers.

The ICP posts read requests to node 1 (the main node) and node 2 (the priority node); all information coming to the ICP from the host processor arrives through these two nodes. These nodes do have write queues, and in rare cases (such as rejecting an erroneous attach request) are used to pass information to the ICP's host, but for the most part they are a one-way path for messages coming from the host; these messages are then demultiplexed to the various links. The remaining nodes are used strictly by the ICP for writing to the host. The ICP read request processing is explained in more detail in Section 6.1.3.1 on page 99 and is shown in Figure 6–7 on page 100.

After a message bound for the application program is processed by the protocol task, it is posted to the board-to-server queue belonging to that link. The utility task subsequently removes the message from that queue, prefixes a properly initialized buffer header (for example, providing information on what to do with process completions), then posts it as a write request to a write queue belonging to one of the nodes created at startup. (The particular node is ascertained by indexing into the session table and accessing the node number field by means of the unique session ID that was assigned to that link as a result of a prior attach command.) XIO then passes the message through to the host processor. The ICP write request processing is explained in more detail in Section 6.1.3.2 on page 101 and is shown in Figure 6–8 on page 102.

Note that when a request completion is received from the host processor, XIO uses the node number and request type to match the completion with a pending request. Therefore XIO does not send the host processor a request for a particular node number until any pending request from the same node number is complete. Additionally, requests for any queue are sent to the host processor in the same order they were posted to the queue, but no order is guaranteed for requests posted to different queues. Likewise, notifications of completion are guaranteed to be in the same order that the completions were received from the host processor, but the host processor is not required to send completions in the same order that it received the requests. XIO provides two options for processing the request completions. These options are described in Section 7.2.3.1 on page 126.

7.2 Queue Elements

In general, a queue element consists of one or more linked buffers, and a queue can contain one or more linked queue elements. Every buffer of a queue element contains a standard system buffer header, as defined in the *OS/Impact Programmer Guide*. A field in each buffer's header is used as a link to the next buffer of the queue element. Two fields in the header are valid only in the first buffer of a queue element. One field is a link to the next element on a queue and the other, if the queue is doubly linked, is a link to the previous element.

A buffer can be obtained from a system partition (using the get buffer, s_breq, system call), but this is not a requirement. Any block of memory large enough to contain a system buffer header can be used as a buffer (for example, a fixed data structure defined within an ICP-resident application). There is no maximum buffer size, no maximum number of buffers in a queue element, and no maximum number of queue elements attached to a queue.

Figure 7–1 shows a singly-linked sample queue containing three queue elements. Figure 7–2 shows a doubly-linked sample queue containing three queue elements.

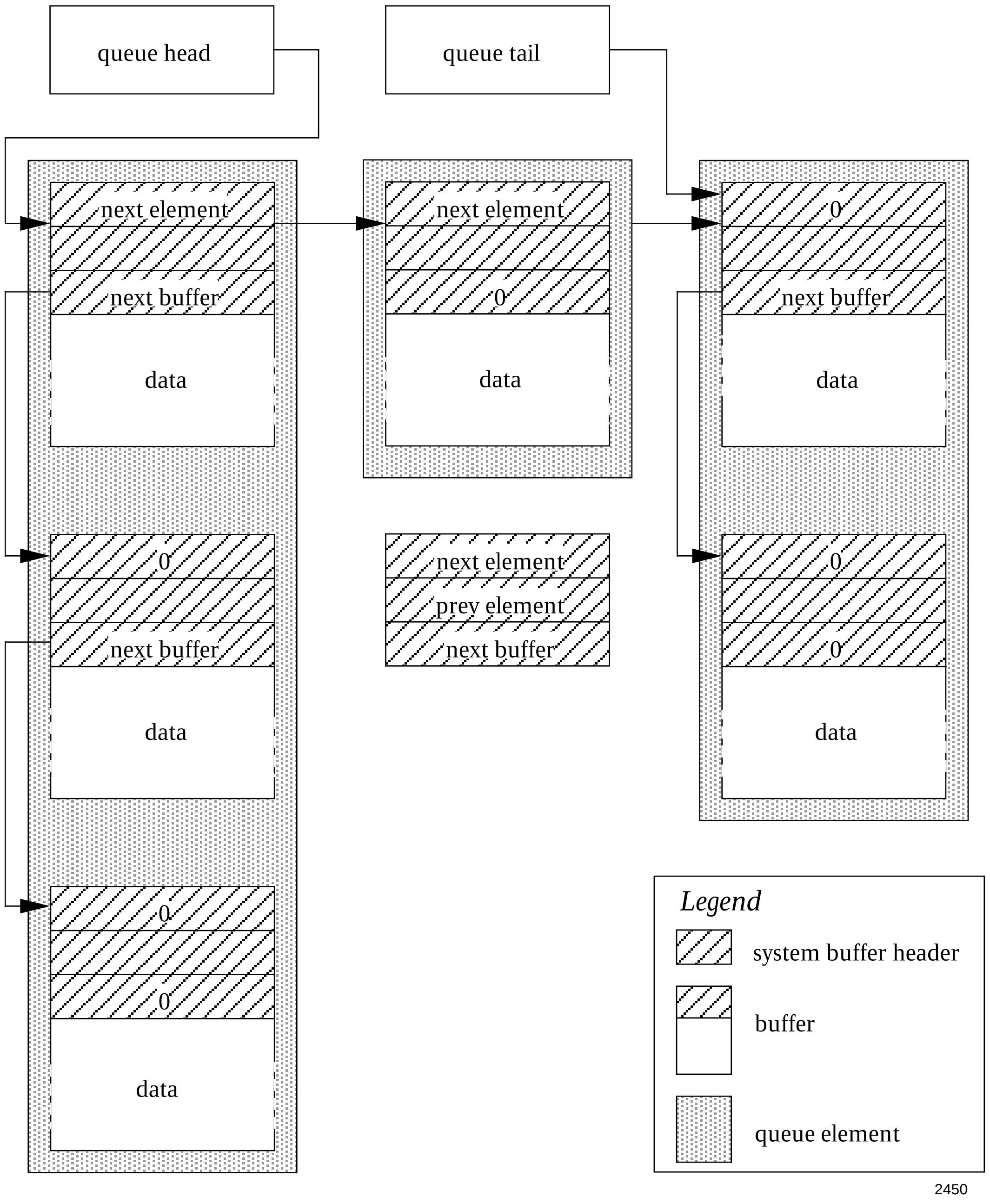


Figure 7–1: Sample Singly-linked Queue with Three Elements

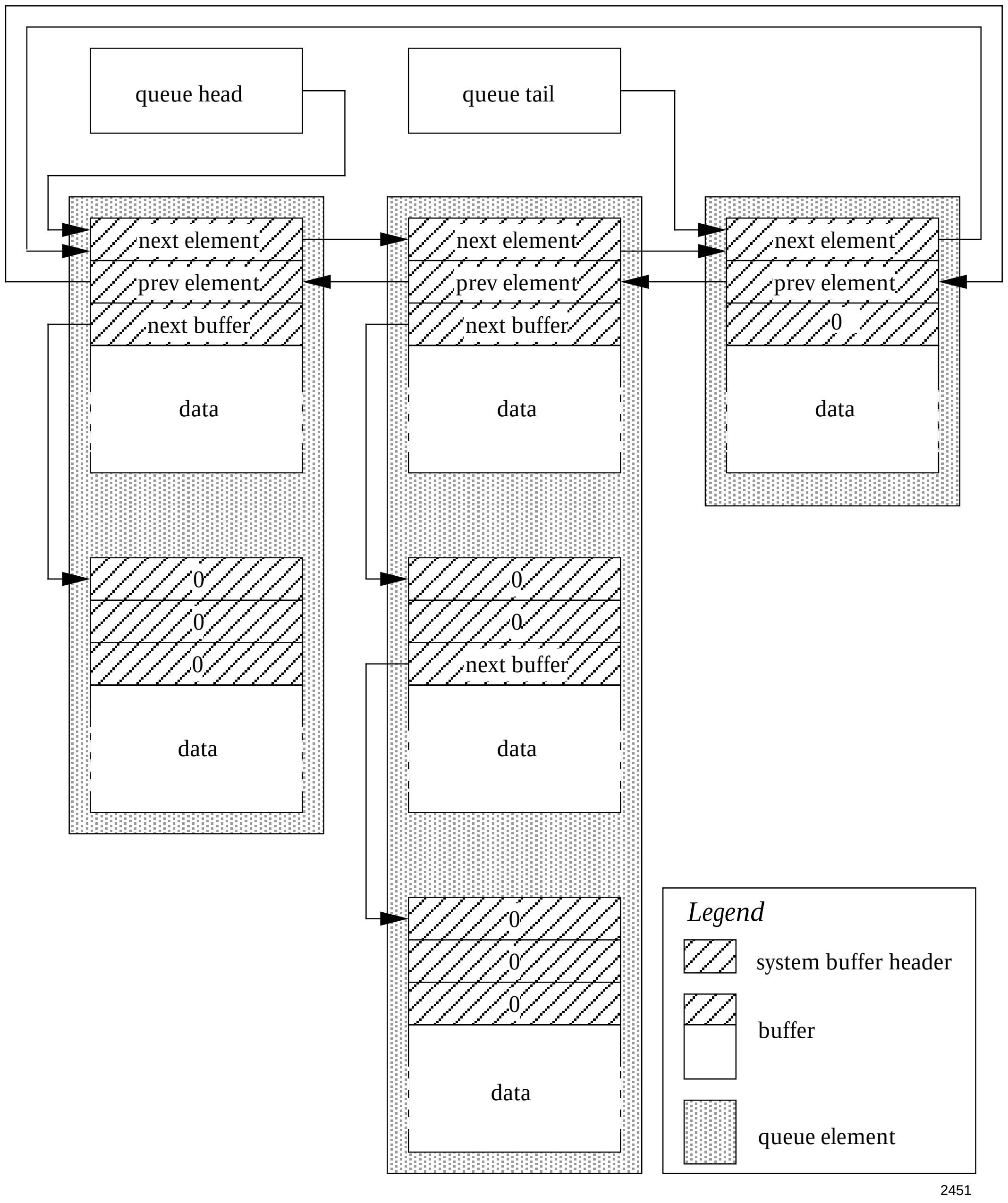


Figure 7–2: Sample Doubly-linked Queue with Three Elements

7.2.1 System Buffer Header

As mentioned previously, every buffer of every queue element must begin with a system buffer header. The following structure defines the format of the system buffer header:

```
struct SBH_TYPE
{
    struct SBH_TYPE *sb_nxte;   /* next element         */
    struct SBH_TYPE *sb_pree;   /* previous element     */
    struct SBH_TYPE *sb_thse;   /* this element         */
    struct SBH_TYPE *sb_nxtb;   /* next buffer          */
    unsigned short   sb_pid;    /* partition ID         */
    unsigned short   sb_dlen;   /* data length          */
    unsigned short   sb_disp;   /* disposition flag     */
    unsigned short   sb_dmod;   /* disposition modifier */
};
```

The header fields, as used by the system, are described below:

Next Element	This field is used only by the operating system, and only in the first buffer of a queue element. While the element is attached to a singly- or doubly-linked queue, this field contains the address of the next element on the queue.
Previous Element	This field is used only by the operating system, and only in the first buffer of a queue element. While the element is attached to a doubly-linked queue, this field contains the address of the previous element on the queue.
This Element	This field is used only by the operating system, and only in the first buffer of the queue element, as a consistency check when the element is posted to or removed from a queue. This field contains the address of the buffer itself (that is, the address of the queue element).

Next Buffer	This field contains the address of the next buffer of the queue element. In general, this field must be zero in the last buffer. In the data buffer of a host request queue element, XIO uses this field for a special purpose, as described in Section 7.2.4.1 on page 131.
Partition ID	This field contains the partition ID if the buffer was obtained from a partition.
Data Length	This field contains the number of valid bytes of data in the buffer (excluding the system buffer header).
Disposition Flag	This field, in combination with the disposition modifier, indicates the action to be taken by XIO when processing of the queue element is complete (when the request completion is received from the host). This flag has the following possible values:

POST_QE	Post queue element to queue
FREE_QE	Zero disposition modifier to mark queue element free
TOKEN_QE	Release queue element to a resource
POST_BUF	Post buffer to queue
FREE_BUF	Zero disposition modifier to mark buffer free
TOKEN_BUF	Release buffer to a resource
REL_BUF	Release buffer to partition

POST_QE, FREE_QE, and TOKEN_QE are valid only in the first buffer of a queue element and apply to the entire queue element (the disposition flag is then ignored in all other buffers of the queue element). POST_BUF, FREE_BUF, TOKEN_BUF, and REL_BUF are valid in all buffers and apply only to an individual buffer. For example, in a queue element consisting of only one buffer, POST_QE is equivalent to POST_BUF, but for a multiple-buffer queue element, the value POST_QE in the first buffer indicates that the queue element is to be posted to a particular queue intact, but the value POST_BUF in every buffer indicates that each buffer is to be posted to a queue as an individual queue element. Section 7.2.3.1 on page 126 and Section 7.2.4.1 on page 131 describe the use of this field in more detail.

Disposition modifier This field provides additional information required for completion processing by XIO. What is contained in this field depends on the value of the disposition flag, as follows:

Disposition Flag	Disposition Modifier
POST_QE	Queue ID
FREE_QE	Non-zero value to be cleared
TOKEN_QE	Resource ID
POST_BUF	Queue ID
FREE_BUF	Non-zero value to be cleared
TOKEN_BUF	Resource ID
REL_BUF	Not used

7.2.2 Queue Element Initialization

For the utility task to communicate with the host, it must post at least three node declaration queue elements, described in Section 7.2.3, to XIO’s public node declaration queue during its initialization. Two of these, the main node and the priority node, are the conduits for passing information from the host to the ICP. The remaining nodes are used by your ICP-resident software to send information in the form of data and command acknowledgments to the host processor.

Each node declaration queue element must contain a unique ICP node number and unique queue IDs which will be used for the read and write queues for that node. After this operation is complete, the utility task can begin posting host request queue elements, described in Section 7.2.4, to these queues. The following sections describe the two types of queue elements.

7.2.3 Node Declaration Queue Element

The utility task, spshio, creates node declaration queue elements, generally during initialization, and posts them to XIO. These queue elements identify the ICP node number that the task will use and queue IDs to which either read or write requests (or both) for that node will be posted. (XIO creates the queues. Only the queue IDs are supplied by the utility task.) In your code, you can declare several nodes (up to the maximum allowed by the driver), but you must post a separate node declaration queue element for each.

Since ICP node numbers must be unique throughout an ICP subsystem, a task can declare a node number only once; no other tasks can make a declaration using that node number. The queue IDs associated with declared node numbers must also be unique. A single ID cannot be used as both the read and write queue for a node, nor can it be used for other nodes or for any other purpose.

The node declaration queue element consists of a single buffer containing a system buffer header followed by a node declaration header. The queue element is shown in Figure 7–3 and has the following format:

```
struct NODEC_TYPE
{
     struct SBH_TYPE sbh;       /* system buffer header                  */
     unsigned short rqid;       /* host read request queue ID     */
     unsigned short wqid;       /* host write request queue ID   */
     unsigned char   node;       /* ICP node number                           */
     unsigned char   status;   /* completion status                         */
};
```

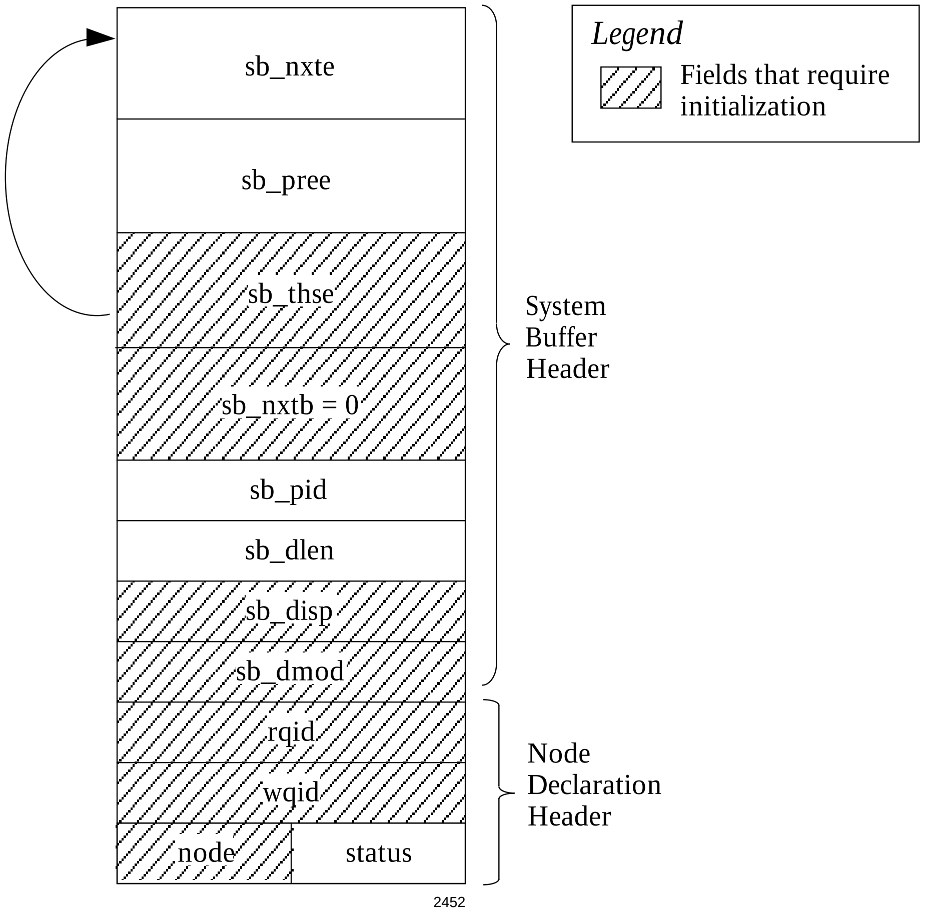


Figure 7–3: Node Declaration Queue Element

7.2.3.1 System Buffer Header Initialization

In the system buffer header, the sb_thse field must be set to the starting address of the buffer. (This field is set by the system if the buffer was obtained from a partition.) The sb_nxtb field must be set to zero. The disposition flag, sb_disp, and disposition modifier, sb_dmod, fields must be initialized as described in the following paragraphs, but no other fields in the system buffer header require specific initialization.

The disposition flag must be set to one of the values defined for the field as described in Section 7.2.1 on page 121. If the requesting task obtained the buffer from a partition, and if it does not require notification when the request has been processed by XIO, the value REL_BUF can be used; this causes XIO to release the buffer to its partition on completion. However, since a post to either of the host request queue IDs specified in the queue element fails if XIO has not yet processed the request (and created the queues), tasks generally request completion notification. Since the queue element consists of only one buffer, POST_QE and POST_BUF are equivalent, and cause XIO to post the queue element to a specified queue. Likewise, FREE_QE and FREE_BUF are equivalent, and cause XIO to clear the disposition modifier. TOKEN_QE and TOKEN_BUF are also equivalent and cause XIO to release the queue element to a specified resource.

If the disposition flag is set to POST_QE or POST_BUF, the disposition modifier must contain a valid queue ID. If the requesting task is the owner of that queue, it then suspends its operation, and resumes when XIO posts the queue element (with a post and resume system call) to the queue on completion.

If FREE_QE or FREE_BUF is specified in the disposition flag, the disposition modifier should be set to a non-zero value, so the requesting task can recognize the completion when the field is cleared by XIO.

If TOKEN_QE or TOKEN_BUF is specified in the disposition flag, the disposition modifier must contain a valid resource ID. The requesting task cannot use this method to obtain completion information unless the node declaration queue element is the only token associated with the resource. If this is the case, the task can make a resource request and obtain the token when it is released by XIO on completion.

7.2.3.2 Completion Status

Before processing the completion of the queue element, XIO stores a completion code in the status field of the node declaration header, as follows:

0	=	Good completion
1	=	The node number is out of range or already declared
2	=	A queue create system call failed (the queue ID is out of range or the queue already exists)

7.2.4 Host Request Queue Element

When your ICP-resident application or utility task posts a read or write request to the host processor, it must create a queue element and post it to the appropriate node's read or write queue. The queue element consists of two buffers, a header buffer and a data buffer. The header buffer contains a system buffer header followed by a host request header. The next buffer (sp_nxtb) field of the system buffer header in the header buffer contains the address of the data buffer. The data buffer also contains a system buffer header, followed by an ICP header, a protocol header, and the received data, if any, that will ultimately be transferred to the application program (in the case of a write request), or the area to which data being sent from the application program will be transferred (in the case of a read request).

Figure 7–4 shows an example of a host request queue element with an encapsulated data buffer.

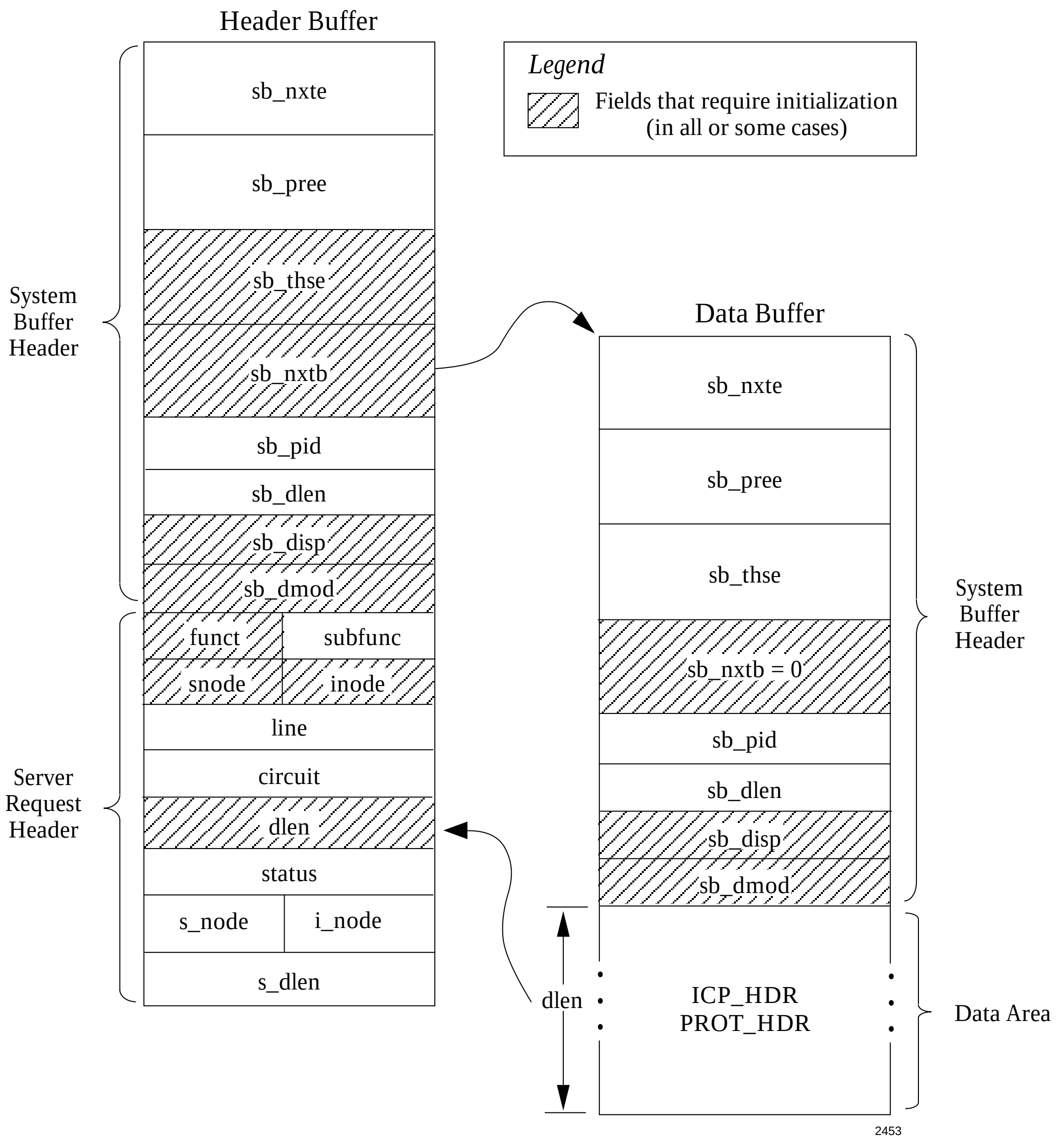


Figure 7–4: Host Request Queue Element with Data Area

The header buffer has the following structure:

```
struct SREQ_HDR_TYPE
{
    struct SBH_TYPE   sbh;
    struct sreq_type req;
};
```

The two structures that make it up are as follows:

```
struct SBH_TYPE
{
        struct SBH_TYPE     *sb_nxte;       /* next element             */
        struct SBH_TYPE     *sb_pree;       /* previous element         */
        struct SBH_TYPE     *sb_thse;       /* this element             */
        struct SBH_TYPE     *sb_nxtb;       /* next buffer              */
        unsigned short      sb_pid;         /* partition ID             */
        unsigned short      sb_dlen;        /* data length              */
        unsigned short      sb_disp;        /* disposition flag         */
        unsigned short      sb_dmod;        /* disposition modifier */
};

struct sreq_type
{
        unsigned char       funct;          /* function code (read or write) */
        unsigned char       subfunct;       /* subfunction code              */
        unsigned char       snode;          /* host node number              */
        unsigned char       inode;          /* ICP node number               */
        unsigned short      line;           /* line number                   */
        unsigned short      circuit;        /* circuit number                */
        unsigned short      dlen;           /* data length, in bytes         */
        unsigned short      status;         /* completion code               */
        unsigned char       s_node;         /* actual host node number
                                               (on completion)               */
        unsigned char       i_node;         /* actual ICP node number
                                               (on completion)               */
        unsigned short      s_dlen;         /* actual number of bytes
                                               transferred                   */
};
```

The data buffer has the following structure:

```
struct data_buffer
{
   struct  SBH_TYPE    sbh;    /* (defined in oscif.h) */
   ICP_HDR  icp_hdr;
   union
   {
      PROT_HDR  prot_hdr;
      XMT_HDR xmt_hdr;
   } prot_hdrs;
   bit8    data;              /* start of data */
};
typedef struct data_buffer DATA_BUFFER;
```

The structures that make it up are as follows:

```
struct SBH_TYPE
{
  struct SBH_TYPE *sb_nxte;   /* next element */
  struct SBH_TYPE *sb_pree;   /* previous element */
  struct SBH_TYPE *sb_thse;   /* this element */
  struct SBH_TYPE *sb_nxtb;   /* next buffer */
  unsigned short   sb_pid;    /* partition ID */
  unsigned short   sb_dlen;   /* data length */
  unsigned short   sb_disp;   /* disposition flag */
  unsigned short   sb_dmod;   /* disposition modifier */
};

struct icp_hdr                    /* ICP message header */
{
      bit16   su_id;            /* service user (client) ID */
      bit16   sp_id;            /* service provider (server) ID */
      bit16   count;            /* size of data following this header */
      bit16   command;          /* function code */
      bit16   status;           /* function status */
      bit16   params[3];        /* API specific parameters  */
};
typedef struct icp_hdr ICP_HDR;
```

```
struct prot_hdr                    /* Protocol message header */
{
    bit16   command;             /* function code */
    bit16   modifier;            /* function modifier */
    bit16   link;                /* physical port number */
    bit16   circuit;             /* data link circuit identifier */
    bit16   session;             /* session identifier */
    bit16   sequence;            /* message sequence number */
    bit16   reserved1;           /* reserved */
    bit16   reserved2;           /* reserved */
};
typedef struct prot_hdr PROT_HDR;

struct xmt_hdr
{
  bit32   flags;      /* local transmit/receive flags */
  bit8    filler;
  bit8    syncs[8];   /* starting sync chars (BSC)    */
  bit8    start_char; /* start char (BSC)             */
  bit16   count;
};
typedef struct xmt_hdr XMT_HDR;
```

7.2.4.1 System Buffer Header Initialization

In the system buffer header of the header buffer (the first buffer of the queue element), sb_thse must be initialized. (This field is set by the system if the buffer was obtained from a partition.) The sb_nxtb field must be set to the starting address of the data buffer (that is, to the start of its system buffer header). In addition, the disposition flag, sb_disp, and possibly the disposition modifier, sb_dmod, must be initialized.

In the system buffer header of the second buffer (the data buffer), initialization of sb_thse is not required. If the sb_nxtb field is set to zero, the remainder of the buffer immediately follows the system buffer header. If the sb_nxtb field is non-zero, it must contain a pointer to the first byte of the API header. For the data buffer, initialization of the system buffer header's disposition flag and disposition modifier might be required, depending on the value of the header buffer's disposition flag.

In the header buffer, the disposition flag must be set to one of the values defined for the field in Section 7.2.1 on page 121. If it is set to POST_QE, FREE_QE, or TOKEN_QE, the disposition flag in the data buffer is ignored. If the disposition flag in the header buffer is set to POST_BUF, FREE_BUF, TOKEN_BUF, or REL_BUF, the disposition flag in the data buffer must also be set to one of those four values, although not necessarily the same one. These options are described in the following paragraphs.

In general, a task requires notification of the completion of a read request so that it can process the message received from the ICP's host. However, it might or might not require notification of the completion of a write request. If the task obtained the buffers of a queue element from a partition, and if it does not require notification when the request has been processed by XIO, the value REL_BUF in the disposition flags of both buffers causes XIO to release the buffers to their partitions on completion.

If the task is maintaining host request queue elements as resource tokens and does not require notification when the request has been processed by XIO, the value TOKEN_QE in the disposition flag and a resource ID in the disposition modifier of the header buffer cause XIO to release the queue element to the resource on completion. Alternatively, the task could maintain the individual buffers of the queue element as resource tokens, in which case TOKEN_BUF should be stored in the disposition flag and resource ID in the disposition modifier of both the header and data buffers.

For notification of the completion of a host request, a task can set the disposition flag in the header buffer to POST_QE, in which case XIO, on completion, posts the queue element, intact, to the queue specified in the disposition modifier of the header buffer. Alternatively, the task can set the disposition flag in the header buffer to FREE_QE, in which case XIO clears the disposition modifier in the header buffer on completion.

If the completion is to be processed separately for the two buffers of the queue element, the requesting task can use the POST_BUF, FREE_BUF, and REL_BUF values, in any combination, for the disposition flags. For example, if the task obtained its data buffer from a partition, but defined a fixed data structure as the header buffer, it might set the disposition flag in the header buffer to FREE_BUF and the disposition flag in the data buffer to REL_BUF. Then, when the request is complete, the header buffer is marked free by XIO, indicating to the task that it is available for re-use. The data buffer is released to its partition by XIO, and requires no further processing.

If the disposition flag in either buffer is set to POST_QE or POST_BUF, the corresponding disposition modifier must contain a valid queue ID. If the requesting task is the owner of the queue, it can suspend its operation and resume when XIO posts the queue element or buffer (with a post and resume, s_post, system call) to the queue on completion of the request.

If FREE_QE or FREE_BUF is specified in the disposition flag of either buffer, the corresponding disposition modifier should be set to a non-zero value so that the requesting task can recognize the completion when the field is cleared by XIO.

7.2.4.2 Host Request Header Initialization

The subfunction, line number, and circuit number fields of the host request header are defined for compatibility with other Simpact products and are not used for the ICP.

The function code must be set to one of the following values:

0x02	=	Write request
0x08	=	Read request

When a node is declared, a host read request queue ID and a host write request queue ID are defined. For both the main and priority nodes, at least one host request queue element containing a read function code (in the funct field of the host request header) must always be posted to that node's read request queue, and a queue element containing a write function code must always be posted to that node's write request queue.

For nodes specific to your ICP-resident task, at least one host request queue element must always be posted to each node's write request queue. For compatibility with other

Protogate implementations, provisions exist for read request queues for these nodes; however, they are not used in the Freeway implementation. In addition, for any node, a host request queue element posted to either the read or write queue must contain a matching ICP node number in the inode field of the host request header. The snode field should be set as defined for the particular application. (This field is passed to the host, but is not interpreted by XIO. In general, it is used on a write request to specify the destination of the data, and is not used on a read request.)

As the data transfer address for the request, XIO passes to the host the address that is stored in the sb_nxtb field of the data buffer's system buffer header. If this value is zero, XIO uses the beginning address of the data buffer plus the length of the system buffer header instead. (The system buffer header itself, as well as any portion of the buffer that separates the system buffer header from the data, are never transferred to or from the host.) For a write request, the dlen field of the host request header should be set to the actual number of bytes of data in the data buffer, excluding the system buffer header and any portion of the buffer that separates the header from the data. For a read request, the dlen field should be set to the maximum length of the data buffer, excluding the system buffer header and any portion of the buffer that separates the header from the data.

No other fields of the host request header require initialization.

7.2.4.3 Completion Status

Before processing the completion of the queue element, XIO stores a completion code in the status field of the host request header, as follows:

If the completion status is good, XIO also returns the node numbers supplied by the host and the actual number of bytes transferred. The ICP node number is returned in the i_node field, and always matches the ICP node number supplied by the requesting SPS task in the inode field. The host node number is returned in the s_node field. For a write, this value always matches the node number supplied by the requesting SPS task

0	=	Good completion
1	=	The queue to which the host request queue element was posted is defined for a node number other than the one specified in the inode field of the host request header
3	=	The host request queue element was posted to a host read request queue but contains a write function code, or was posted to a host write request queue but contains a read function code

in the snode field. For a read, the node number is generally not specified on request (snode is not used), and on completion, the s_node field identifies the node number from which the data was received.

Note that inode and i_node are two separate fields in the host request header, as are snode and s_node.

The number of bytes actually transferred to or from the host is returned in the s_dlen field. This value is never greater than the number requested (dlen), but might be less, depending on the data length requested by the corresponding application program.

7.3 Reserved System Resources: XIO Interface

XIO reserves the following system resources:

Queue IDs	1 and 2 (ID 1 = node declaration queue)
Vector numbers	25 and 26 (hexadecimal offsets 64 and 68)
GST entries	gs_unused [0] (task entry point) gs_unused [1] (panic code)

For proper operation of XIO, ICP-resident SPS tasks added to the system must not use conflicting system resources.

7.4 Executive Input/Output

Executive Input/Output (XIO) consists of three functions which are described in the following sections: s_initxio, s_nodec and s_xio.

The s_initxio function is called once to initialize the internal data structures and devices that allow XIO to communicate with the host's ICP driver. After initialization, the user application can call s_nodec to declare a node. After nodes are declared, the user application issues read and write request using s_xio.

7.4.1 Initialize Executive Input/Output (s_initxio)

The Initialize XIO function sets up interrupt vectors and internal data structures. It notifies the host that the ICP is ready to perform I/O.

C Interface:

```
s_initxio()
```

Return: none

Assembly Interface:

```
jsr       _s_initxio
```

Input: none
Output: none

7.4.2 Node Declaration (s_nodec)

The Node Declaration function declares the nodes as described in Section 7.2.3 on page 124. Any error information is returned in the status field of the node declaration header (NODEC_TYPE).

C Interface:

```
s_nodec ( nodec )
struct NODEC_TYPE *nodec;
```

Return: n/a

Assembly Interface:

```
TRAP   #4
```

Input: A0.L = address of NODEC_TYPE structure

Output: none

Access: task or ISR

7.4.3 XIO Read/Write (s_xio)

Issue a read or write request. Depending on the value of the funct field of the host request header (Figure 7–4 on page 128), the s_xio function issues a read or write request.

C Interface:

```
s_xio ( p_hdr )
SREQ_HDR_TYPE *p_hdr;
```

p_hdr: pointer to host request header

Assembly Interface:

```
TRAP    #4
```

Input: A0.L = address of SREQ_HDR_TYPE structure

Output: none

Access:

task or ISR

7.5 Diagnostics

OS/Impact defines a global system table (GST) that can be accessed at a fixed offset from the load address and contains information used for system initialization and diagnostic purposes. A number of four-byte entries are defined by the operating system as unused and are available for use by ICP-resident system and SPS tasks. (See the *OS/Impact Operating System Programmer's Guide* for a definition of the GST.)

OS/Impact initializes the second unused entry in the GST to zero. If OS/Impact encounters a fatal error during its operation, it stores a panic code at this location and executes an illegal instruction, which causes a trap to the debugger. The panic codes, described below, are each composed of an identifier in the high-order word and a modifier in the low-order word.

Identifier	0x100
Modifier	Error code returned from s_qcreat
Description	Creation of the node declaration queue failed (queue ID 1).

Identifier	0x200
Modifier	Error code returned from s_qcreat
Description	Creation of the pending request queue failed (queue ID 2).

Identifier	0x300
Modifier	Error code returned from s_accpt
Description	An accept message system call on the node declaration queue returned an invalid queue ID error.

Identifier	0x400
Modifier	Queue ID
Description	An accept message system call on a read request queue returned an invalid queue ID error.

Identifier	0x500
Modifier	Queue ID
Description	An accept message system call on a write request queue returned an invalid queue ID error.

Identifier	0x600
Modifier	Error code returned from s_susp
Description	A suspend call failed.

Identifier	0x700
Modifier	Disposition flag value
Description	A buffer contains an illegal disposition flag value.

Identifier	0x800
Modifier	Error code returned from s_accpt
Description	An accept message system call on the pending request queue returned an invalid queue ID or queue empty error. (The queue should not be empty, because s_accpt is not called unless the queue head pointer is non-zero.)

Identifier	0x900
Modifier	8 (error code returned from DMA subroutine)
Description	A data transfer from the host to the ICP failed due to a bus error.

Identifier	0xA00
Modifier	8 (error code returned from DMA subroutine)
Description	A data transfer from the ICP to the host failed due to a bus error.

Chapter 8 Client Applications — DLI Overview

Note

In this document, the term “Freeway” can mean either a Freeway server or an embedded ICP. For the embedded ICP, also refer to the user guide for your ICP and operating system (for example, the *ICP2432 User Guide for Windows NT*).

This chapter describes how to use the data link interface (DLI) functions, part of Protogate’s application program interface (API), to initiate and terminate sessions when developing applications that interface to the ICP sample protocol software (SPS). You should be familiar with the concepts described in the *Freeway Data Link Interface Reference Guide*; however, some summary information is provided in Section 8.1.

If you are using an embedded ICP, you must also refer to the user guide for your specific ICP and operating system regarding the embedded DLI interface (referred to as DLITE).

The following might be helpful references while reading this chapter:

- Section 8.2 compares a typical sequence of DLI function calls using blocking versus non-blocking I/O.
- Appendix C explains error handling and provides a summary table for error codes. The *Freeway Data Link Interface Reference Guide* gives complete DLI error code descriptions.

- The *Freeway Data Link Interface Reference Guide* shows a generic code example which can guide your application program development. The loopback test program (spsalp.c) distributed with the product software is another example.
- Chapter 9 provides detailed command and response header formats.
- The various mnemonic codes mentioned throughout this document are defined in the include files provided with this product, which are described in Table 8–1.

Table 8–1: Include Files

Description	Include File
DLI_PROT_* Codes	dliprot.h
DLI_ICP_ERR_* Codes	dlicperr.h
DLI_ICP_CMD_* Codes	dliicp.h
FW_* Codes	freeway.h

8.1 Summary of DLI Concepts

The DLI presents a consistent, high-level, common interface across multiple clients, operating systems, and transport services. It implements functions that permit your application to use data link services to access, configure, establish and terminate sessions, and transfer data across multiple data link protocols. The DLI concepts are described in detail in the *Freeway Data Link Interface Reference Guide*. This section summarizes the basic information.

8.1.1 Configuration in the Freeway Server or Embedded ICP Environment

Several items must be configured before a client application can run in the Freeway environment:

- boot configuration for Freeway server implementations
- data link interface (DLI) session configuration

- transport subsystem interface (TSI) connection configuration
- protocol-specific ICP link configuration

The Freeway server boot configuration file is normally created during the installation procedures described in the *Freeway User Guide*. DLI session and TSI connection configurations are defined by specifying parameters in DLI and TSI ASCII configuration files and then running two preprocessor programs, dlicfg and tsicfg, to create binary configuration files. The DLI and TSI configuration process is described in Section 8.1.1.1 and Section 8.1.1.2.

Protocol-specific ICP link configuration must be performed by the client application (as described in Section 9.2.7.1 on page 175) after dlOpen completes the DLI session establishment process.

8.1.1.1 DLI Configuration for *Raw* Operation

The application program interface (API) is implemented in two levels: the data link interface (DLI) and the transport subsystem interface (TSI). These levels are documented in the *Freeway Data Link Interface Reference Guide* and the *Freeway Transport Subsystem Interface Reference Guide*.

The DLI provides two levels of operation for ICP protocol software, as described in the *Freeway Data Link Interface Reference Guide*. *Normal* operation is not supported by the SPS. *Raw* operation means that the application programmer must provide link configuration, link enable, and all the other requirements of the ICP protocol software. The SPS is provided as an example to be modified; however, the DLI supports only *Raw* operation for the SPS. The DLI optional arguments data structure (DLI_OPT_ARGS), which is central to *Raw* operation, is described in Section 9.1 on page 157. The embedded DLITE interface also supports only *Raw* operation.

The configuration files for the client application are relatively simple. However, you must specify the DLI configuration parameters whose values differ from the defaults.

Figure 8–1 shows a portion of a typical DLI configuration file, such as spsaldcfg. The BoardNo parameter specifies the target ICP. If BoardNo is not specified, the default is zero. The PortNo parameter may or may not be provided. The PortNo parameter is required if the application requests a DLI session status and expects to see the correct value for iPortNo. If your application does not require the iPortNo value, the DLI configuration file does not need to specify PortNo. If PortNo is not included, only one DLI section (besides the "main" section) is required in the configuration file, which can be referenced in all calls to dlOpen. Refer to the *Freeway Data Link Interface Reference Guide* for more information on requesting DLI session status.

For an embedded ICP using the DLITE interface, Figure 8–2 shows the "main" section and two sessions. You need to include only those parameters whose values differ from the defaults. The DLITE interface supports only *Raw* operation. For more information on the DLITE interface, refer to the user guide for your embedded ICP and operating system (for example, the *ICP2432 User Guide for Windows NT*).

```
//-----------------------------------------------------------------//
// "main" section.  If not defined defaults are used. If present   //
// the main section must be the very first section of the DLI      //
// configuration file.                                             //
//-----------------------------------------------------------------//

main
{
   AsyncIO = "yes";               // Non-blocking I/O              //
   TSICfgName = "spsaltcfg.bin";   // TSI binary config file            //
}

//-----------------------------------------------------------------//
// Define a section for a raw port.                                //
//-----------------------------------------------------------------//

server0icp0port0
{
   AlwaysQIO = "yes";              // DLI always queues I/O          //
   AsyncIO = "Yes";                // Non-blocking I/O            //
   BoardNo = 0;                     // First ICP is board 0            //
   CfgLink = "No";                 // Client must configure link //
   Enable = "No";                  // Client must enable link       //
      PortNo = 0;                     // First link is 0              //
   Protocol = "raw";              // SPS uses Raw operation        //
   Transport = "conn0";            // TSI connection name           //
}
//-----------------------------------------------------------------//
// Define a section for a raw port.                                //
//-----------------------------------------------------------------//

server0icp0port1
{
   AlwaysQIO = "yes";              // DLI always queues I/O          //
   AsyncIO = "Yes";                // Non-blocking I/O            //
   BoardNo = 0;                     // First ICP is board 0            //
   CfgLink = "No";                 // Client must configure link //
   Enable = "No";                  // Client must enable link       //
      PortNo = 1;                     // Second link is 1                //
   Protocol = "raw";              // SPS uses Raw operation        //
   Transport = "conn0";            // TSI connection name           //
}
```

Figure 8–1: DLI Configuration File for Two Links (Freeway Server)

```
main                                    // DLI “main” section:                 //
{
     asyncIO = “yes”;                   // Use non-blocking I/O                //
     tsiCfgName = "."                // tsiCfgName unused for DLITE      //
                           // Exception: For NT =  Location of log/trace svc //
// The following two parameters are for DLITE only:                      //
     maxBuffers = 1024;
     maxBufSize = 1200;
}

ICP0link0                               // First session name:                 //
{                                       // Client-related parameters:          //
     alwaysQIO = “yes”;                 //    Queue I/Os even if complete      //
     asyncIO = “yes”;                   //    Use non-blocking I/O             //
     cfgLink = “no”;                    //    Client configures links          //
     enable = “no”;                     //    Client enables links             //
     localAck = “no”;                   //    Client processes transmit ack    //
     boardNo = 0;                       //    First ICP is zero                //
     portNo = 0;                        //    First ICP link is zero           //
     protocol = “raw”;                  //    DLITE requires Raw operation     //
     maxBufSize = 1200;                 //    Used by DLITE                    //
}

ICP0link1                               // Second session name:                //
{                                       // Client-related parameters:          //
     alwaysQIO = “yes”;                 //    Queue I/Os even if complete      //
     asyncIO = “yes”;                   //    Use non-blocking I/O             //
     cfgLink = “no”;                    //    Client configures links          //
     enable = “no”;                     //    Client enables links             //
     localAck = “no”;                   //    Client processes transmit ack    //
     boardNo = 0;                       //    First ICP is zero                //
     portNo = 1;                        //    First ICP link is zero           //
     protocol = “raw”;                  //    DLITE requires Raw operation     //
     maxBufSize = 1200;                 //    Used by DLITE                    //
}
```

Figure 8–2: DLI Configuration File for Two Embedded ICP Links (DLITE Interface)

8.1.1.2 DLI and TSI Configuration Process

This section summarizes the process for configuring DLI sessions and TSI connections. DLI and TSI text configuration files are used as input to the dlicfg and tsicfg preprocessor programs to produce binary configuration files which are used by the dlInit and dlOpen functions. For embedded ICPs, only a DLI configuration file is used (not a TSI configuration file).

During your client application development and testing, you might need to perform DLI configuration repeatedly (as well as TSI configuration for a Freeway server).

The DLI and TSI configuration files provided with the product are listed in Table 8–2.

Table 8–2: Configuration File Names

	Freeway Server	Embedded ICP
DLI:	spsaldcfg	spsacfg spsscfg
TSI:	spsaltcfg	TSI not applicable for embedded ICP

The DLI and TSI configuration procedures are summarized as follows. Keep in mind that TSI configuration does not apply to an embedded ICP environment.

1. For a Freeway server, create or modify a TSI text configuration file specifying the configuration of the TSI connections (for example, spsaltcfg in the freeway/client/test/sps directory).

2. Create or modify a DLI text configuration file specifying the DLI session configuration for all ICPs and serial communication links in your system (for example, spsaldcfg in the freeway/client/test/sps directory).

3. If you have a UNIX or Windows NT system, skip this step. If you have a VMS system, run the makefc.com command file from the [FREEWAY.CLIENT.TEST.SPS] directory to create the foreign commands used for dlicfg and tsicfg.

   @MAKEFC <*tcp-sys*>

   where <*tcp-sys*> is your TCP/IP package:

MULTINET	(for a Multinet system)
TCPWARE	(for TCPware system)
UCX	(for a UCX system)

   VMS example: @MAKEFC UCX

4. For a Freeway server, go to the freeway/client/test/sps directory and execute tsicfg with the text file from Step 1 as input. This creates the TSI binary configuration file in the same directory as the location of the text file (unless a different path is supplied with the optional filename). If the optional filename is not supplied, the binary file is given the same name as your TSI text configuration file plus a .bin extension.

   tsicfg *TSI-text-configuration-filename [TSI-binary-configuration-filename]*

UNIX example:	freeway/client/*op-sys*/bin/tsicfg spsaltcfg
VMS example:	tsicfg spsaltcfg
NT example:	freeway\client\op-sys\bin\tsicfg spsaltcfg

5. From the freeway/client/test/sps (or the freeway/client/nt_dlite/sps) directory, execute dlicfg with the text file from Step 2 as input. This creates the DLI binary configuration file in the same directory as the location of the text file (unless a different path is supplied with the optional filename). If the optional filename is not supplied, the binary file is given the same name as your DLI text configuration file plus a .bin extension.

   dlicfg *DLI-text-configuration-filename [DLI-binary-configuration-filename]*

UNIX example:	freeway/client/*op-sys*/bin/dlicfg spsaldcfg

VMS example:	dlicfg spsaldcfg
NT example:	freeway\client\op-sys\bin\dlicfg spsaldcfg

Note

You must rerun dlicfg or tsicfg whenever you modify the text configuration file so that the DLI or TSI functions can apply the changes. On all but VMS systems, if a binary file already exists with the same name in the directory, the existing file is renamed by appending the .BAK extension. If the renamed file duplicates an existing file in the directory, the existing file is removed by the configuration preprocessor program.

6. If you have a UNIX system, move the binary configuration files that you created in Step 4 and Step 5 into the appropriate freeway/client/*op-sys*/bin directory where *op-sys* indicates the operating system (for example: dec, hpux, sgi, solaris, or sunos).

   UNIX example: mv spsaldcfg.bin /usr/local/freeway/client/hpux/bin
   mv spsaltcfg.bin /usr/local/freeway/client/hpux/bin

7. If you have a VMS system, run the move.com command file from the [FREEWAY.CLIENT.TEST.SPS] directory. This moves the binary configuration files you created in Step 4 and Step 5 into the bin directory for your particular TCP/IP package.

   @MOVE *filename* <*tcp-sys*>

   where *filename* is the name of the binary configuration file and <*tcp-sys*> is the TCP/IP package:

MULTINET	(for a Multinet system)
TCPWARE	(for TCPware system)
UCX	(for a UCX system)

   VMS example: @MOVE SPSALDCFG.BIN UCX

8. If you have a Windows NT system, move the binary configuration files that you created in Step 4 and Step 5 into the appropriate freeway\client\op-sys\bin directory where *op-sys* indicates the operating system: axp_nt or int_nt (for a Freeway server); axp_nt_emb or int_nt_emb (for an embedded ICP).

   NT example: copy spsaldcfg.bin \freeway\client\axp_nt\bin

   copy spsaltcfg.bin \freeway\client\axp_nt\bin

When your application calls the dlInit function, the DLI and TSI binary configuration files generated in Step 4 and Step 5 are used to configure the DLI sessions and TSI connections. Figure 8–3 shows the configuration process.

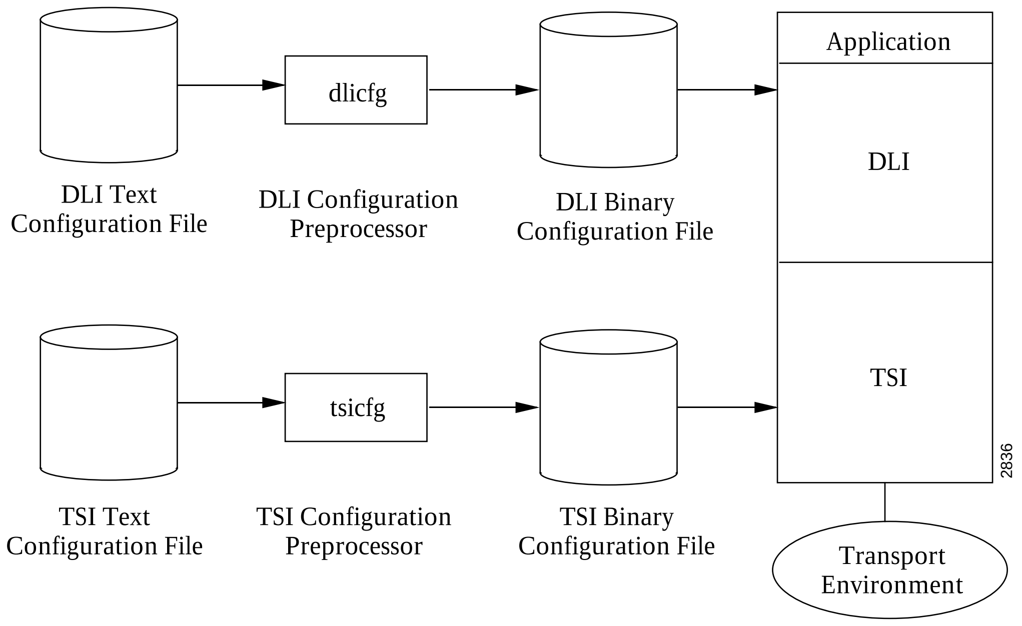

dlicfg
DLI Text Configuration File
DLI Configuration Preprocessor
DLI Binary Configuration File
Application
DLI
TSI
tsicfg
TSI Text Configuration File
TSI Configuration Preprocessor
TSI Binary Configuration File
Transport Environment
2836

Figure 8–3: DLI and TSI Configuration Process

8.1.2 Blocking versus Non-blocking I/O

Note

Earlier Simpact releases used the term “synchronous” for blocking I/O and “asynchronous” for non-blocking I/O. Some parameter names reflect the previous terminology.

Non-blocking I/O applications are useful when doing I/O to multiple channels with a single process where it is not possible to “block” (sleep) on any one channel waiting for I/O completion. Blocking I/O applications are useful when it is reasonable to have the calling process wait for I/O completion.

In the Freeway environment, the term blocking I/O indicates that the dlOpen, dlClose, dlRead and dlWrite functions do not return until the I/O is complete. For non-blocking I/O, these functions might return after the I/O has been queued at the client, but before the transfer to the ICP is complete. The client must handle I/O completions at the software interrupt level in the completion handler established by the dlInit or dlOpen function, or by periodic use of dlPoll to determine the I/O completion status.

The asyncIO DLI configuration parameter specifies whether an application session uses blocking or non-blocking I/O (set asyncIO to “no” to use blocking I/O). The alwaysQIO DLI configuration parameter further qualifies the operation of non-blocking I/O activity. Refer to the *Freeway Data Link Interface Reference Guide* for more information.

The effects on different DLI functions, resulting from the choice of blocking or non-blocking I/O, are explained in the *Freeway Data Link Interface Reference Guide*.

Server-resident applications must use non-blocking I/O; support for blocking I/O in server-resident applications is not available.

8.1.3 Buffer Management

Currently the interrelated Freeway, DLI, TSI, and ICP buffers default to a size of 1024 bytes.

Caution

If you need to change a buffer size for your application, refer to the *Freeway Data Link Interface Reference Guide* for explanations of the complexities that you must consider.

8.2 Example Call Sequences

Table 8–3 shows the sequence of DLI function calls to send and receive data using blocking I/O. Table 8–4 is the non-blocking I/O example. The remainder of this chapter and the *Freeway Data Link Interface Reference Guide* give further information about each function call. Refer back to Section 8.1.2 on page 151 for more information on blocking and non-blocking I/O.

Note

The example call sequences assume that the cfgLink and enable DLI configuration parameters are set to “no” (the default is “yes” for both). This is necessary for the client application to configure and enable the ICP links. Figure 8–1 on page 145 shows an example DLI configuration file.

Table 8–3: DLI Call Sequence for Blocking I/O

1. Call dlInit to initialize the DLI operating environment. The first parameter is your DLI binary configuration file name.
2. Call dlOpen for each required session (link) to get a session ID.
3. Call dlBufAlloc for all required input and output buffers.
4. Call dlWrite to send an attach request to Freeway.
5. Call dlRead to receive the protocol session ID from Freeway.
6. Call dlWrite to send a configuration message to Freeway.
7. Call dlRead to receive the configuration confirmation from Freeway.
8. Call dlWrite to send a link activation message to Freeway.
9. Call dlRead to receive the link activation confirmation from Freeway.
10. Call dlWrite to send requests and data to Freeway.
11. Call dlRead to receive responses and data from Freeway.
12. Repeat Step 10 and Step 11 until you are finished writing and reading.
13. Call dlBufFree for all buffers allocated in Step 3.
14. Call dlClose for each session ID obtained in Step 2.
15. Call dlTerm to terminate your application’s access to Freeway.

Table 8–4: DLI Call Sequence for Non-blocking I/O

1. Call dlInit to initialize the DLI operating environment. The first parameter is your DLI binary configuration file name.
2. Call dlOpen for each required session (link) to get a session ID.
3. Call dlPoll to confirm the success of each session ID obtained in Step 2.
4. Call dlBufAlloc for all required input and output buffers.
5. Call dlRead to queue the initial read request.
6. Call dlWrite to send an attach request to Freeway.
7. Call dlRead to receive the protocol session ID from Freeway.
8. Call dlWrite to send a configuration message to Freeway.
9. Call dlRead to receive the configuration confirmation from Freeway.
10. Call dlWrite to send a link activation message to Freeway.
11. Call dlRead to receive the link activation confirmation from Freeway.
12. Call dlWrite to send requests and data to Freeway.
13. Call dlRead to queue reads to receive responses and data from Freeway.
14. As I/Os complete, call dlPoll to confirm the success of each dlWrite in Step 12 and to accept the data from each dlRead in Step 13.
15. Repeat Step 12 through Step 14 until you are finished writing and reading.
16. Call dlBufFree for all buffers allocated in Step 4.
17. Call dlClose for each session ID obtained in Step 2.
18. Call dlPoll to confirm that each session was closed in Step 17.
19. Call dlTerm to terminate your application's access to Freeway.

Note

Server-resident applications must use non-blocking I/O. It is also necessary to call dlPost before relinquishing task control. See the *Freeway Data Link Interface Reference Guide* for details.

8.3 Overview of DLI Functions

After the protocol software is downloaded to the ICP, the client and ICP can communicate by exchanging messages. These messages configure and activate each ICP link and transfer data. The client application issues reads and writes to transfer messages to and from the ICP.

This section summarizes the DLI functions used in writing a client application. An overview of using the DLI functions is:

- Start up communications (dlInit, dlOpen, dlBufAlloc, dlWrite, dlRead)
- Send requests and data using dlWrite
- Receive responses using dlRead
- For blocking I/O, use dlSyncSelect to query read availability status for multiple sessions
- For non-blocking I/O, handle I/O completions at the software interrupt level in the completion handler established by the dlInit or dlOpen function, or by periodic use of dlPoll to query the I/O completion status
- Monitor errors using dlpErrString
- If necessary, reset and download the protocol software to the ICP using dlControl
- For server-resident applications, use dlPost before relinquishing task control
- Shut down communications (dlBufFree, dlClose, dlTerm)

Table 8–5 summarizes the DLI function syntax and parameters, listed in the most likely calling order. Refer to the *Freeway Data Link Interface Reference Guide* for details.

Chapter 9 describes the dlWrite and dlRead functions. Both functions use the optional arguments parameter to provide the protocol-specific information required for *Raw* operation (see Section 8.1.1.1 on page 143). The "C" definition of the optional arguments is described in Section 9.1 on page 157.

Table 8–5: DLI Functions: Syntax and Parameters (Listed in Typical Call Order)

DLI Function	Parameter(s)	Parameter Usage
int dlInit	(char *cfgFile,	DLI binary configuration file name
	char *pUsrCb,	Optional I/O complete control block
	int (*fUsrIOCH)(char *pUsrCb));	Optional IOCH and parameter
int dlOpen[a]	(char *cSessionName,	Session name in DLI config file
	int (*fUsrIOCH)	Optional I/O completion handler
	(char *pUsrCB, int iSessionID));	Parameters for IOCH
int dlPoll	(int iSessionID,	Session ID from dlOpen
	int iPollType,	Request type
	char **ppBuf,	Poll type dependent buffer
	int *piBufLen,	Size of I/O buffer (bytes)
	char *pStat,	Status or configuration buffer
	DLI_OPT_ARGS **ppOptArgs);	Optional arguments
int dlpErrString	(int dlErrNo);	DLI error number (global variable dlerrno)
char *dlBufAlloc	(int iBufLen);	Minimum buffer size
int dlRead	(int iSessionID,	Session ID from dlOpen
	char **ppBuf,	Buffer to receive data
	int iBufLen,	Maximum bytes to be returned
	DLI_OPT_ARGS *pOptArgs);	Optional arguments structure
int dlWrite	(int iSessionID,	Session ID from dlOpen
	char *pBuf,	Source buffer for write
	int iBufLen,	Number of bytes to write
	int iWritePriority,	Normal or expedite write
	DLI_OPT_ARGS *pOptArgs);	Optional arguments structure
int dlPost	(void);	
int dlSyncSelect	(int iNbrSessID,	Number of session IDs
	int sessIDArray[],	Packed array of session IDs
	int readStatArray[]);	Array containing read status for IDs
char *dlBufFree	(char *pBuf);	Buffer to return to pool
int dlClose	(int iSessionID,	Session ID from dlOpen
	int iCloseMode);	Mode (normal or force)
int dlTerm	(void);	
int dlControl	(char *cSessionName,	Session name in DLI config file
	int iCommand,	Command (*e.g.* reset/download)
	int (*fUsrIOCH)	Optional I/O completion handler
	(char *pUsrCB, int iSessionID));	Parameters for IOCH

[a] It is critical for the client application to receive the dlOpen completion status before making any other DLI requests; otherwise, subsequent requests will fail. After the dlOpen completion, however, you do not have to maintain a one-to-one correspondence between DLI requests and dlRead requests.

Chapter 9 Client Applications — Commands and Responses

This chapter presents the data structures required for the client application to exchange messages with the ICP, followed by the details of the individual commands and responses.

9.1 Client and ICP Interface Data Structures

The data link interface (DLI) provides a session-level interface between a client application and the sample protocol software resident on an ICP. Messages traveling from the client application go over the Ethernet to the Freeway server or ICP driver and end up at the ICP. From the client's perspective, these messages consist of data buffers supplemented with the DLI optional arguments data structure to provide the protocol-specific information required for *Raw* operation (refer back to Section 8.1.1.1 on page 143). Figure 9–1 shows the "C" definition of the DLI optional arguments structure.

From the ICP's perspective, these messages consist of the api_msg data structure shown in Figure 9–2. The icp_hdr structure is of type ICP_HDR and the prot_hdr structure is of type PROT_HDR, as shown in Figure 9–3.

Table 9–1 shows the equivalent fields between the DLI_OPT_ARGS structure and the ICP_HDR and PROT_HDR structures. The client API translates between the DLI_OPT_ARGS and the api_msg data structures. The usICPCommand field of the DLI_OPT_ARGS structure corresponds to the command field of the ICP_HDR structure. The usProtCommand field of the DLI_OPT_ARGS structure corresponds to the command field of the PROT_HDR structure.

```
typedef struct {
unsigned short   usFWPacketType;     /* Client’s packet type */
unsigned short   usFWCommand;        /* Client’s cmd sent or rcvd */
unsigned short   usFWStatus;         /* Client’s status of I/O ops */
unsigned short   usICPClientID;      /* old su_id */
unsigned short   usICPServerID;      /* old sp_id */
unsigned short   usICPCommand;       /* ICP’s command. */
short            iICPStatus;         /* ICP’s command status */
unsigned short   usICPParms[3];      /* ICP’s xtra parameters */
unsigned short   usProtCommand;      /* protocol cmd */
short            iProtModifier;      /* protocol cmd’s modifier */
unsigned short   usProtLinkID;       /* protocol link ID */
unsigned short   usProtCircuitID;    /* protocol circuit ID */
unsigned short   usProtSessionID;    /* protocol session ID */
unsigned short   usProtSequence;     /* protocol sequence */
unsigned short   usProtXParms[2];    /* protocol xtra parms */
} DLI_OPT_ARGS;
```

Figure 9–1: “C” Definition of DLI Optional Arguments Structure

```
struct api_msg {
            ICP_HDR  icp_hdr;
            PROT_HDR prot_hdr;
            bit8     *data;
};
```

Figure 9–2: “C” Definition of api_msg Data Structure

```
typedef struct {                    /* ICP message header                */
            bit16   su_id;          /* service user (client) ID          */
            bit16   sp_id;          /* service provider (server) ID      */
            bit16   count;          /* size of data following this header */
            bit16   command;        /* function code                     */
            bit16   status;         /* function status                   */
            bit16   params[3];      /* ICP-specific parameters           */
} ICP_HDR;

typedef struct {                    /* Protocol message header           */
            bit16   command;        /* function code                     */
            bit16   modifier;       /* function modifier                 */
            bit16   link;           /* physical port number              */
            bit16   circuit;        /* data link circuit identifier      */
            bit16   session;        /* session identifier                */
            bit16   sequence;       /* message sequence number           */
            bit16   reserved1;      /* reserved                          */
            bit16   reserved2;      /* reserved                          */
} PROT_HDR;
```

Figure 9–3: “C” Definition of icp_hdr and prot_hdr Data Structures

Table 9–1: Comparison of DLI_OPT_ARGS and ICP_HDR/PROT_HDR Fields

DLI_OPT_ARGS in DLI Client Program	ICP_HDR and PROT_HDR in ICP SPS Program	Field Description
DLI_OPT_ARGS.usFWPacketType	unused	client's packet type
DLI_OPT_ARGS.usFWCommand	unused	client's command sent or received
DLI_OPT_ARGS.usFWStatus	unused	client's status of I/O operations
DLI_OPT_ARGS.usICPClientID	icp.su_id	old su_id
DLI_OPT_ARGS.usICPServerID	icp.sp_id	old sp_id
count filled in by DLI	icp.count	data size
DLI_OPT_ARGS.usICPCommand	icp.command	ICP's command
DLI_OPT_ARGS.iICPStatus	icp.status	ICP's command status
DLI_OPT_ARGS.usICPParms[3]	icp.params[3]	ICP's extra parameters
DLI_OPT_ARGS.usProtCommand	prot.command	protocol command
DLI_OPT_ARGS.iProtModifier	prot.modifier	protocol command's modifier
DLI_OPT_ARGS.usProtLinkID	prot.link	protocol link ID
DLI_OPT_ARGS.usProtCircuitID	prot.circuit	protocol circuit ID
DLI_OPT_ARGS.usProtSessionID	prot.session	protocol session ID
DLI_OPT_ARGS.usProtSequence	prot.sequence	protocol sequence
DLI_OPT_ARGS.usProtXParms[2]	prot.reserved1	protocol extra parameters
	prot.reserved2	second XParms field

9.2 Client and ICP Communication

The following sections discuss the DLI functions and DLI_OPT_ARGS data structure as used by client applications in communicating with ICP software. In addition, this communication is discussed from the ICP perspective with details regarding the content of the ICP_HDR and PROT_HDR data structures.

The ICP supports the command/response codes shown in Table 9–2, which are encoded into the DLI_OPT_ARGS structure (shown previously in Figure 9–1 on page 158). The remainder of this chapter describes how these commands are used to access and provide data to a wide area network.

Table 9–2: Command/Response Code Summary

Function	usICPCommand Field Code	usProtCommand Field Code	Reference Section
Attach	DLI_ICP_CMD_ATTACH	DLI_ICP_CMD_ATTACH	Section 9.2.3 on page 164
Bind	DLI_ICP_CMD_BIND	DLI_ICP_CMD_BIND	Section 9.2.5 on page 169
Configure link	DLI_ICP_CMD_WRITE DLI_ICP_CMD_READ	DLI_PROT_CFG_LINK	Section 9.2.7.1 on page 175
Request statistics	DLI_ICP_CMD_WRITE DLI_ICP_CMD_READ	DLI_PROT_GET_STATISTICS_REPORT	Section 9.2.7.2 on page 179
Send data	DLI_ICP_CMD_WRITE	DLI_PROT_SEND_NORM_DATA	Section 9.2.7.3 on page 182
Receive acknowledge	DLI_ICP_CMD_READ	DLI_PROT_RESP_LOCAL_ACK	Section 9.2.7.3 on page 182
Receive data	DLI_ICP_CMD_READ	DLI_PROT_SEND_NORM_DATA	Section 9.2.8.1 on page 185
Unbind	DLI_ICP_CMD_UNBIND	DLI_ICP_CMD_UNBIND	Section 9.2.6 on page 172
Detach	DLI_ICP_CMD_DETACH	DLI_ICP_CMD_DETACH	Section 9.2.4 on page 167

9.2.1 Sequence of Client Events to Communicate to the ICP

To exchange data with a wide-area network, a client must follow these steps:

1. Initiate a session with the Freeway server or the embedded product's driver (dlOpen, Section 9.2.2 on page 163)
2. Initiate a session with the ICP link (Attach command, Section 9.2.3 on page 164)
3. Configure the link (Section 9.2.7.1 on page 175)
4. Activate the link (Bind command, Section 9.2.5 on page 169)
5. Send data to and receive data from the link (Section 9.2.7 on page 174 and Section 9.2.8 on page 185)
6. Deactivate the link (Unbind command, Section 9.2.6 on page 172)
7. End the session with the ICP link (Detach command, Section 9.2.4 on page 167)
8. End the session with the Freeway server or the embedded product's driver (dlClose, Section 9.2.4 on page 167)

The following sections describe how to use the DLI subroutine library to perform these steps. Prior to these steps, however, the DLI must be initialized. This is accomplished when the application calls the dlInit function, which is declared as follows:

```
int dlInit (char *pCfgFile,
            char *pUsrCB,
            int  (*pUsrIOCH) (char *pUsrCB));
```

The following is an example of a call to dlInit:

```
status = dlInit (“spsaldcfg.bin”, NULL, NULL);
```

This example indicates to DLI that the file spsaldcfg.bin is available to be read to configure the process, and that if an I/O completion function is to be called, it is specified as individual sessions are opened in calls to dlOpen. For more information, consult the *Freeway Data Link Interface Reference Guide*.

9.2.2 Initiating a Session with the ICP (dlOpen)

A session identifier is used by DLI to manage information exchanged between the client application and the ICP. The session identifier is requested by the client, then defined and returned by the DLI. This is accomplished when the application calls dlOpen. The ICP software is not involved in these two steps. The dlOpen function is declared as follows:

```
int dlOpen (char   *cSessionName,
            short  (*fUsrIOCH) (char *pUseCB,
            int  iSessionID));
```

The first argument is the name of a section in the application's DLI configuration file. The second argument is the name of a function, supplied by the application writer, that DLI calls when it services an I/O condition for the session identifier returned by the dlOpen call.

The following is an example of a call to dlOpen.

```
servSessID = dlOpen (“server0icp0port0”, ioComplete);
```

The string server0icp0port0 is the name of a section in a DLI configuration file, and ioComplete is the name of a function the application writer provides. The value of servSessID is used in further calls to DLI functions.

9.2.3 Initiating a Session with an ICP Link (Attach)

When the DLI configuration file parameter protocol is set to raw (protocol="raw"), a call to the dlOpen function establishes a data path to the ICP for a given link. This path is referenced by the return value of dlOpen and is called the session identifier. A call to dlPoll can be used to verify the success of the dlOpen function. If the status of the new session is DLI_STATUS_READY, the open was successful. Next, the data path must be extended to the ICP with an attach. This is accomplished by issuing a call to dlWrite with the optional argument structure set as shown in Figure 9–4.

Note

The ICP returns a protocol session identifier in the usProtSessionID field. This value must be used in the usProtSessionID field of the optional arguments structure in all future calls to dlWrite for this link.

DLI_OPT_ARGS.usFWPacketType	FW_DATA
DLI_OPT_ARGS.usFWCommand	FW_ICP_WRITE
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_ATTACH
DLI_OPT_ARGS.iICPStatus	*n/a*
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_ICP_CMD_ATTACH
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*Link the session relates to*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*n/a*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–4: Attach Command Format

From the ICP's perspective, the attach command establishes a session between the client application and one of the ICP links. A successful attach command gives the ICP and the client application IDs that are unique to the current session with which they can relay information.

The protocol session identifier is used by the ICP to manage information exchanged between the client application and a specific link. The protocol session identifier is requested by the client, then defined and returned by the ICP.

For the attach command, the fields of the ICP and protocol headers that the ICP receives contain the following values:

ICP_HDR

count	= size of protocol header (16 bytes)
command	= DLI_ICP_CMD_ATTACH
status	= high bits indicate byte ordering
params[0]	= return node number

PROT_HDR

link	= link number

After the ICP processes the attach command, it returns these headers with the following field modifications:

ICP_HDR

status	= error code or zero if successful

PROT_HDR

modifier	= error code or zero if successful
session	= session ID assigned by the ICP

The ICP receives an ICP header containing DLI_ICP_CMD_ATTACH in the command field and a return node number (assigned by msgmux for the Freeway server or the ICP driver for the embedded ICP product) in the params[0] field. It also receives a link number in the link field of the protocol header. If the ICP can successfully complete the attach, it returns a session number in the session field of the protocol header and a zero (indicating success) in both the status field of the ICP header and the modifier field of the protocol header. Any subsequent transactions involving this session number will be transmitted from the ICP via the corresponding node number.

There is a correspondence between node numbers and session numbers. (Chapter 7 provides more information on node numbers and the host/ICP interface). All the commands in Section 9.2.1 on page 162, from the attach command on, must have this session number in the session field of the protocol header. (The msgmux or ICP driver copies the protocol session ID from the usProtSessionID field in the client's DLI_OPT_ARGS to the session field in the protocol header.) If the attach is unsuccessful (for example, the link has already been attached or the link or node number is invalid), the ICP returns an appropriate error code in the status field of the ICP header and the modifier field of the protocol header. The *Freeway Data Link Interface Reference Guide* lists possible error codes.

The response to the attach is read with a call to dlRead. If the attach was successful, the optional argument structure in the response is as shown in Figure 9–5.

DLI_OPT_ARGS.usFWPacketType	*n/a*
DLI_OPT_ARGS.usFWCommand	*n/a*
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_ATTACH
DLI_OPT_ARGS.iICPStatus	DLI_ICP_ERR_NO_ERR
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_ICP_CMD_ATTACH
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*link the session relates to*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Protocol Session ID*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–5: Attach Response Format

9.2.4 Terminating a Session with an ICP Link (Detach)

When the DLI configuration file parameter protocol is set to raw (protocol="raw"), a call to the dlClose function terminates a data path to the ICP for a given link. However, before the session is terminated, it is important to allow the ICP to release the space allocated by it for session management. This is accomplished by issuing a call to dlWrite with the optional argument structure as shown in Figure 9–6. After the ICP releases the session, the application can call dlClose to terminate the session with the ICP

DLI_OPT_ARGS.usFWPacketType	FW_DATA
DLI_OPT_ARGS.usFWCommand	FW_ICP_WRITE
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_DETACH
DLI_OPT_ARGS.iICPStatus	*n/a*
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_ICP_CMD_DETACH
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*link the session relates to*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Session to end*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–6: Detach Command Format

From the ICP's perspective, the detach command terminates an active session between the client and the ICP. When the application is finished with the ICP session, it writes a detach command to the ICP. The application establishes a DLI_OPT_ARGS structure requesting the detach, then sends the structure to the ICP with a call to the DLI dlWrite function.

For the detach command, the fields of the ICP and protocol headers that the ICP receives contain the following values:

```
ICP_HDR
count          = size of protocol header (16 bytes)
command        = DLI_ICP_CMD_DETACH
status         = high bits indicate byte ordering

PROT_HDR
session        = session ID
```

The ICP receives a message consisting of an ICP header with DLI_ICP_CMD_DETACH in the command field and a protocol header with the session number in the session field. The ICP responds to this command by making that session's ID available for future sessions. The ICP also turns off devices and clears the link control table's link active flag for that session's link if this was not already done as a result of a prior unbind command. The ICP always puts a zero, indicating success, in the status field of the ICP header and the modifier field of the protocol header and sends the two headers back to the client as an acknowledgment.

The response to the detach is read with a call to dlRead. If the detach was successful, the optional argument structure in the response is as shown in

DLI_OPT_ARGS.usFWPacketType	*n/a*
DLI_OPT_ARGS.usFWCommand	*n/a*
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_DETACH
DLI_OPT_ARGS.iICPStatus	DLI_ICP_ERR_NO_ERR
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_ICP_CMD_DETACH
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*link the session relates to*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Protocol Session ID*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–7: Detach Response Format

9.2.5 Activating an ICP Link (Bind)

After dlOpen has been called and an attach message written to the ICP, the link can be configured (Section 9.2.7.1 on page 175). After the link is configured, it is necessary to request the ICP to start the link's receiver and transmitter. Starting (enabling) the link is accomplished by sending a bind message to the ICP. The bind command activates one of the ICP's links by initializing flags and turning on that link's receiver. This is accomplished by issuing a call to dlWrite with the optional argument structure set as shown in Figure 9–8.

DLI_OPT_ARGS.usFWPacketType	FW_DATA
DLI_OPT_ARGS.usFWCommand	FW_ICP_WRITE
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_BIND
DLI_OPT_ARGS.iICPStatus	*n/a*
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_ICP_CMD_BIND
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*Link to start*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Protocol Session ID*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	0 or DLI_PROT_SEND_BIND (See Section 9.2.5.1)
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–8: Bind Command Format

From the ICP's perspective, when the application sends a bind command to the ICP, the ICP completes all preparations to receive and transmit on the specified link. For the bind command, the fields of the ICP and protocol headers that the ICP receives contain the following values:

ICP_HDR	
count	= size of protocol header (16 bytes)
command	= DLI_ICP_CMD_BIND
status	= high bits indicate byte ordering
PROT_HDR	
session	= session ID

The constant value DLI_ICP_CMD_BIND is in the command field of the ICP header and a session number is in the session field of the protocol header. The ICP starts that link's receiver, sets the link control table link active flag, and returns an acknowledgment to the client. If the link was already active, the acknowledgment contains an error code in the ICP header's status field and the protocol header's modifier field. Otherwise they contain zero, indicating success.

The response to the bind is a read with a call to dlRead. If the bind was successful, the optional argument structure in the response is as shown in Figure 9–9

DLI_OPT_ARGS.usFWPacketType	*n/a*
DLI_OPT_ARGS.usFWCommand	*n/a*
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_BIND
DLI_OPT_ARGS.iICPStatus	DLI_ICP_ERR_NO_ERR
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_ICP_CMD_BIND
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*Link started*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Protocol Session ID*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	0 or DLI_PROT_SEND_BIND (See Section 9.2.5.1)
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–9: Bind Response Format

9.2.5.1 X21bis Line Status Reports (Optional)

X21bis line status reports are an optional ICP notification of changes in the connection status of the physical circuits on the link. To enable X21bis line status reports, use the DLI_ICP_CMD_BIND command message specifying DLI_PROT_SEND_BIND (instead of 0) in the usProtXparms[0] field of the DLI_OPT_ARGS. The ICP returns the standard DLI_ICP_CMD_BIND response message (see Figure 9–9 on page 170), then begins monitoring the modem signals on the link to determine the connection status of the physical circuits on the link.

After the ICP detects that the physical link connection can support data transfer, it reports a DLI_PROT_RESP_BIND status for the link. If the ICP subsequently detects loss of the physical link connection, it reports a DLI_PROT_RESP_UNBIND status for the link. The ICP reports each such physical line status change by means of a DLI_ICP_CMD_BIND response message in which the usProtXparms fields of the DLI_OPT_ARGS contain information. The usProtXparms[0] field contains DLI_PROT_SEND_BIND to identify the message as an unsolicited X21bis line status report. The usProtXparms[1] field reports the new line status as DLI_PROT_RESP_BIND (online) or DLI_PROT_RESP_UNBIND (offline).

9.2.6 Deactivating an ICP Link (Unbind)

Stopping (disabling) the link is accomplished by sending an unbind message to the ICP. This is accomplished by issuing a call to dlWrite with the optional argument structure set as shown in Figure 9–10.

DLI_OPT_ARGS.usFWPacketType	FW_DATA
DLI_OPT_ARGS.usFWCommand	FW_ICP_WRITE
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_UNBIND
DLI_OPT_ARGS.iICPStatus	*n/a*
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_ICP_CMD_UNBIND
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*Link to stop*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Protocol Session ID*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–10: Unbind Command Format

From the ICP's perspective, when the application sends an unbind command, the ICP immediately terminates all receiving and transmitting on the link. Deactivation means that data structures are initialized and the link's serial transmitter and receiver are disabled.

For the unbind command, the fields of the ICP and protocol headers that the ICP receives contain the following values:

ICP_HDR	
count	= size of protocol header (16 bytes)
command	= DLI_ICP_CMD_UNBIND
status	= high bits indicate byte ordering

PROT_HDR	
session	= session ID

The constant DLI_ICP_CMD_UNBIND is in the command field of the ICP header and a session number is in the session field of the protocol header. The ICP stops devices for that link, clears the link control table link active flag, and returns an acknowledgment to the client. If the link was inactive, the acknowledgment contains an error code in the ICP header's status field and the protocol header's modifier field. Otherwise they contain zero, indicating success.

The response to the unbind is a read with a call to dlRead. If the unbind was successful, the optional argument structure in the response is shown in Figure 9–11.

DLI_OPT_ARGS.usFWPacketType	*n/a*
DLI_OPT_ARGS.usFWCommand	*n/a*
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_UNBIND
DLI_OPT_ARGS.iICPStatus	DLI_ICP_ERR_NO_ERR
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_ICP_CMD_UNBIND
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*Link stopped*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Protocol Session ID*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–11: Unbind Response Format

9.2.7 Writing to an ICP Link

After the application has issued a bind command to the ICP, it can send messages to the ICP for transmission to the wide-area network. When the ICP receives a message from the client for transmission, it prepares it as required and sends it on the specified link. When the last character is transmitted, the ICP sends a message to the application. The message written by the ICP to the client is called an acknowledgment, however, in this case “acknowledgment” means that the client’s message has been transmitted and the memory buffer containing the message has been freed for reuse. It does not mean that the opposite end of the network has acknowledged that it correctly received the message. This is an important area of wide-area communications. It is vital to determine which system is responsible for maintaining a message in case the ultimate end reader does not receive it and the message must be retransmitted. The ICP does not have a disk, and may not be the best platform for maintaining an extensive queue of messages.

9.2.7.1 Configuring the ICP Link

After the client has issued an attach command to the ICP, but before it issues a bind command, it can send ICP link configuration values to the ICP. If no configuration message is received by the ICP, the default link configuration is used. When the ICP receives a configuration message, it validates it and updates the current link configuration. First the client allocates a buffer for the CONF_TYPE structure and fills in the structure. Next the client establishes a DLI_OPT_ARGS structure requesting the write, then sends the structure along with a buffer containing the configuration to the ICP.

To set the link configuration options, a buffer containing the structure shown in Figure 9–12 is sent to the ICP. The fields of the data structure are set to appropriate values by the client application.

```
/* Structure of configuration request message */

struct conf_type
{
   bit8   protocol[1];   /* With Ack: 0x00=BSC, 0x01=Async, 0x02=SDLC   */
                              /* W/out Ack: 0x80=BSC, 0x81=Async, 0x82=SDLC */
   bit8   clock;      /* 0 = external, 1 = internal clock                */
   bit8   baud_rate;  /* index into baudsc or baudas                     */
   bit8   encoding;   /* 0 = NRZ, 1 = NRZI (SDLC only)                   */
   bit8   electrical; /* electrical interface icp24xx                    */
   bit8   parity;     /* 0 = none, 1 = odd, 2 = even                     */
   bit8   char_len;   /* 7 = 7 bits, 8 = 8 bits                          */
                      /*      (asynch only)                              */
   bit8   stop_bits;  /* 1 = 1 stop bit, 2 = 2 stop bits                 */
                      /*      (asynch only)                              */
   bit8   crc;        /* 0 = no CRC, 1 = CRC                             */
                      /*      (SDLC always uses CRC)                     */
   bit8   syncs;      /* # of leading sync chars (1-8)                   */
                      /*      (BSC only)                                 */
   bit8   start_char; /* block start character                           */
                      /*      (not used for SDLC)                        */
   bit8   stop_char;  /* block end char (asynch only)                    */
};
typedef struct conf_type CONF_TYPE;
```

Figure 9–12: Link Configuration “C” Structure

[1] Specifying a protocol with Ack enables DLI_PROT_RESP_LOCAL_ACK transmission acknowledgment messages for the link. Specifying a protocol without Ack disables DLI_PROT_RESP_LOCAL_ACK messages for the link

The data area in the write is an instance of the CONF_TYPE structure. This structure is defined as follows:

```
typedef struct {
unsigned char protocol;     /* With Ack: 0x00=BSC, 0x01=Async, 0x02=SDLC   */
                            /* W/out Ack: 0x80=BSC, 0x81=Async, 0x82=SDLC */
unsigned char clock;          /* (bsc and sdlc only)
                      0 = external, 1 = internal                     */
unsigned char baud_rate;   /* For protocol = async,
                                              the following values apply:
                        0 =    300
                        1 =    600
                        2 =   1200
                        3 =   1800
                        4 =   2400
                        5 =   3600
                        6 =   4800
                        7 =   7200
                        8 =   9600
                        9 =  19200
                       10 =  38400
                       11 =  57600
                       12 = 115000
                       13 = 230400
                                         For bsc and sdlc,
                                             the following values apply:
                        0 =     300
                        1 =     600
                        2 =    1200
                        3 =    2400
                        4 =    4800
                        5 =    9600
                        6 =   19200
                        7 =   38400
                        8 =   57600
                        9 =   64000
                       10 =  307000
                       11 =  460800
                       12 =  614400
                       13 =  737300
                       14 =  921600
                       15 = 1228800
                       16 = 1843200
                                         */

unsigned char encoding;     /* (sdlc only) 0 = NRZ, 1 = NRZI   */
unsigned char electrical;     /* Valid values: 0x02 = EIA 232
                                                  0x0c = EIA 449
                                                  0x0d = EIA 530
                                                  0x0e = V.35             */
unsigned char parity;       /* (async only) 0 = none, 1 = odd,
                               2 = even                      */
unsigned char char_len;     /* (async only) 7 = 7 bits,
                               8 = 8 bits                    */
unsigned char stop_bits;    /* (async only) 1 = 1 stop bit,
                               2 = 2 stop bits               */
unsigned char crc;          /* (async and bsc only)
                               0 = no CRC, 1 = CRC           */
unsigned char syncs;        /* (bsc only) number of leading
                               sync characters 1 to 8        */
unsigned char start_char;   /* (async and bsc only) block
                               start character               */
unsigned char stop_char;    /* (async only) block end
                               character                     */
};
```

To configure an ICP link, the client sends a message with the optional arguments structure shown in Figure 9–13.

DLI_OPT_ARGS.usFWPacketType	FW_DATA
DLI_OPT_ARGS.usFWCommand	FW_ICP_WRITE
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_WRITE
DLI_OPT_ARGS.iICPStatus	*n/a*
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_PROT_CFG_LINK
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*Link ICP is to configure*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Session ID (See attach, Section 9.2.3 on page 164)*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–13: Configure Link Command Format

At the ICP, the fields of the ICP and protocol headers that the ICP receives contain the following values:

ICP_HDR	
count	= size of protocol header (16 bytes) plus data area
command	= DLI_ICP_CMD_WRITE
status	= high bits indicate byte ordering
PROT_HDR	
command	= DLI_PROT_CFG_LINK
session	= session ID
DATA AREA	= configuration data structure

The ICP returns these headers to the client as an acknowledgment that the link configuration was completed. The values in the headers of this acknowledgment are the same as those that were received at the ICP, except that the ICP header's status field and the protocol header's modifier field are filled in with codes reflecting the success of the transaction. The client application receives this acknowledgment by issuing a read command as described in Section 9.2.8 on page 185.

The client's expected response is a DLI_PROT_CFG_LINK message with the iICPStatus field set to DLI_ICP_ERR_NO_ERR, as shown in Figure 9–14. The data area is not applicable. If the ICP discovers an error in the message, it returns the configuration message with the iICPStatus field set to DLI_ICP_ERR_BAD_PARMS.

DLI_OPT_ARGS.usFWPacketType	*n/a*
DLI_OPT_ARGS.usFWCommand	*n/a*
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	*n/a*
DLI_OPT_ARGS.iICPStatus	DLI_ICP_ERR_NO_ERR
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_PROT_CFG_LINK
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*Link ICP configured*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Session ID (See attach, Section 9.2.3 on page 164)*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–14: Configure Link Response Format

9.2.7.2 Requesting Link Statistics From the ICP

The get statistics command requests a configuration report for a particular link. The ICP maintains a set of statistics for each link that keeps track of events occurring on each ICP physical port.

To request the statistics on an ICP link, the client sends a message with the optional arguments structure shown in Figure 9–15. There is no data area for a link statistics request.

DLI_OPT_ARGS.usFWPacketType	FW_DATA
DLI_OPT_ARGS.usFWCommand	FW_ICP_WRITE
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_WRITE
DLI_OPT_ARGS.iICPStatus	*n/a*
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_PROT_GET_STATISTICS_REPORT
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*Link ICP is to report on.*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Session ID (See attach, Section 9.2.3 on page 164)*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–15: Request Link Statistics Command Format

At the ICP, the fields of the ICP and protocol headers that the ICP receives contain the following values:

ICP_HDR

count	= size of protocol header (16 bytes)
command	= DLI_ICP_CMD_WRITE
status	= high bits indicate byte ordering

```
PROT_HDR
command      = DLI_PROT_GET_STATISTICS_REPORT
session      = session ID
```

At the ICP, the fields of the ICP and protocol headers that the ICP sends to the client application contain the following values:

```
ICP_HDR
count        = size of protocol header (16 bytes) plus size of data
command      = DLI_ICP_CMD_READ
status       = 0 (success) or an error code

PROT_HDR
command      = DLI_PROT_GET_STATISTICS_REPORT
modifier     = 0 (success) or an error code
session      = session ID
DATA AREA    = statistics report
```

The ICP copies the link control table's statistics data structure to the data area that follows the protocol header and writes error codes to the status and modifier fields (or zero to indicate success). The ICP always returns a report, even if that link has not yet been enabled. The client receives the statistics report by issuing a read command. (Note that this statistics report serves as an acknowledgment to the write command.)

The client's expected response is a DLI_PROT_GET_STATISTICS_REPORT message with the iICPStatus field set to DLI_ICP_ERR_NO_ERR, as shown in Figure 9–16. If the ICP discovers an error in the message, it returns the statistics request message with the iICPStatus field set to an error code.

The data area for the link statistics report contains the structure SPS_STATS_REPORT as shown in Figure 9–17.

DLI_OPT_ARGS.usFWPacketType	*n/a*
DLI_OPT_ARGS.usFWCommand	*n/a*
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_READ
DLI_OPT_ARGS.iICPStatus	DLI_ICP_ERR_NO_ERR
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_PROT_GET_STATISTICS_REPORT
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*Link ICP is reporting on.*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Session ID (See attach, Section 9.2.3 on page 164)*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–16: Statistics Report Response Format

```
typedef struct {
    bit16   msg_too_long; Number of messages read from WAN
                                    and thrown away
    bit16   dcd_lost;     Number of times receiver restarted
                    because carrier was lost
    bit16   abort_rcvd;   Number of times receiver restarted
                    because abort was received
    bit16   rcv_ovrrun;   Number of messages received with receiver overruns
    bit16   rcv_crcerr;   Number of messages received with bad CRCs
    bit16   rcv_parerr;   Async only. Parity errors
    bit16   rcv_frmerr;   Async only. Number of framing errors
    bit16   xmt_undrun;   Number of transmit underruns
    bit16   frame_sent;   Number of message buffers sent
    bit16   frame_rcvd;   Number of message buffers received
} SPS_STATS_REPORT;
```

Figure 9–17: Statistics Report “C” Structure

9.2.7.3 Writing Data to an ICP Link

The write command provides data to the ICP for transmission on the specified link. The client establishes a DLI_OPT_ARGS structure requesting the write, then sends the structure along with a buffer containing the data to the ICP by calling the DLI dlWrite function.

To transmit data on an ICP link, the client sends a message with the optional arguments structure shown in Figure 9–18. The data area in the write is the data to be transmitted.

DLI_OPT_ARGS.usFWPacketType	FW_DATA
DLI_OPT_ARGS.usFWCommand	FW_ICP_WRITE
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_WRITE
DLI_OPT_ARGS.iICPStatus	*n/a*
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_PROT_SEND_NORM_DATA
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*Link ICP is to transmit on*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Session ID (See attach, Section 9.2.3 on page 164)*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–18: Send Data Command Format

At the ICP, the fields of the ICP and protocol headers that the ICP receives contain the following values:

```
ICP_HDR
count           = size of protocol header (16 bytes) plus size of data
command         = DLI_ICP_CMD_WRITE
status          = high bits indicate byte ordering

PROT_HDR
command         = DLI_PROT_SEND_NORM_DATA
session         = session ID
DATA AREA       = data to be transmitted
```

The ICP protocol task prepares the data for transmission. If the protocol is bsc, the configured number of sync characters are placed at the beginning of the message. If the protocol is async or bsc, the configured start character is placed immediately before the client's data. If the protocol is async, the configured stop character is appended. If a CRC is configured, a CRC is calculated and appended. The ICP then activates the transmit device for the protocol being used by that link.

When the message has been transmitted by the ICP, the client's expected response is a DLI_PROT_RESP_LOCAL_ACK message, as shown in Figure 9–19. The iICPStatus and iProtModifier fields are zero, and there is no data area.

If the ICP cannot transmit the data, the client's expected response is a DLI_PROT_RESP_LOCAL_ACK message with iICPStatus and iProtModifier fields that contain an error code. In this case, the data area contains the original data not sent.

Note

However, if the link was configured for a protocol without Ack (see Figure 9–12 on page 175), then there is no DLI_PROT_RESP_LOCAL_ACK.

DLI_OPT_ARGS.usFWPacketType	*n/a*
DLI_OPT_ARGS.usFWCommand	*n/a*
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_READ
DLI_OPT_ARGS.iICPStatus	0 if successful, else an error code
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_PROT_RESP_LOCAL_ACK
DLI_OPT_ARGS.iProtModifier	0 if successful, else an error code
DLI_OPT_ARGS.usProtLinkID	*Link ICP transmitted data on.*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Session ID (See attach, Section 9.2.3 on page 164)*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–19: Data Acknowledgment Response

9.2.8 Reading from the ICP Link

The ICP sends the following types of messages to the client:

- Command acknowledgments (discussed in earlier sections)
- Responses to information requests (such as link statistics, Section 9.2.7.2 on page 179)
- Data read from the wide area network (discussed below)

The client calls the DLI dlRead function to access these messages. The application determines the content of the read buffer by examining the usProtCommand field of the DLI_OPT_ARGS data structure (refer back to Table 9–2 on page 161).

The application allocates a DLI_OPT_ARGS structure (Figure 9–1 on page 158), then provides the address of the structure along with the address of a pointer to a buffer to the DLI dlRead function.

9.2.8.1 Reading Normal Data

The read command receives normal data that has arrived on one of the ICP ports. The fields of the ICP and protocol headers that the ICP sends to the client application contain the following values:

```
ICP_HDR
count          = size of protocol header (16 bytes) plus size of data
command        = DLI_ICP_CMD_READ
status         = 0 (success) or an error code

PROT_HDR
command        = DLI_PROT_SEND_NORM_DATA
modifier       = 0 (success) or an error code
session        = session ID
DATA AREA      = incoming data
```

To provide the client with messages read from the link, the ICP sends a message with the optional arguments structure shown in Figure 9–20. The ICP places the data read from the link in the area that follows the protocol header. The data area contains the data read. The stop character and CRC characters are not provided.

DLI_OPT_ARGS.usFWPacketType	*n/a*
DLI_OPT_ARGS.usFWCommand	*n/a*
DLI_OPT_ARGS.usFWStatus	*n/a*
DLI_OPT_ARGS.usICPClientID	*n/a*
DLI_OPT_ARGS.usICPServerID	*n/a*
DLI_OPT_ARGS.usICPCommand	DLI_ICP_CMD_READ
DLI_OPT_ARGS.iICPStatus	*n/a*
DLI_OPT_ARGS.usICPParms [0]	*n/a*
DLI_OPT_ARGS.usICPParms [1]	*n/a*
DLI_OPT_ARGS.usICPParms [2]	*n/a*
DLI_OPT_ARGS.usProtCommand	DLI_PROT_SEND_NORM_DATA
DLI_OPT_ARGS.iProtModifier	*n/a*
DLI_OPT_ARGS.usProtLinkID	*Link ICP read data from.*
DLI_OPT_ARGS.usProtCircuitID	*n/a*
DLI_OPT_ARGS.usProtSessionID	*Session ID (See attach, Section 9.2.3 on page 164)*
DLI_OPT_ARGS.usProtSequence	*n/a*
DLI_OPT_ARGS.usProtXParms [0]	*n/a*
DLI_OPT_ARGS.usProtXParms [1]	*n/a*

Figure 9–20: Receive Data from ICP Response

9.3 Additional Command Types Supported by the SPS

In addition to the API function calls described in the preceding sections, the SPS supports a few commands that are used by layers that lie between the SPS and API layers. These commands are described in the following sections.

9.3.1 Internal Termination Message

The dlTerm function call is used by a client application when it loses its connection to an ICP. The API issues the dlTerm function call and provides the return node number to be terminated. The SPS responds by clearing link active flags, turning off devices, and freeing session numbers for all links that had been communicating with the client application using that particular return node number.

The following is an example of the format of the ICP and protocol headers received by the SPS:

```
ICP_HDR
count          = size of protocol header (16 bytes)
command        = DLI_ICP_CMD_TERM
params[0]      = node number to be terminated (ACK returns on this
                   node as well)

PROT_HDR
command        = DLI_ICP_CMD_TERM
```

After performing the dlTerm call, the SPS returns an acknowledgment on the node that was just terminated. This tells msgmux or the ICP driver that the dlTerm call completed successfully and the node number can be reused.

9.3.2 Internal Test Message

The test command is a diagnostic tool used by the client application. Data is written to the SPS in the data area following a protocol header. The utility task immediately returns this data to the client application.

The following is an example of the format of the ICP and protocol headers received by the SPS:

```
ICP_HDR
count        = size of protocol header (16 bytes) plus size of data
command      = DLI_ICP_CMD_WRITE_EXP
params[0]    = return node number assigned by msgmux or the ICP driver

PROT_HDR
command      = DLI_ICP_CMD_TEST
DATA AREA    = sample data
```

9.3.3 Internal Ping

The ping command provides a way for the client application to verify that the SPS is up and running. This message is passed from the utility task to the protocol task before being returned to the client application as an acknowledgment.

The following is an example of the format of the ICP and protocol headers received by the SPS:

```
ICP_HDR
count        = size of protocol header (16 bytes)
command      = DLI_ICP_CMD_PING
params[0]    = return node number assigned by msgmux or the ICP driver

PROT_HDR
command      = DLI_ICP_CMD_PING
```

Appendix A

Application Notes

This appendix clarifies some points made in the technical manuals and describes some peculiarities of the devices and the ICP6000 hardware.

- When the Force Hardware Reset command (bits 6 and 7 of SCC write register 9) is issued to either channel of the SCC, both channels are reset.

- When programming in a high-level language, be sure that your compiler's optimizer handles the special requirements of device-level programming correctly. For example, if you program two writes to a hardware register in sequence, the optimizer could inappropriately remove the first write instruction as superfluous.

- A write to mailbox 15 (ICP6000) generates a level 3 interrupt and normally enters the PTBUG debugging tool. However, if the ICP software is "hung" with the interrupt mask level set to three or higher, the PTBUG interrupt cannot be serviced and the ICP must be reset. It is not possible to disable transmit interrupts on the DMA controller. Receive interrupts can be disabled through a bit in Control Register 0, but only as a group (all channels enabled or all disabled).

- During processing of an SCC interrupt, the pending interrupt must be cleared in both the MFP, with a write to register ISRA or ISRB, and the SCC, with a write to register WR0. In addition, to avoid losing other interrupts pending on the same SCC, you must continue processing SCC interrupts (without returning from the interrupt service routine, S_IRET) until the MFP register GPIP or SCC read requesting 3 A (RR3A) port shows no pending interrupts for the SCC in question.

The code required to correctly process SCC interrupts can be found in the sample protocol software file spsasm.asm.

Appendix B Data Rate Time Constants for SCC/IUSC Programming

This appendix provides some commonly used baud rate time constants for SCC/IUSC programming on the ICP.

Table B–1 shows SCC time constants for 1X mode for the ICP6000, normally used for all synchronous communication modes. To select 1X mode, set bits 7 and 6 in SCC write register 4 to 00 (binary).

Table B–2 shows SCC time constants for 16X mode for the ICP6000, normally used for asynchronous mode. To select 16X mode, set bits 7 and 6 in SCC write register 4 to 01 (binary).

The SCC time constant is a 16-bit value. The most significant byte (MSB) is stored in SCC write register 13, and the least significant byte (LSB) is stored in SCC write register 12.

Table B–3 shows IUSC time constants for 1X mode for the ICP2424 and ICP2432, normally used for all synchronous communication modes. Table B–4 shows IUSC time constants for 16X mode for the ICP2424 and ICP2432, normally used for asynchronous mode. Set the required clock mode in the Channel Mode register of the IUSC.

The IUSC time constant is a 16-bit value stored in Time Constant register 0 or 1.

Table B–1: SCC Time Constants for 1X Clock Rate for ICP6000

Baud Rate (kbits/sec)	Time Constant (hexadecimal) MSB	LSB
0.3	2F	FE
0.6	17	FE
1.2	0B	FE
2.4	05	FE
4.8	02	FE
9.6	01	7E
19.2	00	BE
38.4	00	5E
57.6	00	3E

Table B–2: SCC Time Constants for 16X Clock Rate for ICP6000

Baud Rate (kbits/sec)	Time Constant (hexadecimal) MSB	LSB
0.3	02	FE
0.6	01	7E
1.2	00	BE
2.4	00	5E
4.8	00	2E
9.6	00	16
19.2	00	0A
38.4	00	04
57.6	00	02

Table B–3: IUSC Time Constants for 1X Clock Rate for ICP2424 and ICP2432

Baud Rate (kbits/sec)	Time Constant (hexadecimal)
0.3	2FFF
0.6	17FF
1.2	0BFF
2.4	05FF
4.8	02FF
9.6	017F
19.2	00BF
38.4	005F
57.6	003F

Table B–4: IUSC Time Constants for 16X Clock Rate for ICP2424 and ICP2432

Baud Rate (kbits/sec)	Time Constant (hexadecimal)
0.3	02FF
0.6	017F
1.2	00BF
2.4	005F
4.8	002F
9.6	0017
19.2	000B
38.4	0005
57.6	0003

Appendix C Error Codes

There are several methods used by the DLI and ICP software to report errors, as described in the following sections:

C.1 DLI Error Codes

The error code can be returned directly by the DLI function call in the global variable dlerrno. Typical errors are those described in the *Freeway Data Link Interface Reference Guide*.

C.2 ICP Global Error Codes

Table C–1 lists the ICP-related errors that can be returned in the global variable iICPStatus. The DLI constants are defined in the dlicperr.h file.

C.3 ICP Error Status Codes

The ICP-related errors listed in Table C–1 can also be returned in the dlRead optArgs.iICPStatus field of the response, which is a duplicate of the iIPCStatus global variable. The DLI sets the dlRead optArgs.usProtCommand field to the same value as the dlWrite request that caused the error.

Table C–1: ICP Error Status Codes used by the ICP

Code	Mnemonic	Meaning
0	DLI_ICP_ERR_NO_ERR	A data block has been successfully transmitted or received on the line or a command has been successfully executed.
–101	DLI_ICP_ERR_BAD_NODE	An invalid node number was passed to the ICP from the DLI.
–102	DLI_ICP_ERR_BAD_LINK	The link number from the client program is not a legal value.
–103	DLI_ICP_ERR_NO_CLIENT	A DLI_ICP_CMD_ATTACH status indicating that the maximum number of clients are registered for the link.
–103	DLI_ICP_ERR_DEVICE_UNAVAIL	A DLI_PROT_RESP_LOCAL_ACK status indicating that the requested data transmission failed to complete due to a DLI_PROT_RESP_UNBIND line status condition (see Section 9.2.5.1 on page 171).
–105	DLI_ICP_ERR_BAD_CMD	The command from the client program is not a legal value.
–109	DLI_ICP_ERR_XMIT_TIMEOUT	A DLI_PROT_RESP_LOCAL_ACK status indicating that the requested data transmission failed to complete within the default time limit.
–115	DLI_ICP_ERR_BUF_TOO_SMALL	The size of the data buffer sent from the client exceeds the size of the configured buffers.
–117	DLI_ICP_ERR_LINK_ACTIVE	A client request to enable (bind) a link is rejected by the ICP because the link is already enabled.
–118	DLI_ICP_ERR_LINK_INACTIVE	A client request to disable (unbind) a link is rejected by the ICP because the link is already disabled.
–119	DLI_ICP_ERR_BAD_SESSID	The session identification is invalid.
–121	DLI_ICP_ERR_NO_SESSION	A client request to attach a link is rejected by the ICP because the session identification is invalid.
–122	DLI_ICP_ERR_BAD_PARMS	The values used for the function call are illegal.
–145	DLI_ICP_ERR_INBUF_OVERFLOW	Server buffer input overflow
–146	DLI_ICP_ERR_OUTBUF_OVERFLOW	Server buffer output overflow

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