Power Hawk Series 600 Diskless Systems Administrator's Guide

(Title was formerly "*Diskless Systems Administrator's Guide*")

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Preface

Scope of Manual

Intended for system administrators responsible for configuring and administering diskless system configurations. A companion manual, the *Power Hawk Series 600 Closely-Coupled Programming Guide*, is intended for programmers writing applications which are distributed across multiple single board computers (SBCs).

Structure of Manual

This manual consists of a title page, this preface, a master table of contents, nine chapters, local tables of contents for the chapters, five appendices, glossary of terms, and an index.

- Chapter 1, *Introduction*, contains an overview of Diskless Topography, Diskless boot basics, configuration toolsets, definition of terms, hardware overview, diskless implementation, configuring diskless systems and licensing details.
- Chapter 2, *MTX SBC Hardware Considerations*, provides equipment specifications, hardware preparation, installation instruction and general operating data.
- Chapter 3, *VME SBC Hardware Considerations*, provides equipment specifications, hardware preparation, installation instruction and general operating data.
- Chapter 4, *MCP750 Hardware Considerations*, provides equipment specifications, hardware preparation, installation instruction and general operating data.
- Chapter 5, *Net Boot System Administration*, provides an overview of the steps that must be followed in configuring a loosely-coupled system (LCS) configuration.
- Chapter 6, VME Boot System *Administration*, provides an overview of the steps that must be followed in configuring a closely-coupled system (CCS) configuration.
- Chapter 7, *Flash Boot System Administration*, This chapter is a guide to configuring a diskless single board computer (SBC) to boot PowerMAX OS from flash memory.
- Chapter 8, *Modifying VME Space Allocatio*n. describes how a system administrator can modify the default VME space configuration on Closely-Coupled systems (CCS).

- Chapter 9, *Debugging Tools*, covers the tools available for system debugging on a diskless client. The tools that are available to debug a diskless client depend on the diskless system architecture.
- Appendix A provides a copy of the **`vmebootconfig(1m)`** man page.
- Appendix B provides a copy of the **`netbootconfig(1m)`** man page.
- Appendix C provides a copy of the **`mkvmebstrap(1m)`** man page.
- Appendix D provides a copy of the **`mknetbstrap(1m)`** man page.
- Appendix E provides instructions on how to add a local disk.
- Appendix F provides instructions on how to make a client system run in NFS File Server mode.
- Glossary explains the abbreviations, acronyms, and terms used throughout the manual.

The index contains an alphabetical list of all paragraph formats, character formats, cross reference formats, table formats, and variables.

Syntax Notation

The following notation is used throughout this guide:

italic	Books, reference cards, and items that the user must specify appear in *italic* type. Special terms may also appear in *italic*.
`list bold`	User input appears in **`list bold`** type and must be entered exactly as shown. Names of directories, files, commands, options and man page references also appear in **`list bold`** type.
`list`	Operating system and program output such as prompts and messages and listings of files and programs appears in `list` type.
`[]`	Brackets enclose command options and arguments that are optional. You do not type the brackets if you choose to specify such option or arguments

Referenced Publications

Title	Pubs No.
Concurrent Computer Corporation Manuals	
System Administration Manual (Volume 1)	0890429
System Administration Manual (Volume 2)	0890430
Power Hawk Series 600 Closely-Coupled Programming Guide	0891081
Power Hawk Series 600 PowerMAX OS (*Version x.x*) Release Notes	0891058-reln (reln = OS release number, e.g. 5.1)
MTX Single Board Computer (SBC) Manuals (See Note below)	
MTX Series Motherboard Installation and Use Manual	MTXA/IH1
MTX Series Motherboard Computer Programmer's Reference Guide	MTXA/PG
PPCBug Firmware Package User's Manual (Parts 1)	PPCUGA1/UM
PPCBug Firmware Package User's Manual (Part 2)	PPCUGA2/UM
PPC1Bug Diagnostics Manual	PPCDIAA/UM
MTX PCI Series Single Board Computer (SBC) Manuals (See Note below)	
MTX PCI Series Motherboard Installation and Use Manual	MTXPCI/IH1
MTX PCI Series Programmer's Reference Guide	MTXPCIA/PG
PPCBug Firmware Package User's Manual (Parts 1)	PPCUGA1/UM
PPCBug Firmware Package User's Manual (Part 2)	PPCUGA2/UM
PPC1Bug Diagnostics Manual	PPCDIAA/UM
Note: The Motorola documents are available on the following web site at: **http://www.mcg.mot.com/literature**	

Title	Pubs No.
VME Single Board Computer (SBC) Manuals (See Note below)	
MVME2600 Series Single Board Computer Installation and Use Manual	V2600A/IH1
MVME4600 Series Single Board Computer Installation and Use	VMV4600A/IH1
PPCBug Firmware Package User's Manual (Parts 1)	PPCUGA1/UM
PPCBug Firmware Package User's Manual (Part 2)	PPCUGA2/UM
PPC1Bug Diagnostics Manual	PPCDIAA/UM
MCP750 Single Board Computer (SBC) Manuals (See Note below)	
MCP750 CompactPCI Single Board Computer Installation and Use	MCP750A/IH1
MCP750 CompactPCI Single Board Computer Programmer's Reference Guide	MCP750A/PG
PPCBug Firmware Package User's Manual (Parts 1)	PPCUGA1/UM

PPCBug Firmware Package User's Manual (Part 2)	PPCUGA2/UM
PPC1Bug Diagnostics Manual	PPCDIAA/UM
Manufacturers' Documents (See Note below)	
MCP750™ RISC Microprocessor Technical Summary	MCP750/D
MCP750™ RISC Microprocessor User's Manual	MCP750UM/AD
Note: The Motorola documents are available on the following web site at: **http://www.mcg.mot.com/literature**	

Related Specifications

Title	Pubs No.
Specifications	
IEEE - Common Mezzanine Card Specification (CMC)	P1386 Draft 2.0
IEEE - PCI Mezzanine Card Specification (CMC)	P1386.1 Draft 2.0
Compact PCI Specification	CPCI Rev 2.1 Dated 9/2/97

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1
Introduction

1.1. Overview

This manual is a guide to diskless operation of PowerMAX OS. Diskless operation encompasses the ability to configure, boot, administer and debug systems that do not have attached system disks. It should be noted that such a system might have attached non-system disks. Each diskless system runs its own copy of the PowerMAX operating system. The *Closely-Coupled Programming Guide* is a companion to this manual and contains information on the programming interfaces for inter-process communication between processes that are resident on separate single board computers (SBCs) in diskless configurations where all SBCs share a single VME backplane.

1.1.1. Diskless Topography

There are two basic topographies for configuring a set of single board computers for diskless operation. The topography defines the way that the fileserver, bootserver and diskless client SBCs are connected. The fileserver is an SBC which has attached a system disk that stores the boot images that define the software that is downloaded and runs on a diskless system. The bootserver is an SBC which issues the commands which initiate the boot sequence. The fileserver also serves as the bootserver of the local cluster.

The two basic diskless topologies, Loosely-Coupled Systems (LCS) and Closely-Coupled Systems (CCS), are described below:

Loosely-Coupled - This configuration (see Figure 1-1) is supported when the only attachment between the fileserver and the diskless system is from an ethernet network. Inter-process communication between processes running on separate single board computers is limited to standard networking protocols across ethernet.

Closely-Coupled - This configuration (see Figure 1-2) is supported when the fileserver and the diskless SBC share the same VMEbus. Often multiple diskless clients will be in this same VMEbus. This configuration makes use of the VMEbus to emulate the system bus of a symmetric multiprocessing system. Many forms of inter-process communication between processes that are running on separate single board computers are provided. See the *Closely-Coupled Programming Guide* for detailed information on these interfaces.

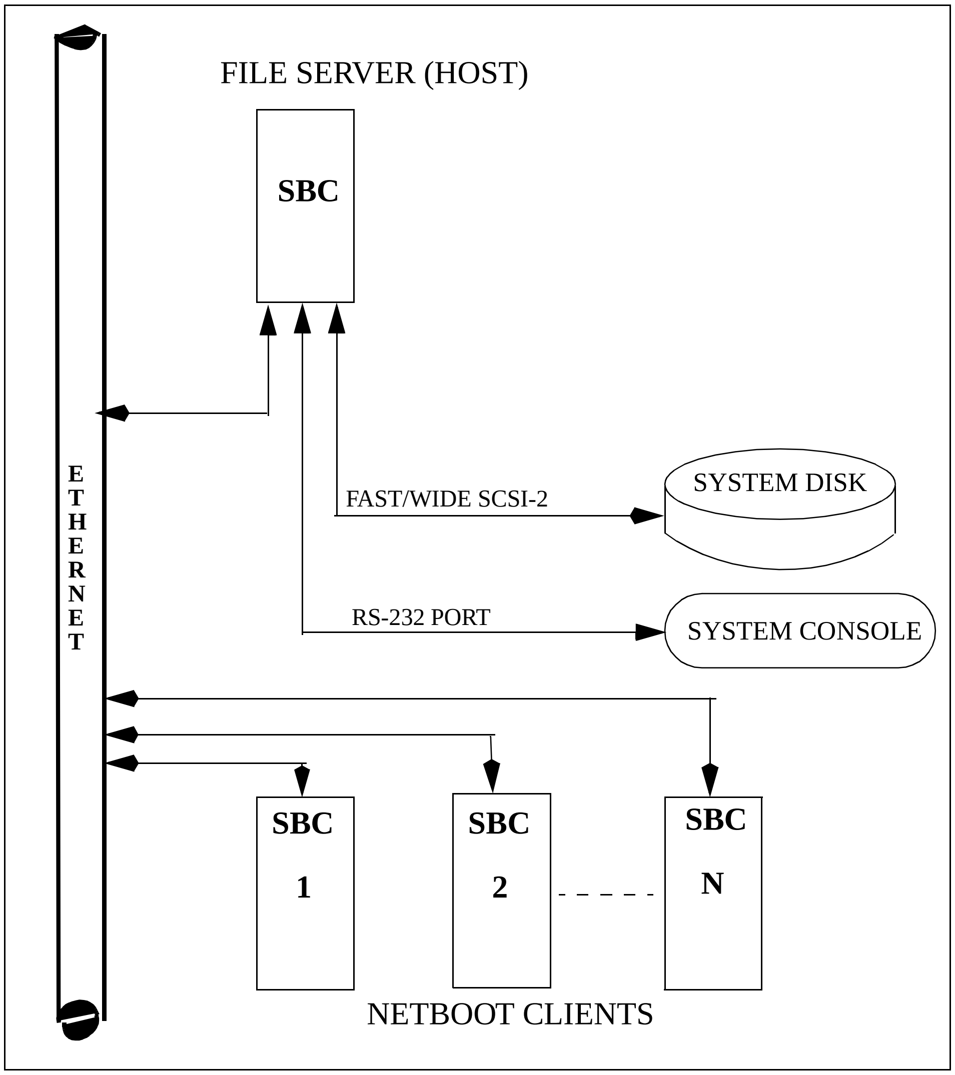


Figure 1-1. Loosely-Coupled System Configuration

There are two possible ways of configuring a diskless client system. The difference between these client configurations is whether the client system maintains an NFS connection to the fileserver after boot such that file system space is available for the client system on the file server. It is important to note that the type of client system configuration selected will impact the resource requirements of the file server as will be explained in more detail later.

The two client configurations are:

Embedded client - Embedded clients are either stand-alone systems which have no attachments to other SBCs or they are not configured with networking and therefore do not use existing network attachments once the system is up and running. The embedded applications must be a part of the original boot image which is downloaded onto the client system and those applications begin execution at the end of the boot sequence.

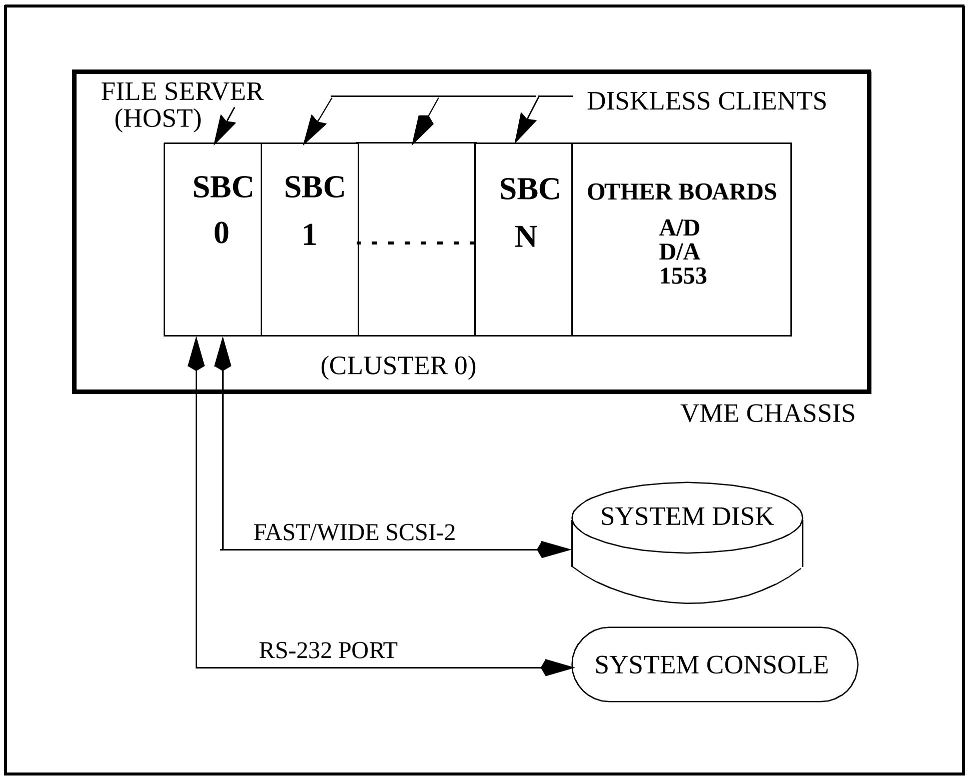


Figure 1-2. Closely-Coupled Cluster of Single Board Computers

NFS client - In an NFS client configuration, the file server provides UNIX file systems for the client system. A client system operates as an NFS client of the file server. This configuration allows substantially more file system space to be available to the client system for storing an application and application data than an embedded configuration.

Note that it is possible to combine the above topographies and configurations in various ways. For example, one could have a Closely-Coupled system where some of the client SBCs are embedded clients and some are NFS clients. Another example would be a Closely-Coupled configuration that is booted from an ethernet connection to the fileserver.

Multiple clusters can also be networked together (Figure 1-3). In this configuration, clusters are connected via a common Ethernet network. As with the single cluster configuration, each processor board runs a separate copy of PowerMAX OS. Each SBC in a remote cluster can be diskless. Note that in this configuration, an appropriate ethernet hub must be used to connect the hardware together.

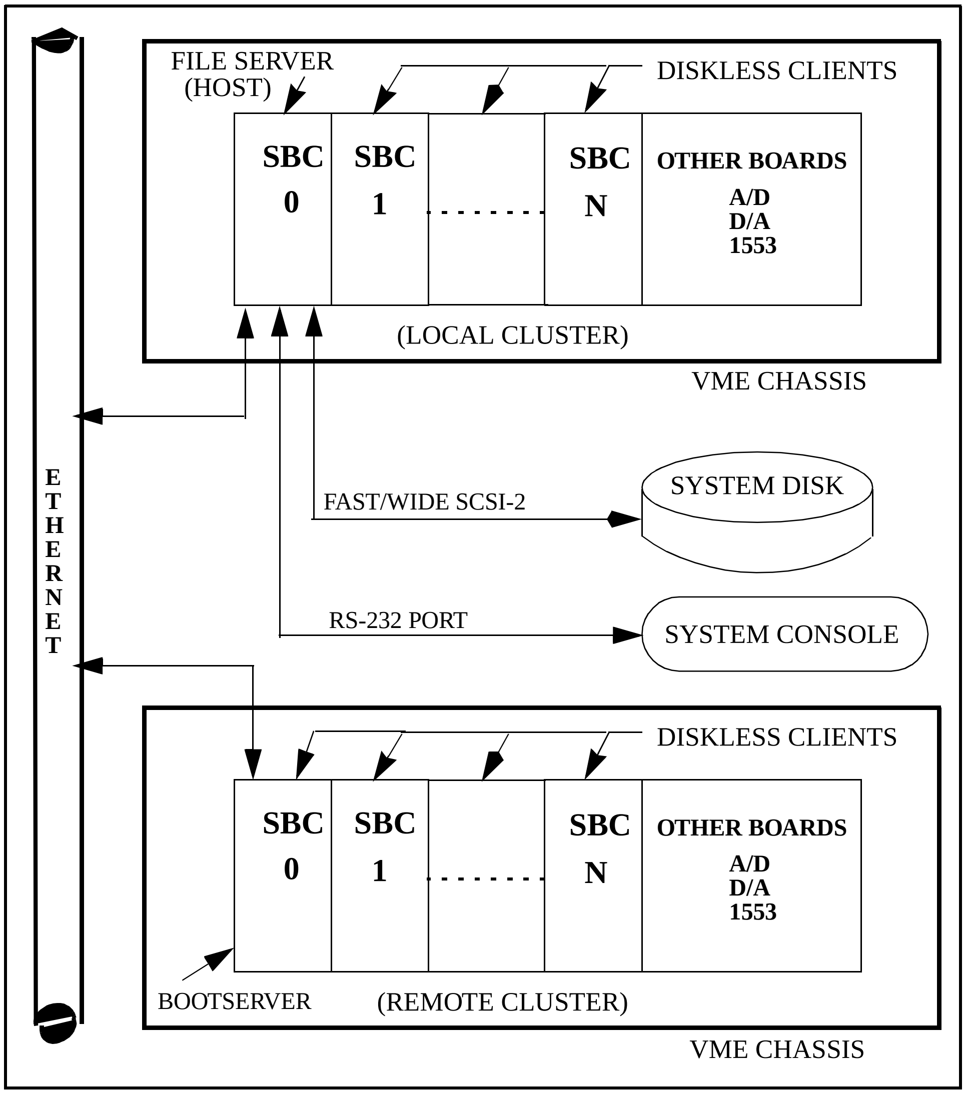


Figure 1-3. Closely-Coupled Multiple Clusters of Single Board Computers

1.1.2. Diskless Boot Basics

The first step in creating a diskless system is to create a boot image which contains both the operating system and a file system that contains at a minimum the executable needed to boot the PowerMAX OS. This file system, which is bundled into the boot image, can also be used to store application programs and data, UNIX commands and libraries or any other file that might live in a disk-based partition. The size of this file system is limited, since it must either be copied into memory or must reside in flash ROM.

The file server is an SBC with attached disks where the boot image and a virtual root partition for each configured diskless system is created. The virtual root is both the environment used to build the boot image and it is also mounted by diskless systems that maintain an NFS connection to the file server. Note that embedded diskless configurations do not maintain such an NFS connection. When the virtual root is mounted by the diskless system, it is used to hold system commands and utilities as well as user-defined files and application programs. The virtual root can be viewed as a resource for additional disk space for a diskless system.

Once a boot image is created, it must be copied from the file server to the diskless system. There are <u>three</u> supported mechanisms for transferring a boot image to a diskless system:

1. A diskless system that is configured to boot from the network will read the boot image via an ethernet network connection to the file server. The firmware uses the Trivial File Transfer Protocol (TFTP) over an ethernet connection to download the boot image.
2. When the diskless system shares the same VMEbus with the boot server, the boot server can transfer the boot image from the file server, across the VMEbus, directly into the memory of the diskless system.
3. The boot image may have already been burned into flash ROM. In this case, the board's firmware (**`PPCBug`**) is configured to copy the boot image from flash ROM into memory.

Closely related to the technique for copying a boot image to a diskless SBC, is the technique for initiating the boot sequence on the diskless SBC. There are <u>four</u> techniques for initiating the boot sequence on a diskless system. Note that in some cases, the loading of the boot image cannot be separated from the initiation of execution within that image.

1. To boot from the ethernet network, the board's firmware (**`PPCBug`**) must be configured to boot from the network. The boot sequence is initiated either by resetting the board, cycling the power on the board or issuing the **`PPCBug`** command to boot. Note that the **`PPCBug`** method is only available when a console terminal is connected to the diskless system.
2. To boot over the VMEbus, the boot sequence is initiated by executing the **`sbcboot`** command on the boot server (which may or may not be the same system as the file server). This command causes the diskless system to be reset, the boot image downloaded over the VMEbus into the diskless system's memory and execution within the downloaded boot image is initiated.
3. To boot from flash ROM, the board's firmware (**`PPCBug`**) must be configured to boot from flash. The boot sequence will be initiated whenever the board is reset, cycling the power on the board or issuing the **`PPCBug`** command to boot.
4. If a diskless system with a flash ROM boot image shares the VMEbus with the boot server, then the **`sbcboot`** command can be executed on the boot server to initiate the boot process. Note that in this case, the bootserver can initiate the boot sequence because the client's memory and command registers are accessible via the VMEbus.

1.1.3. Configuration Toolsets

Two sets of tools are provided for creating the diskless configuration environment on the file server and for creating boot images. The diskless configuration environment includes the generation of the virtual root as well as the creation and modification of relevant system configuration files. The virtual root serves as the environment for configuring a client's kernel, building the boot image and as one of the partitions which is NFS mounted by an NFS client. The tools that comprise both toolsets are executed on the file server. One toolset is used for configuring closely-coupled systems while the other toolset is used for configuring loosely-coupled systems.

The closely-coupled toolset consists of the tools **`vmebootconfig`** and **`mkvmebstrap`**. The closely-coupled or VME toolset must be used if the single board computers in the configuration share a VMEbus and that VMEbus is going to be used for any type of inter-SBC communication. There are instances where clients in a closely-coupled VME configuration may wish to boot from an ethernet connection to the file server or from flash ROM. The VME toolset provides support for such booting. Because these clients are part of a VME cluster, the VME toolset must be used to configure them.

The Net Boot toolset consists of the tools **`netbootconfig`** and **`mknetbstrap`**. These tools handle the simpler case of loosely-coupled systems that boot via an ethernet network or from flash ROM, where no VMEbus-based communication will be utilized on the client system.

The **`netbootconfig`** and **`vmebootconfig`** tools are used to create the diskless configuration environment for a diskless client. The **`mknetbstrap`** and **`mkvmebstrap`** tools are used for creating a diskless client's boot image. More information is provided on these tools in Chapter 5, "Netboot System Administration" and in Chapter 6, "VME Boot System Administration".

1.2. Definitions

Loosely-Coupled System (LCS)	A Loosely-Coupled System (LCS) is a network of Single-Board Computers (SBCs). One of the SBCs must have a system disk and is referred to as the File Server and all other SBCs are generally referred to as clients. An ethernet connection between the file server and the client systems provides the means for inter-board communication.
Closely-Coupled System (CCS)	A Closely-Coupled System (CCS) is a set of Single Board Computers (SBCs) which share the same VMEbus. The first board must have an attached system disk and acts as the file server for the other boards in the VMEbus. The VMEbus can be used for various types of inter-board communication.
Cluster	A cluster is one or more SBC(s) which reside on the same VMEbus. In general, a cluster may be viewed as a number of SBCs which reside in the same VME chassis. Note that “cluster” and “Closely-Coupled system” are synonymous. Multiple clusters (VME chassis) can be configured together in the same CCS using Ethernet.
Local Cluster	The cluster which has the File Server as a member (see File Server below).
Remote Cluster	A cluster which does not have the File Server as a member. In large configurations, multiple Remote Clusters can be configured. Remote Clusters rely on an ethernet network connection back to the File Server for boot loading and NFS mounting of system disk directories.
Board ID (BID)	All SBCs in the same cluster (i.e. reside in the same VME chassis) are assigned a unique board identifier or BID. The BIDs range from 0 to 21 in any given cluster. Every cluster must define a BID 0. Additional SBCs installed in a cluster may assign any remaining unused BID. By convention, BIDs are usually allocated sequentially [1,2,3] but this is not mandatory.
Host	Generic term used to describe Board ID 0 in any cluster (see definition of File Server and Boot Server immediately below).
File Server	The File Server has special significance in Loosely-Coupled and Closely-Coupled systems as it is the only system with physically attached disk(s) that contain file systems and directories essential to running the PowerMAX OS^{TM} (**`/etc`**, **`/sbin`**, **`/usr`**, **`/var`**, **`/tmp`**, and **`/dev`**). The File Server boots from a locally attached SCSI disk and provides disk storage space for configuration and system files for all clients. There is only one file server in a Loosely-coupled or Closely-Coupled system. The file server must be configured as BID 0 for closely-coupled systems. All clients depend on the File Server for booting since all the boot images are stored on the File Server’s disk.

Boot Server	The boot server is a special SBC in a Closely-Coupled system, because it is the SBC that downloads a boot image to all other clients in the same cluster across the VMEbus. This is known as VME booting (or VMEbus booting). The boot server must be configured as board 0 in the cluster in which it resides (applies to both the local and remote clusters). A boot server is capable of resetting, downloading, and starting all other boards in the same cluster (same VMEbus). The VMEbus is utilized to perform these functions. In the local cluster, the File Server and the boot server are the same SBC. In remote clusters, boot server functionality can be provided by the BID 0 SBC if it is configured as an NFS client.
Client	All SBCs, except for the File Server are considered clients. Clients do not have their own "system" disk. Clients must rely on the File Server for such support. However, clients may have local, non-system disk drives configured. The two client configurations, embedded and NFS, are described below:
1) Embedded Client	An embedded client runs self-contained from an internal memory-based file system; they do not offer console or network services. There is no swap space, because there is no media that can be used for swapping pages out of main memory. Applications run in single user mode (**`init state 1`**).
2) NFS Client	NFS clients are diskless SBCs that are configured with networking and NFS. Most directories are NFS mounted from the File Server. In addition to NFS, all standard PowerMAX OS^{TM} network protocols are available. Swap space is configured to be remote and is accessed over NFS. Applications run in multi-user mode (**`init state 3`**).
System Disk	The PowerMAX OS^{TM} requires a number of "system" directories to be available in order for the operating system to function properly. These directories include: **`/etc`**, **`/sbin`**, **`/dev`**, **`/usr`**, **`/var`** and **`/opt`**. The File Server is configured so that these directories are available on one, or more, locally attached SCSI disk drives. Since clients do not have locally attached system disk(s), they will NFS mount these directories from the File Server (an "NFS Client"), or create them in a memory file system which is loaded with the kernel (an "Embedded Client").
VME Boot	A master/slave kernel boot method by which the Boot Server resets, downloads and starts an operating system kernel on a client which is attached to the same VMEbus. Note that the client does not initiate the boot sequence.
Net Boot (or Network Boot)	A client/server kernel boot method that uses standard BOOTP and TFTP protocols for kernel loading from the File Server. Any client can be configured to initiate a net boot operation from the File Server.

Flash Boot	A client boot method where the boot image executed comes from the client's own Flash memory.
Boot Image	This is the object that is downloaded into the memory of a diskless client. It contains a UNIX kernel image and a memory-based root file system. The memory-based file system must contain the utilities and files needed to boot the kernel. In the case of an NFS client, booting must proceed to the point that remote file systems can be mounted. For an embedded kernel, the memory-based file system is the only file system space that is available on the diskless system. Users may add their own files to the memory-base file system.
PowerPC Debugger (**`PPCBug`**)	A debugging tool for the Motorola PowerPC microcomputer. Facilities are available for loading, debugging and executing user programs under complete operator control.
Trivial File Transfer Protocol(TFTP)	Internet standard protocol for file transfer with minimal capability and minimal overhead. TFTP depends on the "connectionless" datagram delivery service (UDP).
System Run Level Init Level	A term used in UNIX-derived systems indicating the level of services available in the system. Those at "**init level 1**" are single user systems which in turn is typical of embedded systems running on client SBCs. Those at "**init level 3**" have full multi-user, networking, and NFS features enabled, and is typical of client SBCs that run as netboot clients. See **`init(1M)`** for complete details.
VMEbus Networking	In a Closely-Coupled system, all Clients within the same cluster are transparently networked together using a VMEbus based point-to-point networking driver. This driver provides a high speed TCP/IP connection between clients which reside on the same VMEbus (i.e. are in the same cluster).
swap space	Swap reservation space, referred to as 'virtual swap' space, is made up of the number of real memory pages that may be used for user space translations, plus the amount of secondary storage (disk) swap space available. Clients in the NFS configuration utilize a file accessed over NFS as their secondary swap space. Embedded clients, which are usually also Flashboot clients, generally do not utilize a swap device, but if a local disk is available then they too may be configured with a swap device.

1.3. Hardware Overview

Diskless capabilities are available for four hardware platforms. All platforms have the requisite network controller, flash memories, and NVRAM which make them suitable as hosts and as clients in a loosely-coupled diskless topographies. Only the VME platforms can support a closely-coupled topography.

The MTX is a PC-style platform whose motherboard can be configured as single or dual processor. The MVME2600 and MVME4600 are single and dual processor single board computers respectively, whose motherboards are in the VME bus 6u form factor. The MCP750 is a single board computer in the 6U CompactPCI form factor.

The MVME2600, MVME4600 and MTX boards all utilize the PowerPC 604e^{TM} microprocessor. The MCP750 utilizes the MPC750 microprocessor. The following tables summarize the hardware features of the various supported single board computers.

Motherboard Designation	System Platform	Number of CPUs	Form Factor	Netboot	VMEboot	Flashboot
MVME2600	Power Hawk 620	1	VME 6U	yes	yes	yes
MVME4600	Power Hawk 640	2	VME 6U	yes	yes	yes
MTX/MTX II	PowerStack II	1 or 2	PC (ATX)	yes	no	yes
MCP750	N/A	1	CPCI 6U	yes	no	yes

1.3.1. MTX SBC Features

Feature	Description
SBC	PowerPC 604™ -based microprocessor module
DRAM	64 MB to 1 GB EDO ECC Memory
Cache Memory	64 KB L1 cache 256 KB L2 cache
Ethernet	10BaseT or 100BaseT
Flash Memory	1 MB slow flash (Flash B) containing **PPCbug** 4 MB fast flash (Flash A) available to hold boot images
SCSI-2	Fast/Wide/Ultra SCSI-2
Ports	Two RS-232 Serial Ports IEEE-1284 Parallel Port
Real-time Counters/Timers	Two 32-bit counter/timers Two 16-bit counter/timers
I/O Busses	33 MHz PCI Bus Fast/Wide/Ultra SCSI Bus

1.3.2. MTX II (MTX604-070) SBC Features

Feature	Description
Microprocessor	Supports BGA 60x processors: 603e, 604c Single/dual processor (604e); Bus clock Frequencies up to 66MHz
DRAM	Two-way Interleaved. ECC protected 32 MB to 1 GB on board. Supports single or dual-bank DIMMS in four on-board connectors.
L2 Cache Memory	Build option for 256 KB or 512 KB Look-aside L2 Cache (Doubletake).
Flash Memory	8 MB (64-bit wide) plus sockets for 1 MB (16-bit)
Memory Controller	Falcon3 Chipset
Real-time Clock	8 KB NVRAM with RTC and battery backup.

Peripheral Support	Two 16550-compatible async serial ports One Host-mode Parallel Port 8-bit/16-bit single-ended SCSI Interface Two 10BaseT/100BaseTX Ethernet Interfaces One PS/2 Keyboard and one PS/2 Mouse One PS/2 Floppy Port
PCI Interface	32/64-bit Data, up to 33 MHz operation.
PCI/ISA Expansion	Seven PCI slots (one shared), one ISA slot (shared)

1.3.3. VME SBC Features

Feature	PH620 (Single Processor)	PH640 (Dual Processor)
SBC	Single PowerPC 604e™ -based microprocessor module	Dual PowerPC 604™ -based microprocessor module
DRAM	32 MB to 256 MB ECC Memory	64 MB to 1 GB ECC Memory
Ethernet	10BaseT or 100BaseT	
Flash	1 MB slow flash (Flash B) containing **PPCbug** 4 MB or 8 MB fast flash (Flash A) available to hold boot images	
SCSI-2	Fast and wide (16-bit) SCSI bus 32-bit PCI local bus DMA	
Ports	Two asynchronous and two synchronous/asynchronous serial communication ports. Centronics bidirectional parallel port	
Time-of-day clock (TOC)	8KB x 8 NVRAM and time-of-day clock with replaceable battery	
Onboard real-time clocks (RTCs)	Four 16-bit programmable counter/timers. Watchdog timer	
I/O Busses	A32/D32/BLT64 VMEbus with Master/slave with controller functions. PMC - slot 32/64-bit PCI local bus interface	

1.3.4. MCP750 SBC Features

Feature	Description
SBC	PowerPC 750^{TM-}based microprocessor module
DRAM	64 MB to 1 GB EDO ECC Memory
Cache	64 KB L1 cache 256 KB L2 cache
Ethernet	10BaseT or 100BaseT
Flash	1 MB slow flash (Flash B) containing **PPCBug** 4 MB fast flash (Flash A) available to hold boot images
SCSI-2	Fast/Wide/Ultra SCSI-2
Ports	Two RS-232 Serial Ports IEEE-1284 Parallel Port
Real-time Counters/Timers	Two 32-bit counter/timers Two 16-bit counter/timers
I/O Busses	33 MHz PCI Bus Fast/Wide/Ultra SCSI Bus

1.4. Diskless Implementation

1.4.1. Virtual Root

The virtual root directory is created on the file server for each client when the client is configured. The virtual root directory is used to store the kernel build environment, cluster configuration and device files. In addition, for clients configured with NFS, the client's **/etc**, **/var**, **/tmp** and **/dev** directories are created here and NFS mounted on the client during system initialization. Note that each configured client has its own, unique virtual root on the file server which is used as the configuration environment for that client.

A client's virtual root directory may be generated in any file system partition on the file server except for those used for the **/** (**root**) and **/var** file systems.

Virtual roots are created on the host for all clients. Clients running embedded systems will utilize their virtual root for configuring the clients's kernel and building the boot image.

1.4.2. Boot Image Creation and Characteristics

One of the primary functions of the virtual root is as the development environment for building the boot image that will be downloaded to diskless client systems. After a client's virtual root development environment has been created, users have the opportunity to tune the development environment in various ways, including that of adding in their own applications and data.

The boot image file, known as **unix.bstrap**, is composed primarily of two intermediate files: **unix**, and **memfs.cpio**. These are located in the same directory as **unix.bstrap**. **unix** is the client's kernel as built by **idbuild(1M)**. **memfs.cpio** is a compressed **cpio** archive of all the files which are to be the contents of that client's **memfs** root filesystem. This archive was compressed using the tool **rac(1).** Conversely, if the user wants to examine the contents, **rac(1)** must be used to decompress it.

The final boot image, **unix.bstrap**, will contain a compressed version of the text and data regions of the unix kernel. These were extracted from the **unix** file. It will also contain bootstrap code, which decompresses the kernel and sets up its execution environment when the boot image is executed on the client, a copy of the compressed **cpio** image from **memfs.cpio**, and a bootstrap record used to communicate information about the client to the kernel and its bootstrap.

At the time of booting, boot files are created as needed based on dependencies established by the makefile "**bstrap.makefile**" under the **/usr/etc/diskless/bin** directory (see table below).

Boot File	Description	Dependencies
`unix`	unix kernel	**`kernel.modlist.add`**
`memfs.cpio`	cpio image of all files to be loaded in the client's memory-based root file system	**`unix`**, **`memfs.files.add`**, system configuration files
`unix.bstrap`	bootstrap image	**`unix`**, **`memfs.cpio`**

1.4.3. MEMFS Root Filesystem

A memory-based filesystem, called the memfs filesystem, becomes the root filesystem of a client as part of its booting process. As the client completes its boot, it may mount other filesystems that are available to it, perhaps those on local disks or from across the network. These other filesystems do not replace the original memfs root filesystem but instead augment it with their extra directories and files. Files needed by diskless applications can be located either in the memfs root filesystem of a client or on the file server in the client's virtual root directory.

For embedded systems, all user applications and data must be placed into the memfs root filesystem, since by definition no other filesystems are available to such clients.

The tools used to build boot images provide a mechanism for adding user-defined files to the memfs filesystem contents and wraps those contents into the boot image that will be later downloaded into the client. When the boot image is downloaded into a diskless client system, it is resident in memory whether or not the files are being used. This means that the number and size of files that can be placed into the memfs file system is thus limited. This effect is minimized when the boot image is loaded into Flash. When the boot image resides in Flash, only those files actually in use will reside in (be copied into) physical memory at any time. In this mode of operation, the root filesystem behaves more like a normal filesystem: pages are automatically fetched from the Flash as needed, and, if not modified by applications, are automatically released when other needs for the space become more urgent.

It is possible for applications running on the client to write to memfs files; however, there not being a disk associated with these files, the changes will be lost on the next reboot of that client. Moreover, such pages remain permanently in memory until the files containing them are deleted or truncated. This ties up precious physical memory. This can be alleviated only by the addition of a swap device to the system, to which the system can write these dirty pages to as necessary, or by careful consideration and minimization of how much file writing is done by embedded applications into the memfs root filesystem.

Memfs filesystems stored in Flash will be in a compressed format, in order to make maximum use of this relatively tiny device.

1.4.4. Booting

Once a bootstrap image is generated, it must be loaded and started on the client for which it was built. Three methods of booting are provided: VME Boot, Net Boot and Flash Boot. All three methods are supported in closely-coupled configurations while only net boot and flash boot are supported in loosely-coupled configurations. (These methods are explained in more detail in the following sub-sections.)

In configuring a diskless configuration, the user must decide which method of booting will be used for each diskless client. Booting of a diskless client consists of two distinct operations. First, the boot image must be downloaded to the diskless client. Downloading can be performed over the VMEbus (supported only in closely-coupled configurations) or across an ethernet network (supported in both closely-coupled and loosely-coupled configurations). Downloading using these two mechanisms differs in that a VME download is a ‘push’ operation, while an ethernet download is a ‘pull’ operation. That is, the VME download is initiated by commands that are executed on the file server, which cause the boot image to be written to the client’s DRAM. An ethernet download is initiated by **`PPCBug`** firmware commands, which are executed on the diskless client and cause the boot image to be read from the file server and downloaded in the client’s DRAM.

The second phase of the boot operation is to initiate execution within the downloaded image. Like the download of the boot image, initiation of execution is also be performed via the VMEbus or via the **`PPCBug`** commands executed on the client system. In managing a diskless configuration, the user will generally be unaware of the distinction between the two phases of the boot process. This is because the command used to boot, using the VMEbus or the **`PPCBug`** commands, executed on the diskless client to boot using ethernet, actually perform both phases of the boot operation. The distinction between these two phases of booting is made here to better understand the third boot mechanism: booting from flash.

The boot image can be burned into flash on the diskless client. Once burned into flash, the complete image no longer needs to be downloaded into DRAM. Instead, only the operating system is copied from flash into DRAM, the compressed **`cpio`** file system is left in flash and only copied into memory as needed. This means that booting from flash doesn’t require phase one of the boot process - the download of the boot image. The method used to initiate execution within the boot image for a flash boot system depends upon the connection between the file server and the client. If the diskless client and the file server are located in the same VMEbus, then a command can be executed on the file server that will initiate the flash boot sequence on the client. If the client has only a network connection to the file server or has no connection at all to the file server, then the boot sequence must be initiated using a **`PPCBug`** command.

Booting from flash is significantly faster than other boot mechanisms and is recommended for final deployed environments. While actively testing and modifying the application and the boot image, downloading the boot image can be performed via the VMEbus or via an ethernet connection. The final version of the boot image can then be burned into flash when the application is deployed.

1.4.4.1. VME Boot

In a Closely-Coupled configuration, the boot server (board ID 0 of cluster) is capable of downloading a boot image to all other clients in the same cluster across the VMEbus.

VME booting (or VMEbus booting) uses the VMEbus to transfer the PowerMAX OS^{TM} bootstrap image from the File Server's disk to the client's DRAM (memory).

A VME boot will result in the hardware reset of the boot client. This stops execution of any code running on the boot client. It is suggested that when rebooting any client that is currently running a PowerMAX OS^{TM} bootstrap image, that it be shutdown (e.g. using **`shutdown(1M)`**) prior to rebooting (if possible).

Once the client is reset, the Boot Server's on-board DMA Controller transfers the bootstrap image from the File Server's disk to the client. A command, sent over the VMEbus to a special memory location on the client, starts execution of the bootstrap image. VME booting is only available for clients which have a "Boot Server" defined which resides on the same VMEbus as the boot client. In the local cluster, the File Server is also the Boot Server for all clients on the local VMEbus.

1.4.4.2. VME Booting in Remote Clusters

A remote cluster is a VME cluster which does not contain the file server. In this case, the Boot Server is the SBC with Board ID 0. The bootserver must be configured as an NFS Client to allow it access to the boot images of the VME boot clients for which it will act as the boot server. If the remote cluster's Board ID 0 SBC is configured as an Embedded Client, then VME booting is not an option for any clients in the same remote cluster. In this case, the Net Booting or Flash Booting method must be used for all clients in the remote cluster.

The Boot Server in a remote VME Cluster must be booted using the Net Boot method described below. This is because the Boot Server is not physically connected to the same VMEbus as the File Server (the SBC which has the Boot Server's bootstrap image on disk).

Once the Boot Server is Net booted, all other clients in the same remote cluster can be VME booted by the cluster's boot server.

1.4.4.3. Net Boot

Net Boot (or Network booting) is an alternative method of loading and executing a kernel image to a client over Ethernet. Note that the **`PPCBug`** firmware supports booting via ethernet but not other networking media. This method is distinguished by the fact that the host cannot actively force a client to accept and boot an image; rather, the client must initiate the transfer with the host and cooperate with the host to complete the transfer. This client initiation may take one of two forms: **`PPCBug`** commands executed on the client console by an operator, or an automatic execution of the same **`PPCBug`** commands by the client whenever it is powered up, or reset (autoboot).

Net booting is performed by **`PPCBug`** using the TFTP (Trivial File Transfer Protocol, RFC783) and optionally, the BOOTP (Bootstrap Protocol, RFC951) network protocols. These are standard protocols supported by the PowerMAX OS^{TM} and are explained in more detail in the *Network Administration* manual (Pubs No. 0890432).

Any client can be net booted as long as the SBC is physically connected to the same Ethernet as the File Server.

In closely-coupled systems, some clients, namely Boot Servers, **must be** net booted. Other SBCs in the same VME chassis as a Boot Server may be, and usually are, booted over the VMEbus by the Boot Server.

Whether manually booting or autobooting a client, that client must first be set up with the information it needs to do net booting. This is accomplished with the **`PPCBug NIOT`** command. Once this is done, the client should not ever need to be reconfigured unless one or more of these parameters change, as the information is saved in NVRAM and thus will be preserved across reboots and powerdown cycles.

The following information is required by the **`PPCBug NIOT`** command to configure each client you want to perform a net boot:

File Server IP Address

IP address for the File Server which should have already been defined in the **`/etc/hosts`** file. You must use the address which defines the Ethernet interface, not the VME network interface.

Client(client) IP Address

IP address which **`PPCBug`** will use as the return address for TFTP data transfer. For NFS clients, this is the Ethernet IP Address.

You may also net boot an Embedded Client. Since this client's kernel does not support networking, no IP address has yet been defined for it. In this situation, select a unique IP address to use. An address should be selected that decodes to the same subnet as the File Server, and does not conflict with any other IP addresses used in the network.

Subnet IP Address Mask

Subnet mask used for this interface. It normally is 255.255.255.0.

Broadcast IP Address

Broadcast address used for this subnet.

Absolute Pathname of UNIX Bootstrap to be Downloaded

The bootstrap is a file generated by the configuration utility as **`<client_virtual_rootpath>/etc/conf/cf.d/unix.bstrap`**.

After the **`PPCBug`** firmware has been initialized with the network parameters, a net boot may be initiated via the **`PPCBug NBO`** command. Refer to Chapter 5, Netboot System Administration, for more information on net booting.

1.4.4.4. Flash Boot

Flash Boot or flash booting, is a method of loading and executing a kernel image from Flash ROM. Flash booting is the preferred method of booting a diskless client in the production or deployed phase of an application. There are two advantages in booting from flash. First, flash boot allows very fast boot times because there are no rotational delays that would normally be associated with reading from disk. Second, the root file system is maintained as a read-only image in flash, providing much greater system stability because the root file system cannot be corrupted by unexpected system crashes which might leave a writable file system in an inconsistent state.

The boot image that is downloaded into flash is the same boot image that can be downloaded via the VME backplane or via an ethernet network connection. Therefore a developer can use one of the other download/boot techniques while actively modifying the boot image during the development phase, and then use the same final boot image in the flash when in the deployed phase of the application. There are no tools specifically targeted towards creating boot images for flash booting. Instead, either the loosely-coupled or closely-coupled configuration tools are used for building the image, depending on whether the client system will be used in a shared VME backplane configuration.

The first step in preparing an SBC for flash boot is to load the boot image into flash ROM on the board. Loading an image into flash ROM may be done via two different processes depending on whether or not the file server and the diskless client share the same VMEbus.

If the two SBCs do share the same VMEbus, then the boot image can be downloaded into memory and burned into flash by running the **`sbcboot`** utility or via **`mkvmebstrap`**. Once the boot image is burned into Flash, the same utilities can be used to initiate a download of the boot image from Flash to memory and begin execution within the downloaded boot image.

If the file server is only connected to the client system via an ethernet network, then the Flash must be burned via a process known as “network loading.” Preparation for loading the boot image into flash is the same method used above for net booting, that is, using the **`PPCBug NIOT`** command. The **`PPCBug NBH`** command is used to load the boot image into memory <u>without</u> execution of that image. The boot image is then burned into Flash from memory via the **`PPCBug PFLASH`** command. Once the image is burned into Flash, then all subsequent booting can be done from the image stored in Flash by configuring the board’s boot device to be the Flash via the **`PPCBug ENV`** command. Refer to Chapter 7, Flash Boot System Administration, for more information.

1.4.5. VME Networking

For closely-coupled configurations, the cluster software package provides the capability of networking between clients and the file server, utilizing the VME bus for data transfer. Figure 1-4 illustrates the streams networking model, which includes interface modules to enable standard networking across the VME bus.

This VME network connection is a point-to-point link and is analogous to a SLIP or PPP connection. A point-to-point VME bus connection is established via the **`vmedlpiattach(1M)`** command. This command is executed at boot time by the file server and clients to establish connections with the other Power Hawk boards.

The **`netstat(1M)`** command shows the VME point-to-point connections:

```
netstat -i
```

```
Name   Mtu    Network     Address     Ipkts    Ierrs   Opkts    Oerrs   Collis
vme0   8320   192.168.1   elroy_vme   34391    0       34392    0       0
lo1    2048   none        none        10       0       10       4       0
dec0   1500   none        none        12374    0       0        0       0
```

The interface **`vme0`** represents one VME point-to-point connection with another Power Hawk board.

When configuring a VME cluster, the IP addresses of the Power Hawk systems on the VME bus are defined based upon the VME IP Base Address of the cluster, and the appropriate entries must be added to the **`/etc/hosts`** file. Required kernel device drivers for VME networking are configured and applicable VME network related tunable parameters are initialized to reflect the configured IP address.

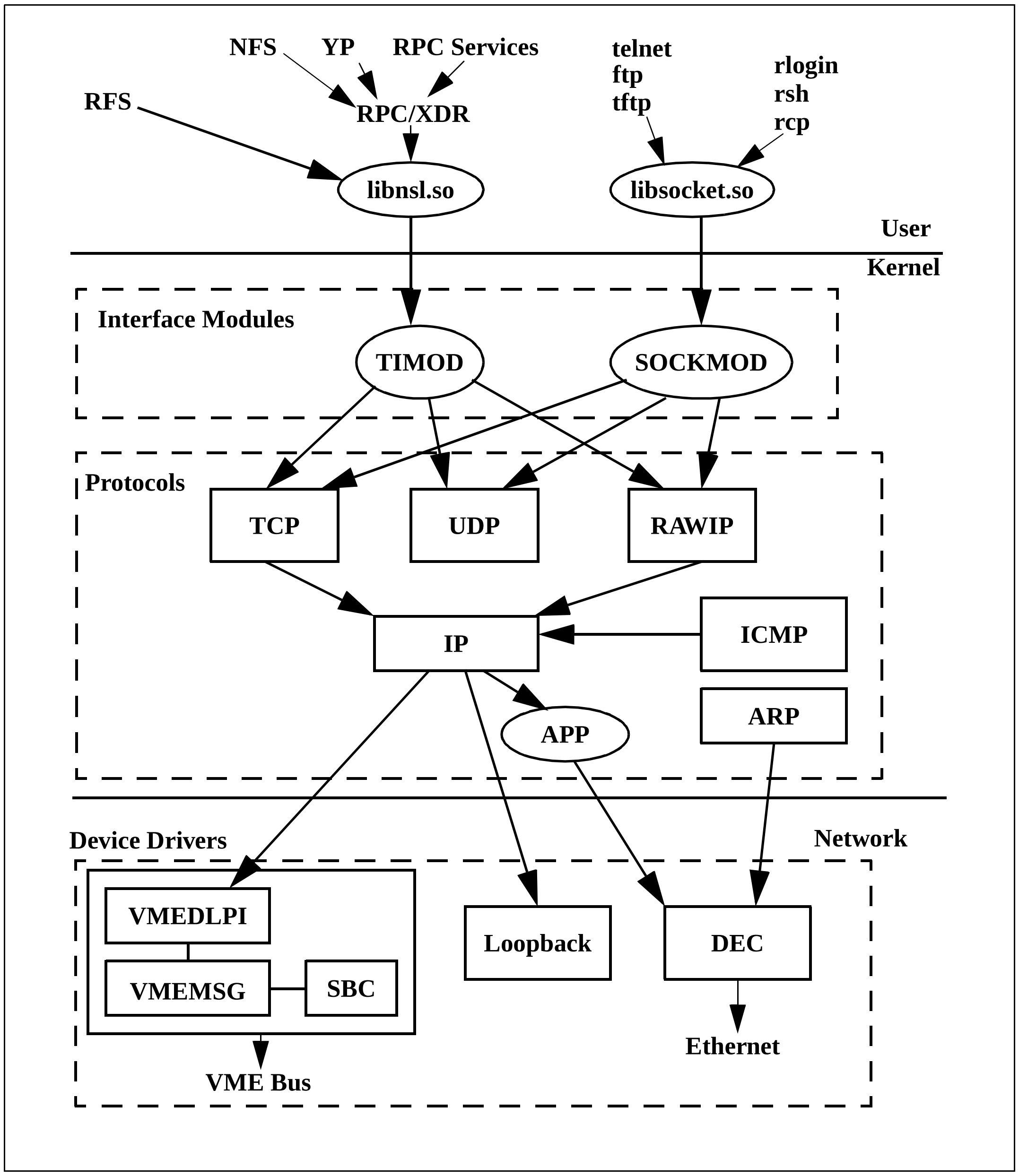


Figure 1-4. Power Hawk Networking Structure

1.4.6. Remote File Sharing

Clients configured as “Embedded Clients” must have in their memory-based root file system all the files needed for booting and all the files needed to run applications. This is because Embedded Clients do not have networking by definition and therefore will not have access to remote files on the file server.

The **memfs** root file system of a client configured with NFS, need only contain the files required for booting. When the client system reaches **init state 3** it is able to NFS mount and access the file server's directories. The NFS mounts are executed from a start-up script in **/etc/rc3.d**.

Two different **inittab** files are used in booting an NFS configuration. When the **etc** directory in a client's virtual root is NFS mounted, the original **inittab** file is overlaid with the one in the virtual root. The directory **etc/rc3.d** is then re-scanned to execute start-up scripts in the virtual root.

The directories **/usr**, **/sbin** and **/opt** are completely shared with the server, while **/etc** and **/var** are shared on a file-by-file basis.

Listed below is the NFS mount scheme in use:

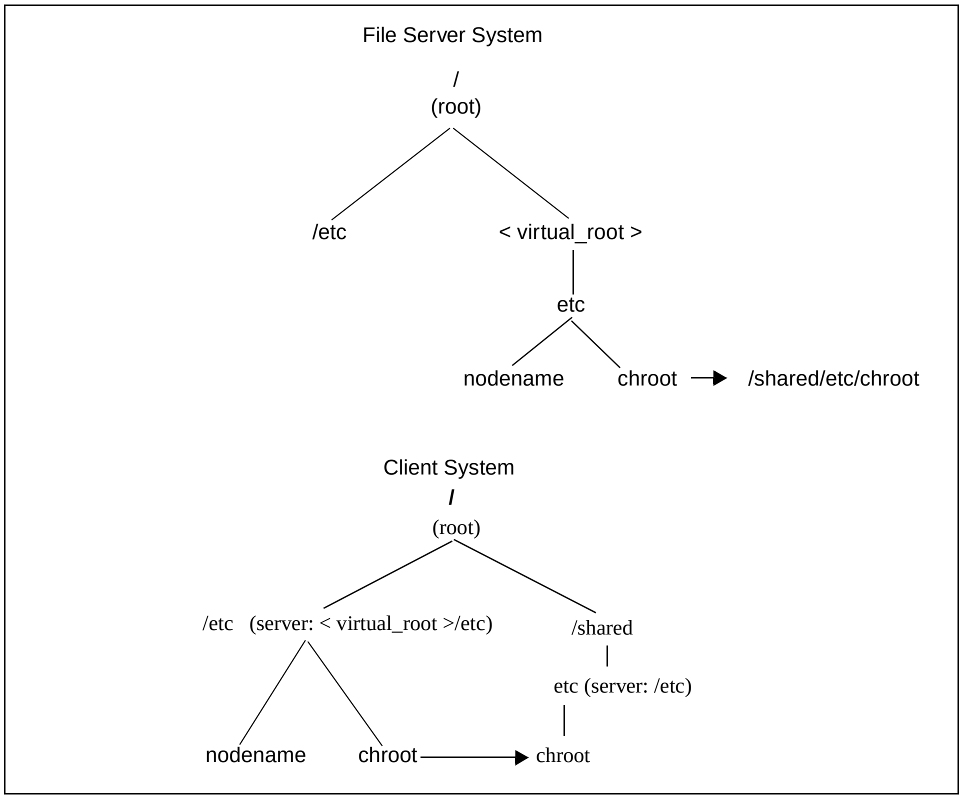
Path on File Server	Mount Point on Client
/usr	**/usr**
/sbin	**/sbin**
/opt	**/opt**
<virtual_rootpath>/etc	**/etc**
<virtual_rootpath>/var	**/var**
<virtual_rootpath>/dev	**/dev**
<virtual_rootpath>/tmp	**/tmp**
/etc	**/shared/etc**
/var	**/shared/var**
/dev	**/shared/dev**

The **/etc** and **/var** directories under the client's virtual root contain some files that are client-specific and therefore these files cannot be shared. These directories also contain files which have the same content for the file server and all client virtual roots on the file server, these files are shared. Because the **/etc** and **/var** directories contain both shared and non-shared files, yet all files must reside in this directory (because the standard utilities expect them to be in those directories), these directories require special treatment in the client's virtual root.

The files **/etc/nodename** (not shared) and **/etc/chroot** (shared) will be used to illustrate how shared and non-shared files are handled in **/etc** and **/var**.

The **/etc/nodename** file is simply created as a real file in the client's virtual root under the **<virtual_rootpath>/etc** directory. The **<virtual_rootpath>/etc** directory is mounted on the diskless client under the **/etc** directory.

The **/etc/chroot** file is created in the client's virtual root not as a real file, but as a symbolic link to the file name **/shared/etc/chroot**. On the file server there is no such directory as **/shared**. On the client system, **/shared** is used as the mount point for mounting the file server's actual **/etc/** directory. Thus any reference on the diskless client to **/etc/chroot** will actually be referencing the **/etc/chroot** file that exists in the file server's **/etc** directory.



As new files are added and removed from the file server's **`/etc`** and **`/var`** directories, the symbolic links under the client's virtual root may become stale. The configuration utilities **`mkvmebstrap`** and **`mknetbstrap`** can be used to update the links in these directories to match the current state of the file server.

The directories **`/dev`** and **`/tmp`** are also created under the client's virtual root but do not share any files with the file server. Device files may have kernel dependencies and so these files are not shared. The directory **`/tmp`** is created as an empty directory.

Once the client system is up and running, the files in the memory-based root file system required for booting are no longer needed and are removed to free up memory.

Permission to access remote files on the file server is automatically granted. During client configuration, the **`dfstab(4)`** and **`dfstab.diskless`** tables are modified to allow a client either read or read/write access to files which reside on the file server.

The **dfstab.diskless** file is generated when the first client is configured. Sample entries from this file are listed below. These entries should not be modified.

```
share  -F  nfs  -o  ro,root=$CLIENTS            -d  "/etc/"   /etc   /shared/etc
share  -F  nfs  -o  ro,root=$CLIENTS            -d  "/dev/"   /dev   /shared/dev
share  -F  nfs  -o  rw=$CLIENTS,root=$CLIENTS  -d  "/var/"   /var   /shared/var
share  -F  nfs  -o  ro,root=$CLIENTS            -d  "/sbin/"  /sbin  /sbin
share  -F  nfs  -o  rw=$CLIENTS,root=$CLIENTS  -d  "/usr/"   /usr   /usr
share  -F  nfs  -o  rw=$CLIENTS,root=$CLIENTS  -d  "/opt/"   /opt   /opt
```

The **dfstab.diskless** file is referenced from a command line entry in **dfstab**, generated when the first client is configured. For every client configured thereafter, the client's name is added to the **CLIENTS** variable. For example, after configuring two clients, **named t1c1_vme** and **t2c1_vme**, the following line appears in the **dfstab** table.

```
CLIENTS=t2c1_vme:t1c1_vme /usr/sbin/shareall -F \
nfs /etc/dfs/dfstab.diskless
```

In addition, an entry to make each client's virtual root directory accessible is generated at configuration time. If a parent directory of the client's virtual root directory is already currently shared (has an entry in **sharetab(4)**), then the matching entry in **dfstab(4)**, if found, is modified to include the client in its `rw=` and `root=` attribute specifications. For example, if the virtual root directory for the client named **t1c1_vme** is in **/home/vroots/t1c1** and the **/home/vroots** directory is currently shared; then the sample entry below would be changed as shown below.

from:

```
/usr/sbin/share -F nfs   -d "/home/vroots" /home/vroots vroots
```

to:

```
/usr/sbin/share -F nfs -o root=t1c1_vme -d \
"/home/vroots" /home/vroots vroots
```

Note that there is no need to add an `rw=` attribute since, when not specified, it defaults to read/write access permissions to all.

If no entry is currently shared that covers the client's virtual root directory, a specific entry for each client is appended to the **dfstab.diskless** file. For example, for the client named **t1c1_vme**, whose virtual root directory is **/home/vroots/t1c1**, the following entry is generated:

```
/usr/sbin/share -F nfs -o rw=t1c1_vme,root=t1c1_vme -d \
"/home/vroots/t1c1" /home/vroots/t1c1 vroot
```

After the files are updated, the "**shareall -F nfs"** command is executed to update the file server's shared file system table.

When a client's configuration is removed, all references to the client and it's virtual root directory are removed from both the **dfstab** and **dfstab.diskless** files and the **shareall(1M)** command is executed to update the shared file system table.

1.4.7. Shared Memory

Closely-Coupled systems can be configured such that SBCs within the same VME cluster can share memory with each other in two ways. These methods are explained below. Refer to Chapter 3, Shared Memory and Appendix A both located in the *Closely-Coupled Programmers Guide*, for further information.

Slave MMAP

This interface allows **`mmap(2)`**, **`shmbind(2), read(2)`** and **`write(2)`** access to a shared memory area on each SBC configured with Slave MMAP support. In this shared memory implementation, each SBC with memory to share with other SBCs, maps it's own contiguous memory into a predefined VMEbus A32 address range. All memory mapped in this way is accessible simultaneously by all SBCs in the cluster.

Master MMAP (formerly called Master MMAP Type 2)

This interface allows **`mmap(2)`** and **`shmbind(2`**) access to any single contiguous VMEbus A32 address range, with the exception of the VMEbus A32 space used to map the local SBC's DRAM and the address range occupied by the Slave MMAP interface described above (i.e. you cannot access your own DRAM through this interface). The amount of external VMEbus address space that can be mapped is dependent on the amount of unassigned PCI memory space in the configured system. In some systems, 512MB (or more) of VMEbus A32 address space could be mapped in this manner. Only one Master MMAP interface can be defined on a given SBC.

1.4.8. Swap Space

Embedded systems generally do not have swap space. Nevertheless, some aspects of swap space configuration do affect even embedded systems, so this section should be read even for these users. In particular, every client system, NFS or embedded, should have the kernel tunable **`DISSWAPRES`** enabled. The meaning and consequences of this tunable are described later in this section.

Normal systems have a disk partition reserved for swap space. For diskless nfs clients, swap space is implemented using a regular file created in the client's virtual root directory and accessed over NFS. The size of the swap file is user-configurable.

Swap reservation space, referred to as 'virtual swap' space, is made up of the number of real memory pages that may be used for user space translations, plus the amount of secondary storage (disk) swap space available. Note that if no secondary storage swap space is available, then the amount of virtual swap space degenerates to the number of real memory pages available for user address space.

A virtual swap space reservation is made by decrementing the amount of available virtual swap space. If no virtual swap space is available, then the reservation will fail, and subsequently, either the page fault or segment create operation will not succeed. Virtual swap reservations are made so that as real memory becomes low, the pageout and process swap daemons can guarantee that there will be an appropriate number of user pages that can be swapped out to secondary storage and subsequently freed, in order to maintain an adequate level of free memory pages for new page allocations.

Even when there is no swap space configured into the kernel, the virtual swap reservations will prevent the kernel from overcommitting real memory to user pages that cannot be swapped and freed if and when the number of free real memory pages becomes low. If these daemons did not maintain an adequate number of free memory pages for page allocations, then applications might become blocked forever in the kernel, waiting for their page allocation requests (or internal kernel memory page allocation requests) to complete.

There are a number of possible swap space configurations on client systems:

1. no swap space	typically, this would be a client configured in Embedded mode
2. remote swap space	client would be configured as a NFS diskless system with the swap space accessed through the NFS subsystem
3. local disk swap space	client configured in either NFS or Embedded mode, client configured to use a local disk for swap space

When there is no swap space, or a small amount of swap space, it may be necessary to modify the default values of certain system tunables in order to maximize system performance and user virtual space capacities.

The following are some of the system tunables that are relevant to system swap space management in a system with little or no secondary storage swap space.

1. Systems with no swap space should be tuned such that process swapping does not become aggressively active before process growth is limited by virtual swap reservations, as this will impact system performance without providing significant amounts of additional free memory. The address space aging interval should also be increased.

   System tunables that govern the address space aging interval are:

   INIT_AGEQUANTUM
   MIN_AGEQUANTUM
   MAX_AGEQUANTUM
   LO_GROW_RATE
   HI_GROW_RATE

   In order to ensure longer address space aging intervals, all of these tunables may be set to a higher than default value.

2. The **GPGSLO** tunable value can be decreased in order to lower the free memory level at which process swapping will become aggressively active.

3. The **DISSWAPRES** tunable disables virtual swap reservations by setting the amount of available virtual swap space to an artificially large value.

   The **DISSWAPRES** tunable allows more user page identities/objects to be created than what can be accommodated for in virtual swap space. Since typically, applications do not tend to access all the pages that may potentially be considered writable (and therefore require a virtual swap reservation), this tunable may allow for a larger number of applications to run simultaneously on a system by not requiring virtual swap space for every potentially writable user page.

However, when the **DISSWAPRES** tunable is enabled, it becomes possible for page allocations to block forever, since the pageout and process swap daemons may not be able to swap out an adequate number of user pages in order to free up pages for additional allocations. At this point, the system will enter a state where little or no useful work is being accomplished. Therefore, caution is advised when using the **DISSWAPRES** tunable.

The **DISSWAPRES** tunable may be useful when a fixed set of applications and their corresponding virtual address space working sets are known to fit into the amount of available real memory (and secondary storage swap space, if any), even though their total virtual swap space requirements exceed the system's virtual swap space capacity.

1.5. Configuring Diskless Systems

1.5.1. Closely-Coupled System Hardware Prerequisites

A Closely-Coupled VME cluster requires the following hardware:

- VME card chassis
- One host Power Hawk single board computer: (minimum of 32 MB of DRAM)
- One Power Hawk single board computer: (minimum of 32 MB of DRAM) for each desired client system.
- A minimum of one transition module. Note that a second transition module is recommended so that a console terminal can be attached to diskless SBCs for debug purposes.
- One SCSI 2 GB (4 GB preferred) disk drive for PowerMAX OS^{TM} software installation
- SCSI tape drive for software installation
- One console terminal

A Closely-Coupled remote cluster requires the following:

- a remote file server single board computer
- VME card chassis
- One Power Hawk single-board computer (minimum of 32 MB of DRAM) for each desired remote client system.
- An appropriate Ethernet interconnect (for example, multiport hub) with cabling to connect local cluster and all remote clusters

1.5.2. Loosely-Coupled System Hardware Prerequisites

A loosely-coupled configuration requires the following hardware:

- a card chassis
- One host single board computer: (minimum of 32 MB of DRAM)
- One single board computer: (minimum of 32 MB of DRAM) for each desired client system.
- A minimum of one transition module. Note that a second transition module is recommended so that a console terminal can be attached to diskless SBCs for debug purposes.
- One SCSI 2 GB (4 GB preferred) disk drive for PowerMAX OS^{TM} software installation
- SCSI tape drive for software installation
- One console terminal
- An appropriate Ethernet interconnect (for example, multiport hub) with cabling to connect local cluster and all remote clusters

1.5.3. Disk Space Requirements

The table below details the amount of available disk space required per client single board computer for the virtual root partition. These values are for the default shipped configuration. Added applications may increase disk space requirements. Values in this table do not include swap space for the diskless system. The amount of swap space is configurable, but should be at least one and one-half times the size of physical memory on the single board computer.

Also note that the boot images of remote clients configured to vmeboot are stored in the virtual root directory of the bootserver of the cluster. Therefore, clients serving as bootservers of remote clusters require more disk space in their virtual root partitions. The additional disk space can be calculated as the number of clients in the remote cluster configured to vmeboot multiplied times the boot image size. The default compressed boot image is approximately 3.5 megabytes.

A client's virtual root directory can be generated in any disk partition on the file server. The **`/(root)`** and **`/var`** file systems are not recommended for use as client virtual partitions..

Client Configuration	Disk Space
NFS	25 Megabytes
Embedded	15 Megabytes

1.5.4. Software Prerequisites

The following software packages must be installed on the host system prior to installing the cluster package (prerequisite packages listed alphabetically by package name):

Package Name	**Package Description**	**Package Dependencies (See note)**
base	Base System (Release 4.3 or later)	
cmds	Advanced Commands	lp, nsu
dec	DEC Ethernet Driver	nsu
dfs	Distributed File System Utilities	inet
inet	Internet Utilities	nsu
lp	Printer Support	
ncr	Internal NCR SCSI Driver	
netcmds	Commands Networking Extension	lp, inet
nfs	Network File System Utilities	nsu, inet, rpc, dfs
nsu	Network Support Utilities	
rpc	Remote Procedure Call Utilities	inet
Note: All packages are dependent on base package		

1.6. Installation Guidelines

The following instructions assume that all the prerequisite hardware has been installed. For details, see “Hardware Prerequisites” and depending on your SBC board type, refer to one of the following chapters:

- Chapter 2, MTX SBC Hardware Considerations
- Chapter 3, VME SBC Hardware Considerations
- Chapter 4, MCP750 Hardware Considerations

1.7. Licensing Information

The system installed on the file server carries a license for the number of processors allowed to be booted. The license also carries a limit for the number of users allowed to log on to the file server. All diskless client SBCs are limited to a maximum of 2 users each.

To print the processor and user limits set for your machine, use the **`-g`** option of the **`keyadm(1M)`** command.

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MTX SBC Hardware Considerations

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2
MTX SBC Hardware Considerations

2.1. Introduction

This chapter provides hardware preparation, installation instructions and general operating information. The MTX Single Board Computers (SBCs) including optional PMC or PCI adapter boards, can be packaged in various chassis configurations depending on end-user application requirements.

Refer to the applicable Motorola MTX Series Installation and Use Manual for more detailed information on hardware considerations that may be applicable to your particular hardware configuration. Refer to the Preface of this manual for specific manual titles, document numbers, and Motorola's web site address to access documents online.

NOTE

MTX boards come with a variety of minor differences. Unless otherwise stated, all the information provided in this chapter is generally applicable to all variations of MTX boards. However, please reference the applicable online documents for a complete description of the MTX604-070 family of motherboards (sometimes referred to as "MTX II" in this manual).

CAUTION

Avoid touching areas of integrated circuitry; static discharge can damage circuits.

Concurrent strongly recommends that you use an antistatic wrist strap and a conductive foam pad when installing or upgrading a system. Electronic components, such as disk drive, computer boards, and memory modules, can be extremely sensitive to Electrostatic Discharge (ESD). After removing the component from the system or its protective wrapper, place the component flat on a grounded, static-free surface (and in the case of a board, component side up). Do not slide the component over any surface.

If an ESD station is not available, you can avoid damage resulting from ESD by wearing an antistatic strap (available at electronic stores) that is attached to an unpainted metal part of the system chassis.

2.2. Unpacking Instructions

NOTE

If the shipping container is damaged upon receipt, request that the carrier's agent be present during unpacking and inspection of the equipment.

Unpack the equipment from the shipping container. Refer to the packing list and verify that all items are present. Save the packing material for storing and reshipping of the equipment.

2.3. Hardware Configuration

In order to produce the desired system configuration and ensure proper operation of the MTX, you may need to perform certain hardware modifications before installing the module.

The MTX provides software control over most options. These options are described in detail in the applicable Motorola *MTX Series Programmer's Reference Guide.*

Some options are not software-programmable. These options are controlled through manual installation or removal of header jumpers.

2.4. MTX Motherboard Preparation

NOTE

Refer to the applicable Motorola *MTX Series Installation and Use Manual* for complete description of your specific MTX/MTX II motherboard. (The MTX II motherboard is not illustrated herein.)

Figure 2-1 shows the location of the switches, jumper headers, connectors, and LED indicators on the MTX. Manually configurable items on the motherboard include:

- Cache mode control (J15) (J5 on MTX II board)
- Flash bank selection (J37) (J24 on MTX II board)
- Power Control for power supply (J27) (J19/J20 on MTX II board)
- Hardware/firmware disable of SCSI (J36) (J21 on MTX II board)

The MTX Motherboard is shipped with the factory settings described in the following sections. The debug monitor, **PPCBug**, operates with those settings.

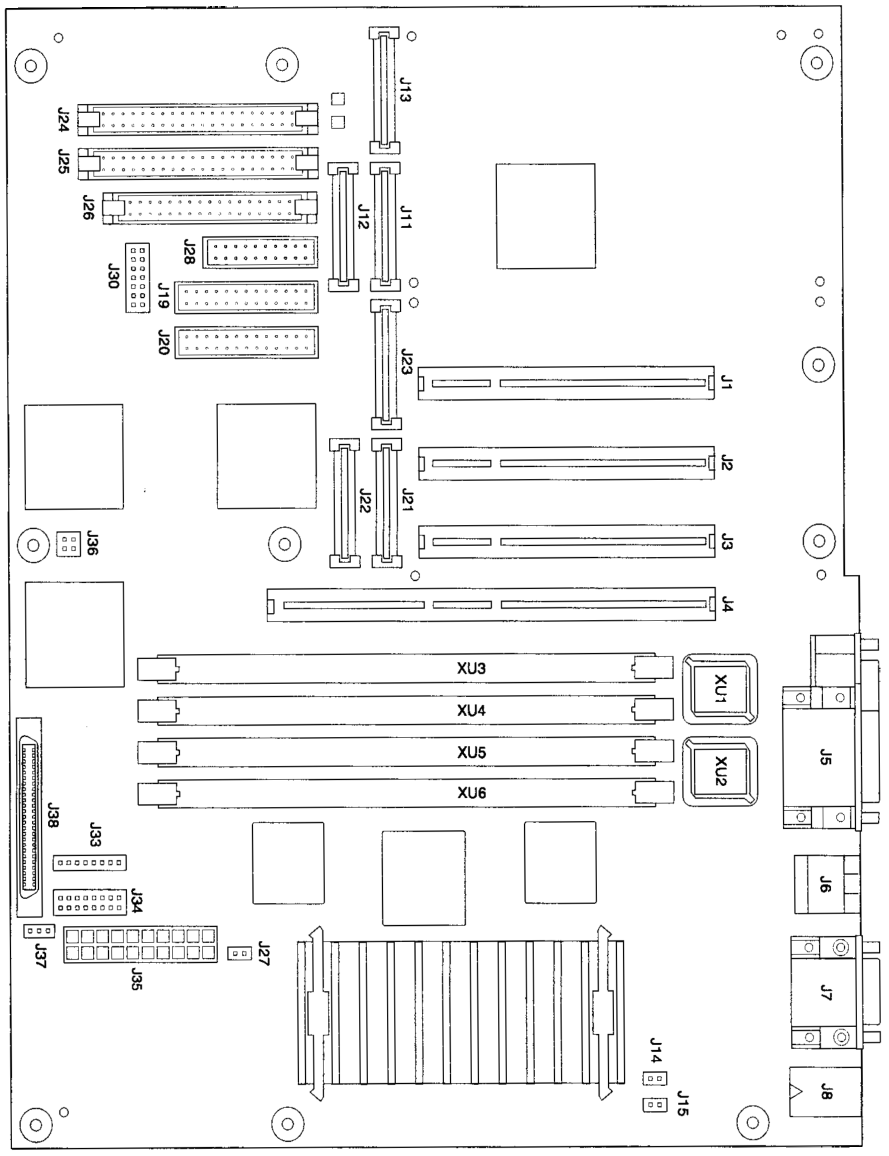

Figure 2-1. MTX Motherboard Component Locations

2.4.1. Cache Mode Control (J15)

If the optional L2 cache is provided on the MTX motherboard, the Cache Mode Control setting for header J15 (J5 on MTX II boards) is shown in Figure 2-2. For normal operation, jumper J15 should be left off (open).

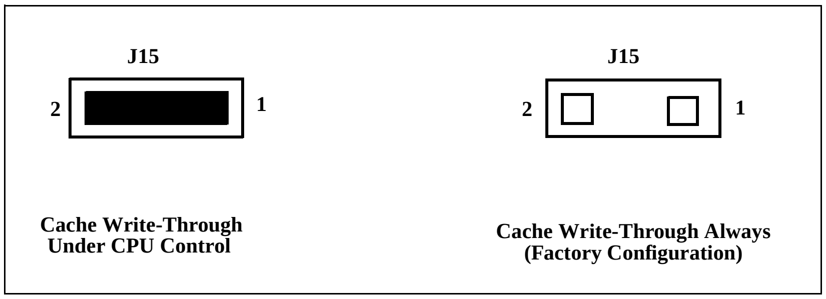

Figure 2-2. Cache Mode Control (J15)

2.5. Flash Bank Selection (J37)

The MTX motherboard contains two banks of FLASH memory. To enable Flash Bank A, place jumper across header J37 (Figure 2-3) pins 1 and 2. To enable Flash Bank B, place jumper across header J37 pins 2 and 3. Bank B must be selected if the board is to be configured for Flash Booting of a PowerMAX OS boot image. (J24 is the applicable connector on the MTX II board.)

Note

Before changing jumper **J37**, first verify that the selected Flash memory has a copy of **`PPCBug`**. This can be accomplished by powering up the system and use the **`md`** command to verify that the contents of the two Flash memories are the same. (Refer to Chapter 7 for an example.)

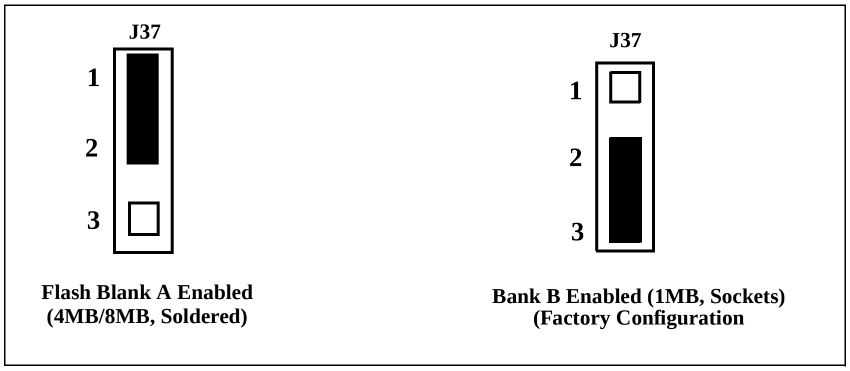

Figure 2-3. Flash Bank Selection (J37)

2.5.1. Power Control for ATX Power Supply (J27)

The MTX motherboard supports remote control of an ATX power supply (if supplied) by the use of two-pin header J27 (J19/J20 on MTX II board). Connecting pin J21-1 to J27-2 will connect the power supply PS-ON signal to ground allowing the power supply to supply power to the board.

2.5.2. Hardware/Firmware Disable of SCSI (J36)

Jumper J36 (Figure 2-4) is used to disable on-board SCSI terminators and to disable the firmware negotiation of UltraSCSI. To disable on-board SCSI terminators connect a jumper from J36-1 to J36-2. To disable firmware negotiation of UltraSCSI connect a jumper from J36-3 to J36-4. (J21 is the applicable connector on the MTX II board.)

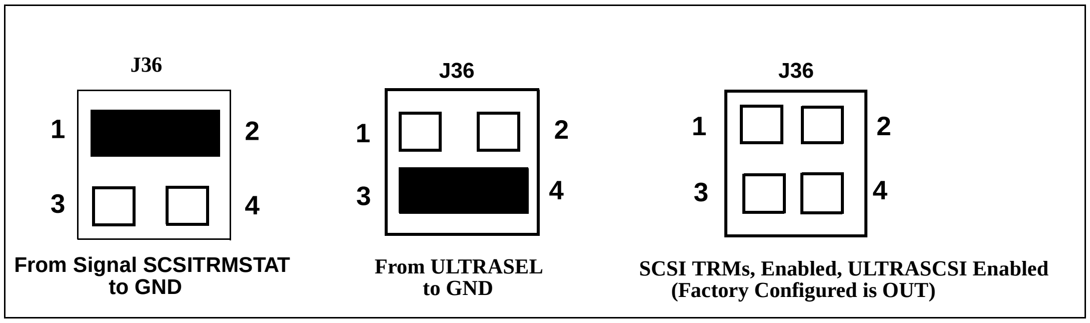

Figure 2-4. Hardware/Firmware Disable of SCSI (J36)

2.5.3. Remote Status and Control

For testing purposes, the MTX front panel LEDs and switches are mounted on a removable mezzanine board. Removing the LED mezzanine board makes the mezzanine connector (J30, a keyed double-row 14-pin connector) available for service as a remote status and control connector. In this application, J30 can be connected to a user-supplied external cable (15 feet max.) to carry the Reset and Abort signals and the LED lines to a control panel located apart from the MTX.

2.6. Hardware Installation

The following sections describe the installation of mezzanine or adapter cards on the MTX motherboard, the installation of the complete MTX assembly into a chassis enclosure, and the system considerations important to the installation. Before installing the MTX, be certain that all header jumpers are configured as desired.

2.7. DIMM Memory Installation

DIMM modules install into sockets XU3 through XU6 on the MTX motherboard (XU1 through XU4 on MTX II). To upgrade or install DIMM modules, refer to Figure 2-5 and proceed as follows:

1. Attach an ESD strap to your wrist. Attach the other end of the strap to the chassis as a ground. The ESD strap must remain on your wrist and connected to ground throughout the entire procedure
2. Do an operating system shutdown. Turn off AC and/or DC power and remove the AC and/or DC power lines from the system. Remove chassis or system covers(s) as necessary for access to the motherboard.

Cautions

1. Removing modules with power on may result in damage to module components.
2. Avoid touching areas of integrated circuits; static discharge can damage these circuits.

Warning

Dangerous voltages capable of causing death are present in this equipment. Exercise extreme caution when handling, testing, and adjusting.

3. Install the DIMM into XU3 through XU6 as needed, with pin 1 of the DIMM located at the rear of the motherboard (toward the external I/O connectors). Note that the DIMMs must be installed in pairs, XU5 with XU6 (XU3 with XU4 on MTX II), or XU3 with XU4 (XU1 with XU2 on MTX II), and that at least one pair of DIMMS is required for MTX operation. Load XU3/XU4 first.

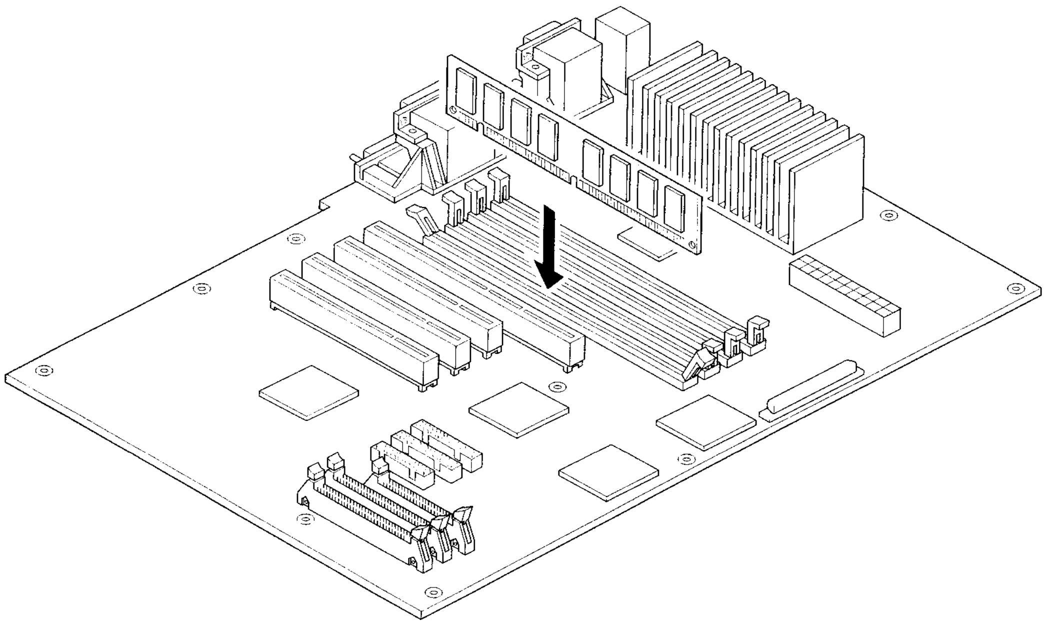

Figure 2-5. DIMM Placement on MTX

2.8. PCI Adapter Installation

PCI adapter boards mount to connectors J1 through J3 on the MTX motherboard (J31 through J37 on MTX II). To install PCI adapters, refer to Figure 2-6 and proceed as follows:

1. Attach an ESD strap to your wrist. Attach the other end of the strap to the chassis as a ground. The ESD strap must remain on your wrist and connected to ground throughout the entire procedure
2. Do an operating system shutdown. Turn off AC and/or DC power and remove the AC and/or DC power lines from the system. Remove chassis or system covers(s) as necessary for access to the motherboard.

Caution

1. Removing modules with power on may result in damage to module components.

Warning

Dangerous voltages capable of causing death are present in this equipment. Exercise extreme caution when handling, testing, and adjusting.

3. Remove the PCI filler from the chassis.

Caution

Avoid touching areas of integrated circuits; static discharge can damage these circuits.

4. Install the PCI adapter card into slots J1 through J3 (J31 through J37 on MTX II).

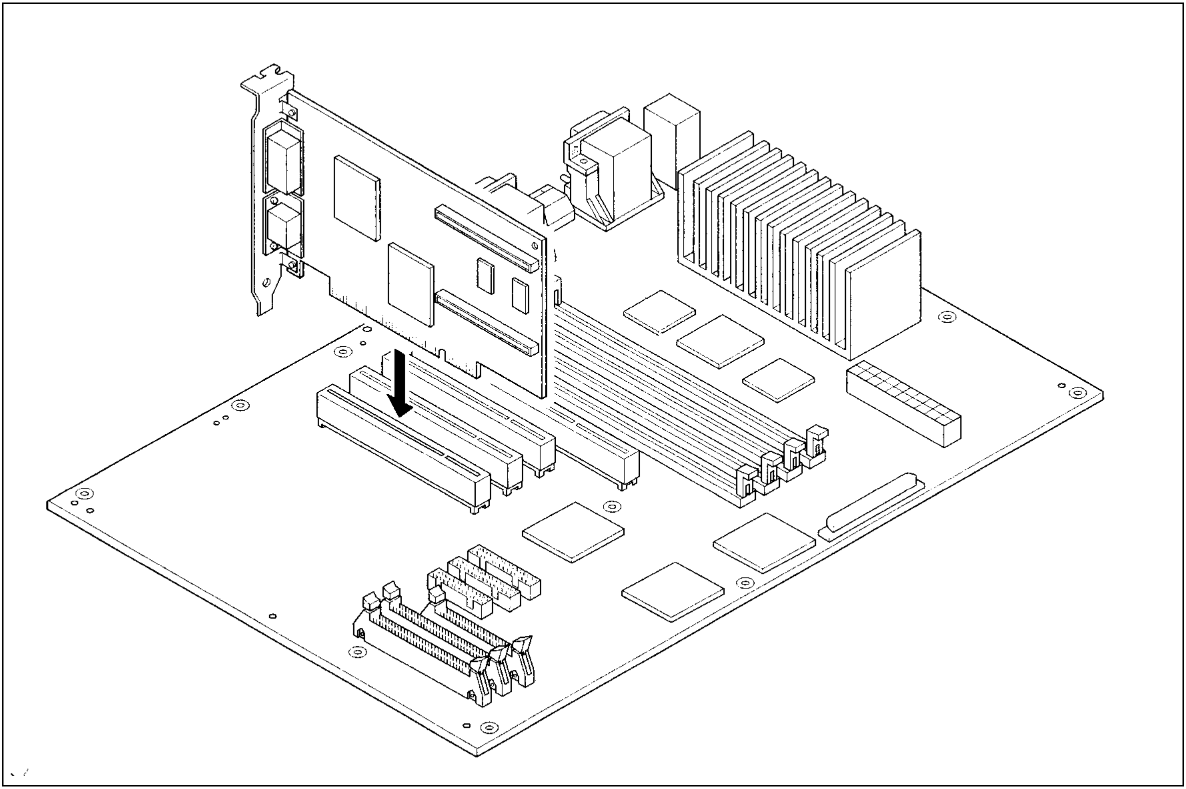

Figure 2-6. PCI Adapter Card Placement on MTX

2.9. PMC Module Installation

PCI mezzanine card (PMC) modules mount to connectors J11, J12 and J13, or J21, J22 and J23 on selected models of the MTX motherboard (not available on MTX II board). To install a PMC module, refer to Figure 2-7 and proceed as follows:

1. Attach an ESD strap to your wrist. Attach the other end of the strap to the chassis as a ground. The ESD strap must remain on your wrist and connected to ground throughout the entire procedure
2. Do an operating system shutdown. Turn off AC and/or DC power and remove the AC and/or DC power lines from the system. Remove chassis or system covers(s) as necessary for access to the motherboard.

Caution

Removing modules with power on may result in damage to module components.

Warning

Dangerous voltages capable of causing death are present in this equipment. Exercise extreme caution when handling, testing, and adjusting.

3. Carefully remove the MTX from the chassis and lay it flat.

Caution

Avoid touching areas of integrated circuits; static discharge can damage these circuits.

4. Remove the PMC filler from the rear panel of the chassis.
5. Place the PMC module on top of the motherboard. The connector on the underside of the PMC module should then connect smoothly with the corresponding connectors (either J11/12/13 or J21/J22/J23) on the MTX.
6. Insert the two short Phillip screws through the holes at the forward corners of the PMC module from the backside of the MTX motherboard, into the standoffs on the PMC module. Tighten the screws.
7. Reinstall the MTX assembly into the chassis.
8. Replace the chassis or system cover(s), reconnect the system to the AC or DC power source, and turn on the power to the system.

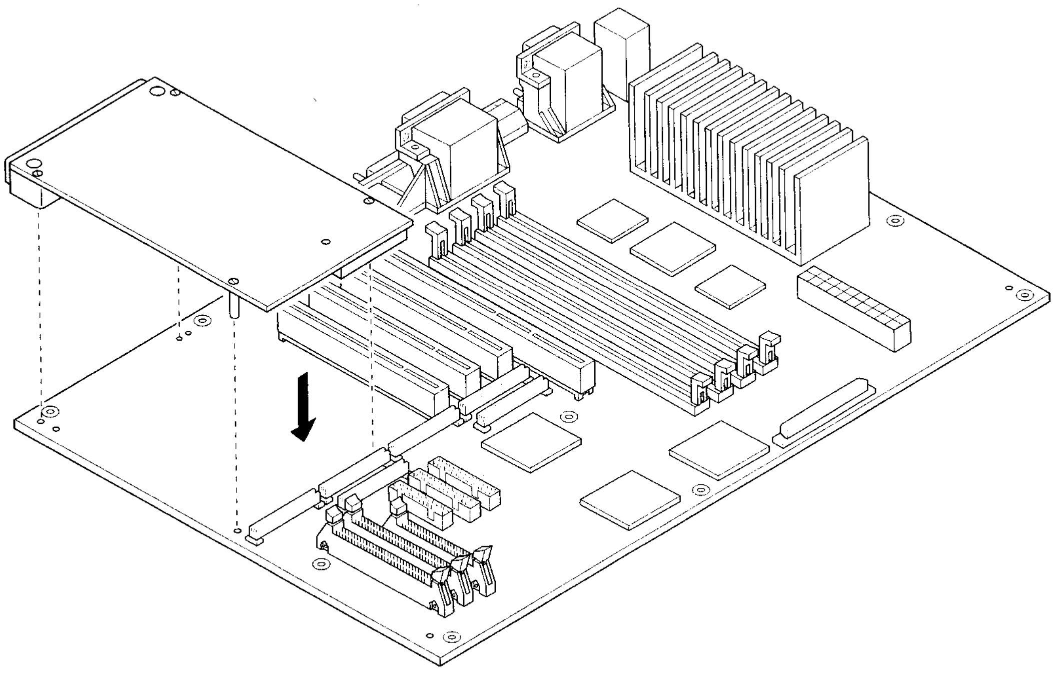

Figure 2-7. PMC Module Placement on MTX

2.10. MTX Motherboard Installation

With PCI or PMC boards(s) installed (if required) and headers properly configured, proceed as follows to install the MTX in the chassis.

1. Attach an ESD strap to your wrist. Attach the other end of the strap to the chassis as a ground. The ESD strap must remain on your wrist and connected to ground throughout the entire procedure
2. Do an operating system shutdown. Turn off AC and/or DC power and remove the AC and/or DC power lines from the system. Remove chassis or system covers(s) as necessary for access to the motherboard.

Caution

Removing modules with power on may result in damage to module components.

Warning

Dangerous voltages capable of causing death are present in this equipment. Exercise extreme caution when handling, testing, and adjusting.

3. Install standoffs provided with the chassis in locations aligning with the MTX motherboard mounting holes. Use as many screw-down metal standoffs as possible.

Caution

Avoid touching areas of integrated circuits; static discharge can damage these circuits.

4. Secure the MTX in the chassis with the screws provided.
5. Install jackposts on the rear panel COM2 and parallel port connectors.
6. Replace the chassis or system cover(s), making sure no cables are pinched. Cable the peripherals to the panel connectors, reconnect the system to the AC or DC power source, and turn on the power to the system.

2.10.1. MTX Motherboard

Fused +5V dc power is supplied to the keyboard and mouse connector through a polyswitch and to the 14-pin combined LED-mezzanine/remote-reset connector, J30.

The MTX motherboard supplies a SPEAKER_OUT signal to the 14-pin combined LED-mezzanine/remote-reset connector, J30. When J30 is used as a remote reset connector with the LED-mezzanine removed, the SPEAKER_OUT signal can be cabled to an external speaker.

On the MTX motherboard, the standard serial DTE port (COM1) serves as the PPCBug debugger console port. The firmware console should be set up for initial power-up as follows:

- Eight bits per character
- One stop bit per character
- Parity disabled (no parity)
- Baud rate of 9600 baud

After power-up you can change the baud rate if necessary, using the PPCBug **PF** (Port Format) command via the command line interface. Whatever the baud rate, some type of handshaking -- either XON/OFF or via the RTS/CTS line--is necessary if the system supports it.

2.11. MTX Series Connectors

2.11.1. Front Panel Function Header

Table 2-1. Front Panel Function Header

Signal Name	Pin #	Pin #	Signal Name
GND	1	2	RESETSW_L
NO CONNECT	3	4	ABPRTSW_L
PCILED_L	5	6	FAILLED_L
NO CONNECT	7	8	STATLED_L
SBSYLED_L	9	10	RUNLED_L
EIDELED	11	12	LANLED_L
+5V_LED	13	14	SPEAKER

2.11.2. Rear Panel Keyboard/Mouse Connectors

The Keyboard and Mouse connectors are 6-pin circular DIN connectors located on the rear panel of the MTX. The pin assignments for the Keyboard and Mouse connectors are shown inTable 2-2.

Table 2-2. Keyboard/Mouse Conn. Pin Assign'mt

Pin #	Keyboard Connector Signal Name	Mouse Connector Signal Name
1	KADA	MDATA
2	NO CONNECT	NO CONNECT
3	GND	GND
4	+5VF	+5VF
5	KCLK	MCLK
6	NO CONNECT	NO CONNECT

2.11.3. 10BaseT/100BaseT Connector

The 10BaseT/100BaseT connection is an RJ45 connector (two connectors on MTX II Board) located on the rear panel of the Transition Module. The pin assignment for this connector is shown in Table 2-3.

Table 2-3. 10/100BaseT Conn. Pin Assign'mt

Pin #	Signal Name
1	TD+
2	TD+
3	RD+
4	Common Mode Termination
5	Common Mode Termination
6	RD-
7	Common Mode Termination
8	Common Mode Termination

2.11.4. AUI Connector

The AUI connector is a 15-pin connector located on the rear panel (not available on MTX II board). The pin assignments for this connector are shown in Table 2-4.

Table 2-4. AUI Conn. Pin Assign'mt

Pin #	Signal Name
1	GND
2	C+
3	T+
4	GND
5	R+
6	GND
7	No Connect
8	GND
9	C-
10	T-
11	GND
12	R-

Table 2-4. AUI Conn. Pin Assign'mt (Cont.)

13	GND
14	+12VF
15	GND

2.11.5. Serial Ports 1 and 2 Connectors

Planar headers provide the interface to Serial Ports 1 (COM1) and 2 (COM2). The pin assignments for these headers is shown in Table 2-5

Table 2-5. Serial Ports 1/2 Pin Assign'mts

Pin #	Signal Name
1	DCD
2	RXD
3	TXD
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

2.11.6. Power Connector

The MTX power connector is a 20-pin connector compatible with the ATX specified Molex. Pin assignments are shown in Table 2-6.

Table 2-6. Power Conn. Pin Assign'mts

Pin #	Signal Name
1	NC
2	NC
3	GND
4	+5.0V
5	GND

Table 2-6. Power Conn. Pin Assign'mts (Cont.)

6	+5.0V
7	GND
8	PW-OK
9	NC
10	+12.0V
11	NC
12	-12.0V
13	GND
14	PS-ON
15	GND
16	GND
17	GND
18	NC
19	+5.0V
20	+5.OV

2.12. Reset Button

Some systems make available a **RESET** button. Depressing this button resets the SBC in much the same manner that a powerup does. **`PPCBug`** is entered and the initialization code is executed.

Chapter 3
VME SBC Hardware Considerations

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3
VME SBC Hardware Considerations

3.1. Introduction

This chapter provides hardware preparation, installation instructions and general operating information. The Single Board Computers (SBCs) including other VME modules, can be packaged in various VME chassis configurations depending on end-user application requirements. The chassis can vary in the number of slots available, and also, may be either rack-mount or desk top versions.

Refer to either the *Motorola MVME2600 Series Single Board Computer Installation and Use Manual* or *Motorola MVME4600 VME Processor Module Installation and Use Manual* for more detailed information on hardware considerations that may be applicable to your particular hardware configuration. Refer to the Preface of this manual for specific manual titles, document numbers, and Motorola's web site address to access documents online.

NOTE

Unless otherwise stated, this chapter applies to both the MVME2604 and MVME4604 base boards.

CAUTION

Avoid touching areas of integrated circuitry; static discharge can damage circuits.

Concurrent strongly recommends that you use an antistatic wrist strap and a conductive foam pad when installing or upgrading a system. Electronic components, such as disk drive, computer boards, and memory modules, can be extremely sensitive to Electrostatic Discharge (ESD). After removing the component from the system or its protective wrapper, place the component flat on a grounded, static-free surface (and in the case of a board, component side up). Do not slide the component over any surface.

If an ESD station is not available, you can avoid damage resulting from ESD by wearing an antistatic strap (available at electronic stores) that is attached to an unpainted metal part of the system chassis.

3.2. Unpacking Instructions

NOTE

If the shipping container is damaged upon receipt, request that the carrier’s agent be present during unpacking and inspection of the equipment.

Unpack the equipment from the shipping container. Refer to the packing list and verify that all items are present. Save the packing material for storing and reshipping of the equipment.

3.3. Backplane Daisy-Chain Jumpers

A daisy-chain mechanism is used to propagate the BUS GRANT (BG) and INTERRUPT ACKNOWLEDGE (IACK) signals in the backplane. Certain backplanes utilized in the Loosely-Coupled and MediaHawk products have an “autojumpering” feature for automatic propagation of the BG and IACK signals. Typically, the 21-slot VME chassis has the autojumpering feature. The 12-slot VME chassis is available in two versions; with autojumpering and without autojumpering.

The following information is only applicable to the 12-slot VME chassis without autojumpering. Note that backplane daisy-chain jumpers normally are shipped with the chassis. The following procedure should be followed when installing additional VMEmodules:

1. Ensure that the power is turned off to avoid damage to the equipment.
2. At the front or rear of the backplane, select the row(s) of header pins that require jumpers. See Figure 3-1 for location of headers. Also refer to Table 3-1 for supporting information. Any backplane slot that will not be occupied by a VMEmodule requires jumpers on the front or rear backplane pins to propagate the BG and IACK signals to the next slot that is occupied by a VMEmodule. Jumpers are not required if no additional VMEmodules will be installed to the right (viewed from front) of an occupied slot.

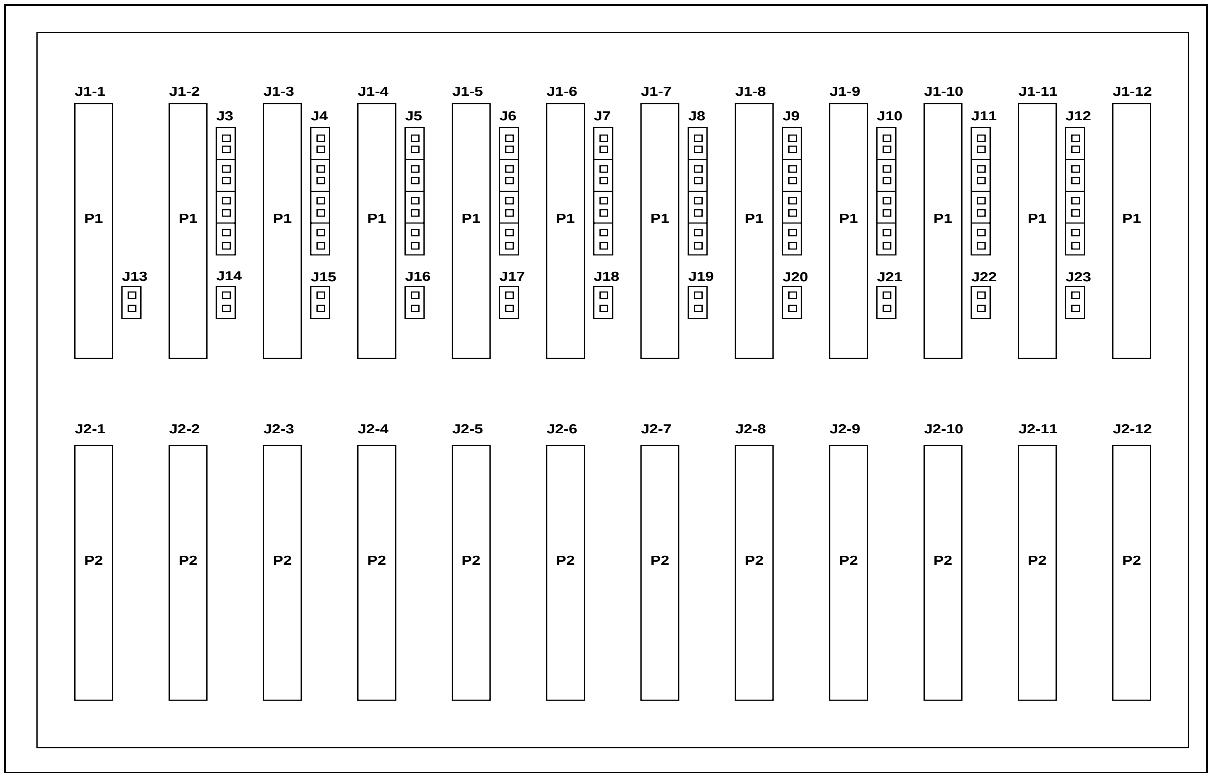

Figure 3-1. 12-Slot Chassis Backplane

Table 3-1. 12-Slot Chassis Backplane Headers

SLOT NO.	P1	BUS GRANT HEADER	IACK HEADER
1	J1-1	None	J13
2	J1-2	J3	J14
3	J1-3	J4	J15
4	J1-4	J5	J16
5	J1-5	J6	J17
6	J1-6	J7	J18
7	J1-7	J8	J19
8	J1-8	J9	J20
9	J1-9	J10	J21

Table 3-1. 12-Slot Chassis Backplane Headers

SLOT NO.	P1	BUS GRANT HEADER	IACK HEADER
10	J1-10	J11	J22
11	J1-11	J12	J23
12	J1-12	None	None

3.4. MVME2604 Base Board Preparation

Figure 3-2 shows the location of the switches, jumper headers, connectors, and LED indicators on the MVME2604. The only manually configurable items on the base board that needs to be discussed at this time are the VMEbus system controller selection jumpers at J22 and the Flash Bank selection jumpers at J10.

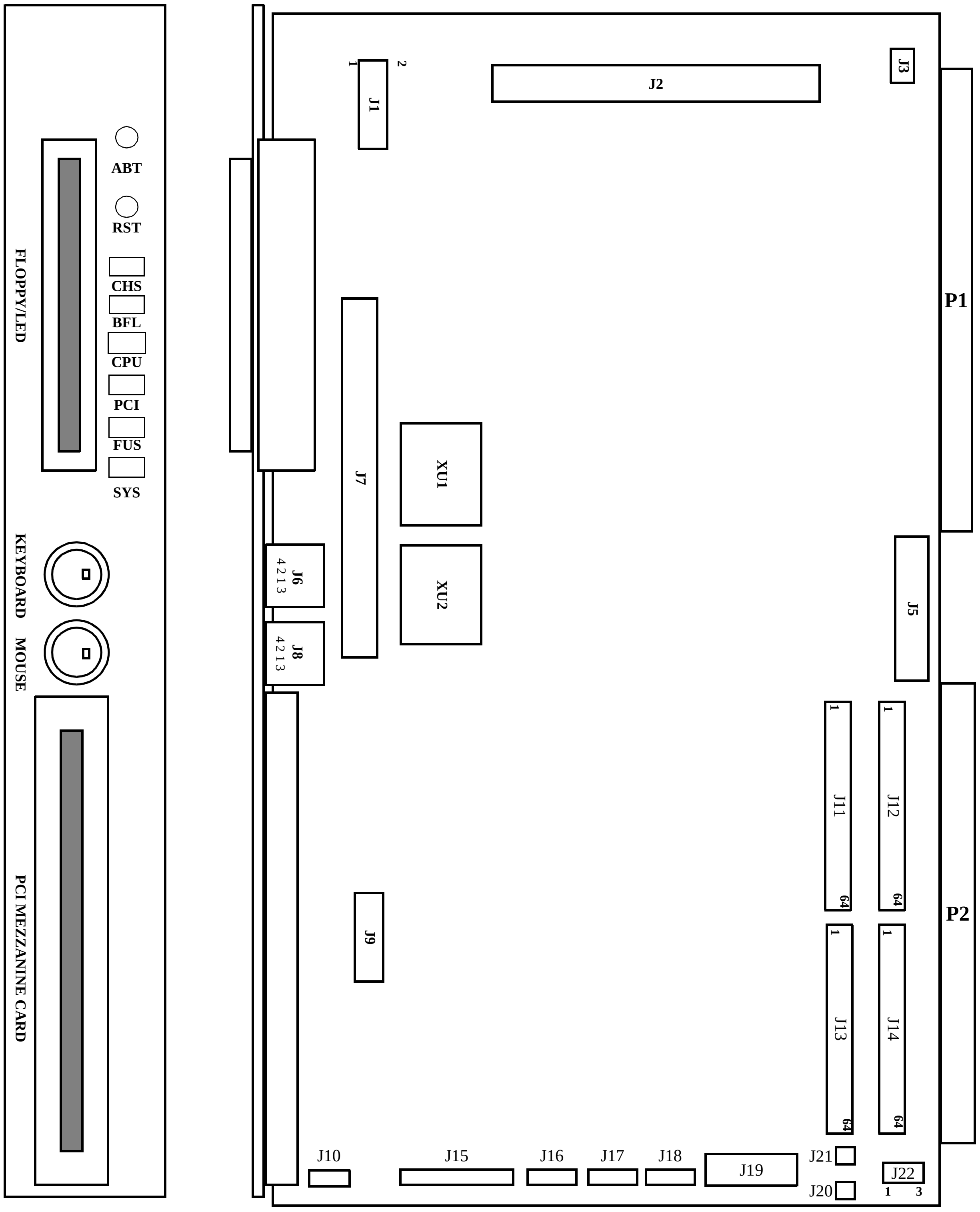

Figure 3-2. MVME2604 Component Locations

3.4.1. VMEbus System Controller Selection (J22)

The MVME2604 is factory-configured in "automatic" system controller mode (i.e. a jumper is installed across pins 2 and 3 of base board header J22 as shown in Figure 3-3).

The SBC board in each VME chassis must be configured as a "System Controller" by removing the jumper across header J22 pins 2 and 3 (header J22 must have <u>no</u> jumper installed).

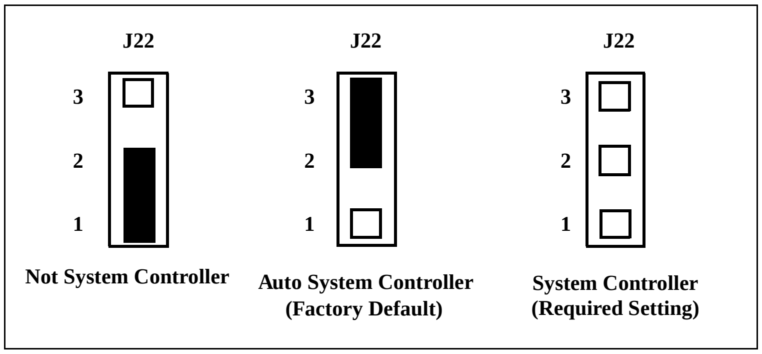

Figure 3-3. VMEbus System Controller Selection (J22)

3.4.2. Flash Bank Selector (J10)

The MVME2604 base board has provision for 1MB of 16-bit-wide Flash memory. The RAM200 memory mezzanine accommodates 4MB or 8MB of additional 64-bit-wide Flash memory.

The Flash memory is organized in either one or two banks, each bank either 16 or 64 bits wide. Both banks <u>should</u> contain the onboard debugger, **`PPCBug`**. If they do not, changing this jumper will cause the system to fail to boot. Refer to Chapter 7 for an example on how to verify and correct this condition, if necessary.

To enable Flash bank A (4MB or 8MB of firmware resident on soldered-in devices on the RAM200 mezzanine), place a jumper across header J10 pins 1 and 2 as shown in Figure 3-4. To enable Flash bank B (1MB of firmware located in sockets on the base board), place a jumper across header J10 pins 2 and 3 as shown in Figure 3-4. The factory configuration uses Flash bank A.

Flash Bank B must be enabled if a PowerMAX OS image will eventually be installed into Flash.

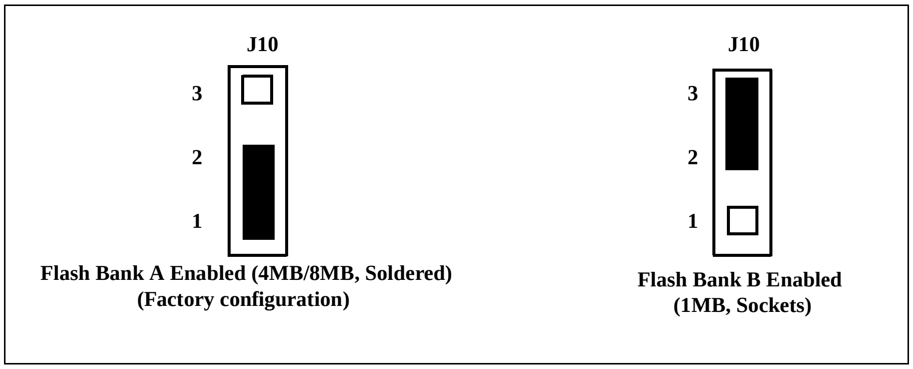

Figure 3-4. MVME2604 Flash Bank Selector (J10)

3.5. MVME4604 Base Board Preparation

Figure 3-5 shows the location of the switches, jumper headers, connectors, and LED indicators on the MVME4604. The only manually configurable items on the base board that needs to be discussed at this time are the VMEbus system controller selection jumpers at J5 and the Flash Bank selection jumpers at J2.

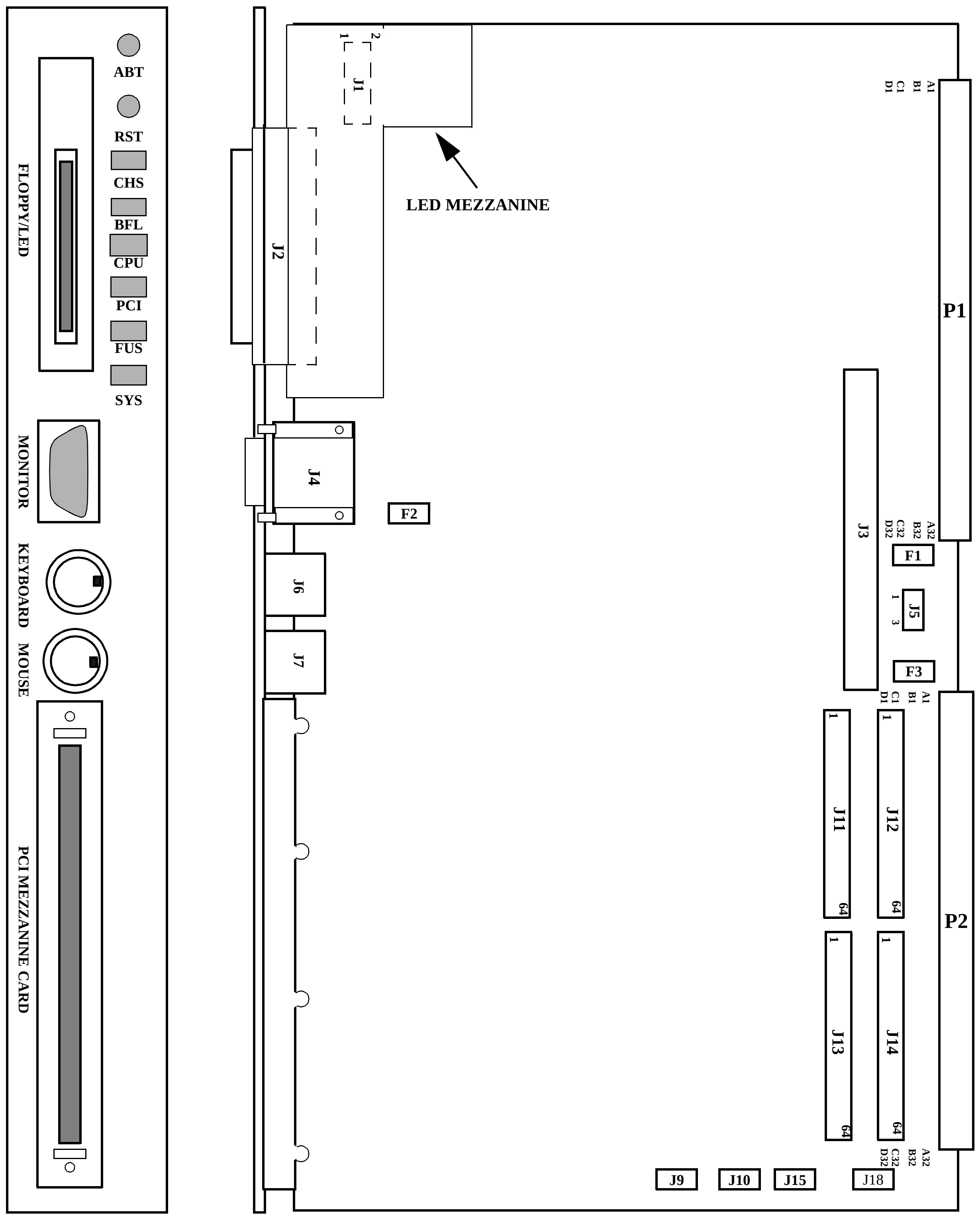

Figure 3-5. MVME4604 Component Locations

3.5.1. VMEbus System Controller Selection (J5)

The MVME4604 is factory-configured as an autoselective VMEbus system controller (i.e. a jumper is installed across pins 2 and 3 of base board header J5 as shown in Figure 3-6).

The SBC board in each VME chassis must be configured as a “System Controller” by removing the jumper across header J5 pins 2 and 3 (header J5 must have no jumper installed).

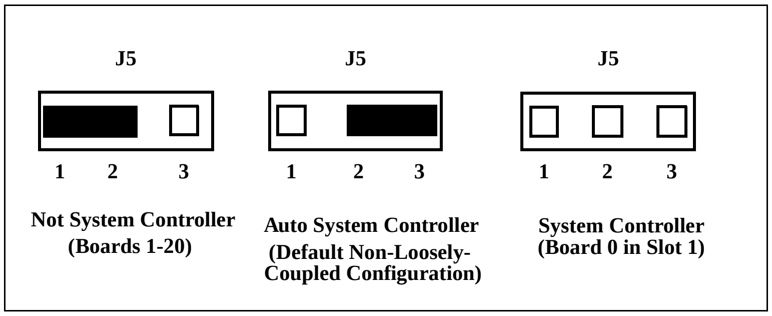
J5
1 2 3
Not System Controller (Boards 1-20)
J5
1 2 3
Auto System Controller (Default Non-Loosely-Coupled Configuration)
J5
1 2 3
System Controller (Board 0 in Slot 1)

Figure 3-6. VMEbus System Controller Selection (J5)

3.5.2. Flash Bank Selection (J2)

The MVME4604 series processor/memory mezzanine has provision for 1MB of 16-bit-wide Flash memory for the onboard firmware (or for customer-specific applications). In addition, it accommodates 4MB or 8MB of 64-bit-wide Flash memory specifically for customer use.

The Flash memory is organized in either one or two banks, each bank either 16 or 64 bits wide. Both banks should contain the onboard debugger, **`PPCBug`**. If they do not, changing this jumper will cause the system to fail to boot. Refer to Chapter 7 for an example on how to verify and correct this condition if necessary.

To enable Flash bank A (4MB or 8MB of firmware resident on soldered-in devices on the processor/mezzanine), place a jumper across header J2 pins 1 and 2 as shown in Figure 3-7. To enable Flash bank B (1MB of firmware located in sockets on the processor/memory mezzanine), place a jumper across header J2 pins 2 and 3 as shown in Figure 3-7. The factory configuration uses Flash bank A.

Flash Bank B must be enabled if a PowerMAX OS image will eventually be installed into Flash “A”.

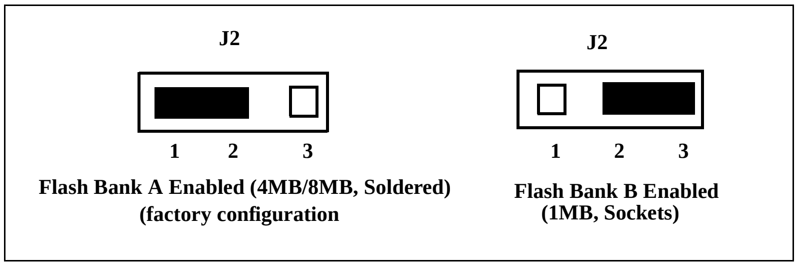

Figure 3-7. MVME4604 Flash Bank Selector (J2)

3.6. MVME761 Transition Module Preparation

The MVME761 transition module is used in conjunction with the MVME2604/ MVME4604 base boards. Figure 3-8 shows the placement of the switches, jumper headers, connectors, and LED indicators on the MVME761 module.

3.6.1. Configuration of Serial Ports 1 and 2

On the MVME761-compatible base boards (both the MVME2604 and the MVME4604) the asynchronous serial ports (Serial Ports 1 and 2) are permanently configured as data circuit-terminating equipment (DCE).

3.6.2. Configuration of Serial Ports 3 and 4

The synchronous Serial Port 3 and Port 4 are configurable via a combination of serial interface module (SIM) selection and jumper settings. Table 3-2 lists the SIM connectors and jumper headers corresponding to each of the synchronous serial ports. Port 3 is routed to board connector J7. Port 4 is available at board connector J8.

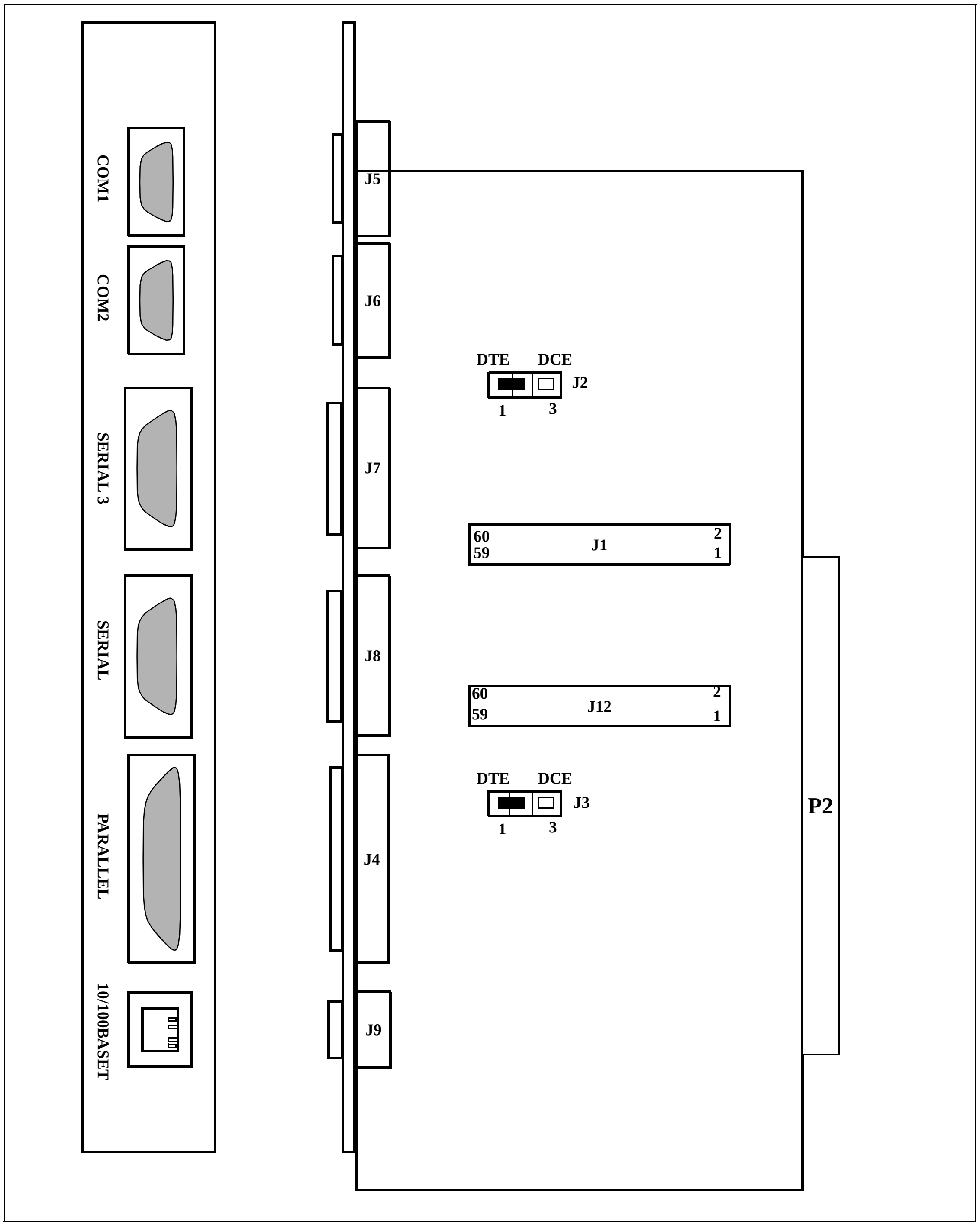

Figure 3-8. MVME761 Transition Module Connector and Header Placement

Table 3-2. Serial Ports 3 and 4 Configuration

Synchronous Port	Board Connector	SIM Connector	Jumper Header
Port 3	J7	J1	J2
Port 4	J8	J12	J3

To configure serial ports 3 and 4, headers J2 and J3 respectively, are used in tandem with SIM selection (i.e., for Port 3 use Board Connector J7, SIM connector J1 and Header Jumper J2.). To configure the port as a DTE place the jumper in position 1-2. To configure the port as a DCE place the jumper in position 2-3, as shown in Figure 3-9.

NOTE

The jumper setting of the port should match the configuration of the corresponding SIM module i.e., Port 4, Board Connector J8, SIM connector J12, and Header Jumper J3.)

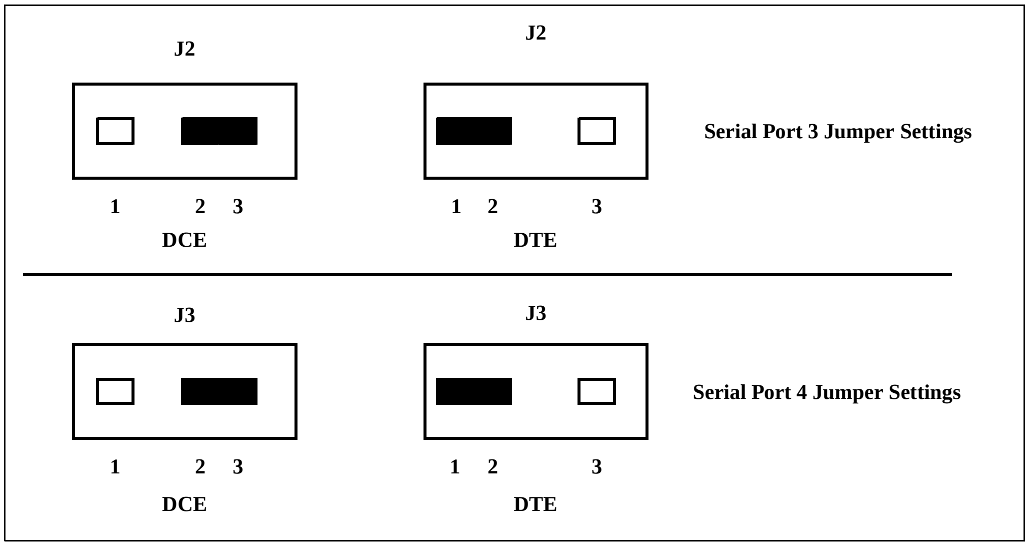

Figure 3-9. Headers J2 and J3 Jumper Settings

3.7. Three-Row P2 Adapter Preparation

The three-row P2 adapter, shown in Figure 3-10, is used to route synchronous and asynchronous serial, parallel, and Ethernet signals to the MVME761 transition module. The three-row P2 adapter's 50-pin female connector (J2) carries 8-bit signals from the base board.

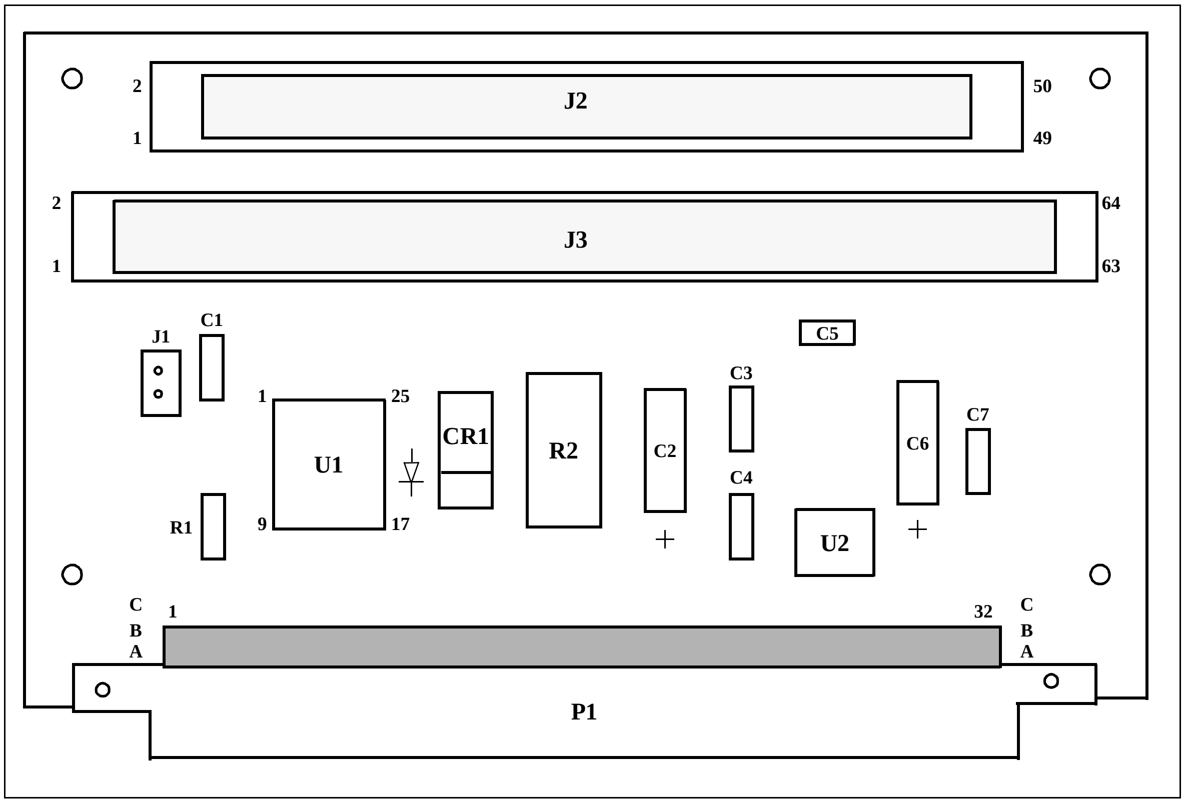

Figure 3-10. MVME761 Three-Row P2 Adapter Component Placement

Preparing the three-row P2 adapter for the MVME761 transition module consists of installation of a jumper on header J1. The installation of this jumper enables the SCSI terminating resistors, when they are required. Figure 3-10 shows the location of the jumper header, resistors, fuse, and connectors.

NOTE

A jumper must be installed across J1 in our system if the base board is the first and only board, or if the base board is the last in line when there are multiple boards.

3.8. Optional Five-Pin P2 Adapter Preparation

The optional five-row P2 adapter, shown in Figure 3-11, is also used to route synchronous and asynchronous serial, parallel, and Ethernet signals to the MVME761 transition module. The five-row P2 adapter's 68-pin female connector(J1) carries 16-bit signals from the base board. The five-row P2 adapter also supports PMC I/O via connector J3.

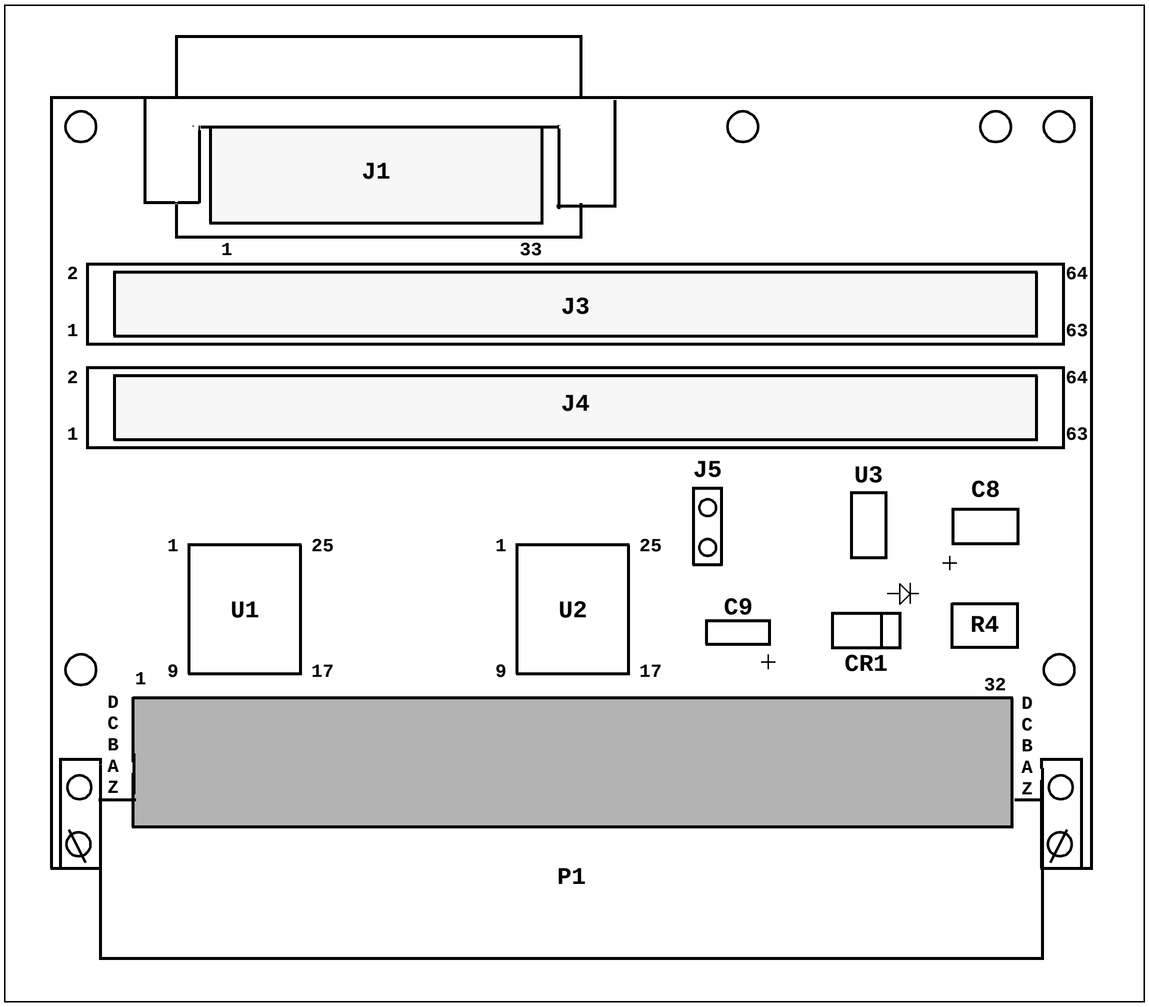

Figure 3-11. MVME761 Five-Row P2 Adapter Component Placement

NOTE

To run external SCSI devices, you may install an optional front panel extension (MVME761EXT) next to the MVME761.

Preparing the five-row P2 adapter for the MVME761 transition module consists of installation of a jumper on header J5. The installation of this jumper enables the SCSI terminating resistors, when they are required. Figure 3-11 shows the location of the jumper header, resistors, fuse (polyswitch R4), and connectors.

NOTE

A jumper must be installed across J5 in our system if the base board is the first and only board, or if the base board is the last in line when there are multiple boards.

3.9. Base Board Connectors

The following tables summarize the pin assignments of connectors that are specific to the base boards used with MVME761 transition modules.

3.9.1. VME Connector P2 (MVME761 Mode)

As shown in Figure 3-2, two 160-pin connectors (P1 and P2) supply the interface between the base board and VMEbus. P1 provides power and VME signals for 24-bit addressing and 16-bit data. Its pin assignments are set by the VMEbus specification. P2 rows A, C, Z and D provide power and interface signals to the MVME761 transition module. P2 row B supplies the base board with power, with the upper eight VMEbus address lines, and with an additional 16 VMEbus data lines. The pin assignments for P2 are listed in Table 3-3.

3.9.2. Serial Ports 1 and 2 (MVME761 I/O Mode)

The base boards provide both asynchronous (port 1 and 2) and synchronous/ asynchronous (port 3 and 4) serial connections. For the MVME2604 base board shown in Figure 3-2, the asynchronous interface is implemented with a pair of DB9 connectors (COM1 and COM2) located on the MVME761 transition module shown in Figure 3-8. The pin assignments are listed in Table 3-4.

3.9.3. Serial Ports 3 and 4 (MVME761 I/O Mode)

The base boards synchronous/asynchronous interface for ports 3 and 4 is implemented via a pair of HD26 connections (J7 and J8) located on the front panel of the transition module shown in Figure 3-8. The pin assignments for serial ports 3 and 4 are listed in Table 3-5.

3.9.4. Parallel Connector (MVME761 I/O Mode)

The base board parallel interface is implemented via an IEEE P1284 36-pin connector (J4) located on the MVME761 transition module shown in Figure 3-8. The pin assignments for the parallel connector are listed in Table 3-6.

3.9.5. Ethernet 10Base-T /100Base-T Connector

The base boards provide 10/100Base-T LAN connections. The base board LAN interface is a 10Base-T/100Base-T connection implemented with a standard RJ45 socket located on the MVME761 transition module. The pin assignments are listed in Table 3-7.

Table 3-3. VMEbus Connector P2

Pin No.	Row Z	Row A	Row B	Row C	Row D	Pin No.
1	SDB8*	SDB0*	+5V	RD-(10/100)	PMCIO0	1
2	GND	SDB1*	GND	RD+(10/100)	PMCIO1	2
3	SDB9*	SDB2*	RETRY	TD-(10/100)	PMCIO2	3
4	GND	SDB3*	VA24	TD+(10/100)	PMCIO3	4
5	SDB10*	SDB4*	VA25	Not Used	PMCIO4	5
6	GND	SDB5*	VA26	Not Used	PMCIO5	6
7	SDB11*	SDB6*	VA27	+12VF	PMCIO6	7
8	GND	SDB7*	VA28	PR_STB*	PMCIO7	8
9	SDB12*	SDBP0	VA29	PR_DATA0	PMCIO8	9
10	GND	SATN*	VA30	PR_DATA1	PMCIO9	10
11	SDB13*	SBSY*	VA31	PR_DATA2	PMCIO10	11
12	GND	SACK*	GND	PR_DATA3	PMCIO11	12
13	SDB14*	SRST*	+5V	PR_DATA4	PMCIO12	13
14	GND	SMSG*	VD16	PR_DATA5	PMCIO13	14
15	SDB15*	SSEL*	VD17	PR_DATA6	PMCIO14	15
16	GND	SCD*	VD18	PR_DATA7	PMCIO15	16
17	SDBP1	SREQ*	VD19	PR_ACK*	PMCIO16	17
18	GND	SIO*	VD20	PR_BUSY	PMCIO17	18
19	Not Used	AFD*	VD21	PR_PE	PMCIO18	19
20	GND	SLIN*	VD22	PR_SLCT	PMCIO19	20
21	Not Used	TxD3	VD23	PR_INIT*	PMCIO20	21
22	GND	RxD3	GND	PR_ERR*	PMCIO21	22
23	Not Used	RTxC3	VD24	TxD1	PMCIO22	23
24	GND	TRxC3	VD25	RxD1	PMCIO23	24
25	Not Used	TxD3	VD26	RTS1	PMCIO24	25
26	GND	RxD3	VD27	CTS1	PMCIO25	26
27	Not Used	RTxC4	VD28	TxD2	PMCIO26	27

Table 3-3. VMEbus Connector P2 (Cont.)

Pin No.	Row Z	Row A	Row B	Row C	Row D	Pin No.
28	GND	TRxC4	VD29	RxD2	PMCIO27	28
29	PMCIO30	Not Used	VD30	RTS2	PMCIO28	29
30	GND	-12VF	VD31	CTS2	PMCIO29	30
31	PMCIO31	MSYNC*	GND	MD0	GND	31
32	GND	MCLK	+5V	MD1	VPC	32

Table 3-4. Serial Connections - Ports 1 and 2

Pin No.	Definition
1	SP*n*DCD
2	SP*n*RXD
3	SP*n*TXD
4	SP*n*DTR
5	GND
6	SP*n*DSR
7	SP*n*RTS
8	SP*n*CTS
9	SP*n*RI
Note that *n*=1 or 2	

Table 3-5. Serial Connections - Ports 3 and 4

Pin No.	Definition
1	No Connection
2	TXD*n*
3	RXD*n*
4	RTS*n*
5	CTS*n*
6	DSR*n*
7	GND
8	DCD*n*
9	SP*n*_P9
10	SP*n*_P10
11	SP*n*_P11

Table 3-5. Serial Connections - Ports 3 and 4 (Cont.)

Pin No.	Definition
12	SP*n*_P12
13	SP*n*_P13
14	SP*n_P14*
15	TXCI*n*
16	SP*n_P16*
17	RXCI*n*
18	LLB*n*
19	SP*n_19*
20	DTR*n*
21	RLB*n*
22	RI*n*
23	SP*n_23*
24	TXCO*n*
25	TM*n*
26	No Connection
Note that *n*=3 or 4	

Table 3-6. Parallel I/O Connector

Pin No	Signal	Signal	Pin No.
1	PRBSY	GND	19
2	PRSEL	GND	20
3	PRACK*	GND	21
4	PRFAULT*	GND	22
5	PRPE	GND	23
6	PRD0	GND	24
7	PRD1	GND	25
8	PRD2	GND	26
9	PRD3	GND	27
10	PRD4	GND	28
11	PRD5	GND	29
12	PRD6	GND	30
13	PRD7	GND	31

Table 3-6. Parallel I/O Connector (Cont.)

Pin No	Signal	Signal	Pin No.
14	INPRIME*	GND	32
15	PRSTB*	GND	33
16	SELIN*	GND	34
17	AUTOFD*	GND	35
18	Pull-up	No Connection	36

Table 3-7. Ethernet 10/100Base-T Connector

Pin No.	Definition
1	TD+
2	TD-
3	RD+
4	No Connection
5	No Connection
6	RD-
7	No Connection
8	No Connection

3.10. P2 Adapter Connectors

The P2 adapter, shown in Figure 3-10, has a 50-pin female connector (J2) that carries 8-bit SCSI signals from the base board. The pin assignments and signal mnemonics for this connector are listed in Table 3-8. The P2 adapter, shown in Figure 3-11, has a 68-pin female connector (J1) that carries 16-bit SCSI signals from the base board. The pin assignments and signal mnemonics for this connector are listed in Table 3-9.

The P2 adapter shown in Figure 3-11 also has a 64-pin PMC I/O connector, J3. The pin assignments and signal mnemonics for this connector are listed in Table 3-10.

Table 3-8. 8-Bit SCSI Connector

Pin No	Signal	Signal	Pin No.
1	GND	TERMPWR	26
2	SDB0	GND	27
3	GND	GND	28

Table 3-8. 8-Bit SCSI Connector (Cont.)

Pin No	Signal	Signal	Pin No.
4	SDB1	GND	29
5	GND	GND	30
6	SDB2	GND	31
7	GND	ATN	32
8	SDB3	GND	33
9	GND	GND	34
10	SDB4	GND	35
11	GND	BSY	36
12	SDB5	GND	37
13	GND	ACK	38
14	SDB6	GND	39
15	GND	RST	40
16	SDB7	GND	41
17	GND	MSG	42
18	DBP	GND	43
19	GND	SEL	44
20	GND	GND	45
21	GND	D/C	46
22	GND	GND	47
23	GND	REQ	48
24	GND	GND	49
25	No Connection	O/I	50

Table 3-9. 16-Bit SCSI Connector

Pin No	Signal	Signal	Pin No.
1	GND	SD12	35
2	GND	SD13	36
3	GND	SD14	37
4	GND	SD15	38
5	GND	DBP1	39
6	GND	SDB0	40
7	GND	SDB1	41

Table 3-9. 16-Bit SCSI Connector (Cont.)

Pin No	Signal	Signal	Pin No.
8	GND	SDB2	42
9	GND	SDB3	43
10	GND	SDB4	44
11	GND	SDB5	45
12	GND	SDB6	46
13	GND	SDB7	47
14	GND	DBP0	48
15	GND	GND	49
16	GND	GND	50
17	TERMPWR	TERMPWR	51
18	TERMPWR	TERMPWR	52
19	No Connect	No Connect	53
20	GND	GND	54
21	GND	ATN	55
22	GND	GND	56
23	GND	BSY	57
24	GND	ACK	58
25	GND	RST	59
26	GND	MSG	60
27	GND	SEL	61
28	GND	D/C	62
29	GND	REQ	63
30	GND	O/I	64
31	GND	SDB8	65
32	GND	SDB9	66
33	GND	SDB10	67
34	GND	SDB11	68

Table 3-10. PMC I/O Connector

Pin No	Signal	Signal	Pin No.
1	GND	GND	33
2	PMCIO0	PMCIO16	34
3	GND	GND	35
4	PMCIO1	PMC1017	36
5	GND	GND	37
6	PMCIO2	PMCIO18	38
7	GND	GND	39
8	PMCIO3	PMCIO19	40
9	GND	GND	41
10	PMCIO4	PMCIO20	42
11	GND	GND	43
12	PMCIO5	PMCIO21	44
13	GND	GND	45
14	PMCIO6	PMCIO22	46
15	GND	GND	47
16	PMCIO7	PMCIO23	48
17	GND	GND	49
18	PMCIO8	PMCIO24	50
19	GND	GND	51
20	PMCIO9	PMCIO25	52
21	GND	GND	53
22	PMCIO10	PMCIO26	54
23	GND	GND	55
24	PMCIO11	PMCIO27	56
25	GND	GND	57
26	PMCIO12	PMCIO28	58
27	GND	GND	59
28	PMCIO13	PMCIO29	60
29	GND	GND	61
30	PMCIO14	PMCIO30	62
31	GND	GND	63
32	PMCIO15	PMCIO31	64

3.11. Reset Button

These boards make available an **RESET** button. Depressing this button resets the SBC in much the same manner that a powerup does. **`PPCBug`** is entered and the initialization code is executed. This button only resets the SBC to which it is attached; it does not reset any other VME boards that may be present in other VME slots of the chassis.

3.12. Abort Button

These boards make available an **ABORT** button. Depressing this button sends a unique interrupt vector to the board. If an operating system, such as PowerMAX OS was running, then pressing the **ABORT** button will invoke the system-level debugger that has been installed at this interrupt vector. Otherwise, **`PPCBug`** is invoked, or <u>no</u> action is taken.

Chapter 4
MCP750 Hardware Considerations

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4
MCP750 Hardware Considerations

4.1. Introduction

This chapter provides general information, hardware preparation, installation instructions and general operating information pertaining to the MCP750 Single Board Computer (SBC). The MCP750 consists of the base board and a ECC DRAM module (RAM300) for memory. An optional PCI mezzanine card (PMC) is also available.

Refer to the *MCP750 CompactPCI Single Board Computer Installation and Use* manual for more detailed information on hardware considerations that may be applicable to your particular hardware configuration. Refer to the Preface of this manual for specific manual titles, document numbers, and Motorola's web site address to access documents online.

CAUTION

Avoid touching areas of integrated circuitry; static discharge can damage circuits.

Concurrent strongly recommends that you use an antistatic wrist strap and a conductive foam pad when installing or upgrading a system. Electronic components, such as disk drive, computer boards, and memory modules, can be extremely sensitive to Electrostatic Discharge (ESD). After removing the component from the system or its protective wrapper, place the component flat on a grounded, static-free surface (and in the case of a board, component side up). Do not slide the component over any surface.

If an ESD station is not available, you can avoid damage resulting from ESD by wearing an antistatic strap (available at electronic stores) that is attached to an unpainted metal part of the system chassis.

4.2. Unpacking Instructions

NOTE

If the shipping container is damaged upon receipt, request that the carrier's agent be present during unpacking and inspection of the equipment.

Unpack the equipment from the shipping container. Refer to the packing list and verify that all items are present. Save the packing material for storing and reshipping of the equipment.

4.3. Hardware Configuration

In order to produce the desired system configuration and ensure proper operation of the MCP750, you may need to perform certain hardware modifications before installing the module.

The MCP750 provides software control over most options. These options are described in detail in Chapter 3 of the *MCP750 CompactPCI Single Board Computer Installation and Use* manual and/or, in the *MCP750 Series Programmer’s Reference Guide.*

Some options are not software-programmable. These options are controlled through manual installation or removal of header jumpers or interface modules on the base board or the associated transition module.

4.4. MCP750 Base Board Preparation

Figure 4-1 depicts the placement of the switches, jumper headers, connector and LED indicators on the MCP750. Manually configured items on the base board include:

- Flash bank selector (J6)

For a description of the configurable items on the transition module, see the section “TMCP700 Transition Module Preparation” on page 4-4 for details.

The MCP750 is factory tested and shipped with the configurations described in the following sections. The MCP750’s required and factory-installed debug monitor, **PPCBug**, operates with those factory settings.

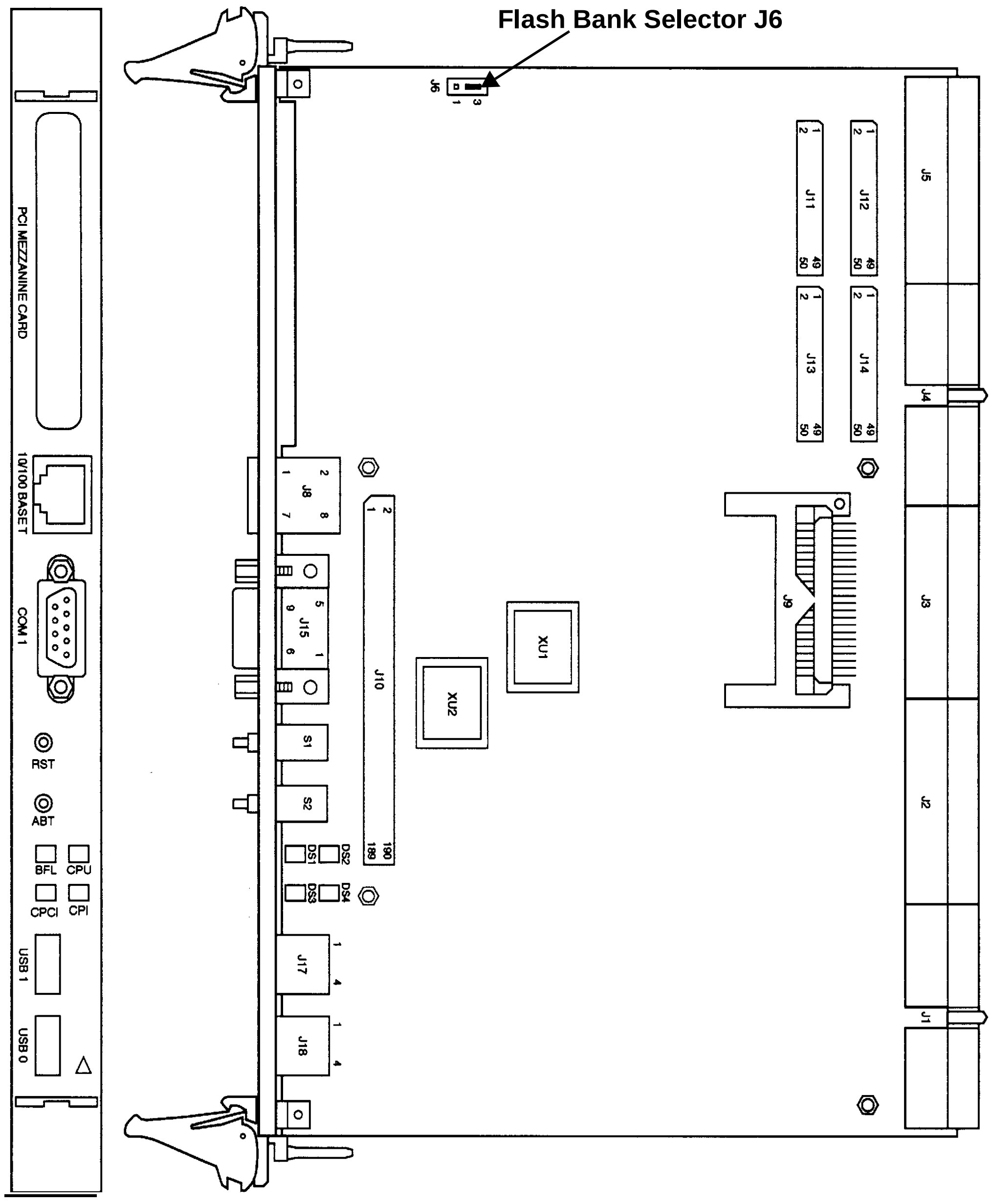


Figure 4-1. MCP750 Base Board Component Location

4.4.1. Flash Bank Selection (J6)

The MCP750 base board has provision for 1MB of 16-bit Flash memory. The RAM300 memory mezzanine accommodates 4MB or 8MB of additional 64-bit Flash memory.

The Flash memory is organized in either one or two banks, each bank either 16 or 64 bits wide. Bank B contains the onboard debugger, **PPCBug**.

To enable Flash Bank A (4MB or 8MB of firmware resident on soldered-in devices on the RAM300 mezzanine), place a jumper across header J6 (Figure 4-2) pins 1 and 2. To enable Flash Bank B (1MB of firmware located in sockets on the base board), place a jumper across header J6, pins 2 and 3.

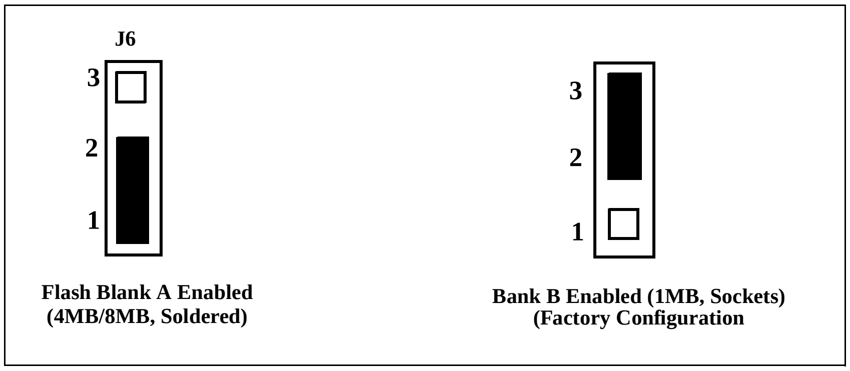


Figure 4-2. Flash Bank Selection (J6)

4.5. TMCP700 Transition Module Preparation

The TMCP700 transition module (Figure 4-3) is used in conjunction with all models of the MCP750 base board:

The features of the TMCP700 include:

- A parallel printer port (IEEE 1284-I compliant)
- Two EIA-232-D asynchronous serial ports (identified as COM1 and COM2 on the transition module panel)
- Two synchronous serial ports (SERIAL 3 and SERIAL 4 on the transition module panel), configured for EIA-232-D, EIA-530, V.35, or X.21 protocols via SIM modules
- Two 60-pin Serial Interface Module (SIM) connectors, used for configuring serial ports 3 and 4
- A combination keyboard/mouse connector
- A 40-pin header for the EIDE port connection

- A 34-pin header for floppy port connection
- Two 64-pin headers for PMC IO (1 ground pin provided with each signal)
- A 2-pin header for speaker output

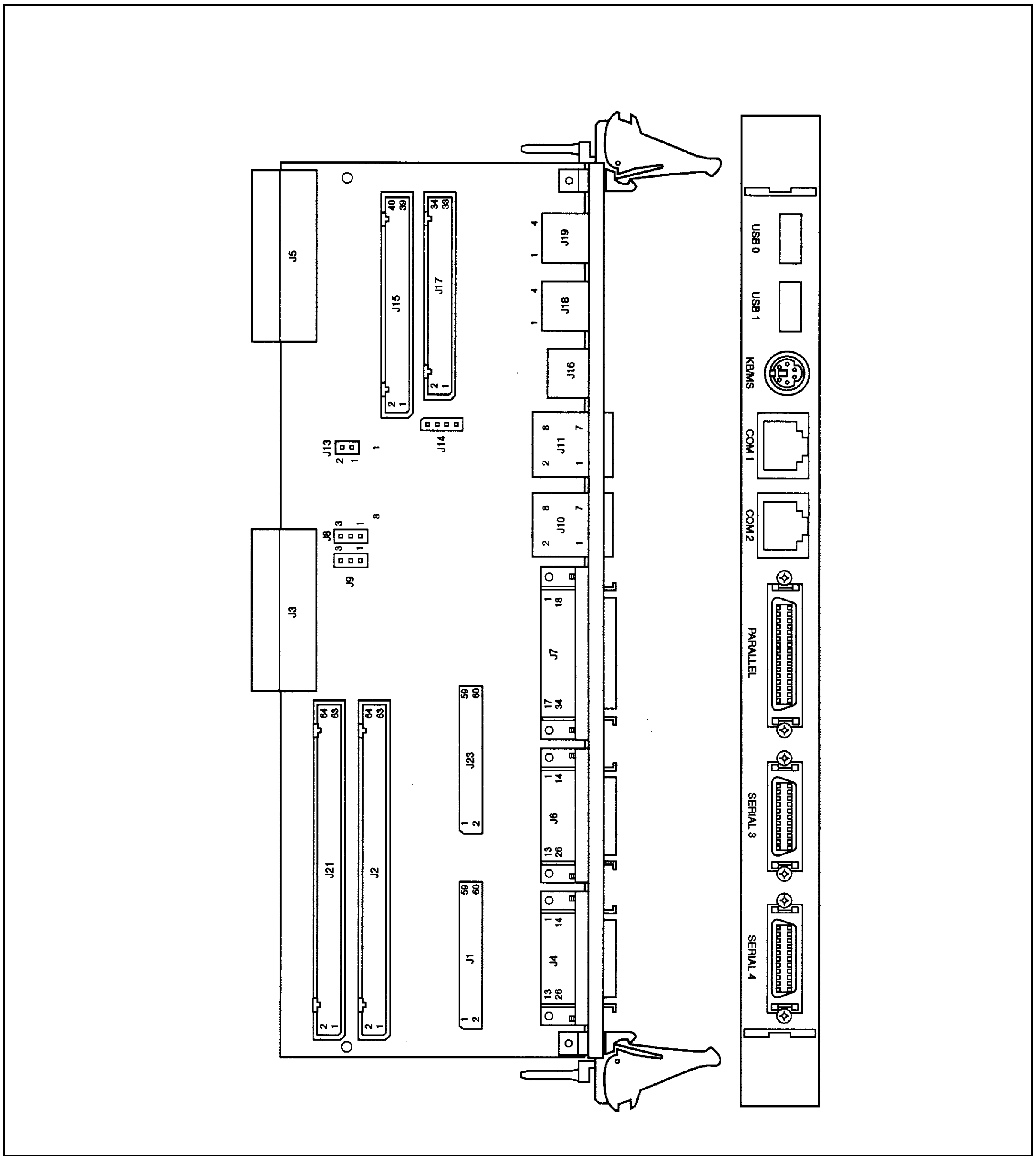


Figure 4-3. TMCP700 Connector and Header Location

4.5.1. Serial Ports 1 and 2

On the TMCP700, the asynchronous serial ports (Serial Ports 1 and 2) are configured permanently as data circuit-terminating equipment (DTE). The COM1 port is also routed to a DB9 connector on the front panel of the processor board. A terminal for COM1 may be connected to either the processor board or the transition module, but not both.

4.5.2. Configuration of Serial Ports 3 and 4

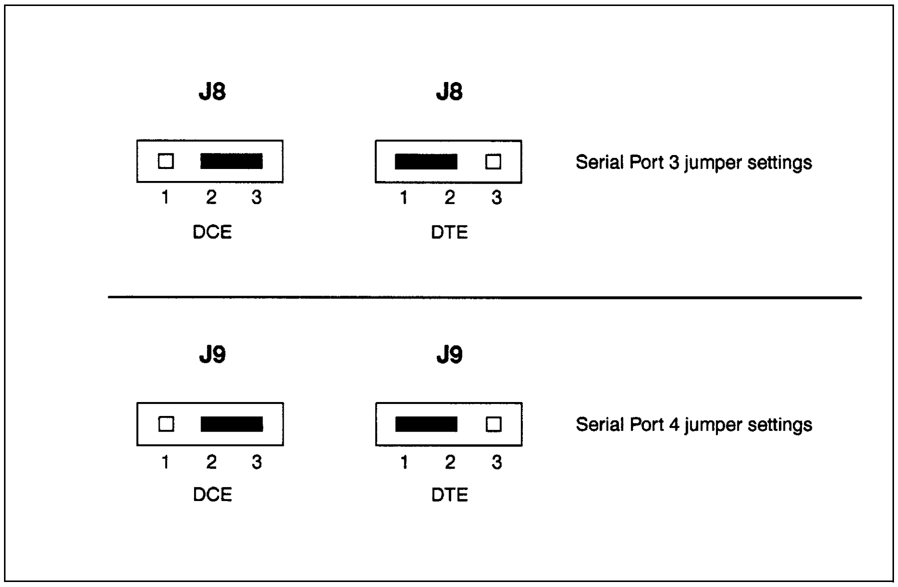
The synchronous serial ports, Serial Port 3 and Serial Port 4, are configured through a combination of serial interface module (SIM) selection and jumper settings. The following table lists the SIM connectors and jumper headers corresponding to each of the synchronous serial ports.

Synchronous Port	**Board Connector**	**SIM Connector**	**Jumper Header**
Port 3	J6	J23	J8
Port 4	J4	J1	J9

Port 3 is routed to board connector J6. Port 4 is available at board connector J4. Typical interface modules include:

- EIA-232-D (DCE and DTE)
- EIA-530 (DCE and DTE)
- V.35 (DCE and DTE)
- X.21 (DCE and DTE)

You can configure Serial Ports 3 and 4 for any of the above serial protocols by installing the appropriate serial interface module and setting the corresponding jumper. Headers J8 and J9 are used to configure Serial Port 3 and Serial Port 4, respectively, in tandem with SIM selection. With the jumper in position 1-2, the port is configured as a DTE. With the jumper in position 2-3, the port is configured as a DCE. The jumper setting of the port should match the configuration of the corresponding SIM module.



When installing the SIM modules, note that the headers are keyed for proper orientation. Refer to the *MCP750 CompactPCI Single Board Computer Installation and Use* manual for more detailed information.

4.6. Hardware Installation

The following sections discuss the placement of mezzanine cards on the MCP750 base board, the installation of the complete MCP750 assembly into a CompactPCI chassis, and the system considerations relevant to the installation. Before installing the MCP750, ensure that the serial ports and all header jumpers are configured as desired.

In most cases, the mezzanine card - the RAM300 ECC DRAM module, is already in place on the base board. The user-configured jumpers are accessible with the mezzanines installed.

Should it be necessary to install mezzanines on the base board, refer to the following sections for a brief description of the installation procedure.

4.6.1. ESD Precautions

It is recommended that you use an antistatic wrist strap and a conductive foam pad when installing or upgrading a system. Electronic components, such as disk drives, computer boards, and memory modules, can be extremely sensitive to ESD. After removing the component from the system or its protective wrapper, place the component flat on a grounded, static-free surface (and in the case of a board, component side up). Do not slide the component over any surface.

If an ESD station is not available, you can avoid damage resulting from ESD by wearing an antistatic wrist strap (available at electronics stores) that is attached to an unpainted metal part of the system chassis.

4.7. Compact FLASH Memory Card Installation

The Compact FLASH memory card mounts on the MCP750 base board, under the RAM300 memory mezzanine. To upgrade or install a Compact FLASH memory card, refer to Figure 4-1 (page 4-3) and Figure 4-4 and proceed as follows:

1. Attach an ESD strap to your wrist. Attach the other end of the ESD strap to the chassis as a ground. The ESD strap must be secured to your wrist and to ground throughout the procedure.
2. Perform an operating system shutdown. Turn the AC or DC power off and remove the AC cord or DC power lines from the system. Remove chassis or system cover(s) as necessary for access to the compact PCI module.

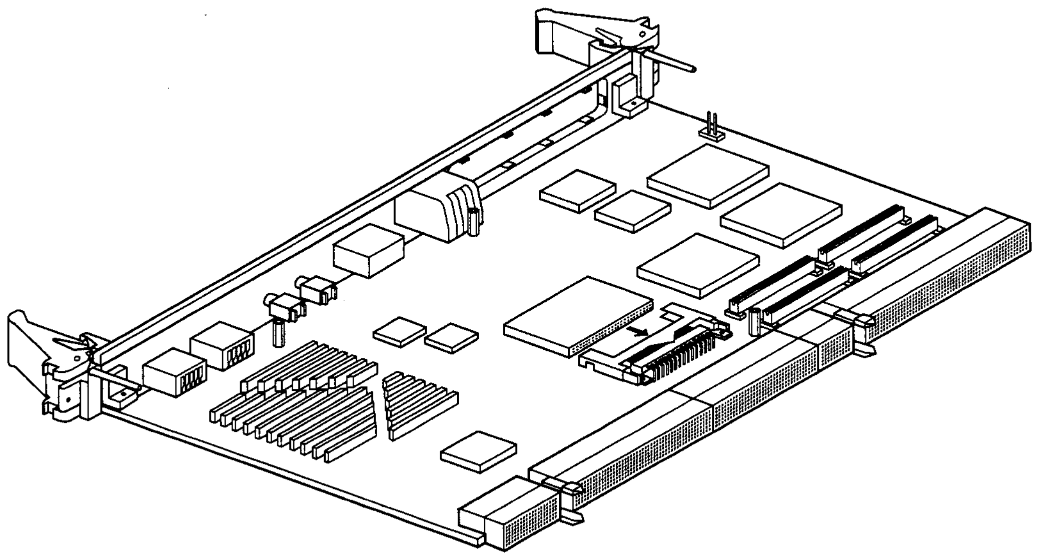


Figure 4-4. Compact FLASH Placement on MCP750 Base Board

Caution

Inserting or removing modules with power applied may result in damage to module components.

Warning

Dangerous voltages, capable of causing death, are present in this equipment. Use extreme caution when handling, testing, and adjusting.

3. Carefully remove the MCP750 from its CompactPCI card slot and lay it flat, with connectors J1 and J5 facing you.

Caution

Avoid touching areas of integrated circuitry; static discharge can damage these circuits.

4. If necessary, remove the RAM300 mezzanine module by removing the four Phillips screws at the corners of the RAM300 and gently lifting the module near the connector end of the module.
5. Slide the Compact FLASH memory card into the J9 connector making sure that pin 1 of the card aligns with pin 1 of J9.
6. Place the RAM300 mezzanine module on top of the base board. The connector on the underside of the RAM300 should connect smoothly with the corresponding connector J10 on the MCP750.
7. Insert the four short Phillips screws through the holes at the corners of the RAM300, into the standoffs on the MCP750. Tighten the screws.
8. Reinstall the MCP750 assembly in its proper card slot. Be sure the module is well seated in the backplane connectors. Do not damage or bend connector pins.
9. Replace the chassis or system cover(s), reconnect the system to the AC or DC power source, and turn the equipment power on.

4.8. RAM300 Memory Mezzanine Installation

The RAM300 DRAM mezzanine mounts on top of the MCP750 base board. To upgrade or install a RAM300 mezzanine, refer to Figure 4-5 and proceed as follows:

1. Attach an ESD strap to your wrist. Attach the other end of the ESD strap to the chassis as a ground. The ESD strap must be secured to your wrist and to ground throughout the procedure.
2. Perform an operating system shutdown. Turn the AC or DC power off and remove the AC cord or DC power lines from the system. Remove chassis or system cover(s) as necessary for access to the compact PCI module.

Caution

Inserting or removing modules with power applied may result in damage to module components.

Warning

Dangerous voltages, capable of causing death, are present in this equipment. Use extreme caution when handling, testing, and adjusting.

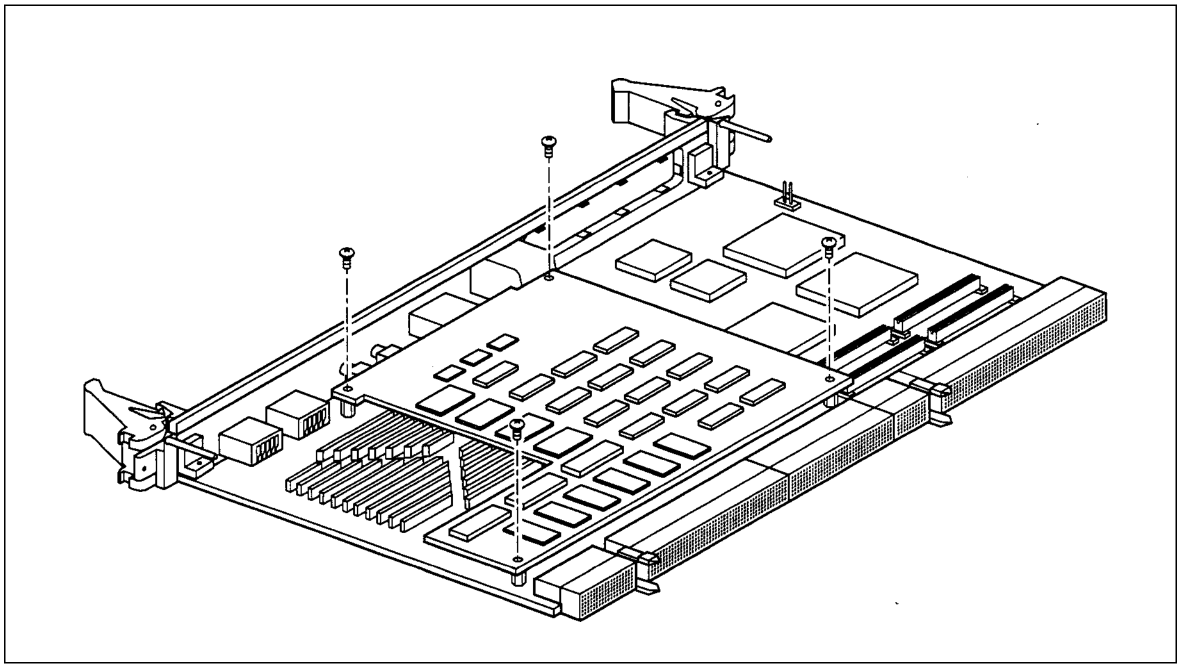


Figure 4-5. RAM300 Placement on MCP750

3. Carefully remove the MCP750 from its CompactPCI card slot and lay it flat, with connectors J1 and J5 facing you.

Caution

Avoid touching areas of integrated circuitry; static discharge can damage these circuits.

Warning

Dangerous voltages, capable of causing death, are present in this equipment. Use extreme caution when handling, testing, and adjusting.

4. Place the RAM300 mezzanine module on top of the base board. The connector on the underside of the RAM300 should connect smoothly with the corresponding connector J10 on the MCP750.
5. Insert the four short Phillips screws through the holes at the corners of the RAM300, into the standoffs on the MCP750. Tighten the screws.
6. Reinstall the MCP750 assembly in its proper card slot. Be sure the module is well seated in the backplane connectors. Do not damage or bend connector pins.
7. Replace the chassis or system cover(s), reconnect the system to the AC or DC power source, and turn the equipment power on.

4.9. PMC Module Installation

PCI mezzanine card (PMC) modules mount beside the RAM300 mezzanine on top of the MCP750 base board. To install a PMC module, refer to Figure 4-6, PMC Carrier Board Placement on MCP750, and proceed as follows:

1. Attach an ESD strap to your wrist. Attach the other end of the ESD strap to the chassis as a ground. The ESD strap must be secured to your wrist and to ground throughout the procedure.
2. Perform an operating system shutdown. Turn the AC or DC power off and remove the AC cord or DC power lines from the system. Remove chassis or system cover(s) as necessary for access to the CompactPCI.

Caution

Inserting or removing modules with power applied may result in damage to module components.

Warning

Dangerous voltages, capable of causing death, are present in this equipment. Use extreme caution when handling, testing, and adjusting.

3. Carefully remove the MCP750 from its CompactPCI card slot and lay it flat, with connectors J1 through J5 facing you.
4. Remove the PCI filler from the front panel.
5. Slide the edge connector of the PMC module into the front panel opening from behind and place the PMC module on top of the base board. The four connectors on the underside of the PMC module should then connect smoothly with the corresponding connectors (J11/12/13/14) on the MCP750.
6. Insert the four short Phillips screws, provided with the PMC, through the holes on the bottom side of the MCP750 into the PMC front bezel and rear standoffs. Tighten the screws.
7. Reinstall the MCP750 assembly in its proper card slot. Be sure the module is well seated in the backplane connectors. Do not damage or bend connector pins.
8. Replace the chassis or system cover(s), reconnect the system to the AC or DC power source, and turn the equipment power on.

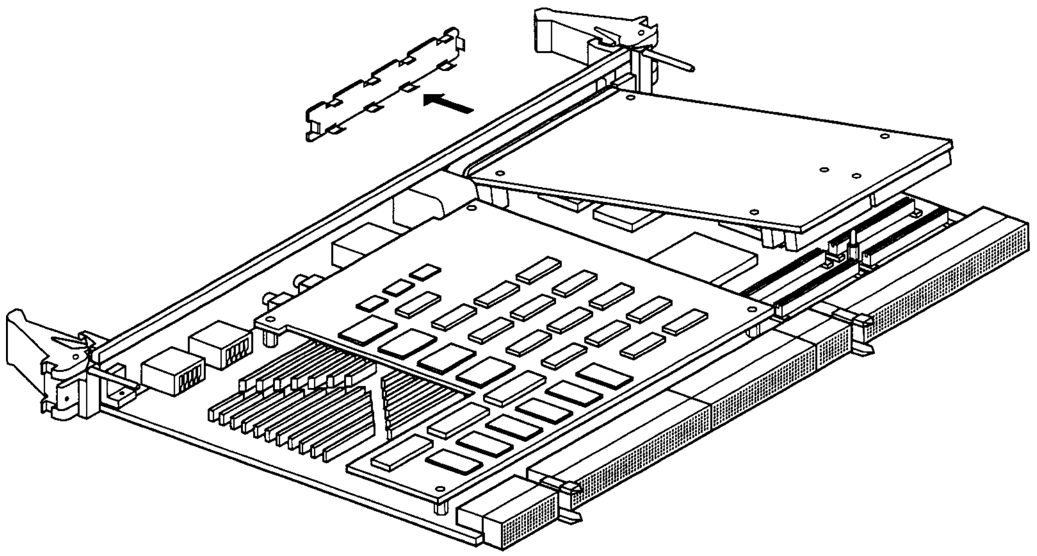


Figure 4-6. PMC Carrier Board Placement on MCP750

4.10. MCP750 Module Installation

With mezzanine board(s) installed and headers properly configured, proceed as follows to install the MCP750 in the CompactPCI chassis:

1. Attach an ESD strap to your wrist. Attach the other end of the ESD strap to the chassis as a ground. The ESD strap must be secured to your wrist and to ground throughout the procedure.
2. Perform an operating system shutdown. Turn the AC or DC power off and remove the AC cord or DC power lines from the system. Remove chassis or system cover(s) as necessary for access to the CompactPCI.

Caution

Avoid touching areas of integrated circuitry; static discharge can damage these circuits.

Warning

Dangerous voltages, capable of causing death, are present in this equipment. Use extreme caution when handling, testing, and adjusting.

3. Remove the filler panel from card slot 1 (system slot).

Note

The MCP750 must be installed in the CompactPCI system slot in order to provide clocks and arbitration to the other slots. The system slot is identified with a triangle symbol); which is marked on the backplane. Some CompactPCI subracks may have a red guide rail to mark the system slot.

4. Set the VIO on the backplane to either 3.3V or 5V, depending upon your cPCI system signaling requirements and ensure the backplane does not bus J3, J4 or J5 signals.
5. Slide the MCP750 into the system slot. Grasping the top and bottom injector handles, be sure the module is well seated in the P1 through P5 connectors on the backplane. Do not damage or bend connector pins.
6. Secure the MCP750 in the chassis with the screws provided, making good contact with the transverse mounting rails to minimize RF emissions.
7. Replace the chassis or system cover(s), making sure no cables are pinched. Cable the peripherals to the panel connectors, reconnect the system to the AC or DC power source, and turn the equipment power on.

4.11. TMCP700 Transition Module Installation

The TMCP700 Transition Module may be required to complete the configuration of your particular MCP750 system. If so, perform the following install steps to install this board. For more detailed information on the TMCP700 Transition Module refer to the *MCP750 CompactPCI Single Board Computer Installation and Use* manual.

1. Attach an ESD strap to your wrist. Attach the other end of the ESD strap to the chassis as a ground. The ESD strap must be secured to your wrist and to ground throughout the procedure.
2. Perform an operating system shutdown. Turn the AC or DC power off and remove the AC cord or DC power lines from the system. Remove chassis or system cover(s) as necessary for access to the CompactPCI.

Caution

Inserting or removing modules with power applied may result in damage to module components.

Warning

Dangerous voltages, capable of causing death, are present in this equipment. Use extreme caution when handling, testing, and adjusting.

3. If Serial Ports 3 and 4 are used, be sure they are properly configured on the TMCP700 before installing the board. Refer to the section TMCP700 Transition Module Preparation, on page 4-4 for instructions on how to do this.

Caution

Avoid touching areas of integrated circuitry; static discharge can damage these circuits.

4. With the TMCP700 in the correct vertical position that matches the pin positioning of the corresponding MCP750 board carefully slide the transition module into the appropriate slot and seat tightly into the backplane. Refer to Figure 4-7, TMCP700/MCP750 Mating Configuration, for the correct board/connector orientation.
5. Secure in place with the screws provided, making good contact with the transverse mounting rails to minimize RF emissions.
6. Replace the chassis or system cover(s), making sure no cables are pinched. Cable the peripherals to the panel connectors, reconnect the system to the AC or DC power source, and turn the equipment power on.

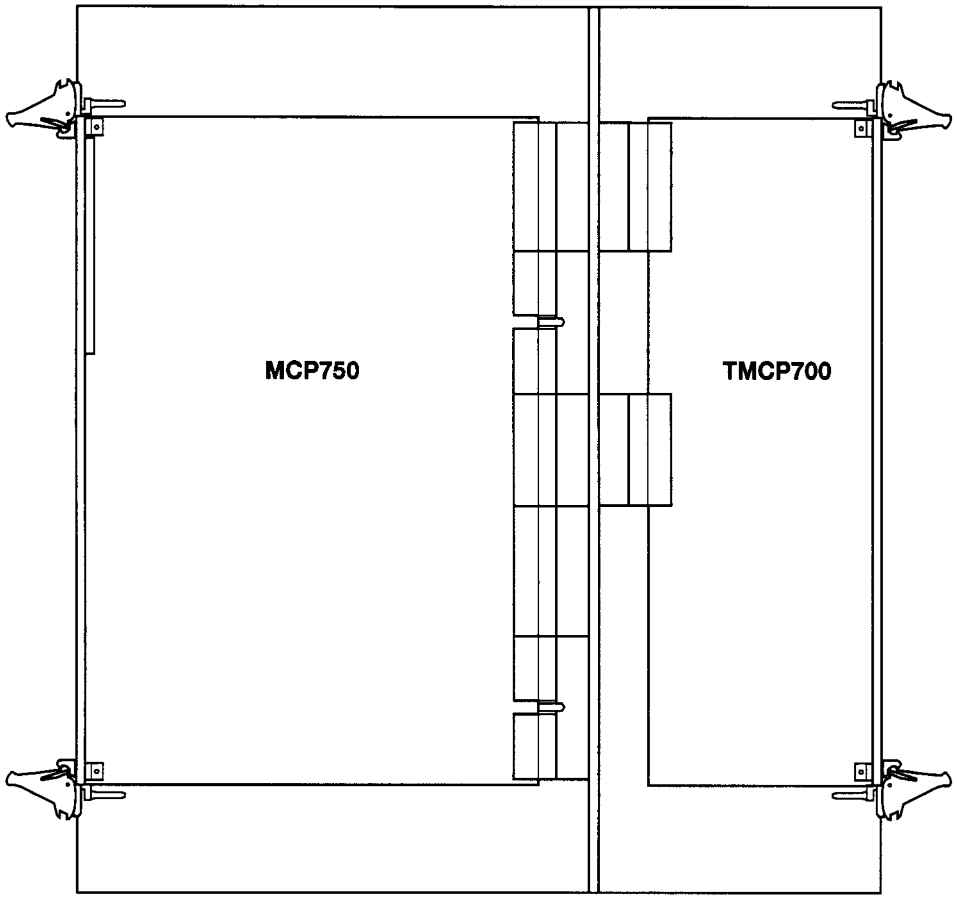


Figure 4-7. TCMP700/MCP750 Mating Configuration

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5
Netboot System Administration

5.1. Configuration Overview

This is a overview of the steps that must be followed in configuring a loosely-coupled configuration. Some of these steps are described in more detail in the sections that follow.

A loosely-coupled system consists of a file server and one or more diskless clients which download their private boot image residing on the file server. A loosely-coupled system uses an ethernet network connection between each diskless client and the file server for communication, there is no sharing of a VME bus in this configuration.

The following instructions assume that all the prerequisite hardware has been installed and each netboot client is network connected to the subnet on which the File Server resides. For details, see “Loosely-Coupled System Hardware Prerequisites” on page 1-28, and depending on your SBC board type, refer to following applicable chapter for specific hardware considerations:

- Chapter 2, MTX SBC Hardware Considerations
- Chapter 3, VME SBC Hardware Considerations
- Chapter 4, MCP750 Hardware Considerations

5.1.1. Installing a Loosely-Coupled System

Follow these steps to configure a loosely-coupled system.

1. Install the file server with the prerequisite software packages, the diskless package and all patches. Refer to the “Software Prerequisites” on page 1-29 and the applicable system release notes for more information.
2. On the file server system, configure and mount a file system(s) (other than **`/`** (root) or **`/var`**) that can be used to store the virtual root directories for each client. If not already present, an entry for this file system must be added to **`/etc/vfstab(4)`**. An existing file system can be used, but there must be sufficient file space to hold the client’s virtual root files. See “Disk Space Requirements” on page 1-28 for details of the amount of file space required.
3. On the file server system, add configuration information for each client to be configured to the following tables: **`/etc/dtables/nodes.netboot`** and **`/etc/hosts`**. See “Configuration Tables” on page 5-6 for more information.

4. On the file server system, execute **`netbootconfig(1m)`** to configure the build environment of each diskless client to be configured. See "Configuring Clients Using netbootconfig" on page 5-8 for more information.
5. On the file server system, execute **`mknetbstrap(1m)`** to create the boot images of each diskless client. See "Booting and Shutdown" on page 5-22 for more information.
6. On each client, connect a console terminal and power up the netboot client. Use **`PPCBug`** to set the hardware clock, **`env`** and **`niot`** NVRAM parameters. Refer respectively to the following sections: "Setting the Hardware Clock" on page 5-3, "PPCBug env Setup" on page 5-4 and "PPCBug niot Setup" on page 5-5.
7. On each client execute **`PPCBug`**'s **`nbo`** command to boot. See "Netboot Using NBO" on page 5-25 for more information.
8. On the file server system, customize the client configuration as needed and then run **`mknetbstrap(1m)`** to process the changes. If a new boot image is created as a result of the changes, shutdown the client and then reboot it. See "Booting and Shutdown" on page 5-22 for more information.

5.1.2. Installing Additional Boards

To add additional boards after the initial configuration, follow procedural steps 2-8 described above.

5.2. SBC Configuration

This section covers modifications that must be made to a board's NVRAM in order to support network booting. Changes to NVRAM are made using **`PPCBug`**, Motorola's loader/debugger. This section describes the following:

- PPCBug Overview (page 5-3)
- Setting the Hardware Clock (page 5-3)
- PPCBug env Setup (page 5-4)
- PPCBug niot Setup (page 5-5)

Note

The **`PPCBug`** examples in this chapter describe **`PPCBug`** Version 3.6 running on a PowerStack II (MTX). Minor differences may appear when running a different version of **`PPCBug`** or when running on a different platform (e.g. Power Hawk).

5.2.1. PPCBug Overview

`PPCBug` is the first level of software that is executed by an SBC whenever the board is powered up. Some of the most important functions of **`PPCBug`** are to initialize the SBC hardware on startup, permit autobooting of an operating system or manual booting, and provide diagnostic (debug) capabilities to the operating system after it is booted.

`PPCBug` communicates to the operator through COM Port #1. It is up to the operator to connect a terminal to this RS232 port whenever communication to **`PPCBug`** is desired. Some systems make available an ABORT button. By default, depressing this button interrupts whatever is running. When done, the interrupted software can be continued with the **`PPCBug`** command **`G`** (the **`go`** command).

Board initialization and booting is a process that can be configured in advance by the user using the **`PPCBug`** commands **`env`** and **`niot`**. These two commands save the desired startup configuration information in the board's NVRAM (non-volatile RAM). **`PPCBug`** will examine the NVRAM each time the SBC board is powered up or reset.

NVRAM parameters are modified using the **`PPCBug`** **`env`**, **`niot`** and **`set`** commands.

`ENV - Set Environment`

This command defines many parameters which influence the SBC operation. Part of the **`ENV`** command allows for "Network Auto Boot" or "Flash Auto Boot". When "Network Auto Boot" is enabled, the SBC upon power-on, or optionally at system RESET, will automatically attempt a network boot. Manual intervention is not required. If Flash autoboot is selected instead, the same attempt is made, but from the designated Flash Memory device.

`NIOT - Network I/O Teach`

Define various network parameters used during the network boot operation.

`SET` The **`SET`** command starts the real-time clock and sets the time and date.

`TIME` The **`TIME`** command displays the current date and time of day.

`PPCBug` contains many other useful commands, some of which are an assembler and disassembler, memory patch and examination commands, and breakpoint commands. For a full description of **`PPCBug`** capabilities, refer to the Motorola *PPCBug Debugging Package Users* Manual (refer to Referenced Publications section in the Preface for more information).

5.2.2. Setting the Hardware Clock

The netboot clients hardware clock must be updated to match the date on the system designated as the file server.

Use the **`PPCBug`** **`TIME`** command to display the current date and time and the **`SET`** command to initialize the clock. Hours should be specified in **GMT** using the 24-hour military time format. The format of the **`PPCbug SET`** command is: **`SET "MMDDYYhhmm`**".

For example, if the **date(1M)** command on the file server shows the time is set to:
“Tue Jul 7 11:20:00 **EST** 1998”,
set the netboot client hardware clock using **PPCBug** as follows:

```
PPC1-Bug>TIME
Thu Jan 1 00:00:00.00 1970
PPC1-Bug>SET 0707981620
Tue Jul 7 16:20:00.00 1998
```

Note

If the hardware clock is not updated you may not be able to login to the client system. The login command will error with the following message:

```
UX:login: ERROR: your password has expired.
```

5.2.3. PPCBug env Setup

PPCBug displays a line describing the **ENV** variable being set. Each line always displays the default value to be used. If the default value is acceptable enter a RETURN to go to the next line. To change the default, enter the appropriate value and then enter RETURN. Updates are saved by entering a ‘Y’ when prompted (last line in sample below). Note that the default value is the last value set into NVRAM.

The parameters marked below with a double underline (sample) must be set as shown to allow network booting.

```
PPC1-Bug>env
Bug or System environment [B/S] - B?
Field Service Menu Enable [Y/N] - N?
Probe System for Supported I/O Controllers [Y/N] - Y?
Auto-Initialize of NVRAM Header Enable [Y/N] - Y?
Network PReP-Boot Mode Enable [Y/N] - N? N
SCSI Bus Reset on Debugger Startup [Y/N]     - N?
Primary SCSI Bus Negotiations Type [A/S/N]   - A?
Primary SCSI Data Bus Width [W/N]            - N?
Secondary SCSI Identifier                    - “07”?
NVRAM Boot List (GEV.fw-boot-path) Boot Enable [Y/N] - N?
NVRAM Boot List (GEV.fw-boot-path) Boot at power-up only [Y/N]- N?
NVRAM Boot List (GEV.fw-boot-path) Boot Abort Delay           - 5?
Auto Boot Enable [Y/N]          - N?
Auto Boot at power-up only [Y/N] - N?
Auto Boot Scan Enable [Y/N]     - N?
Auto Boot Scan Device Type List - FDISK/CDROM/TAPE/HDISK/?
Auto Boot Controller LUN   - 00?
Auto Boot Device LUN       - 00?
Auto Boot Partition Number - 00?
Auto Boot Abort Delay      - 7?
Auto Boot Default String [NULL for an empty string] -?
ROM Boot Enable [Y/N]            - N?
ROM Boot at power-up only [Y/N]  - Y?
ROM Boot Abort Delay             - 5?
ROM Boot Direct Starting Address - FFF00000?
ROM Boot Direct Ending Address   - FFFFFFFC?
Network Auto Boot Enable [Y/N]   - N? Y
Network Auto Boot at power-up only [Y/N] - N?
```

NOTE: **Y** or **N** are both valid here:

N a network boot will be attempted following any RESET.
This includes RESETs that occur as a result of a normal system shutdown.
Y a network boot will only be attempted automatically following a power-on-reset.

```
Network Auto Boot Controller LUN - 00? 0
Network Auto Boot Device LUN     - 00? 0
Network Auto Boot Abort Delay    - 5? 5
Network Auto Boot Configuration Parameters Offset (NVRAM) 00001000?
Memory Size Enable [Y/N]         - Y? Y
Memory Size Starting Address     - 00000000? 0
Memory Size Ending Address          - 04000000?
```

NOTE: Ensure that this field matches the actual
memory size installed on the board being configured.
Use the table below as your guide:

Memory Size	Ending Address
16mb	01000000
32mb	02000000
64mb	04000000
128mb	08000000
256mb	10000000
512mb	20000000
1gb	40000000

```
DRAM Speed in NANO Seconds       - 60?
ROM First Access Length (0 - 31) - 10?
ROM Next Access Length  (0 - 15) - 0?
DRAM Parity Enable [On-Detection/Always/Never - O/A/N]    - O?
L2Cache Parity Enable [On-Detection/Always/Never - O/A/N] - O?
PCI Interrupts Route Control Registers (PIRQ0/1/2/3) -0A000E0F?
Serial Startup Code Master Enable [Y/N] - N?
Serial Startup Code LF Enable [Y/N] -     N?

Update Non-Volatile RAM (Y/N)? Y
```

5.2.4. PPCBug niot Setup

The following is an example **`PPCBug`** setup for network booting and network loading. The example assumes that the File Server's Ethernet IP address is 129.76.244.105 and the net-boot client's Ethernet IP address is 129.76.244.36 and the client is called "orbity" and the path to its virtual root is **`/home/vroots/orbity`**.

```
PPC1-Bug> niot
Controller LUN    =00? 0
Device LUN        =00? 0
Node Control Memory Address =03FA0000?
Client IP Address      =0.0.0.0? 129.76.244.36
Server IP Address      =0.0.0.0? 129.76.244.105
Subnet IP Address Mask =255.255.255.0? 255.255.255.0
Broadcast IP Address   =255.255.255.255? 129.76.244.255
Gateway IP Address     =0.0.0.0? 0.0.0.0
Note: A gateway IP address is necessary if the server and the
      netboot client do not reside on the same network.
      Otherwise, it should be left as 0.0.0.0
Boot File Name (“NULL” for None) =?
/home/vroots/orbity/etc/conf/cf.d/unix.bstrap
Argument File Name (“NULL” for None) =? NULL
Boot File Load Address              =001F0000? 1000000
Boot File Execution Address         =001F0000? 1000000
Boot File Execution Delay           =00000000? 0
Boot File Length                    =00000000? 0
Boot File Byte Offset               =00000000? 0
BOOTP/RARP Request Retry            =00? 0
TFTP/ARP Request Retry              =00? 0
Trace Character Buffer Address      =00000000? 0
BOOTP/RARP Request Control: Always/When-Needed (A/W)   =W? W
BOOTP/RARP Reply Update Control: Yes/No (Y/N)          =Y? Y
Update Non-Volatile RAM (Y/N)? Y
PPC1-Bug>
```

5.3. Client Configuration

This section describes the steps in creating the environment on the file server necessary to support netboot diskless clients using **`netbootconfig(1m)`**. Major topics described are:

- Configuration Tables (page 5-6)
- Client Configuration Using **`netbootconfig`** (page 5-8)

Information about each client is specified via configuration tables. The administrator updates the configuration tables and then invokes **`netbootconfig(1m)`** to create, on the file server system, the file environment necessary to support a private virtual root directory and a private boot image for each client.

5.3.1. Configuration Tables

`netbootconfig(1m)`, gathers information from the two tables described below. Before executing this tool, the following tables must be updated with configuration information about each diskless client.

- nodes table (below)

- hosts table (page 5-8)

5.3.1.1. Nodes Table

The nodes table is found under the path **`/etc/dtables/nodes.netboot`**. This table defines the parameters that are specific to each SBC in a diskless configuration. Each line in this table defines a diskless client.

Each line in the nodes table is composed of multiple fields, which are separated by spaces or tabs. The fields in the nodes table are described below. A description of each field and example entries are also included, as comments, at the top of the table.

1. Ethernet Hostname

   This field contains the nodename to be used by the client. An entry in the **`/etc/hosts(4)`** table must exists for this host prior to running **`netbootconfig(1m)`** for a given client. The nodename must be unique in the **`/etc/hosts`** table.

2. Virtual Root Path

   This field specifies the path to the client's private virtual root directory. If the directory doesn't exist it will be created by the configuration tool. Any file system partition except for **`/`** (root) and **`/var`** may be used.

3. Subnetmask

   This field specifies the ethernet subnet network mask in decimal dot notation. If this client's base configuration (see field description below) is set to "nfs" enter a subnetmask; otherwise enter '-'.

4. Size of Swap Space

   For clients with a base configuration of "nfs", enter the number of megabytes of remote swap space to be configured. This value is recommended to be at least 1.5 times the size of DRAM (physical memory) on the client system. Clients with a base configuration of "emb" should specify '-' for this field to indicate no swap space is to be allocated. The client's virtual partition must have enough free disk space to allocate a swap file of the specified size.

5. Platform

   This field must specify one of the supported platforms. The value of the field is a string specified as one of the following:

"4600"	Motorola MVME4600, a dual processor SBC also known as the Power Hawk 640.
"2600"	Motorola MVME2600, a single processor SBC also known as the Power Hawk 620.
"mtx"	Motorola MTX/MTXII, a single or dual processor also known as PowerStack II.
"750"	Motorola MCP750, a single processor also known as MCP750.

6. Base Configuration

   This field specifies whether the client is an NFS client or an embedded client. An NFS client is configured with networking and uses NFS for mounting remote directories from the file server. An NFS client will also execute in multi-user mode and has the ability to swap memory pages, which have not been accessed recently, to a remote swap area on the file server. An embedded client does not have networking configured, cannot swap out memory pages, runs in single user mode and is generally used only as a standalone system. The field value is a string specified as either "nfs" or "emb".

7. Gateway IP Address

   This field specifies the IP address, in decimal dot notation, of the gateway system or dash "-" if a gateway is not required. A gateway is necessary if the file server and the netboot client do not reside on the same network.

5.3.1.2. Hosts Table

For each SBC listed in the nodes.netboot table an entry for the ethernet networking interface must be added to the system's **`hosts(4C)`** table. The hosts table is found under the path **`/etc/hosts`**. The hostname must match the name entered in the "Ethernet Hostname" field of the **`nodes.netboot`** table. The IP address is chosen based on local rules for the ethernet subnet.

5.3.2. Configuring Clients Using netbootconfig

The **`netbootconfig(1m)`** tool is used to create, remove or update one or more diskless client configurations. Prior to running this tool, configuration information must be specified in the configuration tables (see "Configuration Tables" on page 5-6). For more details on running this tool, see the manual page available on-line and also included in Appendix B.

`Netbootconfig(1m)` gathers information from the configuration tables and stores this information in a ksh-loadable file, named **`.client_profile`**, under the client's virtual root directory. The **`.client_profile`** is used by **`netbootconfig(1m)`**, by other configuration tools and by the client initialization process during system start-up. It is accessible on the client from the path **`/.client_profile`**.

`Netbootconfig(1m)` appends a process progress report and run-time errors to the client-private log file, **`/etc/dlogs/<client_hostname>`** on the file server, or if invoked with the **`-t`** option, to stdout.

With each invocation of the tool, an option stating the mode of execution must be specified. The modes are create client (**`-C`**), remove client (**`-R`**) and update client (**`-U`**).

5.3.2.1. Creating and Removing a Client Configuration

By default, when run in create mode (**`-C`** option), **`netbootconfig(1m)`** performs the following tasks:

- Populates a client-private virtual root directory.
- Modifies client-private configuration files in the virtual root.
- Creates the **`<virtual_rootpath>/.client_profile`**
- Modifies the **`dfstab(4C)`** table and executes the **`shareall(1m)`** command to give the client permission to access, via NFS, its virtual root directory and system files that reside on the file server.
- Generates static networking routes to communicate with the client.
- Creates the client-private custom directory **`/etc/diskless.d \ /custom.conf/client.private/<client_hostname>`**

By default, when run in remove mode (**`-R`** option), **`netbootconfig(1m)`** performs the following tasks:

- Removes the virtual root directory
- Removes client's name from the **`dfstab(4C)`** tables and executes an **`unshare(1M)`** of the virtual root directory.
- Removes static networking routes
- Removes the client-private log file - /**`etc/dlogs/<client_hostname>`**
- Removes the client-private custom directory **`/etc/diskless.d \ /custom.conf/client.private/<client_hostname>`**

The update option (**`-U`**) indicates that the client's environment already exists and, by default, nothing is done. The task to be performed must be indicated by specifying additional options. For example, one might update the files under the virtual root directory.

Examples:

Create the diskless client configuration of all clients listed in the **`nodes.netboot`** table. Process at most three clients at the same time.

```
netbootconfig -C -p3 all
```

Remove the configuration of client *rosie*. Send the output to stdout instead of to the client's log file.

```
netbootconfig -R -t rosie
```

Update the virtual root directories of clients *fred* and *barney.*

Process one client at a time.

```
netbootconfig -U -v -p 1 fred barney
```

5.3.2.2. Subsystem Support

A subsystem is a set of software functionality (package) that is optionally installed on the file server during system installation or via the **`pkgadd(1M)`** utility. Additional installation steps are sometimes required to make the functionality of a package usable on a diskless client.

Subsystem support is added to a diskless client configuration via **`netbootconfig(1m)`** options, when invoked in either create or update mode. Subsystem support is added to a client configuration via the **`-a`** option and removed via the **`-r`** option. For a list of the current subsystems supported see the **`netbootconfig(1m)`** manual page or invoke **`netbootconfig(1m)`** with the help option (**`-h`**).

Note that if the corresponding package software was added on the file server after the client’s virtual root was created, you must bring the client’s virtual root directory up-to-date using the **`-v`** option of **`netbootconfig(1m)`** before adding subsystem support.

Example 1:

Create client wilma’s configuration and add support for the IWE subsystem.

```
netbootconfig -C -a IWE wilma
```

Example 2:

Remove support for the IWE subsystem from clients *wilma* and *fred*

```
netbootconfig -U -r IWE wilma fred
```

5.4. Customizing the Basic Client Configuration

This section contains information on the following major topics:

- Modifying the Kernel Configuration (page 5-11)
- Custom Configuration Files (page 5-13)
- Modifying Settings in the Netboot Configuration Tables (page 5-18)
- Launching Applications (page 5-21)
  - Embedded Clients (page 5-21)
  - NFS clients (page 5-22)

5.4.1. Modifying the Kernel Configuration

A diskless client's kernel configuration directory is resident on the file server and is a part of the client's virtual root partition. Initially, it is a copy of the file server's **/etc/conf** directory. The kernel object modules are symbolically linked to the file server's kernel object modules to conserve disk space.

By default, a client's kernel is configured with a minimum set of drivers to support the chosen client configuration. The set of drivers configured by default for an NFS client and for an embedded configuration are listed in **modlist.nfs.netboot** and **modlist.emb.netboot** respectively, under the directory path **/etc/diskless.d/sys.conf/kernel.d**. These template files should not be modified.

Note that, for diskless clients, only one copy of the unix file (the kernel object file) is kept under the virtual root. When a new kernel is built, the current unix file is over-written. System diagnostic and debugging tools, such as **crash(1M)** and **hwstat(1M)**, require access to the unix file that matches the currently running system. Therefore, if the kernel is being modified while the client system is running and the client is not going to be immediately rebooted with the new kernel, it is recommended that the current unix file be saved.

Modifications to a client's kernel configuration can be accomplished in various ways. Note that all the commands referenced below should be executed on the file server system.

1. Additional kernel object modules can be automatically configured and a new kernel built by specifying the modules in the **kernel.modlist.add** custom file and then invoking **mknetbstrap(1m)**. The advantage of this method is that the client's kernel configuration is recorded in a file that is utilized by **mknetbstrap(1m).** This allows the kernel to be easily re-created if there is a need to remove and recreate the client configuration.
2. Kernel modules may be manually configured or deconfigured using options to **mknetbstrap(1m)**.
3. All kernel configuration can be done using the **config(1M)** utility and then rebuilding the unix kernel.
4. The **idtuneobj(1M)** utility may be used to directly modify certain kernel tunables in the specified unix kernel without having to rebuild the unix kernel.

5.4.1.1. kernel.modlist.add

The **kernel.modlist.add** custom table is used by the boot image creating tool, **mknetbstrap(1m)** for adding user-defined extensions to the standard kernel configuration of a client system. When **mknetbstrap(1m)** is run, it compares the modification date of this file with that of the unix kernel. If **mknetbstrap(1m)** finds the file to be newer than the unix kernel, it will automatically configure the modules listed in the file and rebuild a new kernel and boot image. This file may be used to change the kernel configuration of one client or all the clients. For more information about this table, see "Custom Configuration Files" on page 5-13.

5.4.1.2. mknetbstrap

Kernel modules may be configured or deconfigured via the **`-k`** option of **`mknetbstrap(1m)`**. A new kernel and boot image is then automatically created. For more information about **`mknetbstrap(1m)`**, see the on-line manual page which is also reproduced in Appendix D.

5.4.1.3. config utility

The **`config(1m)`** tool, may be used to modify a client's kernel environment. It can be used to enable additional kernel modules, configure adapter modules, modify kernel tunables, or build a kernel. You must use the **`-r`** option to specify the root of the client's kernel configuration directory.

Note that if you do not specify the **`-r`** option, you will modify the file server's kernel configuration instead of the client's. For example, if the virtual root directory for client rosie was created under **`/vroots/rosie`**, then invoke **`config(1m)`** as follows:

```
config -r /vroots/rosie
```

After making changes using **`config(1m)`**, a new kernel and boot image must be built. There are two ways to build a new boot image:

1. Use the Rebuild/Static menu from within **`config(1m)`** to build a new unix kernel and then invoke **`mknetbstrap(1m)`**. **`mknetbstrap(1m)`** will find the boot image out-of-date compared to the newly built unix file and will automatically build a new boot image.
2. Use **`mknetbstrap(1m)`** and specify "unix" on the rebuild option (**`-r`**).

5.4.1.4. idtuneobj

In situations where only kernel tunables need to be modified for an already built host and/or client kernel(s), it is possible to directly modify certain kernel tunable values in a client and/or host unix object files without the need for rebuilding the kernel.

The **`idtuneobj(1m)`** utility may be used to directly modify certain kernel tunables in the specified unix or Dynamically Linked Module (DLM) object files.

The tunables that **`idtuneobj(1m)`** supports are contained in the **`/usr/lib/idtuneobj/tune_database`** file and can be listed using the **`-l`** option of **`idtuneobj(1m)`**.

The **`idtuneobj(1M)`** utility can be used interactively, or it can process an ASCII command file that the user may create and specify.

Note that although the unix kernel need not be rebuilt, the tunable should be modified in the client's kernel configuration (see "config utility" above) to avoid losing the update the next time a unix kernel is rebuilt.

Refer to the **`idtuneobj(1m)`** man page for additional information.

5.4.2. Custom Configuration Files

The files installed under the **`/etc/diskless.d/custom.conf`** directory may be used to customize a diskless client system configuration.

In some cases a client's configuration on the server may need to be removed and re-created. This may be due to file corruption in the client's virtual root directory or because of changes needed to a client's configuration. In such cases, the client configuration described by these files may be saved and used again when the client configuration is re-created. The **`-s`** option of **`netbootconfig(1m)`** must be specified when the client configuration is being removed to prevent these files from being deleted.

The custom files listed below and described in-depth later in this section, are initially installed under the **`client.shared/nfs`** and **`client.shared/emb`** directories under the **`/etc/diskless.d/custom.conf`** path. Some of these files are installed as empty templates, while others contain the entries needed to generate the basic diskless system configuration. The files used for client customizing include:

K00client	to execute commands during system start-up
S25client	to execute commands during system shutdown
memfs.inittab	to modify system initialization and shutdown
inittab	to modify system initialization and shutdown (nfs clients only)
vfstab	to automatically mount file systems (nfs clients only)
kernel.modlist.add	to configure additional modules into the unix kernel
memfs.files.add	to add files to the memfs **`/`** (root) file system

When a client is configured using **`netbootconfig(1m)`**, a directory is created specifically for that client under the client.private directory. To generate a **`client-private`** copy of any of the custom files you must copy it from the appropriate configuration-specific directory under the **`client.shared`** directory as follows:

```
cd /etc/diskless.d/custom.conf

cp client.shared/<client_config>/<custom_file> \
client.private/<client_hostname>
```

Note that "**`client_config`**" refers to the client configuration (either 'nfs' or 'emb') established in the "Base Configuration" field in the **`/etc/dtables/nodes.netboot`** table, "**`client_hostname`**" is from the "Ethernet Hostname" field also in that table and "**`custom_file`**" is one of the custom files described below.

Changes to the customization files are processed the next time the boot image generating utility, **`mknetbstrap(1m)`**, is invoked. If **`mknetbstrap(1m)`** finds that a customization file is out-of-date compared to a file or boot image component, it will implement the changes indicated. If applicable (some changes do not affect the boot image), the boot image component will be rebuilt and a new boot image will be generated.

Each custom file described here might be located in one of several directories. The directory chosen determines whether the customization affects a single client or all clients that are built using a given file server. **`mknetbstrap(1m)`** uses the following method to determine which file path to process:

1. **`/etc/diskless.d/custom.conf/client.private/<client_hostname>`**

This is the first location where **`mknetbstrap(1m)`** will check for a version of the customization file. The customizing affects only the client that is named in the pathname of the customization file.

2. **`/etc/diskless.d/custom.conf/client.shared/nfs`**

If no private version of the customization file exists for a given client and the client is configured with NFS support, the file under this directory is used. The changes will affect all the clients configured with NFS support that do not have a version of this file installed in their **`client.private`** directory.

3. **`/etc/diskless.d/custom.conf/client.shared/emb`**

If no private version of the customization file exists for a given client and the client is configured as embedded, the file under this directory is used. The changes will affect all the clients configured as embedded that do not have a version of this file installed in their **`client.private`** directory.

Note that when a subsystem is configured via the node configuration tool **`netbootconfig(1m)`**, the tool may generate a client-private version of the customization files to add support required for that subsystem. Before modifying the **`client-shared`** versions, verify that a **`client-private`** version does not already exist. If a **`client-private`** version already exists, make the changes to that file, as the **`client.shared`** versions will be ignored for this client.

The customization files are described below in terms of their functionality.

5.4.2.1. S25client and K00client rc Scripts

Commands added to these **`rc`** scripts will be executed during system initialization and shutdown. The scripts must be written in the Bourne Shell (**`sh(1)`**) command language.

These scripts are available to both NFS and embedded type client configurations. Since embedded configurations run in **`init level 1`** and NFS configurations run in **`init level 3`**, the start-up script is executed from a different **`rc`** level directory path depending on the client configuration.

Any changes to these scripts are processed the next time the **`mknetbstrap(1m)`** utility is invoked on the file server. For embedded clients, a new **`memfs.cpio`** image and a new boot image is generated. An embedded client must be rebooted using the new boot image in order for these changes to take effect.

For NFS clients, the modified scripts will be copied into the client's virtual root and are accessed by the client during the boot process via NFS. Therefore, the boot image does not need to be rebuilt for an NFS client and the changes will take effect the next time the system is booted or shutdown.

These scripts may be updated in one of the two subdirectories under the **`client.shared`** directory to apply globally to all clients. If the customizing is to be applied to a specific client, the customized **`rc`** file should be created in the

client.private directory. Note that if there is already an existing shared customization file, and those customizations should also be applied to this client, then the shared **rc** file should be copied into the **client.private** directory and edited there.

K00client	Script is executed during system shutdown. It is executed on the client from the path **/etc/rc0.d/K00client**. By default this file is empty.
S25client	Script is executed during system start-up. It is executed on a client configured with NFS support from the path **/etc/rc3.d/S25client**. For embedded configurations, it is executed from **/etc/rc1.d/S25client**. By default this file is empty.

5.4.2.2. memfs.inittab and inittab Tables

These tables are used to initiate execution of programs on the client system. Programs listed in these files are dispatched by the init process according to the **init level** specified in the table entry. When the system initialization process progresses to a particular init level the programs specified to run at that level are initiated. It should be noted that embedded clients can only execute at **init level 1**, since an embedded client never proceeds beyond **init level 1**. NFS clients can execute at **init levels 1**, **2** or **3**. **Init level 0** is used for shutting down the system. See the on-line man page for **inittab(4**) for more information on **init levels** and for information on modifying this table.

The **memfs.inittab** table is a part of the memory-based file system, which is a component of the boot image. Inside the boot image, the files to be installed in the memory-based file system are stored as a compressed cpio file. When the **memfs.inittab** file is modified a new **memfs.cpio** image and a new boot image will be created the next time **mknetbstrap(1m)** is invoked. A client must be rebooted using the new boot image in order for any changes to take effect.

Any programs to be initiated on an embedded client must be specified to run at **init level 1**. NFS clients may use the **memfs.inittab** table for starting programs at **init levels 1-3**. However, part of the standard commands executed at **init level 3** on an NFS client is the mounting of NFS remote disk partitions. At this time, an NFS client will mount its virtual root. The memfs-based **/etc** directory is used as the mount point for the **<virtual_root>/etc** directory that resides on the file server. This causes the **memfs.inittab** table to be replaced by the **inittab** file. This means that any commands to be executed in **init state 0** (system shutdown) or commands which are to be respawned in **init state 3**, should be added to both the **memfs.inittab** and the **inittab** file if they are to be effective.

Note that after configuring an NFS client system, the **inittab** table contains entries that are needed for the basic operation of a diskless system configuration. The default entries created by the configuration utilities in the **inittab** file should not be removed or modified.

Changes to **inittab** are processed the next time **mknetbstrap(1m)** is invoked. The **inittab** table is copied into the client's virtual root and is accessed via NFS from the client system. Therefore, the boot image does not need to be rebuilt after modifying the **initab** table and the changes to this table will take effect the next time the system is booted or shutdown.

Like the other customization files, these tables may be updated in one of two subdirectories. Changes made under the **/usr/etc/diskless.d/custom.conf/client.shared/** directory apply globally to all clients that share this file server. If the changes are specific to a particular client, the shared file should be copied to the client's private directory, **/usr/etc/diskless.d/custom.conf/client.private/<client_hostname>**, and edited there.

5.4.2.3. vfstab Table

The **vfstab** table defines attributes for each mounted file system. The **vfstab** table applies only to NFS client configurations. The **vfstab(4)** file is processed when the **mountall(1m)** command is executed during system initialization to **run level 3**. See the **vfstab(4)** on-line manual page for rules on modifying this table.

Note that configuring an NFS client configuration causes this table to be installed with entries needed for basic diskless system operation and these entries should not be removed or modified.

The **vfstab** table is part of the client's virtual root and is accessed via NFS. The boot image does not need to be rebuilt after modifying the **vfstab** table, the changes will take effect the next time the system is booted or shutdown.

Like the other customization files, these tables may be updated in one of the two subdirectories. Changes made under the **/usr/etc/diskless.d/custom.conf /client.shared/** directory apply globally to all clients that share this file server. If the changes are specific to a particular client, the shared file should be copied to the client's private directory, **/usr/etc/diskless.d/custom.conf /client.private/<client_hostname>**, and edited there.

5.4.2.4. kernel.modlist.add Table

New kernel object modules may be added to the basic kernel configuration using the **kernel.modlist.add** file. One module per line should be specified in this file. The specified module name must have a corresponding system file installed under the **<virtual_rootpath>/etc/conf/sdevice.d** directory. For more information about changing the basic kernel Configuration, see "Modifying the Kernel Configuration" on page 5-11.

Changes to this file are processed the next time **mknetbstrap(1m)** is invoked, causing the kernel and the boot image to be rebuilt. When modules are specified that are currently not configured into the kernel (per the module's **System(4)** file), those modules will be enabled and a new unix and boot image will be created. If **mknetbstrap(1m)** finds that the modules are already configured, the request will be ignored. A client must be rebooted using the new boot image in order for these changes to take effect.

Like the other customization files, these tables may be updated in one of the two subdirectories. Changes made under the **/usr/etc/diskless.d/custom.conf /client.shared/** directory apply globally to all clients that share this file server. If the changes are specific to a particular client, the shared file should be copied to the client's private directory, **/usr/etc/diskless.d/custom.conf /client.private/<client_hostname>**, and edited there.

5.4.2.5. memfs.files.add Table

When the **mknetbstrap(1m)** utility builds a boot image, it utilizes several files for building the compressed cpio file system. The set of files included in the basic diskless memory-based file system are listed in the files **devlist.nfs.netboot** and **filelist.nfs.netboot** for NFS clients and **devlist.emb.netboot** and **filelist.emb.netboot** for embedded clients under the **/etc/diskless.d/sys.conf/memfs.d** directory. Note that there is a file named **mem.files.add** also under this directory, which is the template used for installing the system. Additional files may be added to the memory-based file system via the **memfs.files.add** table located under the **/etc/diskless.d/custom.conf** directory. Guidelines for adding entries to this table are included as comments at the beginning of the table.

A file may need to be added to the **memfs.files.add** table if:

1. The client is configured as embedded. Since an embedded client does not have access to any other file systems, then all user files must be added via this table.
2. The client is configured with NFS support and:
   a. the file needs to be accessed early during a diskless client's boot, before **run level 3** when the client is able to access the file on the file server system via NFS
   b. it is desired that the file is accessed locally rather than across NFS.

Note that, for NFS clients, the system directories **/etc**, **/usr, /sbin**, **/dev**, **/var**, **/opt** and **/tmp** all serve as mount points under which remote file systems are mounted when the diskless client reaches **run level 3**. Files added via the **memfs.files.add** table should not be installed under any of these system directories if they need to be accessed in **run level 3** as the NFS mounts will overlay the file and render it inaccessible.

Also note that files added via the **memfs.files.add** table are memory-resident and diminish the client's available free memory. This is not the case for a system where the boot image is stored in flash, since pages are brought into DRAM memory from flash only when referenced.

Changes to the **memfs.files.add** file are processed the next time **mknetbstrap(1m)** is invoked. A new memfs image and boot image is then created. A client must be rebooted using the new boot image in order for these changes to take effect.

You can verify that the file has been added to the **memfs.cpio** image using the following command on the server:

```
rac -d < <virtual_rootpath>/etc/conf/cf.d/memfs.cpio \
| cpio -itcv | grep <file>
```

5.4.3. Modifying Configuration Table Settings

Once a diskless configuration has been established, it is often necessary to modify some aspect of the configuration. It is strongly recommended that the client configurations be removed and recreated by modifying the parameters in the **`nodes.netboot`**. This will prevent errors caused by modifying one part of a configuration and missing one of the dependencies that this modification required.

There may be special circumstances, however, where manual updates of the diskless configuration may be justified. When parameters that are defined in the configuration tables are manually modified, it may also be necessary to update one or more of the following:

a. the client's kernel configuration - modifications to the kernel configuration may be accomplished in numerous ways. See "Modifying the Kernel Configuration" on page 5-11.

b. the client's **`<virtual_root>/.client_profile`** - this file is stored under the client's virtual root directory. It is an ASCII, ksh-loadable file with client-specific settings. This file can be directly edited.

c. system configuration files - specific instructions are included below when the system configuration files need to be updated.

In the following table descriptions, you will be instructed as to what changes are required when a particular field in **`nodes.netboot`** table is manually modified. Refer to the section "Nodes Table" on page 5-7, for more information about each field in the table.

5.4.3.1. Nodes Table

Changes to the **`/etc/dtables/nodes.netboot`** table affect only one client. The easiest way to change a client configuration is to remove it and re-create it as follows:

1. Look in the client's log file and note the command used to create the client configuration. The log file will be deleted when the client configuration is removed.
2. Remove the client configuration using **`netbootconfig(1m)`** and specifying the **`-R -s`** options.
3. Change the **`nodes.netboot`** table entry(ies).
4. Recreate the client configuration using **`netbootconfig(1m)`**.

To apply changes manually, use the follow guidelines specified for each field. Updating some fields requires extensive changes to the environment and are therefore, not supported. Note that it is recommended that the user destroy and rebuild the client configuration using **`netbootconfig(1m)`** rather that manually performing these changes.

1. Hostname -

   Manual changes to this field are not supported. The client configuration must be <u>removed</u> and <u>re-created</u>.

2. Virtual Root -

   To manually change this field perform the following steps:

   a. Update the field in the **`/etc/dtables/nodes.netboot`** table.

   b. Update the **`<virtual_rootpath>./client_profile`** variable, **`CLIENT_VROOT`**, with the new virtual root path.

   c. Update the virtual root path specified in **`/etc/dfs/dfstab.diskless`** table.

   d. After step c, execute the **`shareall(1m)`** command on the file server.

   e. After steps a and b, rebuild the memfs component and boot image using **`mknetbstrap(1m)`** and specifying "**`-r memfs`**", for example:

   ```
   mknetbstrap -r  memfs <client_hostname>
   ```

Since the virtual root directory is NFS mounted on the client, the client must be given permission to access the new directory path by changing the pathname in the **`dfstab.diskless`** table and then executing the **`share(1m)`** or **`shareall(1M)`** commands. The **`.client_profile`** file is included in the memfs boot image, and because the virtual root field must be known during the early stages of booting, the boot image must be rebuilt.

3. Subnetmask -

   A change to this field requires the following steps:

   a. Update the field in the **`/etc/dtables/nodes.netboot`** table.

   b. Update the subnetmask field for the "dec" network interface entry in the file **`<virtual_rootpath>/etc /confnet.d /inet/interface`**.

   c. update the **`<virtual_rootpath>./client_profile`** variable: **`CLIENT_SUBNETMASK`**.

   d. After steps a, b and c, rebuild the memfs component and boot image using **`mknetbstrap`** and specifying "**`-r memfs`**", for example:

   ```
   mknetbstrap -r memfs <client_hostname>
   ```

   e. Update the NVRAM subnet network parameter. See "PPCBug niot Setup" on page 5-5 for more information.

   f. Reboot the client.

4. Size of Remote Swap -

   To manually change this field, perform the following steps:

   a. Update the field in the **`/etc/dtables/nodes.netboot`** table.

   b. Bring down the client system.

   c. After step a, create a new swap file (see instructions below).

   d. Update the **`<virtual_rootpath>./client_profile`** variable: **`CLIENT_SWAPSZ`**.

   e. Boot the client.

Remote swap is implemented as a file under the **`dev`** directory in the client's virtual root directory. The file is named **`swap_file`**. To create a different sized swap file run the following command on the file server system. **`<virtual_root>`** is the path to the client's virtual root directory and <mgs> is the size of the swap in megabytes.

```
/sbin/dd if=/dev/zero of=<virtual_root>/dev    \
/swap_file bs=1024k count=<mgs>
```

5. Platform -

   To manually change this field, perform the following steps:

   a. Update the field in the **`/etc/dtables/nodes.netboot`** table.

   b. Update the **`<virtual_rootpath>./client_profile`** variable: **`CLIENT_PLATFORM`**.

   c. Disable/enable the platform specific kernel drivers using **`config(1M)`** and specifying "**`-r <virtual_rootpath>`**"

   d. After steps a, b and c, build a new kernel and boot image using **`mknetbstrap(1m)`** specifying "**`-r unix`**", for example:

   ```
   mknetbstrap -r unix <client_hostname>
   ```

   e. Reboot the client.

The current platform-specific kernel driver must be disabled and the new one enabled. For example if changing from a 2600 to a 4600 board, disable the **bsp2600** and enable the **bsp4600** kernel driver. Optionally, the **bspall** kernel driver may be used. This generic driver (**bspall**) can be used with all Motorola architectures.

6. Base Configuration -

   Changes to this field are not supported. The client configuration must be removed and re-created.

7. Gateway -

   A change to this field requires the following steps:

   a. Update the field in the **`/etc/dtables/nodes.netboot`** table.

b. Update the **<virtual_rootpath>./client_profile** variable: **CLIENT_GATEWAY**.

c. After steps a, and b, rebuild the memfs component and boot image using **mknetbstrap** and specifying "**-r memfs**", for example:

```
mknetbstrap -r memfs <client_hostname>
```

d. Update the NVRAM gateway network parameter. See "PPCBug niot Setup" on page 5-5 for more information.

5.4.4. Launching Applications

Following are descriptions on how to launch applications for:

- Embedded Clients
- NFS Clients

5.4.4.1. Launching an Application (Embedded Client)

For diskless embedded clients, all the application programs and files referenced must be added to the memfs root file system via the **memfs.files.add** file. See "memfs.files.add Table" on page 5-17 for more information on adding files via the **memfs.files.add** file.

As an example, the command name **myprog** resides on the file server under the path **/home/myname/bin/myprog**. We wish to automatically have this command executed from the path **/sbin/myprog** when the client boots. This command reads from a data file expected to be under **/myprog.data**. This data file is stored on the server under **/home/myname/data/myprog.data**.

The following entries are added to the **memfs.files.add** table:

```
f   /sbin/myprog 0755   /home/myname/bin/myprog
f   /myprog.data 0444   /home/myname/data/myprog.data
```

The following entry is added to the client's start-up script:

```
#
#  Client's start-up script
#
/sbin/myprog
```

See "Custom Configuration Files" above for more information about the **memfs.files.add** table and the **S25client rc** script.

5.4.4.2. Launching an Application for NFS Clients

Clients configured with NFS support may either add application programs to the memfs root file system or they may access applications that reside on the file server across NFS. The advantage to using the memfs root file system is that the file can be accessed locally on the client system rather than across the network. The disadvantage is that there is only limited space in the memfs file system. Furthermore, this file system generally uses up physical memory on the client system. When the client system is booted from an image stored in flash ROM, this is not the case, since the memfs file system remains in flash ROM until the pages are accessed and brought into memory.

To add files to the memfs root file system follow the procedures for an embedded client above.

When adding files to the client's virtual root so that they can be accessed on the client via NFS, the easiest method is to place the file(s) in one of the directories listed below. This is because the client already has permission to access these directories and these directories are automatically NFS mounted during the client's system initialization.

Storage Path on File Server	**Access Path on the Client**
`/usr`	`/usr`
`/sbin`	`/sbin`
`/opt`	`/opt`
`<virtual_root>/etc`	`/etc`
`<virtual_root>/var`	`/var`

As an example, the command name **`myprog`** was created under the path **`/home/myname/bin/myprog`**. To have this command be accessible to all the diskless clients, on the file server we could **`mv(1)`** or **`cp(1)`** the command to the **`/sbin`** directory.

```
mv /home/myname/bin/myprog /sbin/myprog
```

If only one client needs access to the command, it could be moved or copied to the **`/etc`** directory in that client's virtual root directory.

```
mv /home/myname/bin/myprog <virtual_root>/etc/myprog
```

To access an application that resides in directories other than those mentioned above, the file server's directory must be made accessible to the client by adding it to the **`dfstab(4)`** table and then executing the **`share(1M)`** or **`shareall(1M)`** command on the file server. To automatically have the directories mounted during the client's system start-up, an entry must be added to the client's **`vfstab`** file. See "Custom Configuration Files" on page 5-13 for more information about editing the **`vfstab`** file.

5.5. Booting and Shutdown

This section describes the following major topics:

- The Boot Image (page 5-23)

- Creating the Boot Image (page 5-24)
- Net Booting (page 5-25)
- Verifying Boot Status (page 5-28)
- Shutting Down the Client (page 5-28)

5.5.1. The Boot Image

The boot image is the file that is loaded from the file server to a diskless client. The boot image contains everything needed to boot a diskless client. The components of the boot image are:

- unix kernel binary
- compressed cpio archive of a memory-based file system
- a bootstrap loader that uncompresses and loads the unix kernel

Each diskless client has a unique virtual root directory. Part of that virtual root is a unique kernel configuration directory (**`etc/conf`**) for each client. The boot image file (**`unix.bstrap`**), in particular two of its components: the kernel image (**`unix`**) and a memory-based file system (**`memfs.cpio`**), are created based on configuration files that are part of the client's virtual root.

The makefile, **`/etc/diskless.d/bin/bstrap.makefile`**, is used by **`mknetbstrap(1m)`** to create the boot image. Based on the dependencies listed in that makefile, one or more of the following steps may be taken by **`mknetbstrap(1m)`** in order to bring the boot image up-to-date.

1. Build the unix kernel image and create new device nodes.
2. Create and compress a cpio image of the files to be copied to the memfs root file system.
3. Insert the loadable portions of the unix kernel, the bootstrap loader, the compressed cpio image and certain bootflags into the **`unix.bstrap`** file. The unix kernel portion in **`unix.bstrap`** is then compressed.

When **`mknetbstrap`** is invoked, updates to key system files on the file server (i.e. **`/etc/inet/hosts`**) will cause the automatic rebuild of one or more of the boot image components. In addition, updates to user-configurable files also affect the build of the boot image. A list of the user-configurable files and the boot image component that is affected when that file is modified are shown below in Table 5-1. These files are explained in detail under section "Customizing the Basic Client Configuration" on page 5-10.

Table 5-1. Boot Image Dependencies

Boot Image Component	**User-Configurable File**
`unix kernel`	**`kernel.modlist.add`**
`memfs cpio`	**`memfs.files.add`**
	`memfs.inittab`
	`K00client` **`(embedded client configurations only)`**
	`KS25client` **`(embedded client configurations only)`**

The boot image and its components are created under **`etc/conf/cf.d`** in the client's virtual root directory.

5.5.2. Creating the Boot Image

The **`mknetbstrap(1m)`** tool is used to build the boot image. This tool gathers information about the client(s) from the **`/etc/dtables/nodes.netboot`** table and from the ksh-loadable file named **`.client_profile`** under the client's virtual root directory. The manual page for this command is included in Appendix D. Some example uses follow. Note that building a boot image is resource-intensive. When creating the boot image of multiple clients in the same call, use the **`-p`** option of **`mknetbstrap(1m)`** to limit the number of client boot images which are simultaneously processed.

5.5.2.1. Examples on Creating the Boot Image

Example 1.

Update the boot image of all the clients configured in the **`nodes.netboot`** table. Limit the number of clients processed in parallel to 2.

```
mknetbstrap -p2 all
```

Example 2.

Update the boot image of clients *wilma* and *fred*. Force the rebuild of the unix kernels and configure the boot images to stop in **`kdb`** early during system initialization.

```
mknetbstrap -r unix -b kdb wilma fred
```

Example 3.

Update the boot image of all the clients listed in the **`nodes.netboot`** table. Rebuild their **`unix`** kernel with the **`kdb`** module configured and the **`rtc`** kernel module deconfigured. Limit the number of clients processed in parallel to 3.

```
mknetbstrap -p 3 -k kdb -k "-rtc" all
```

5.5.3. Net Booting

Netboot diskless clients boot from an image downloaded via an ethernet network connection. Net booting (also referred to as "Network booting") is performed by the PPCBug ROM based firmware using the TFTP (Trivial File Transfer Protocol, RFC783) and optionally, the BOOTP (Bootstrap Protocol), RFC951) network protocols.

A netboot client may download the boot image and, instead of booting from it, may burn the boot image into its Flash Memory for later booting. This is called Flash booting and its described in a separate chapter. Refer to "Flash Booting" on page 6-58 for more information on Flash Booting.

Netboot diskless clients depend on the file server for the creation and storage of the boot image. Once booted, netboot clients configured with NFS support rely on the file server for accessing their system files across NFS. Clients configured as embedded, once up and running, do not depend on any other system.

Prior to net booting, verify that the following steps have been completed:

1. Verify that the NVRAM net boot parameters have been set (see "PPCBug niot Setup" on page 5-5).
2. Verify that the boot image has been created. (See "Creating the Boot Image" on page 5-24.)
3. Verify that the file server is up and running in **`run level 3`**.

Network auto boot may be selected using the **`PPCBug env`** command which instructs **`PPCBug`** to attempt network boot at any system reset, or optionally only at power-on reset. The **`PPCBug env`** command allows setting several types of auto boot modes. All other auto boot loaders (Auto Boot and ROM Boot) must be disabled for the network auto boot to function correctly.

Following is an example run of **`PPCBug's nbo`** command and a listing of the boot error codes that **`PPCBug`** will display in the event that the network boot fails. The network information displayed when the **`nbo`** command is run had to be stored in NVRAM by an earlier invocation of the **`PPCBug niot`** command (see "PPCBug niot Setup" on page 5-5).

5.5.3.1. Netboot Using NBO

Once the boot image is generated and the File Server is accepting network requests (is "up" and is at **init state 3**), you can test the network boot using the **`PPCBug NBO`** command:

```
PPC1-Bug> NBO
Network Booting from: DEC21140, Controller 0, Device 0
Device Name: /pci@80000000/pci1011,9@e,0:0,0
Loading: /home/vroots/orbity/etc/conf/cf.d/unix.bstrap
Client IP Address           = 129.76.244.36
Server IP Address           = 129.76.244.105
Gateway IP Address          = 0.0.0.0
Subnet IP Address Mask      = 255.255.255.0
Boot File Name               = /home/vroots/orbity/etc  \
                               /conf/cf.d/unix.bstrap
Argument File Name          =
Network Boot File load in progress... To abort hit <BREAK>
Bytes Received =&6651904, Bytes Loaded =&6651904
Bytes/Second =&246366, Elapsed Time =27 Second(s)
*** Kernel boot messages will appear here ***
```

Network Auto Boot may be selected using the **PPCBug ENV** command which instructs **PPCBug** to attempt network boot at any system reset, or optionally only at power-on reset. All other auto boot loaders (Auto Boot and ROM Boot) must be disabled.

5.5.3.2. Boot Error Codes

In the event that the **NBO** command fails, **PPCBug** will display an error:

```
Network Boot Logic Error
Packet Status: XXYY
```

The status word returned by the network system call routine flags an error condition if it is not zero. The most significant byte of the status word reflects the controller-independent errors. These errors are generated by the network routines. The least-significant byte of the status word reflects controller-dependent errors. These errors are generated by the controller. The status word is shown in Figure 5-1.

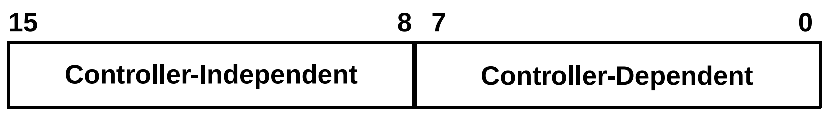

Figure 5-1. Command Packet Status Word

The Controller-Independent error codes are independent of the specified network interface. These error codes are normally some type of operator error. The Controller-Independent error codes are shown in Table 5-2.

Table 5-2. Controller-Independent Error Codes

Code	Description	Code	Description
$01	Invalid Controller Logical Unit Number	$0A	Time-Out Expired
$02	Invalid Device Logical Unit Number	$81	TFTP, File Not Found
$03	Invalid Command Identifier	$82	TFTP, Access Violation
$04	Clock (RTC) is Not Running	$83	TFTP, Disk Full or Allocation Exceeded
$05	TFTP Retry Count Exceeded	$84	TFTP, Illegal TFTP Operation
$06	BOOTP Retry Count Exceeded	$85	TFTP, Unknown Transfer ID
$07	NVRAM Write Failure	$86	TFTP, File Already Exists
$08	Illegal IPL Load Address	$87	TFTP, No Such User
$09	User Abort, Break Key Depressed	----	------------------------

The Controller-Dependent error codes relate directly to the specific network interface. These errors occur at the driver level out to and including the network. The Controller-Dependent error codes are shown in Table 5-3.

Table 5-3. Controller-Dependent Error Codes

Code	Description	Code	Description
$01	Buffer Not 16-Byte Aligned	$16	Transmitter Loss of Carrier
$02	Shared Memory Buffer-Limit Exceeded (Software)	$17	Transmitter 10Base T Link Fail Error
$03	Invalid Data Length (MIN <= LNGTH <= MAX)	$18	Transmitter No Carrier
$04	Initialization Aborted	$19	Transmitter Time-out on PHY
$05	Transmit Data Aborted	$20	Receiver CRC Error
$06	PCI Base Address Not Found	$21	Receiver Overflow Error
$07	No Ethernet Port Available On Base-Board	$22	Receiver Framing Error
$10	System Error	$23	Receiver Last Descriptor Flag Not Set
$11	Transmitter Babble Error	$24	Receiver Frame Damaged by Collision
$12	Transmitter Excessive Collisions	$25	Receiver Runt Frame Received
$13	Transmitter Process Stopped	$28	Transmitter Time-Out During a Normal Transmit
$14	Transmitter Underflow Error	$29	Transmitter Time-Out During a Port Setup
$15	Transmitter Late Collision Error	$30	SROM Corrupt

The error codes are returned via the driver and they will be placed in the controller-dependent field of the command packet status word. All error codes must not be zero (an error code of $00 indicates No Error).

5.5.4. Verifying Boot Status

If the client is configured with NFS support, you can verify that the client was successfully booted using any one of the following methods:

- **`rlogin(1)`** or **`telnet(1)`** from the file server system, or
- attach a terminal to the console serial port and login.

You can also use the **`ping(1m)`** command to verify that the network interface is running. Note, however, that this does not necessarily mean that the system successfully booted.

If the client does not boot, verify that the NFS daemons are running by executing the **`nfsping(1m)`** command on the file server. An example run of this command is shown below.

```
# nfsping -a
nfsping: rpcbind is running
nfsping: nfsd is running
nfsping: biod is running
nfsping: mountd is running
nfsping: lockd is running
nfsping: statd is running
nfsping: bootparamd is running
nfsping: pcnfsd is running
nfsping: The system is running in client, server, bootserver,
         and pc server modes
```

If there is a console attached to the client and the client appears to boot successfully but cannot be accessed from any other system, verify that the **`inetd(1m)`** daemon is running on the client.

5.5.5. Shutting Down the Client

From the client's console, the client may be shutdown using any of the system shutdown commands, e.g. **`shutdown(1M)`** or **`init(1M)`**.

A client configured with NFS can be shutdown from the file server using the **`rsh(1)`** command. For example, the following **`shutdown(1m)`** command would bring the system configured with the ethernet hostname '*fred*' to **`init state 0`** immediately.

rsh *fred* **/sbin/shutdown -g0 -y -i0**

By default, clients configured in Embedded mode do not require an orderly shutdown but an application may initiate it.

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6
VME Boot System Administration

6.1. Overview

This chapter describes in detail the following operations and/or procedures:

- Cluster Configuration Overview (below)
- SBC Configuration (page 6-5)
- Cluster Configuration (page 6-22)
- Customizing the Basic Configuration (page 6-34)
- Booting and Shutdown (page 6-50)

6.2. Cluster Configuration Overview

This is an overview of the steps that must be followed in configuring a closely-coupled configuration. Each of these steps is described in more detail in the sections that follow.

This section covers the following topics:

- Installing the Local and Remote Clusters (page 6-2)
- How To Boot the Local Cluster (page 6-3)
- How To Boot Each Remote Cluster (page 6-3)
- Installing Additional Boards and Clusters (page 6-4)

A closely-coupled configuration consists of one local cluster and optionally one or more remote clusters. The cluster that has the file server as a member is defined as local, all others are remote.

The standard way of booting clients in a local cluster is over the VMEbus. The first client (SBC 0) in a remote cluster must be network booted via a network connection to the file server. Other clients in the remote cluster can be VME booted from SBC 0, which acts as a boot server for the remote cluster. The actual commands that cause remote clients to be booted are run on the file server. In the case of a remote cluster, those commands will cause remote execution of the boot sequence from the boot server in the remote cluster.

Any client, in any cluster, could be configured to network boot via an ethernet network connection. Network booting requires a physical connection to the subnet on which the File Server resides. This is normally accomplished by using an appropriate Ethernet

Multi-Port Hub (AUI or 10BaseT), or connecting to a 10Base2 (BNC) subnet using an AUI-to-BNC transceiver. VME booting is the preferred booting method since it does not require additional hardware setup.

6.2.1. Installing the Local and Remote Clusters

Follow these instructions to install the local cluster.

Remote clusters may be added at the same time or at a later date using the instructions described under "Installing Additional Boards and Clusters" on page 6-4.

1. Install all SBC boards and program the NVRAM parameter settings of each (see "Procedure for Installing SBC Boards" on page 6-7 for more information).

2. Install the file server (SBC 0 in the local cluster) with the prerequisite software packages, the diskless package and all patches. Refer to Chapter 1, "Software Prerequisites" on page 1-29, and the applicable system release notes for more information.

3. Configure and mount a filesystem(s) (other than **`/`** (root) or **`/var`**) that can be used to store the virtual root directories for each client. If not already present, an entry for this filesystem must be added to **`/etc/vfstab`**. An existing filesystem can be used, but there must be sufficient file space to hold the client's virtual root files. See "Disk Space Requirements" on page 1-28 for details of the amount of file space required.

4. For each board installed, add client configuration information to the following tables: **`/etc/dtables/clusters.vmeboot`**, **`/etc/dtables/nodes.vmeboot`** and **`/etc/hosts`**. See "Cluster Configuration" on page 6-22 for more information.

5. Execute **`vmebootconfig(1m)`** to configure the build environment for all diskless clients listed in the **`nodes.vmeboot`** table and to modify the file server's kernel configuration to run in closely-coupled mode. You can monitor a particular client's configuration process by viewing the log file **`/etc/dlogs/<client_vmehostname>`**. See "Node Configuration Using vmebootconfig(1m)" on page 6-29 for more information.

6. Rebuild the file server's kernel (using **`idbuild(1M)`**) and reboot the file server.

7. Boot the default client configuration before attempting to customize any client configurations. First boot the local and then each of the remote clusters. See "How To Boot the Local Cluster", "How To Boot Each Remote Cluster" both immediately below, and "Booting and Shutdown" on page 6-50 for more information.

   You can monitor a particular client's boot process by viewing the log file **`/etc/dlogs/<client_vmehostname>`**.

8. As needed, customize the client configuration and reboot using **`mkvmebstrap`**. See section "Customizing the Basic Configuration" on page 6-34 for more information.

6.2.2. How To Boot the Local Cluster

The method for booting a client system depends on whether the client boot is initiated via the VME backplane (VME boot) or is initiated from the client system (self boot). Note that systems which boot from a boot image that is loaded in flash fall into either the VME boot or self boot categories depending on whether or not the boot process is initiated over the VME bus. A client that is booted over ethernet is always self booted. A client that downloads its boot image over the VME bus is always VME booted.

When a client boot is initialized via the VME backplane, there is the option of automatically booting client systems as part of the file server's initialization. Listed below are three possible scenarios for booting client systems. For full details of the interaction of the boot interface and automatic booting, see "Booting Options" on page 6-52.

a. <u>VME boot clients with autoboot</u>

   When the file server is booted, the client systems that have autoboot configured will automatically be booted as part of the file server's system initialization. Note that client booting in this case is performed by background processes. If a manual boot of the client is initiated while the background processes are actively booting the client, the results for the client will be undefined.

b. <u>VME boot clients with no autoboot</u>

   In this case clients must be manually booted by running commands on the file server. Use **`mkvmebstrap(1M)`** to create the boot image and boot the client. Note that these operations can be combined in a single invocation of **`mkvmebstrap(1M)`**.

c. <u>Netboot clients</u>

   These clients are booted via **`PPCBug`** firmware commands. The NVRAM Network Parameters must be set up (see "Example PPCBUG NIOT Configuration" on page 6-21 for details). Use **`mkvmebstrap(1M)`** to create the boot image. Execute **`PPCBug`** firmware commands on the client system's console to boot the client from an ethernet connection or from flash ROM.

6.2.3. How To Boot Each Remote Cluster

Follow these instructions to boot each remote cluster.

a. Create the boot images for all remote cluster client system by running **`mkvmebstrap(1M)`** on the file server.

b. Once the boot images have been created, boot the boot server of the remote cluster by executing **`PPCBug nbo`** command on the attached console.

c. Once the boot server is up and running, the remote clients can be booted. As in booting clients in the local cluster, the method for booting of client systems depends on whether the client is using netboot, vmeboot and whether the autoboot option is enabled.

a. VME boot clients with autoboot

A background process was started on the boot server during the boot server’s system initialization to boot the autoboot clients. Nothing further needs to be done.

b. VME boot clients with no autoboot

A manual boot of vmeboot clients can be performed with the **`mkvmebstrap(1M)`** command on the file server. The **`sbcboot(1M)`** command can also be run on the boot server or the remote cluster.

c. Netboot clients

Before attempting to boot a netboot client, verify that the NVRAM network parameters have been set (see “Example PPCBUG NIOT Configuration” on page 6-21 for details). Execute **`PPCBug nbo`** command on the client system.

6.2.4. Installing Additional Boards and Clusters

Use these instructions when adding additional boards or clusters after the initial configuration of the closely-coupled system.

1. If the board(s) have not yet been installed:

   a. For each configured cluster in which a board will be added, perform an orderly system shutdown of each client running in the cluster and power down the cluster. If the local cluster is affected, it means that the file server will be shut down. Depending upon the application’s dependence upon the file server, this could mean that the remote clusters should also be shutdown when the local cluster is shutdown.

   b. Install all additional SBC boards and program the NVRAM parameter settings of each. See “Procedure for Installing SBC Boards” on page 6-7 for more information.

2. For each additional board, add client configuration information to the configuration tables: **`/etc/dtables/nodes.vmeboot`** and **`/etc/hosts`**. If defining a new cluster also add an entry to the **`/etc/dtables/clusters.vmeboot`** table. See “Configuration Tables” on page 6-22 for more information.

3. Execute **`vmebootconfig(1m)`** to configure the build environment for the new clients. Specify each client’s VME hostname or the **`-c`** option when defining a new cluster. See “Node Configuration Using vmebootconfig(1m)” on page 6-29 for more information.

4. Follow the standard rules in step 7 above for booting any clusters where a new board or boards have been installed.

5. As needed, customize the configuration of the new clients and reboot using **`mkvmebstrap`**. See “Customizing the Basic Configuration” on page 6-34 for more information.

6.3. SBC Configuration

This section covers both the PH620 and PH640 SBC boards. Major topics covered in this section are as follows:

- Hardware Jumpers (page 6-5)
- NVRAM Modifications (page 6-6)
- NVRAM Board Settings (page 6-9)
- Example PPCBUG ENV Configuration (page 6-18)
- Example PPCBUG NIOT Configuration (page 6-21)

Unless otherwise specified, information presented is applicable to both the PH620 and PH640 SBC boards. Each SBC board requires minor modifications to their default NVRAM settings and hardware jumpers. These modifications enable sharing of the VME bus, inter-board communication and DRAM access between boards. Please read Chapter 3, “VME SBC Hardware Considerations” for proper board installation procedures and for location of headers, jumper configurations, connectors, front panel switches and LEDs.

6.3.1. Hardware Jumpers

The host is defined as SBC 0 of the cluster. This system will serve as the boot server for the other clients in the cluster. The host board must reside in VME slot 1, and must have its VMEbus System Controller Selection header J22 (PH620) or J5 (PH640) configured to be the “System Controller”. The “Auto System Controller” option should not be used.

Additional Power Hawk boards residing on the same VMEbus must have their VMEbus System Controller Selection header J22 (PH620) or J5 (PH640) configured so they are “Not System Controller”. The “Auto System Controller” option should not be used.

6.3.1.1. Backplane Daisy-Chain Jumpers

A form of daisy-chain mechanism is used to propagate the BUS GRANT and INTERRUPT ACKNOWLEDGE signals in the backplane. For more information on the daisy-chain mechanism, which varies depending on the VME chassis being used, refer to “Backplane Daisy-Chain Jumpers” on page 3-2.

6.3.2. NVRAM Modifications

In the installation instructions that follow you will be asked to modify the NVRAM settings of each board. **PPCBug**'s **env** command is used to define parameters which influence SBC operation and the **niot** command is used to define network parameters when the board will be configured to boot over ethernet.

Example **env** and **niot** sessions follow the installation instructions.

6.3.2.1. PPCBug Overview

PPCBug is the first level of software that is executed by an SBC whenever the board is powered up. Some of the most important functions of **PPCBug** are to initialize the SBC hardware on startup, permit autobooting of an operating system or manual booting, and provide diagnostic (debug) capabilities to the operating system after it is booted.

PPCBug communicates to the operator through COM Port #1. It is up to the operator to connect a terminal to this RS232 port whenever communication to **PPCBug** is desired. Some systems make available an ABORT button. By default, depressing this button interrupts whatever is running. When done, the interrupted software can be continued with the **PPCBug** command **G** (the **go** command).

Board initialization and booting is a process that can be configured in advance by the user using the **PPCBug** commands **env** and **niot**. These two commands save the desired startup configuration information in the board's NVRAM (non-volatile RAM). **PPCBug** will examine the NVRAM each time the SBC board is powered up or reset.

NVRAM parameters are modified using the **PPCBug env**, **niot** and **set** commands.

ENV - Set Environment

This command defines many parameters which influence the SBC operation. Part of the **ENV** command allows for "Network Auto Boot" or "Flash Auto Boot". When "Network Auto Boot" is enabled, the SBC upon power-on, or optionally at system RESET, will automatically attempt a network boot. Manual intervention is not required. If Flash autoboot is selected instead, the same attempt is made, but from the designated Flash Memory device.

NIOT - Network I/O Teach

Define various network parameters used during the network boot operation.

SET The **SET** command starts the real-time clock and sets the time and date.

TIME The **TIME** command displays the current date and time of day.

PPCBug contains many other useful commands, some of which are an assembler and disassembler, memory patch and examination commands, and breakpoint commands. For a full description of **PPCBug** capabilities, refer to the Motorola *PPCBug Debugging Package Users* Manual (refer to Referenced Publications section in the Preface for more information).

6.3.2.2. Procedure for Installing SBC Boards

The following tasks must be performed to install SBC boards and optional VME boards in the VME card cage. Refer to Chapter 3, VME SBC Hardware Considerations, for additional information you may need to perform these procedures. For applicable backplane daisy-chain jumper requirements, refer to “Backplane Daisy-Chain Jumpers” on page 3-2.

Note that the name host refers to board number 0 or the boot server of the cluster. In the case of the local cluster, the boot server is the file server. The name client<n> refers to board number n. For example, client1 refers to board number 1, client2 refers to client board number 2 and so on.

Also note that the SBC in VME slot 1 must be configured as board number 0. Other SBCs installed on the same VMEbus must be assigned a unique ID number between 1 and the maximum as defined by the DRAM window size (see “DRAM Window Size and VMEbus Slave Image 1 Settings” on page 6-11). By convention, boards are usually assigned the next available ID number in a left-to-right fashion.

Caution

Attach an ESD strap to your wrist. Attach the other end of the ESD strap to the chassis as a ground. The ESD strap must be secured to your wrist and to ground throughout the procedure.

1. Perform an orderly shutdown of the Power Hawk system.
2. Power down the Power Hawk system.
3. Verify that the host SBC board is physically installed in Slot 1of the VMEbus and is configured as a “System Controller”.
4. Install additional client SBC board(s). Be sure to configure these boards to be the “Not System Controller” board. (Observe any applicable backplane daisy-chain jumper requirements.)
5. Install additional optional VME boards. (Observe any applicable backplane daisy-chain jumper requirements.)
6. Power up the system and abort the booting of the host system.
7. Modify the NVRAM parameter settings of the host board using the **PPCBug env** command. See “Example PPCBUG ENV Configuration” on page 6-18.
8. We now need to modify the NVRAM setting on each of the installed client SBCs. Access to **PPCbug** is normally provided through a serial port on the SBC. In order to attach an ASCII RS-232 terminal, a Transition Module must be attached to the same VME slot in which the SBC resides (refer to “MVME761 Transition Module Preparation” on page 3-10 for more information on the Transition Module).

NOTE

In a closely-coupled cluster, only the HOST and clients that boot over Ethernet are required to have a Transition Module installed. However, a transition module will be needed to trace system problems and to modify the board's NVRAM settings.

If the client SBC being initialized does not have a Transition Module installed, it may be temporarily swapped with the host board residing in VME slot 1. Select a procedure below based on the availability of a Transition Module with the SBC being initialized:

A. The SBC **does** **not** have a Transition Module attached

   Power OFF the VME chassis. Temporarily remove the HOST SBC (i.e. SBC #0 in VME slot 1 initialized in Step 7). Insert the SBC which is to be initialized in VME Slot 1 (where the HOST was). Turn the VME power ON. Use the existing Console to perform steps 9 through 12 which will complete the NVRAM initialization of this SBC. When NVRAM initialization is complete, power OFF the VME chassis and return the SBC to it's original slot. Repeat this procedure for each client SBC which does not have a Transition Module attached.

B. The SBC has a Transition Module attached.

   Attach a RS232 terminal to COM1 on the SBCs Transition Module. You may disconnect the HOST Console cable from the Transition Module in slot 1 and move it to COM1 on the Transition Module of the SBC being initialized (power can remain ON while moving the cable). This allows you to use one Console terminal to program all the SBCs NVRAM. Repeat this procedure for each client SBC which has a Transition Module attached.

9. Use the **`PPCBug`** **`TIME`** command to display the current date and the SET command to initialize the clock. Hours should be specified in **GMT** using the 24-hour military time format. The format of the **`PPCbug`** **`SET`** command is: **`SET "MMDDYYhhmm`**".

   For example, to set the system's time to "Tue Jul 7 11:20:00 **EST** 1998" set the hardware clock using **`PPCBug`** as follows:

```
PPC1-Bug>TIME
Thu Jan 1 00:00:00.00 1970
PPC1-Bug>SET 0707991620
Tue Jul 7 16:20:00.00 1999
```

Note

If the hardware clock is not updated, you may not be able to login to the client system. The login command will error with the following message.

```
UX:login: ERROR: your password has expired.
```

10. Modify the NVRAM parameter settings of the client board using the **PPCBug env** command. See “Example PPCBUG ENV Configuration” on page 6-18.
11. If this board will be configured to network boot, modify NVRAM network boot parameters using the **NIOT** command. Note that the boot server in a remote cluster (SBC 0) must be configured to network boot. See “Example PPCBUG NIOT Configuration” on page 6-21.
12. Repeat steps 8 through 11 for all remaining client SBC boards, moving the console terminal cable to the next client SBC board each time.
13. Reconnect the console terminal cable to the host system board.
14. If the HOST SBC was removed in step 8A, power OFF the VME chassis and replace the HOST SBC in slot 1. Re-apply power when completed.
15. If the HOST Console cable was moved in Step 8B, reconnect it to the COM1 on the HOST (slot 1) Transition Module.

6.3.3. NVRAM Board Settings

The following tables define the NVRAM settings that must be modified for each Power Hawk board within a VME cluster. Consult the PPCBug Debugging Package User's Manual for information regarding the use of the **ENV** command to modify NVRAM settings. The board name **host** refers to the boot server, SBC 0. The board name **client1** refers to the first client board SBC 1, **client2** refers to the second client board, SBC 2 and so on.

6.3.3.1. VME ISA Reg Mapping & VMEbus Slave Image 0 Settings

Power Hawk 620/640 closely-coupled systems define a 256kB region in VME A32 address space. Each SBC in the system, maps it's ISA registers in a predetermined 8KB slot in this region. Each 8KB region is probed at system initialization time to identify other PH620/640 SBCs in the system. Note that the entire 256KB region is reserved by closely-coupled software.

The VME ISA register base address must be defined in VME A32 address accessible with programmed I/O. This area is defined by the VME driver tunables `PH620_VME_A32_START` and `PH620_VME_A32_END`. By default, these tunables define a window at `0xc0000000-0xfaffffff`.

The default VME ISA Register area, defined in **`/etc/dtables/clusters.vmeboot`** to be at `0xeffc0000-0xeffffffff`.

The VMEbus Slave Image 0 registers are used to perform this mapping. Table 6-1 defines the default settings for VMEbus Slave Image 0 which maps a board's 8kB ISA memory space onto VME A32 address space. Table 6-1 assumes that the default VME ISA register base address, `0xEFFC0000`, is used (in VME A32 address space).

Table 6-1. ENV Settings (VMEbus Slave Image 0)

Board Number	Control	Start Address	Bound Address	Translation Offset
0	80F20001	EFFC0000	EFFC2000	10040000
1	80F20001	EFFC2000	EFFC4000	1003E000
2	80F20001	EFFC4000	EFFC6000	1003C000
3	80F20001	EFFC6000	EFFC8000	1003A000
4	80F20001	EFFC8000	EFFCA000	10038000
5	80F20001	EFFCA000	EFFCC000	10036000
6	80F20001	EFFCC000	EFFCE000	10034000
7	80F20001	EFFCE000	EFFD0000	10032000
8	80F20001	EFFD0000	EFFD2000	10030000
9	80F20001	EFFD2000	EFFD4000	1002E000
10	80F20001	EFFD4000	EFFD6000	1002C000
11	80F20001	EFFD6000	EFFD8000	1002A000
12	80F20001	EFFD8000	EFFDA000	10028000
13	80F20001	EFFDA000	EFFDC000	10026000
14	80F20001	EFFDC000	EFFDE000	10024000
15	80F20001	EFFDE000	EFFE0000	10022000
16	80F20001	EFFE0000	EFFE2000	10020000
17	80F20001	EFFE2000	EFFE4000	1001E000
18	80F20001	EFFE4000	EFFE6000	1001C000
19	80F20001	EFFE6000	EFFE8000	1001A000
20	80F20001	EFFE8000	EFFEA000	10018000

If you need to change the VME ISA register base to a different address, a new table can be generated using the following equations (pseudo code):

```
control =  0x80F20001; # for all boards
start   =  NEW_VME_ISA_BASE_ADDR + (Board # * 0x2000)
bound   =  start + 0x2000
offset  =  -start (i.e. ~start + 1)
```

For example, changing the VME ISA base address to `0xE0000000` results in the following VMEbus Slave Image 0 Settings:

```
Board 0 control = 0x80F20001
Board 0 start   = 0xE0000000  (i.e. 0xE0000000 + (0*0x2000))
Board 0 bound   = 0xE0002000  (i.e. 0xE0000000 + 0x2000)
Board 0 offset  = 0x20000000  (i.e. -0xE0000000)
Board 1 control = 0x80F20001
Board 1 start   = 0xE0002000  (i.e. 0xE0000000 + (1*0x2000))
Board 1 bound   = 0xE0004000  (i.e. 0xE0002000 + 0x2000)
Board 1 offset  = 0x1FFFE000  (i.e. -0xE0002000)
Board 7 control = 0x80F20001
Board 7 start   = 0xE000E000 (i.e. 0xE0000000 + (7*0x2000))
Board 7 bound   = 0xE0010000 (i.e. 0xE000E000 + 0x2000)
Board 7 offset  = 0x1FFF2000 (i.e. -0xE000E000)
```

6.3.3.2. DRAM Window Size and VMEbus Slave Image 1 Settings

A closely-coupled cluster defines a “DRAM Window Size” configuration parameter which is used to define where SBC DRAM is mapped into VME A32 address space.

SBC DRAM mapping is necessary to allow other VMEbus devices (i.e. VME SCSI controller, 1553 interface, et al) to directly access each processor's DRAM. The closely-coupled software uses this VMEbus slave window to download client software (i.e. kernel bootstrap image) and start execution of the bootstrap. The VMEMSG driver (VME based network driver) also uses this area to transfer packets from one SBC to another.

The DRAM window size represents the maximum amount of DRAM that may be configured in a given cluster. Note that this is a maximum value - the actual configured boards may, and usually do, have less memory installed than the DRAM window supports.

The closely-coupled system reserves the first 2GB of VME A32 address space (`0x00000000-0x7fffffff`) for this purpose. Five DRAM window sizes are supported: 64MB, 128MB, 256MB, 512MB and 1GB. Since only 2GB of VME space is available for mapping, the DRAM window size forces limits on the number of SBCs that can be installed in a VME chassis. Table 6-2 shows the relationship between DRAM window size and the maximum number of SBCs that can be configured in a VME chassis.

Table 6-2. DRAM Window Sizes

DRAM Window Size	Maximum SBC's per Chassis
1 GB	2
512 MB	4
256 MB	8
128 MB	16
64 MB	21

Table 6-3 through Table 6-7 defines various settings for VMEbus Slave Image 1 which maps the board's DRAM memory space into VME address space. To determine which table to use, you need to know the amount of physical DRAM installed in each SBC being configured, and the maximum number of SBCs which will be installed. Choose the appropriate MAX DRAM Window table by answering the questions below:

1. Do you have any PH640 SBCs with 1024MB DRAM?
   If Yes, use Table 6-6 to setup for a 1024MB DRAM window.
2. If not, do you have any PH640 SBCs with 512MB DRAM?
   If Yes, use Table 6-7 to setup for a 512MB DRAM window.
3. If not, do you need to install more than 4 PH640 SBCs?
   If No, use Table 6-7 to setup for a 512MB DRAM window. This allows for future memory upgrades without the need to reconfigure the cluster.
4. Do you have any SBCs with 256MB DRAM?
   If Yes, use Table 6-3 to setup for a 256MB DRAM window.
5. If not, do you need to install more than 8 SBCs?
   If No, use Table 6-3 to setup for a 256MB DRAM window. This allows for future memory upgrades without the need to reconfigure the cluster.
6. If so, do you have any SBCs with 128MB DRAM?
   If Yes, use Table 6-4 to setup for a 128MB DRAM window.
7. If not, do you need to install more than 16 SBCs?
   If No, use Table 6-4 to setup for a 128MB DRAM window. This allows for future memory upgrades, up to 128MB per board without the need to reconfigure the cluster.
8. If so, use Table 6-5 to setup for a 64MB DRAM window.

NOTE

The DRAM Window Size is an attribute of a cluster. This means the same cluster MAX DRAM Window table must be used to define all boards in the same cluster.

When defining the cluster using the table at **`/etc/dtables/clusters.vmeboot`**, the Max DRAM index field selection must correspond to the DRAM Window Size used here to program the board’s NVRAM.

Changing the DRAM Window Size in an existing cluster requires changing the **`PPCBug`** variables for each board in the cluster, and redefining the cluster, file server, and all clients in the cluster.

Table 6-3. 256MB MAX DRAM Window - ENV Settings/VMEbus Slave Image 1

Board Number	**VME Slave Register**	**Amount Of Physical On-Board Memory (DRAM)**			
		32MB	**64MB**	**128MB**	**256MB**
0	**control** **start** **bound** **offset**	E0F20080 00000000 02000000 80000000	E0F20080 00000000 04000000 80000000	E0F20080 00000000 08000000 80000000	E0F20080 00000000 10000000 80000000
1	**control** **start** **bound** **offset**	E0F20080 10000000 12000000 70000000	E0F20080 10000000 14000000 70000000	E0F20080 10000000 18000000 70000000	E0F20080 10000000 20000000 70000000
2	**control** **start** **bound** **offset**	E0F20080 20000000 22000000 60000000	E0F20080 20000000 24000000 60000000	E0F20080 20000000 28000000 60000000	E0F20080 20000000 30000000 60000000
3	**control** **start** **bound** **offset**	E0F20080 30000000 32000000 50000000	E0F20080 30000000 34000000 50000000	E0F20080 30000000 38000000 50000000	E0F20080 30000000 40000000 50000000
4	**control** **start** **bound** **offset**	E0F20080 40000000 42000000 40000000	E0F20080 40000000 44000000 40000000	E0F20080 40000000 48000000 40000000	E0F20080 40000000 50000000 40000000
5	**control** **start** **bound** **offset**	E0F20080 50000000 52000000 30000000	E0F20080 50000000 54000000 30000000	E0F20080 50000000 58000000 30000000	E0F20080 50000000 60000000 30000000
6	**control** **start** **bound** **offset**	E0F20080 60000000 62000000 20000000	E0F20080 60000000 64000000 20000000	E0F20080 60000000 68000000 20000000	E0F20080 60000000 70000000 20000000

Table 6-3. 256MB MAX DRAM Window - ENV Settings/VMEbus Slave Image 1 (Cont.)

Board Number	**VME Slave Register**	**Amount Of Physical On-Board Memory (DRAM)**			
		32MB	**64MB**	**128MB**	**256MB**
7	**control** **start** **bound** **offset**	E0F20080 70000000 72000000 10000000	E0F20080 70000000 74000000 10000000	E0F20080 70000000 78000000 10000000	E0F20080 70000000 80000000 10000000

NOTES

PPCbug “ENV” prompt:

VMEbus Slave Image 1 Control: use table “**control**” field
VMEbus Slave Image 1 Base Address Register: use table “**start**” field
VMEbus Slave Image 1 Bound Address Register: use table “**bound**” field
VMEbus Slave Image 1 Translation Offset: use table “**offset**” field

Table 6-4. 128MB MAX DRAM Window - ENV Settings/VMEbus Slave Image 1

Board No	**VME Slave Reg**	**Amount Of Physical On-Board Memory (DRAM)**			**Board No**	**VME Slave Reg**	**Amount Of Physical On-Board Memory (DRAM)**		
		32MB	**64MB**	**128MB**			**32MB**	**64MB**	**128MB**
0	**control** **start** **bound** **offset**	E0F20080 00000000 02000000 80000000	E0F20080 00000000 04000000 80000000	E0F20080 00000000 08000000 80000000	8	**control** **start** **bound** **offset**	E0F20080 40000000 42000000 40000000	E0F20080 40000000 44000000 40000000	E0F20080 40000000 48000000 40000000
1	**control** **start** **bound** **offset**	E0F20080 08000000 0A000000 78000000	E0F20080 08000000 0C000000 78000000	E0F20080 08000000 10000000 78000000	9	**control** **start** **bound** **offset**	E0F20080 48000000 4A000000 38000000	E0F20080 48000000 4C000000 38000000	E0F20080 48000000 50000000 38000000
2	**control** **start** **bound** **offset**	E0F20080 10000000 12000000 70000000	E0F20080 10000000 14000000 70000000	E0F20080 10000000 18000000 70000000	10	**control** **start** **bound** **offset**	E0F20080 50000000 52000000 30000000	E0F20080 50000000 54000000 30000000	E0F20080 50000000 58000000 30000000
3	**control** **start** **bound** **offset**	E0F20080 18000000 1A000000 68000000	E0F20080 18000000 1C000000 68000000	E0F20080 18000000 20000000 68000000	11	**control** **start** **bound** **offset**	E0F20080 58000000 5A000000 28000000	E0F20080 58000000 5C000000 28000000	E0F20080 58000000 60000000 28000000
4	**control** **start** **bound** **offset**	E0F20080 20000000 22000000 60000000	E0F20080 20000000 24000000 60000000	E0F20080 20000000 28000000 60000000	12	**control** **start** **bound** **offset**	E0F20080 60000000 62000000 20000000	E0F20080 60000000 64000000 20000000	E0F20080 60000000 68000000 20000000
5	**control** **start** **bound** **offset**	E0F20080 28000000 2A000000 58000000	E0F20080 28000000 2C000000 58000000	E0F20080 28000000 30000000 58000000	13	**control** **start** **bound** **offset**	E0F20080 68000000 6A000000 18000000	E0F20080 68000000 6C000000 18000000	E0F20080 68000000 70000000 18000000

Table 6-4. 128MB MAX DRAM Window - ENV Settings/VMEbus Slave Image 1 (Cont.)

Board No	VME Slave Reg	Amount Of Physical On-Board Memory (DRAM)			Board No	VME Slave Reg	Amount Of Physical On-Board Memory (DRAM)		
		32MB	64MB	128MB			32MB	64MB	128MB
6	**control** **start** **bound** **offset**	E0F20080 30000000 32000000 50000000	E0F20080 30000000 34000000 50000000	E0F20080 30000000 38000000 50000000	14	**control** **start** **bound** **offset**	E0F20080 70000000 72000000 10000000	E0F20080 70000000 74000000 10000000	E0F20080 70000000 78000000 10000000
7	**control** **start** **bound** **offset**	E0F20080 38000000 3A000000 48000000	E0F20080 38000000 3C000000 48000000	E0F20080 38000000 40000000 48000000	15	**control** **start** **bound** **offset**	E0F20080 78000000 7A000000 08000000	E0F20080 78000000 7C000000 08000000	E0F20080 78000000 80000000 08000000

NOTES

`PPCbug` "ENV" prompt:

VMEbus Slave Image 1 Control: use table "**control**" field
VMEbus Slave Image 1 Base Address Register: use table "**start**" field
VMEbus Slave Image 1 Bound Address Register: use table "**bound**" field
VMEbus Slave Image 1 Translation Offset: use table "**offset**" field

Table 6-5. 64MB MAX DRAM Window - ENV Settings/VMEbus Slave Image 1

Board Number	VME Slave Regis-ter	Amount Of Physical On-Board Memory (DRAM)		Board Number	VME Slave Register	Amount Of Physical On-Board Memory (DRAM)	
		32MB	64MB			32MB	64MB
0	**control** **start** **bound** **offset**	E0F20080 00000000 02000000 80000000	E0F20080 00000000 04000000 80000000	11	**control** **start** **bound** **offset**	E0F20080 2C000000 2E000000 54000000	E0F20080 2C000000 30000000 54000000
1	**control** **start** **bound** **offset**	E0F20080 04000000 06000000 7C000000	E0F20080 04000000 08000000 7C000000	12	**control** **start** **bound** **offset**	E0F20080 30000000 32000000 50000000	E0F20080 30000000 34000000 50000000
2	**control** **start** **bound** **offset**	E0F20080 08000000 0A000000 78000000	E0F20080 08000000 0C000000 78000000	13	**control** **start** **bound** **offset**	E0F20080 34000000 36000000 4C000000	E0F20080 34000000 38000000 4C000000
3	**control** **start** **bound** **offset**	E0F20080 0C000000 0E000000 74000000	E0F20080 0C000000 10000000 74000000	14	**control** **start** **bound** **offset**	E0F20080 38000000 3A000000 48000000	E0F20080 38000000 3C000000 48000000

Table 6-5. 64MB MAX DRAM Window - ENV Settings/VMEbus Slave Image 1 (Cont.)

Board Number	**VME Slave Regis-ter**	**Amount Of Physical On-Board Memory (DRAM)**		**Board Number**	**VME Slave Register**	**Amount Of Physical On-Board Memory (DRAM)**	
		32MB	**64MB**			**32MB**	**64MB**
4	**control** **start** **bound** **offset**	E0F20080 10000000 12000000 70000000	E0F20080 10000000 14000000 70000000	15	**control** **start** **bound** **offset**	E0F20080 3C000000 3E000000 44000000	E0F20080 3C000000 40000000 44000000
5	**control** **start** **bound** **offset**	E0F20080 14000000 16000000 6C000000	E0F20080 14000000 18000000 6C000000	16	**control** **start** **bound** **offset**	E0F20080 40000000 42000000 40000000	E0F20080 40000000 44000000 40000000
6	**control** **start** **bound** **offset**	E0F20080 18000000 1A000000 68000000	E0F20080 18000000 1C000000 68000000	17	**control** **start** **bound** **offset**	E0F20080 44000000 46000000 3C000000	E0F20080 44000000 48000000 3C000000
7	**control** **start** **bound** **offset**	E0F20080 1C000000 1E000000 64000000	E0F20080 1C000000 20000000 64000000	18	**control** **start** **bound** **offset**	E0F20080 48000000 4A000000 38000000	E0F20080 48000000 4C000000 38000000
8	**control** **start** **bound** **offset**	E0F20080 20000000 22000000 60000000	E0F20080 20000000 24000000 60000000	19	**control** **start** **bound** **offset**	E0F20080 4C000000 4E000000 34000000	E0F20080 4C000000 50000000 34000000
9	**control** **start** **bound** **offset**	E0F20080 24000000 26000000 5C000000	E0F20080 24000000 28000000 5C000000	20	**control** **start** **bound** **offset**	E0F20080 50000000 52000000 30000000	E0F20080 50000000 54000000 30000000
10	**control** **start** **bound** **offset**	E0F20080 28000000 2A000000 58000000	E0F20080 28000000 2C000000 58000000				

NOTES

`PPCbug` "ENV" prompt:

VMEbus Slave Image 1 Control: use table "**control**" field
VMEbus Slave Image 1 Base Address Register: use table "**start**" field
VMEbus Slave Image 1 Bound Address Register: use table "**bound**" field
VMEbus Slave Image 1 Translation Offset: use table "**offset**" field

Table 6-6. 1024MB MAX DRAM Window - VMEbus Slave Image 1 Initialization (PH640 Only)

Board Number	VME Slave Register	Amount Of Physical On-Board Memory (DRAM)					
		32MB	64MB	128MB	256MB	512MB	1024MB
0	**control** **start** **bound** **offset**	E0F20080 00000000 02000000 80000000	E0F20080 00000000 04000000 80000000	E0F20080 00000000 08000000 80000000	E0F20080 00000000 10000000 80000000	E0F20080 00000000 20000000 80000000	E0F20080 00000000 40000000 80000000
1	**control** **start** **bound** **offset**	E0F20080 40000000 42000000 40000000	E0F20080 40000000 44000000 40000000	E0F20080 40000000 48000000 40000000	E0F20080 40000000 50000000 40000000	E0F20080 40000000 60000000 40000000	E0F20080 40000000 80000000 40000000

NOTES

PPCbug "ENV" prompt:

VMEbus Slave Image 1 Control: use table "**control**" field
VMEbus Slave Image 1 Base Address Register: use table "**start**" field
VMEbus Slave Image 1 Bound Address Register: use table "**bound**" field
VMEbus Slave Image 1 Translation Offset: use table "**offset**" field

Table 6-7. 512MB MAX DRAM Window - VMEbus Slave Image 1 Initialization (PH640 Only)

Board Number	VME Slave Register	Amount Of Physical On-Board Memory (DRAM)				
		32MB	64MB	128MB	256MB	512MB
0	**control** **start** **bound** **offset**	E0F20080 00000000 02000000 80000000	E0F20080 00000000 04000000 80000000	E0F20080 00000000 08000000 80000000	E0F20080 00000000 10000000 80000000	E0F20080 00000000 20000000 80000000
1	**control** **start** **bound** **offset**	E0F20080 20000000 22000000 60000000	E0F20080 20000000 24000000 60000000	E0F20080 20000000 28000000 60000000	E0F20080 20000000 30000000 60000000	E0F20080 20000000 40000000 60000000

Table 6-7. 512MB MAX DRAM Window - VMEbus Slave Image 1 Initialization (PH640 Only) (Cont.)

Board Number	VME Slave Register	Amount Of Physical On-Board Memory (DRAM)				
		32MB	**64MB**	**128MB**	**256MB**	**512MB**
2	**control** **start** **bound** **offset**	E0F20080 40000000 42000000 40000000	E0F20080 40000000 44000000 40000000	E0F20080 40000000 48000000 40000000	E0F20080 40000000 50000000 40000000	E0F20080 40000000 60000000 40000000
3	**control** **start** **bound** **offset**	E0F20080 60000000 62000000 20000000	E0F20080 60000000 64000000 20000000	E0F20080 60000000 68000000 20000000	E0F20080 60000000 70000000 20000000	E0F20080 60000000 80000000 20000000

NOTES

PPCbug "ENV" prompt:

VMEbus Slave Image 1 Control: use table "**control**" field
VMEbus Slave Image 1 Base Address Register: use table "**start**" field
VMEbus Slave Image 1 Bound Address Register: use table "**bound**" field
VMEbus Slave Image 1 Translation Offset: use table "**offset**" field

6.3.4. Example PPCBUG ENV Configuration

PPCBug displays a line describing the **ENV** variable being set. Each line always displays a default value to be used in the event a value is not entered, or the default value is acceptable (enter CARRIAGE RETURN). Note that the default value is the last value set into NVRAM. Read each line carefully. You will need to know the DRAM size of each client being configured. It is also required that the VMEbus slot 1 SBC be configured as the System Controller (see "VMEbus System Controller Selection (J22)" on page 3-6 for PH620 or "VMEbus System Controller Selection (J5)" on page 3-9 for PH640) and that the slot 1 SBC be configured as Board ID 0. Other SBCs installed on the same VMEbus must be assigned a unique ID between 1 and the SBC board count maximum as defined by the "DRAM window size". By convention, boards are usually assigned the next available ID number in a left-to-right fashion.

Note

The following describes **PPCBug** Version 3.2. Minor differences may appear when a different version of **PPCBug** is used.

```
PPC1-Bug>env
Bug or System environment [B/S] = B?
     S  for File Server (board 0 with system disk attached)
     S  for Boot Server (board 0 in a Remote Cluster)
     B  for all other clients (i.e. boards 1-20)
Field Service Menu Enable [Y/N] = N? N
```

```
Remote Start Method Switch [G/M/B/N] = B?
      N   for File Server
      N   for Boot Server
      M   for all other clients (i.e. boards 1-20)
Probe System for Supported I/O Controllers [Y/N] = Y? Y
Auto-Initialize of NVRAM Header Enable [Y/N] = Y? Y
Network PReP-Boot Mode Enable [Y/N] = N? N
Negate VMEbus SYSFAIL* Always [Y/N] = N? N
Local SCSI Bus Reset on Debugger Startup [Y/N] = N? Y
Local SCSI Bus Negotiations Type [A/S/N] = A? A
Local SCSI Data Bus Width [W/N] = N?
     This value must be set to reflect the type of SCSI devices
     attached to the Local SCSI controller.This value is normally set
     to the correct value unless NVRAM has been corrupted.
      N   for systems shipped with 8 bit SCSI devices (default)
      W   for systems shipped with 16 bit SCSI devices (optional)
NVRAM Bootlist (GEV.fw-boot-path) Boot Enable [Y/N] = N? N
NVRAM Bootlist (GEV.fw-boot-path) Boot at power-up only [Y/N] = N? N
NVRAM Bootlist (GEV.fw-boot-path) Boot Abort Delay = 5? 5
Auto Boot Enable [Y/N] = N?
      Y   for File Server if auto boot from disk is desired
      N   for File Server if auto boot from disk is NOT desired
      N   for Boot Server and all clients
Auto Boot at power-up only [Y/N] = N?
     This option is only significant when “Auto Boot Enable” is Y.
     This is application dependent (so you choose):
      N   a disk autoboot will be attempted following any RESET.
          This includes RESETs that occur as a result of a normal
          system shutdown.
      Y   a disk autoboot will only be attempted automatically
          following a power-on reset.
Auto Boot Scan Enable [Y/N] = Y? Y
Auto Boot Scan Device Type List = FDISK/CDROM/TAPE/HDISK/? HDISK
Auto Boot Controller LUN = 00? 00
Auto Boot Device LUN = 00? 00
Auto Boot Partition Number = 00? 00
Auto Boot Abort Delay = 7? 7
Auto Boot Default String [NULL for an empty string] =? NULL
ROM Boot Enable [Y/N]= N? N
ROM Boot at power-up only [Y/N] = Y? Y
ROM Boot Enable search of VMEbus [Y/N] = N? N
ROM Boot Abort Delay = 5? 5
ROM Boot Direct Starting Address = FFF00000? FFF00000
ROM Boot Direct Ending Address   = FFFFFFFC? FFFFFFFC
Network Auto Boot Enable [Y/N] = N?
      N   for File Server
      Y   for Boot Server
      N   for other clients (suggested).Choosing this option
          indicates that this client will be booted by the File/Boot
          server using the VMEbus.
      Y   for other clients (optional). Choosing this option
          indicates that this client will boot itself using TFTP over
          Ethernet. You must insure that this client is physically
          connected to the same ethernet as the File Server and that
          you specify ETHERNET BOOT for this client during
          configuration.
Network Auto Boot at power-up only [Y/N] = N?
          This option is only significant when “Network Auto Boot
          Enable” is Y.This is application dependent (so you choose):
```

```
      N   a network boot will be attempted following any RESET. This
          includes RESETs that occur as a result of a normal system
          shutdown.
      Y   a network boot will only be attempted automatically
          following a power-on reset.
Network Auto Boot Controller LUN = 00? 00
Network Auto Boot Device LUN     = 00? 00
Network Auto Boot Abort Delay    = 5? 5
Network Auto Boot Configuration Parameters Offset (NVRAM) = 00001000?
1000
Memory Size Enable [Y/N]        = Y? Y
Memory Size Starting Address    = 00000000? 0
Memory Size Ending Address      = 04000000?
    Insure that this field indicates the actual memory size
    installed on the board being configured. Use the table below as
    your guide:
         Memory Size       Ending Address
            16mb            01000000
            32mb            02000000
            64mb            04000000
           128mb            08000000
           256mb            10000000
           512mb            20000000
             1gb            40000000
DRAM Speed in NANO Seconds      = 60? 60
ROM First Access Length (0 - 31) = 10? 10
ROM Next Access Length (0 - 15) = 0? 0
DRAM Parity Enable [On-Detection/Always/Never - O/A/N]    = O? 0
L2Cache Parity Enable [On-Detection/Always/Never - O/A/N] = O? 0
PCI Interrupts Route Control Registers (PIRQ0/1/2/3) = 0A0B0E0F?
0A0B0E0F
Serial Startup Code Master Enable [Y/N]      = N? N
Serial Startup Code LF Enable [Y/N]          = N? N
VME3PCI Master Master Enable [Y/N]           = Y? Y
PCI Slave Image 0 Control                    = 00000000? 0
PCI Slave Image 0 Base Address Register      = 00000000? 0
PCI Slave Image 0 Bound Address Register     = 00000000? 0
PCI Slave Image 0 Translation Offset         = 00000000? 0
PCI Slave Image 1 Control                    = C0820000? C0820000
PCI Slave Image 1 Base Address Register      = 01000000? 01000000
PCI Slave Image 1 Bound Address Register     = 20000000? 20000000
PCI Slave Image 1 Translation Offset         = 00000000? 0
PCI Slave Image 2 Control                    = C0410000? C0410000
PCI Slave Image 2 Base Address Register      = 20000000? 20000000
PCI Slave Image 2 Bound Address Register     = 22000000? 22000000
PCI Slave Image 2 Translation Offset         = D0000000? D0000000
PCI Slave Image 3 Control                    = C0400000? C0400000
PCI Slave Image 3 Base Address Register      = 2FFF0000? 2FFF0000
PCI Slave Image 3 Bound Address Register     = 30000000? 30000000
PCI Slave Image 3 Translation Offset         = D0000000? D0000000
VMEbus Slave Image 0 Control                 = E0F20000? See *
VMEbus Slave Image 0 Base Address Register   = 00000000? See *
VMEbus Slave Image 0 Bound Address Register  = 04000000? See *
VMEbus Slave Image 0 Translation Offset      = 80000000? See *
    *The VMEbus Slave Image 0 variables depend on Board Id and are
     defined in Table 6-1.
VMEbus Slave Image 1 Control                 = 00000000? See **
VMEbus Slave Image 1 Base Address Register   = 00000000? See **
VMEbus Slave Image 1 Bound Address Register  = 00000000? See **
VMEbus Slave Image 1 Translation Offset      = 00000000? See **
     **The VMEbus Slave Image 0 variables depend on Max DRAM Window
       Size and are defined in Table 6-3, Table 6-4, Table 6-5,
       Table 6-6 and Table 6-7
VMEbus Slave Image 2 Control                 = 00000000? 0
VMEbus Slave Image 2 Base Address Register   = 00000000? 0
VMEbus Slave Image 2 Bound Address Register  = 00000000? 0
VMEbus Slave Image 2 Translation Offset      = 00000000? 0
VMEbus Slave Image 3 Control                 = 00000000? 0
VMEbus Slave Image 3 Base Address Register   = 00000000? 0
VMEbus Slave Image 3 Bound Address Register  = 00000000? 0
VMEbus Slave Image 3 Translation Offset      = 00000000? 0
PCI Miscellaneous Register                   = 10000000? 10000000
Special PCI Slave Image Register             = 00000000? 0
Master Control Register                      = 80C00000? 80C00000
Miscellaneous Control Register               = 52060000? 52060000
User AM Codes                                = 00000000? 0

Update Non-Volatile RAM (Y/N)? Y

PPC1-Bug>
```

6.3.5. Example PPCBUG NIOT Configuration

The following is an example **PPCBug** setup for network booting. The example assumes that the File Server Ethernet IP address is 129.76.244.105. The client being configured is a Boot Server in a Remote Cluster and was assigned the Ethernet IP address of 129.76.244.36 during the closely-coupled configuration process using the **vmebootconfig(1m)** utility. In the examples, replace **<VROOT>** with virtual root path of the client initiating the network boot (for example: **/home/vroots/t1c1**).

```
PPC1-Bug>
PPC1-Bug>niot
Controller LUN    =00? 0
Device LUN        =00? 0
Node Control Memory Address =03FA0000? <CR> (let this default)
Client IP Address      =0.0.0.0? 129.76.244.36
Server IP Address      =0.0.0.0? 129.76.244.105
Subnet IP Address Mask =255.255.255.0? 255.255.255.0
Broadcast IP Address   =255.255.255.255? 129.76.244.255
Gateway IP Address     =0.0.0.0? 0.0.0.0
     Note: Booting through a gateway is currently not supported.
Boot File Name ("NULL" for None) =? <VROOT>/etc/conf/cf.d/unix.bstrap
     The <VROOT> is defined during the configuration of the client by
     the vmebootconfig tool
     (See "Example PPCBUG NIOT Configuration" on page 6-21 for more details).

Argument File Name ("NULL" for None) =? NULL
Boot File Load Address              =001F0000? 0
Boot File Execution Address         =001F0000? 2200
Boot File Execution Delay           =00000000? 0
Boot File Length                    =00000000? 0
Boot File Byte Offset              =00000000? 0
BOOTP/RARP Request Retry           =00? 0
TFTP/ARP Request Retry             =00? 0
Trace Character Buffer Address     =00000000? 0
BOOTP/RARP Request Control: Always/When-Needed (A/W)   =W? W
BOOTP/RARP Reply Update Control: Yes/No (Y/N)          =Y? Y
Update Non-Volatile RAM (Y/N)? Y

PPC1-Bug>
```

NOTE

Previous versions of the closely-coupled system boot loader started execution at address 3200. Starting with PowerMAX OS 4.2, the “Boot File Execution Address” has changed to 2200.

6.4. Cluster Configuration

This section describes the steps in creating the environment on the file server necessary to support diskless clients using **`vmebootconfig(1m)`**. Major topics described are:

- Configuration Tables (page 6-22)
- Node Configuration Using vmebootconfig(1m) (page 6-29)

Information about the file server and each client in a cluster is specified via configuration tables. The administrator updates the configuration tables and then invokes **`vmebootconfig(1m)`** to create, on the file server system, the file environment necessary to support a private virtual root directory and a private boot image for each client.

`Vmebootconfig(1m)` is also used to modify the file server’s kernel configuration so that it is configured to operate with the other SBCs in the same VMEbus. After the kernel configuration is modified and prior to booting a diskless client, the file server system’s kernel must be rebuilt and the system rebooted. After rebooting the file server, it is configured to support the booting of diskless SBCs that reside in the same VMEbus as the file server SBC.

6.4.1. Configuration Tables

`vmebootconfig`, gathers information from the three tables described below. Before executing this tool, the following tables must be updated with configuration information about the file server and each diskless client.

- clusters table
- nodes table
- hosts table

6.4.1.1. Clusters Table

The clusters table is found under the path **`/etc/dtables/clusters.vmeboot`**. This table defines each cluster supported by the file server including the local and remote clusters. The definition of each cluster provides the VME parameters shared by all the systems in a cluster. A one-line entry must be added for each cluster to be served by the file server.

A cluster is defined as one or more SBCs residing in the same VME chassis. The local cluster is the cluster that has the file server as a member. All other clusters are remote and communicate with the file server by an ethernet network connection.

Each line in the clusters file defines one cluster. The fields that make up each cluster definition are described below. Fields are separated by spaces or tabs. All the fields in a cluster definition are required to have a value. A description of these fields and example table entries are also included, as comments, at the top of the table

1. Cluster id

   This field is the id number used to identify the cluster.Each line of the clusters table must have a unique cluster id. This field is referenced by entries in the **`nodes.vmeboot`** table.

2. VME Base IP Address

   This field is an internet address, in conventional dot notation, of a unique subnet to be used by the cluster for VMEnet networking. VMEnet networking is the capability for running standard IP-based protocol layers on the VMEbus. The VMEnet internet address for each SBC in the cluster will be created based on this field's value. This field is used to set the kernel tunables: VMENET_IPADDR_HI and VMENET_IPADDR_LOW. See the section below on the "hosts table" for more information on how VME internet addresses are created.

3. VME Slave Window Base Address

   This field is the upper 16 bits of the base address of VME A32 space that will be used for the VME slave window. The VME slave window is used by the kernel for passing messages over the VME in support of both VMEnet and other high level kernel interfaces that pass messages between SBCs using the VMEbus. The VME slave window is also the area where slave shared memory regions will be mapped so as to be accessible from all SBCs in the cluster. This field is used to set the kernel tunable VME_SLV_WINDOW_BASE. The default value is f000 (corresponding to VME A32 address 0xf0000000). See the "*Closely-coupled Programming Guide*" for more information on shared memory regions.

   Warning

   Care must be taken when using a value other than the default to not overlap other reserved sections in VME space.

4. VME Slave Window Size

   The value of this field determines the maximum amount of memory that can be reserved by each client in the cluster for Slave Shared Memory. The kernel reserves the first four kilobytes of this space for its use. Size is specified in kilobyte units and must be specified in multiples of 64. This field's value is used to set the kernel tunable VME_SLV_WINDOW_SZ. Minimum allowed value is 64, maximum allowed is 8192. For example, a value of 64 allows each client in the cluster to reserve a shared memory segment as large as 60KB; accessible by all the other clients in the cluster.

   The size of the VME space reserved for slave windows can be calculated as follows:

   vme_space_sz = slv_window_sz(KB) * (max_id+1)

   where slv_window_sz corresponds to the value in the field VME Slave Window Size and max_id is the highest board id assigned in the cluster.

5. VME ISA Register Base Address

   This value is the upper 16 bits of the base address in VME A32 space used for mapping the ISA registers. The value in this field is used to set the kernel tunable VME_VMEISA_BASEADDR. The default value is **effc** (VME A32 address 0xeffc0000).

   The ISA registers are used by the operating system for identifying the type of SBC, resetting of a remote SBC across the VME backplane and for interrupting a remote SBC (mailbox interrupt mechanism).

   The ISA register base address is programmed in each board's NVRAM parameter VMEbus Slave Image 0 Base. The total VME space reserved for the ISA Register Window is 256 kilobytes.

   Warning

   Care must be taken when using a value other than the default to not overlap other reserved sections in VME space.

6. Max DRAM index:

   This index value defines the maximum DRAM (physical memory) size that is allowed on any SBC in the cluster and determines the maximum number of boards that can be supported by the cluster. A total of 2 gigabytes is reserved for mapping DRAM into VME space. The complete DRAM of each SBC must be mapped into VME space so that the boot image can be downloaded into DRAM and so devices can DMA into DRAM. Each SBC in the cluster is allotted an equal amount of VME space for mapping its DRAM. This means that each SBC consumes VME space equivalent to the size of the largest DRAM in the cluster.

The value of this field is used to set the kernel tunable VME_DRAM_WINDOW and must match the DRAM Window Size Table used to program a board's NVRAM parameters. The following table relates the index value to the maximum DRAM size of any configured SBC in the cluster and the number of boards that can be supported in the cluster.

Index Value	Maximum DRAM (MB)	Maximum Number of Boards
1	64	21
2	128	16
3	256	8
4	512	4
5	1024	2

For example, an index value of '3' indicates that the cluster supports a maximum of 8 boards each of which may have up to 256 megabytes of DRAM

```
(8 * 256MB = 2GB)
```

6.4.1.2. Nodes Table

The nodes table is found under the path **`/etc/dtables/nodes.vmeboot`**. This table defines the parameters that are specific to each SBC in a diskless configuration. Each line in this table defines an SBC which is being configured. Both the file server and each diskless client must be defined.

Each line in the nodes table is composed of multiple fields, which are separated by spaces or tabs. The fields in the nodes table are described below. A description of each field and example entries are also included, as comments, at the top of the table. Note that Fields 1-5 are required for both the file server and diskless client. Fields 6-12 apply to only diskless clients.

1. Cluster id

   This field contains the cluster id of the cluster that contains this SBC. The cluster id of the cluster was defined in the clusters table. See the section above on the clusters table for more information.

2. Board id

   This field contains the board id number of the SBC. Board ids within the same cluster must be unique numbers in the range of 0 to 21. Every cluster must have a board id 0. By convention, board ids are usually allocated sequentially, but this is not mandatory.

3. VME Hostname

This field contains the hostname used for VME networking. An entry in the **`/etc/hosts(4)`** table must exist for this host prior to configuring the client. The VME hostname must be a unique hostname in the hosts table. If the client is configured to VMEboot (see Boot interface field below), then the VME hostname will also be the system nodename.

4. Ethernet Hostname

This is the hostname used for ethernet networking. Filling in this field causes the on-board ethernet adapter to be configured for use on the client system. In general, configuring the ethernet adapter is optional. When the boot interface is "eth" and the base configuration is "nfs", the ethernet adapter will be used by the client for communicating with the file server so, in this case, the ethernet adapter must be configured. The ethernet hostname chosen must be a unique hostname in the **`hosts(4)`** table. If the client's boot interface is "eth", the ethernet hostname will also be the system nodename. Enter a '-' for this field if you do not wish to have the ethernet interface configured.

5. IRQ Levels

This field specifies which interrupt levels are reserved for the node. Because of the hardware constraints of the VMEbus, only one SBC in a cluster may be configured to respond to a particular VME interrupt level. A board that responds to a given VME interrupt level will receive the interrupt for all VME devices that interrupt at that level, which also means that those VME devices are not accessible from other SBCs in the cluster. VME interrupt levels range from 1-7. A node may enable more than one level. The field format is a comma-separated string of levels (i.e. "1,2,3,6") or enter a '-' for this field if no interrupt levels are to be reserved by this SBC.

6. Virtual Root Path

This field specifies the path to the client SBC's private virtual root directory. If the directory doesn't exist it will be created by the configuration tool. Any file system partition except for **`/`** (root) and **`/var`** may be used. See section "Virtual Root" on page 1-14 for more about the virtual root directory.

7. Autoboot

This field indicates whether the client should be automatically rebooted and, for NFS clients, shutdown each time the boot server is rebooted. Enter either ‘y’ or ‘n’. For more information about this option, see “Booting Options” on page 6-52.

8. Base Configuration

This field specifies whether the client is an NFS client or an embedded client. An NFS client is configured with networking and uses NFS for mounting remote directories from the file server. An NFS client will also execute in multi-user mode and has the ability to swap memory pages, which have not been accessed recently, to a remote swap area on the file server. An embedded client does not have networking configured, cannot swap out memory pages, runs in single user mode and is generally used only as a standalone system. The field value is a string specified as either “nfs” or “emb”.

9. Boot Interface

This field specifies the interface used to download the boot image and to initiate the boot sequence on the diskless client. Setting of this field affects network routing and whether the client can be restarted from the file server. It also determines whether the client is automatically booted from DRAM or FLASH when the auto-boot feature is selected. See “Booting Options” on page 6-52 for a complete discussion of how setting of this field and the autoboot field affect the boot process. See section “Booting and Shut-down” on page 6-50 for a complete discussion of the various boot mechanisms.

The value of this field is specified as a string, with the following meanings:

“eth”	Client downloads the boot image over ethernet. Once downloaded, the system might directly boot from the downloaded image in DRAM. The image could also be burned into flash and subsequently the SBC could be booted from the flash boot image.
“vme”	Client downloads the boot image over the VMEbus and boots from the image downloaded in its memory.
“vmeflash”	Client downloads the boot image from flash. The VMEbus is used to initiate the download process and to initiate execution within the downloaded image.

10. Platform

This field must specify one of the supported platforms. The value of the field is a string specified as one of the following:

“4600”	Motorola MVME4600, a dual processor SBC also known as the Power Hawk 640.
“2600”	Motorola MVME2600, a single processor SBC also known as the Power Hawk 620.

11. Size of Remote Swap

    For clients with a base configuration of "nfs", enter the number of megabytes of remote swap space to be configured. This value is recommended to be at least 1.5 times the size of DRAM (physical memory) on the client system. Clients with a base configuration of "emb" should specify '-' for this field to indicate no swap space is to be allocated. The client's virtual root partition must have enough free disk space to allocate a swap file of the specified size.

12. Subnetmask

    This field specifies the ethernet subnet network mask in decimal dot notation. This field is required only if the ethernet interface is to be configured (See Ethernet Hostname field above); otherwise enter '-' for this field.

6.4.1.3. Hosts Table

For each SBC listed in the **`nodes.vmeboot`** table (including the file server) add an entry for the vme networking interface to the system's **`hosts(4C)`** table. The hosts table is found under the path **`/etc/hosts`**. If a client has specified an ethernet hostname then an additional entry must be added to the hosts table that specifies the ethernet hostname.

6.4.1.3.1. VME Host Entry

The VME hostname must match the name entered in the "VME Hostname" field of the **`nodes.vmeboot`** table. A client's VME IP address is generated by adding the client's board id number to the address entered in the field "VME Base IP Address" in the **`clusters.vmeboot`** table.

For example, if Base IP address is set to 192.168.1.1, the following IP addresses correspond to the clients in that cluster that are assigned board ids 0-2:

Board Id	IP Address
0	192.168.1.1
1	192.168.1.2
2	192.168.1.3

6.4.1.3.2. Optional Ethernet Host Entry

The hostname must match the name entered in the "Ethernet Hostname" field of the **`nodes.vmeboot`** table. The IP address is unimportant to the cluster software and can be chosen based on local rules for the ethernet subnet.

6.4.2. Node Configuration Using vmebootconfig(1m)

The **`vmebootconfig(1m)`** tool is used to create, remove or update one or more diskless client configurations. It is also used to modify the file server's kernel configuration to run in closely-coupled mode. Prior to running this tool, configuration information must be specified in the configuration tables (see "Configuration Tables" on page 6-22 for updating details'). For more details on running this tool, see the **`vmebootconfig(1m)`** manual page available on-line and also included in Appendix A.

`Vmebootconfig(1m)` gathers information from the various tables and stores this information in a ksh-loadable file, named **`.client_profile`**, under the client's virtual root directory. The **`.client_profile`** is used by **`vmebootconfig(1m)`**, by other configuration tools and by the client during system start-up. It is accessible on the client from the path **`/.client_profile`**.

Most of the tasks performed by **`vmebootconfig(1m)`** are geared toward configuring a diskless client however, some configuration is also done for the file server. When the file server system is specified in the node list argument, options that are not applicable to the file server are silently ignored.

`Vmebootconfig(1m)` appends a process progress report and run-time errors to the client-private log file, **`/etc/dlogs/<client_vmehostname>`** on the file server, or if invoked with the **`-t`** option, to stdout.

With each invocation of the tool, an option stating the mode of execution must be specified. The modes are create client (**`-C`**), remove (**`-R`**) and update client (**`-U`**).

6.4.2.1. Creating and Removing a Client

By default, when run in create mode (**`-C`** option), **`vmebootconfig(1m)`** performs the following tasks:

diskless client	1. Populates a client-private virtual root directory. 2. Modifies client-private configuration files in the virtual root. 3. Creates the **`<virtual_rootpath>/.client_profile`**. 4. Modifies the **`dfstab(4C)`** table and executes the **`shareall(1m)`** command to give the client permission to access, via NFS, its virtual root directory and system files that reside on the file server. 5. Generates static networking routes to communicate with the client. 6. Modifies the client's kernel configuration.
file server	1. Modifies the file server's kernel configuration to run in closely-coupled mode.

By default, when run in remove mode (**-R** option), **vmebootconfig(1m)** performs the following tasks:

diskless client	1. Removes the virtual root directory 2. Removes client's name from the **dfstab(4C)** tables and executes an **unshare(1M)** of the virtual root directory. 3. Removes static networking routes.
file server	1. Removes closely-coupled tunables from the file server's kernel configuration

The update option (**-U**) indicates that the client's environment already exists and, by default, nothing is done. The task to be performed must be indicated by specifying additional options. For example, one might update the files under the virtual root directory or reserve physical memory for slave shared memory.

Examples:

Create the diskless client configuration of all clients listed in the **nodes.vmeboot** table who are members of cluster id #1. Process at most three clients at the same time.

```
vmebootconfig -C -p3 -c1 all
```

Remove the configuration of client *rosie_vme*. Send the output to stdout instead of to the client's log file.

vmebootconfig -R -t *rosie_vme*

Update the virtual root directories of all the clients listed in the nodes.vmeboot table. Process one client at a time.

```
vmebootconfig -U -v -p1 all
```

6.4.2.2. Subsystem Support

A subsystem is a set of software functionality (package) that is optionally installed on the file server during system installation or using the **pkgadd(1M)** utility. Additional installation steps are sometimes required to make the functionality of a package usable on a diskless client.

Subsystem support is added to a diskless client configuration using **vmebootconfig(1m)** options, when invoked in either the create or update mode.

Subsystem support is added to a client configuration via the **-a** option and removed using the **-r** option. For a list of the current subsystems supported see the **vmebootconfig(1m)** manual page or invoke **vmebootconfig(1m)** with the help option (**-h**).

Note that if the corresponding package software was added on the file server after the client's virtual root was created, you must first bring the client's virtual root directory up-to date using the **-v** option of **vmebootconfig(1m)**.

Example 1.

Create diskless client *wilma_vme*'s configuration and add subsystem support for remote message queues and remote semaphores (CCS_IPC) and for the frequency based scheduler (CCS_FBS).

```
vmebootconfig -C -a CCS_FBS -a CCS_IPC wilma_vme
```

Example 2.

Update the virtual roots of all the clients in cluster id 1 and add support for the frequency based scheduler. Process one client at a time.

```
vmebootconfig -U -v -p1 -a CCS_FBS -c1 all
```

Example 3.

Remove support for the frequency based scheduler from the clients *wilma_vme* and *fred_vme*.

```
vmebootconfig -U -r CCS_FBS wilma_vme fred_vme
```

6.4.2.3. Slave Shared Memory Support

The **-m** option of **vmebootconfig(1m)** may be used to reserve a local memory region, which can then be accessed by the other members of the cluster via the slave shared memory interface. Local memory regions may be reserved on both the file server and diskless clients. The option to create these regions may be used in the create or update mode of **vmebootconfig(1m)**. See the Closely-Coupled Programming Guide for more information on the slave shared memory interface.

The memory reservation may be requested as dynamic or static. A dynamic reservation is one in which the kernel determines where in physical memory the reserved memory will be placed. For a static reservation the administrator specifies the starting address of the reserved physical memory region. A static reserved memory region can be attached to a process' address space via both the **mmap(2)** and **shmop(2)** shared memory interfaces. Dynamic reserved memory regions can only support the **mmap(2)** shared memory interface.

When configuring a static reserved memory region, the starting physical memory address of the region and the size are specified as one comma-separated argument to the **-m** option. The size is specified in kilobytes and the address is specified as the upper 16 bits of the address in hexadecimal. For example, to specify a physical region starting at address **0x01000000** and of size 60KB one would specify:

```
-m 0x0100,60
```

When configuring a dynamic reserved memory region, the starting address is specified as zero. For example, to specify a reserved region of size 80KB one would specify:

```
-m 0,80
```

Only one shared memory segment is allowed per node; therefore, if there is an existing segment reserved when a new segment is requested, the existing configuration is first removed. To remove a reserved memory segment that was previously configured without adding another, the address of the previously configured reserved region is specified as before (the upper 16 bits of the starting address if the memory was allocated statically or zero if the memory was reserved dynamically), while the size field is specified as zero. For example, to remove the regions reserved in the example above:

```
-m 0x0100,0
```

```
-m 0,0
```

The size of the region must be specified in multiples of a page (4KB). The actual amount of physical memory reserved is this value plus 4 kilobytes of kernel-dedicated area. The shared memory size plus the 4 kilobytes dedicated to the kernel must be equal to or less than the VME area configured for the “Slave Window Size” field in the **`clusters.vmeboot`** table.

6.4.2.3.1. Static Memory Allocations

The allocated memory region is considered “static” when the administrator specifies the starting address of the contiguous physical memory (DRAM) that is to be reserved. A reasonable start address value to use is `0x0100` (16Mb boundary). The board DRAM size (which must be > = 32 MB to use the `0x0100` value) and other user-reserved memory allocations must be taken into account when selecting the start address. Both **`mmap(2)`** and **`shmop(2)`** operations are supported when the memory is allocated statically.

Examples:

Create the closely-coupled configuration for the file server, *rosie_vme*, and reserve static physical memory starting at 16 megabytes and of size 124 kb.

```
vmebootconfig -C -m 0x0100,124 rosie_vme
```

Replace the static memory reservation with one starting at 32 mb and of size 64 kb.

```
vmebootconfig -U -m 0x0200,64 rosie_vme
```

Remove the current static memory reservation by specifying zero for size.

```
vmebootconfig -U -m 0x0200,0 rosie_vme
```

6.4.2.3.2. Dynamic Memory Allocations

A dynamic memory allocation allows the operating system to choose the starting address for the reserved memory. Dynamic allocation is indicated by specifying zero for the starting address. When DRAM is dynamically allocated, the **`mmap(2)`** interface but not the **`shmop(2)`** interfaces are supported for attaching a user address space to the shared memory.

Examples:

Update client *fred_vme* with a dynamic shared memory reservation of size 124 kb.

```
vmebootconfig -U -m 0,124 fred_vme
```

Replace the dynamic memory reservation with one of size 60 kb.

```
vmebootconfig -U -m 0,60 fred_vme
```

Remove the dynamic memory reservation by specifying zero for size.

```
vmebootconfig -U -m 0,0 fred_vme
```

6.4.2.4. System Tunables Modified

The following tunables may be set by **`vmebootconfig(1m)`** using predefined settings, or based on information provided by the user, in the either the **`clusters.vmeboot`** table or by **`vmebootconfig(1m)`** options.

1. System tunables to support VME clusters. Those marked as user-defined are assigned a value based on settings in the **`clusters.vmeboot`** table. Every member of the cluster must have the same value assigned for each of these.

Tunable Name	**Value**
VME_CLOSELY_COUPLED	1
IGNORE_BUS_TIMEOUTS	1
VMENET_IPADDR_HI	<user-defined>
VMENET_IPADDR_LO	<user-defined>
VME_IRQ1_ENABLE	<user-defined>
VME_IRQ2_ENABLE	<user-defined>
VME_IRQ3_ENABLE	<user-defined>
VME_IRQ4_ENABLE	<user-defined>
VME_IRQ5_ENABLE	<user-defined>
VME_IRQ6_ENABLE	<user-defined>
VME_IRQ7_ENABLE	<user-defined>
VME_DRAM_WINDOW	<user-defined>
VME_SLV_WINDOW_BASE	<user-defined>
VME_SLV_WINDOW_SIZE	<user-defined>
VME_VMEISA_BASEADDR	<user-defined>

2. System tunables to support Slave Shared Memory. Values are input via the **`-m`** option of **`vmebootconfig(1m)`** and are unique to each client.

Tunable Name	**Value**
SBC_SLAVE_DMAP_START	<user-defined>
SBC_SLAVE_MMAP_SIZE	<user-defined>

3. System tunables to support subsystems. These are set by the **`-a`** option of **`vmebootconfig(1m)`** and are unique to each client.

Tunable Name	**Value**
INCLUDE_ALL_FONTS	1 (IWE subsystem)

6.5. Customizing the Basic Configuration

This section discusses the following major topics dealing with customizing the basic client configuration:

- Modifying the Kernel Configuration (page 6-34)
- Custom Configuration Filespage 6-36
- Modifying Configuration Table Settingspage 6-41
- Launching Applications (page 6-49)

6.5.1. Modifying the Kernel Configuration

A diskless client's kernel configuration directory is resident on the file server and is a part of the client's virtual root partition. Initially, it is a copy of the file server's **/etc/conf** directory. The kernel object modules are symbolically linked to the file server's kernel object modules to conserve disk space.

By default, a client's kernel is configured with a minimum set of drivers to support the chosen client configuration. The set of drivers configured by default for an NFS client and for an embedded configuration are listed in **modlist.nfs.vmeboot** and **modlist.emb.vmeboot** respectively, under the directory path **/etc/diskless.d/sys.conf/kernel.d**. These template files should not be modified.

Note that, for diskless clients, only one copy of the unix file (the kernel object file) is kept under the virtual root. When a new kernel is built, the current unix file is over-written. System diagnostic and debugging tools, such as **crash(1M)** and **hwstat(1M)**, require access to the unix file that matches the currently running system. Therefore, if the kernel is being modified while the client system is running and the client is not going to be immediately rebooted with the new kernel, it is recommended that the current unix file be saved.

Modifications to a client's kernel configuration can be accomplished in various ways. Note that all the commands referenced below should be executed on the file server system.

a. Additional kernel object modules can be automatically configured and a new kernel built by specifying the modules in the **kernel.modlist.add** custom file and then invoking **mkvmebstrap(1m)**. The advantage of this method is that the client's kernel configuration is recorded in a file that is utilized by **mkvmebstrap(1m)**. This allows the kernel to be easily re-created if there is a need to remove and recreate the client configuration.

b. Kernel modules may be manually configured or de-configured using options to **`mkvmebstrap(1m)`**.

c. All kernel configuration can be done using the **`config(1M)`** utility and then rebuilding the unix kernel.

d. The **`idtuneobj(1M)`** utility may be used to directly modify certain kernel tunables in the specified unix kernel without having to rebuild the unix kernel. This method is recommended when modifying cluster configuration tunables that would otherwise require the rebuild of all of the kernels for the clients in a given cluster.

6.5.1.1. kernel.modlist.add

The **`kernel.modlist.add`** custom table is used by the boot image creating tool, **`mkvmebstrap(1m)`** for adding user-defined extensions to the standard kernel configuration of a client system. When **`mkvmebstrap(1m)`** is run, it compares the modification date of this file with that of the unix kernel. If **`mkvmebstrap(1m)`** finds the file to be newer than the unix kernel, it will automatically configure the modules listed in the file and rebuild a new kernel and boot image. This file may be used to change the kernel configuration of one client or all the clients. For more information about this table, see the section on “Custom Configuration Files” below.

6.5.1.2. mkvmebstrap

Kernel modules may be configured or de-configured via the **`-k`** option of **`mkvmebstrap(1m)`**. A new kernel and boot image is then automatically created. For more information about **`mkvmebstrap(1m)`**, see the manual page which is available on-line or refer to Appendix C.

6.5.1.3. config Utility

The **`config(1m)`** tool, may be used to modify a client’s kernel environment. It can be used to enable additional kernel modules, configure adapter modules, modify kernel tunables, or build a kernel. You must use the **`-r`** option to specify the root of the client’s kernel configuration directory. Note that if you do not specify the **`-r`** option, you will modify the file server’s kernel configuration instead of the client’s. For example, if the virtual root directory for client *rosie_vme* was created under **`/vroots/rosie`**, then invoke **`config(1m)`** as follows:

```
config -r /vroots/rosie
```

After making changes using **`config(1m)`**, a new kernel and boot image must be built. There are two ways to build a new boot image:

a. Use the Rebuild/Static menu from within **`config(1m)`** to build a new unix kernel and then invoke **`mkvmebstrap(1m)`**. **`mkvmebstrap(1m)`** will find the boot image out-of-date compared to the newly built unix file and will automatically build a new boot image.

b. Use **`mkvmebstrap(1m)`** and specify “unix” on the rebuild option (**`-r`**).

6.5.1.4. idtuneobj

In situations where only kernel tunables need to be modified for an already built host and/or client kernel(s), it is possible to directly modify certain kernel tunable values in a client and/or host unix object files without the need for rebuilding the kernel.

The **`idtuneobj(1m)`** utility may be used to directly modify certain kernel tunables in the specified unix or Dynamically Linked Module (DLM) object files.

The tunables that **`idtuneobj(1m)`** supports are contained in the **`/usr/lib/idtuneobj/tune_database`** file and can be listed using the **`-l`** option of **`idtuneobj(1m)`**.

The **`idtuneobj(1M)`** utility can be used interactively, or it can process an ASCII command file that the user may create and specify.

Note that although the unix kernel need not be rebuilt, the tunable should be modified in the client's kernel configuration (see config above) to avoid losing the update the next time a unix kernel is rebuilt.

Refer to the on-line **`idtuneobj(1m)`** man page for additional information.

6.5.2. Custom Configuration Files

The files installed under the **`/etc/diskless.d/custom.conf`** directory may be used to customize a diskless client system configuration.

In some cases a client's configuration on the server may need to be removed and re-created. This may be due to file corruption in the client's virtual root directory or because of changes needed to a client's configuration. In such cases, the client configuration described by these files may be saved and used again when the client configuration is re-created. The **`-s`** option of **`vmebootconfig(1m)`** must be specified when the client configuration is being removed to prevent these files from being deleted.

The custom files listed below and described in-depth later in this section, are initially installed under the **`client.shared/nfs`** and **`client.shared/emb`** directories under the **`/etc/diskless.d/custom.conf`** path. Some of these files are installed as empty templates, while others contain the entries needed to generate the basic diskless system configuration. The files used for client customization include:

`K00client`	to execute commands during system start-up
`S25client`	to execute commands during system shutdown
`memfs.inittab`	to modify system initialization and shutdown
`inittab`	to modify system initialization and shutdown (nfs clients only)
`vfstab`	to automatically mount file systems (nfs clients only)
`kernel.modlist.add`	to configure additional modules into the unix kernel
`memfs.files.add`	to add files to the **`memfs /`** (root) file system

When a client is configured using **`vmebootconfig(1m)`**, a directory is created specifically for that client under the **`client.private`** directory. To generate a client-private copy of any of the custom files you must copy it from the appropriate configuration-specific directory under the **`client.shared`** directory as follows:

```
cd /etc/diskless.d/custom.conf

cp client.shared/<client_config>/<custom_file>  \
   client.private/<client_vmehostname>
```

Note that "**`client_config`**" refers to the client configuration (either 'nfs' or 'emb') established in the "**`Base Configuration`**" field in the **`/etc/dtables/nodes.vmeboot`** table, "**`client_vmehostname`**" is from the "**`VME Hostname`**" field also in that table and "**`custom_file`**" is one of the custom files described below.

Changes to the customization files are processed the next time the boot image generating utility, **`mkvmebstrap(1m)`**, is invoked. If **`mkvmebstrap(1m)`** finds that a customization file is out-of-date compared to a file or boot image component, it will implement the changes indicated. If applicable (some changes do not affect the boot image), the boot image component will be rebuilt and a new boot image will be generated.

Each custom file described here might be located in one of several directories. The directory chosen determines whether the customization affects a single client or all clients that are built using a given file server. **`mkvmebstrap(1m)`** uses the following method to determine which file path to process:

1. `/etc/diskless.d/custom.conf/client.private/<client_vmehostname>`

This is the first location where **`mkvmebstrap(1m)`** will check for a version of the customization file. The customization affects only the client that is named in the pathname of the customization file.

2. `/etc/diskless.d/custom.conf/client.shared/nfs`

If no private version of the customization file exists for a given client and the client is configured with NFS support, the file under this directory is used. The changes will affect all the clients configured with NFS support that do not have a version of this file installed in their **`client.private`** directory.

3. `/etc/diskless.d/custom.conf/client.shared/emb`

If no private version of the customization file exists for a given client and the client is configured as embedded, the file under this directory is used. The changes will affect all the clients configured as embedded that do not have a version of this file installed in their **`client.private`** directory.

Note that when a subsystem is configured via the node configuration tool **`vmebootconfig(1m)`**, the tool may generate a client-private version of the customization files to add support required for that subsystem. Before modifying the client-shared versions, verify that a client-private version does not already exist. If a client-private version already exists, make the changes to that file, as the client.shared versions will be ignored for this client.

The customization files are described below in terms of their functionality.

6.5.2.1. S25client and K00client rc Scripts

Commands added to these **`rc`** scripts will be executed during system initialization and shutdown. The scripts must be written in the Bourne Shell (**`sh(1)`**) command language.

These scripts are available to both NFS and embedded type client configurations. Since embedded configurations run in **init level 1** and NFS configurations run in **init level 3**, the start-up script is executed from a different **`rc`** level directory path depending on the client configuration.

Any changes to these scripts are processed the next time the **`mkvmebstrap(1m)`** utility is invoked on the file server. For embedded clients, a new memfs.cpio image and a new boot image is generated. An embedded client must be rebooted using the new boot image in order for these changes to take effect.

For NFS clients, the modified scripts will be copied into the client's virtual root and are accessed by the client during the boot process via NFS. Therefore, the boot image does not need to be rebuilt for an NFS client and the changes will take effect the next time the system is booted or shutdown.

These scripts may be updated in one of the two subdirectories under the **`client.shared`** directory to apply globally to all clients. If the customization is to be applied to a specific client, the customized **`rc`** file should be created in the **`client.private`** directory. Note that if there is already an existing shared customization file, and those customizations should also be applied to this client, then the shared **`rc`** file should be copied into the **`client.private`** directory and edited there.

K00client	Script is executed during system shutdown. It is executed on the client from the path **`/etc/rc0.d/K00client`**. By default this file is empty.
S25client	Script is executed during system start-up. It is executed on a client configured with NFS support from the path **`/etc/rc3.d/S25client`**. For embedded configurations, it is executed from **`/etc/rc1.d/S25client`**. By default this file is empty.

6.5.2.2. Memfs.inittab and Inittab Tables

These tables are used to initiate execution of programs on the client system. Programs listed in these files are dispatched by the **init** process according to the **init level** specified in the table entry. When the system initialization process progresses to a particular **init level** the programs specified to run at that level are initiated. It should be noted that embedded clients can only execute at **init level 1**, since an embedded client never proceeds beyond **init level 1**. NFS clients can execute at **init levels 1**, **2** or **3**. **Init level 0** is used for shutting down the system. See the on-line man page for **`inittab(4)`** for more information on init levels and for information on modifying this table.

The **`memfs.inittab`** table is a part of the memory-based file system, which is a component of the boot image. Inside the boot image, the files to be installed in the memory-based file system are stored as a compressed **`cpio`** file. When the **`memfs.inittab`** file is modified a new **`memfs.cpio`** image and a new boot image will be created the next time **mknetbstrap(1m)** is invoked. A client must be rebooted using the new boot image in order for any changes to take effect.

Any programs to be initiated on an embedded client must be specified to run at **init level 1**. NFS clients may use the **memfs.inittab** table for starting programs at **init levels 1-3**. However, part of the standard commands executed at **init level 3** on an NFS client is the mounting of NFS remote disk partitions. At this time, an NFS client will mount its virtual root. The memfs-based **/etc** directory is used as the mount point for the **<virtual_rootpath>/etc** directory that resides on the file server. This causes the **memfs.inittab** table to be replaced by the **inittab** file. This means that any commands to be executed in **init state 0** (system shutdown) or commands which are to be respawned in **init state 3**, should be added to both the **memfs.inittab** and the **inittab** file if they are to be effective.

Note that after configuring an NFS client system, the **inittab** table contains entries that are needed for the basic operation of a diskless system configuration. The default entries created by the configuration utilities in the **inittab** file should not be removed or modified.

Changes to **inittab** are processed the next time **mknetbstrap(1m)** is invoked. The **inittab** table is copied into the client's virtual root and is accessed via NFS from the client system. Therefore, the boot image does not need to be rebuilt after modifying the **inittab** table and the changes to this table will take effect the next time the system is booted or shutdown.

Like the other customization files, these tables may be updated in one of two subdirectories. Changes made under the **/usr/etc/diskless.d/custom.conf/client.shared/** directory apply globally to all clients that share this file server. If the changes are specific to a particular client, the shared file should be copied to the client's private directory, **/usr/etc/diskless.d/custom.conf/client.private/<client_hostname>**, and edited there.

6.5.2.3. vfstab Table

The **vfstab** table defines attributes for each mounted file system. The **vfstab** table applies only to NFS client configurations. The **vfstab(4)** file is processed when the **mountall(1m)** command is executed during system initialization to run **level 3**. See the **vfstab(4)** manual page for rules on modifying this table.

Note that configuring an NFS client configuration causes this table to be installed with entries needed for basic diskless system operation and these entries <u>should</u> <u>not</u> be removed or modified.

The **vfstab** table is part of the client's virtual root and is accessed via NFS. The boot image does not need to be rebuilt after modifying the **vfstab** table, the changes will take effect the next time the system is booted or shutdown.

Like the other customization files, these tables may be updated in one of the two subdirectories. Changes made under the **/usr/etc/diskless.d/custom.conf/client.shared/** directory apply globally to all clients that share this file server. If the changes are specific to a particular client, the shared file should be copied to the client's private directory, **/usr/etc/diskless.d/custom.conf/client.private/<client_vmehostname>**, and edited there.

6.5.2.4. kernel.modlist.add Table

New kernel object modules may be added to the basic kernel configuration using the **`kernel.modlist.add`** file. One module per line should be specified in this file. The specified module name must have a corresponding system file installed under the **`<virtual_rootpath>/etc/conf/sdevice.d`** directory. For more information about changing the basic kernel Configuration, see "Modifying the Kernel Configuration" on page 6-34.

Changes to this file are processed the next time **`mkvmebstrap(1m)`** is invoked, causing the kernel and the boot image to be rebuilt. When modules are specified that are currently not configured into the kernel (per the module's **`System(4)`** file), those modules will be enabled and a new unix and boot image will be created. If **`mkvmebstrap(1m)`** finds that the modules are already configured, the request will be ignored. A client must be rebooted using the new boot image in order for these changes to take effect.

Like the other customization files, these tables may be updated in one of the two subdirectories. Changes made under the **`/usr/etc/diskless.d/custom.conf/client.shared/`** directory apply globally to all clients that share this file server. If the changes are specific to a particular client, the shared file should be copied to the client's private directory, **`/usr/etc/diskless.d/custom.conf/client.private/<client_vmehostname>`**, and edited there.

6.5.2.5. memfs.files.add Table

When the **`mkvmebstrap(1m)`** utility builds a boot image, it utilizes several files for building the compressed cpio file system. The set of files included in the basic diskless memory-based file system are listed in the files **`devlist.nfs.vmeboot`** and **`filelist.nfs.vmeboot`** for NFS clients and **`devlist.emb.vmeboot`** and **`filelist.emb.vmeboot`** for embedded clients under the **`/etc/diskless.d/sys.conf/memfs.d`** directory.

Note that there is a file named **`mem.files.add`** also under this directory, which is the template used for installing the system. Additional files may be added to the memory-based file system via the **`memfs.files.add`** table located under the **`/etc/diskless.d/custom.conf`** directory. Guidelines for adding entries to this table are included as comments at the top of the table.

A file may need to be added to the **`memfs.files.add`** table if:

1. The client is configured as embedded. Since an embedded client does not have access to any other file systems, then all user files must be added via this table.

2. The client is configured with NFS support and

    a. the file needs to be accessed early during a diskless client's boot, before run **level 3** when the client is able to access the file on the file server system via NFS.

    b. it is desired that the file is accessed locally rather than across NFS.

Note that, for NFS clients, the system directories **`/etc`**, **`/usr`**, **`/sbin`**, **`/dev`**, **`/var`**, **`/opt`** and **`/tmp`** all serve as mount points under which remote file systems are mounted when the diskless client reaches run **level 3**. Files added via the **`memfs.files.add`** table should not be installed under any of these system directories if they need to be accessed in run **level 3** as the NFS mounts will overlay the file and render it inaccessible.

Also note that files added via the **`memfs.files.add`** table are memory-resident and diminish the client's available free memory. This is not the case for a system where the boot image is stored in flash, since pages are brought into DRAM memory from flash only when referenced.

Changes to the **`memfs.files.add`** file are processed the next time **`mkvmebstrap(1m)`** is invoked. A new **`memfs.cpio`** image and boot image is then created. A client must be rebooted using the new boot image in order for these changes to take effect.

You can verify that a file has been added to the **`memfs.cpio`** image using the following command on the server:

```
rac -d < <virtual_rootpath>/etc/conf/cf.d/memfs.cpio | cpio -itcv | grep
<file>
```

6.5.3. Modifying Configuration Table Settings

Once a diskless configuration has been established, it is often necessary to modify some aspect of the configuration. It is strongly recommended that the client configurations be removed and recreated by modifying the parameters in the **`nodes.vmeboot`** and **`clusters.vmeboot`** tables. This will prevent errors caused by modifying one part of a configuration and missing one of the dependencies that this modification required.

There may be special circumstances, however, where manual updates of the diskless configuration may be justified. When parameters that are defined in the configuration tables are manually modified, it may also be necessary to update one or more of the following:

1. the client's kernel configuration - modifications to the kernel configuration may be accomplished in numerous ways. See "Modifying the Kernel Configuration" section above.
2. the client's **`<virtual_rootpath>/.client_profile`** - this file is stored under the client's virtual root directory. It is an ASCII, ksh-loadable file with client-specific as well as cluster-wide variable settings. This file can be directly edited.
3. system configuration files - specific instructions are included below when the system configuration files need to be updated.
4. NVRAM settings - board NVRAM settings for VMEbus Slave Image 0 and Slave Image 1 may need to be modified when changing table settings. Refer to "NVRAM Board Settings" on page 6-9 for information on changing NVRAM settings.

In the following table descriptions, you will be instructed to what changes are required when a particular field in the **`clusters.vmeboot`** or the **`nodes.vmeboot`** table is manually modified. Refer to the section "Configuration Tables" on page 6-22 for more information about each field in the tables.

6.5.3.1. Clusters Table

Changes to the **/etc/dtables/clusters.vmeboot** table affect every member of the cluster and require that system tunables and the client's profile file be modified. In some cases the board's NVRAM settings must also be modified.

Changes must be applied to all the members of the cluster at the same time. Booting a client when these parameters are not identical for all clients in a given cluster may result in bad system behavior, including panics and hangs on the file server when the file server is a member of the modified cluster.

Refer to the section "Node Configuration Using vmebootconfig(1m)" on page 6-29 for more information on creating and removing a cluster and the on-line manual page for **vmebootconfig(1m)** which is also reproduced in Appendix A.

The following techniques can be used to modify settings in the cluster table after the cluster has been configured (technique #1 is the recommended method):

1. Remove the configuration of all the clients in the cluster and recreate the cluster.

    a. Perform a shutdown on all the diskless client systems in the cluster.

    b. Remove the configuration of all the clients in the cluster using **vmebootconfig(1m)** and specifying the "**all**" argument and the **-R**, **-c** and **-s** options, for example:

    ```
    vmebootconfig -R -c<clusterid> -s all
    ```

    c. Change the setting(s) in **/etc/dtables/clusters.vmeboot**

    d. Recreate all the client configurations using **vmebootconfig(1m)**. Specify the '**all**' argument and the **-C** and **-c** options to create all the configurations in the cluster, for example:

    ```
    vmebootconfig -C -c<cluster_id> -p2 all
    ```

    e. Rebuild the unix kernel and boot images of each client using **mkvmebstrap(1m)**.

    f. If modifying the local cluster, rebuild the file server's kernel using **idbuild(1m)**.

    g. Boot the boot server of the cluster. Note that the file server is the boot server of the local cluster.

    h. Boot the clients in the cluster.

2. Manually manipulate the files and modify the kernel configuration of each client. Use the following procedure when changing one or more parameters in the clusters table:

    a. Bring down all the diskless client systems in the cluster.

    b. Change the setting(s) in **/etc/dtables/clusters.vmeboot**

c. Other changes will be required which are dependent on which field(s) are being modified. A per-parameter description of the required changes is described below.

d. Rebuild the unix kernel and boot images of each client by invoking **mkvmebstrap(1m)** with the **-r** option and specifying **unix** as the component to be rebuilt, for example:

```
mkvmebstrap -r unix -p1 -c<clusterid> all
```

e. If processing the local cluster, rebuild the file server's kernel using **idbuild(1M)**.

f. Boot the boot server of the cluster. For the local cluster this is the file server.

g. Boot the clients in the cluster.

When a field in the **clusters.vmeboot** table is modified, other changes are required. The following is a description of the changes that must be manually performed when a given parameter in the clusters table is modified. The changes must be applied to every member of the cluster, including the file server if it is a member of the cluster. Any modifications to the **.client_profile** file would not need to be applied to the file server, since this file does not exist for the file server.

Note that it is recommended that the user destroy and rebuild the cluster using **vmebootconfig(1m)** rather that manually performing these changes.

- Cluster Id - this value is arbitrary and should never need to be changed.

- VME Base IP Address - This field affects the cluster's base VME IP addresses and the VME IP addresses for every member of the VME cluster. For each member of the cluster the following must be performed:

  1. Change the client's VME IP addresses in the **/etc/hosts** table.

  The system tunables VMENET_IPADDR_HI and VMENET_IPADDR_LOW must be modified. Note that the tunables should be set to the value corresponding to the cluster's (not the client's) VME Base IP Address and is specified using hex format (not conventional IP dot notation). See **inet_addr(3N)** for help in converting dot notation into a hex format and **/etc/conf/mtune.d/vme** for more information on the system tunables.

  2. Change the client profile residing at **<virtual_rootpath>/.client_profile**.

  The variables CLUSTER_IPADDR and CLIENT_VME_IPADDR must reflect the new VME IP addresses. CLUSTER_IPADDR should be assigned the new IP address of the cluster. CLIENT_VME_IPADDR can be generated by adding the client's board id to the new IP address. Both addresses should be specified in conventional dot notation.

3. VME Slave Window Base Address: Changes to this field affect system tunables and the client's profile file.

   - The system tunable VME_SLV_WINDOW_BASE must be modified to the new value.

   - The client profile at **`<virtual_rootpath>/.client_profile`** must be modified. The variable CLUSTER_SLVW_BASE must be set to the new value.

4. VME Slave Window Size: Changes to this field affect system tunables and the client's profile file.

   - The system tunable VME_SLV_WINDOW_SZ must be set to the new value.
   - The client profile at **`<virtual_rootpath>/.client_profile`** must be modified. The variable CLUSTER_SLVW_SZ must be set to the new value.

5. VME Isa Register Base Addr: Changes to this field affect system tunables and the client's profile file. In addition, the new value must be programmed in each board's NVRAM.

   - The NVRAM parameter settings for VMEbus Slave Image 0 must be recalculated using this new value and saved in NVRAM. See "VME ISA Register Mapping and VMEbus Slave Image 0 Settings" on page 6-9.

   - The system tunable VME_VMEISA_BASEADDR must be set to the new value.

   - The client profile at **`<virtual_rootpath>/.client_profile`** must be modified. The variable CLUSTER_ISAW_BASE must be set to the new value.

6. Max DRAM index: Changes to this field affect system tunables and the client's profile file. In addition, the new value must be programmed in each board's NVRAM.

   - The NVRAM settings for VMEbus Slave Image 1 must be updated based on the values specified in the table that corresponds to the new Max DRAM index. See "DRAM Window Size and VMEbus Slave Image 1 Settings" on page 6-11.

   - The system tunable VME_DRAM_WINDOW must be set to the new value.

   - The client profile at **`<virtual_rootpath>/.client_profile`** must be modified. The variable CLUSTER_DRAM_INDEX must be set to the new value.

6.5.3.2. Nodes Table

Changes to the **`/etc/dtables/nodes.vmeboot`** table affect only one client. The easiest way to change a client configuration is to remove it and re-create it as follows:

1. Look in the client's log file and note the command used to create the client configuration. The log file will be deleted when the client configuration is removed.
2. Remove the client configuration using **`vmebootconfig(1m)`** and specifying the **`-R`** and **`-s`** options.
3. Change the **`nodes.vmeboot`** table entry(ies).
4. Recreate the client configuration using **`vmebootconfig(1m)`**.

To apply changes manually, use the follow guidelines specified for each field. Updating some fields requires extensive changes to the environment and are therefore, not supported. Note that it is recommended that the user destroy and rebuild the client configuration using **`vmebootconfig(1m)`** rather that manually performing these changes. These instructions are supplied for unusual situations which require manual updates of a cluster configuration.

1. Cluster Id - this value is arbitrary and should never need to be changed.
2. Board Id - a change to this field requires the following steps:
   a. Update the field in the **`/etc/dtables/nodes.vmeboot`** table.
   b. Update the client's VME IP address in the **`/etc/hosts`** table.
   c. Update the **`<virtual_rootpath>/.client_profile`** variable: CLIENT_BID and CLIENT_VME_IPADDR. Set CLIENT_BID to the new value and CLIENT_VME_IPADDR with an IP address based on the new board id value.
   d. After steps a, b and c, rebuild the memfs component and boot image using **`mkvmebstrap`** and specifying "**`-r memfs`**", for example:

      ```
      mkvmebstrap -r memfs <client_vmehostname>
      ```

   e. Shutdown the client and change the board's NVRAM settings for slave image 0 and slave image 1.

      The client's VME IP Address is affected because the board id is used in calculating the VME IP address. For information on generating a client's VME IP address see "VME Host Entry" on page 6-28. The NVRAM settings for Slave Image 0 and Slave Image 1 must be modified since the board id is used as an index into the tables used for configuring NVRAM. See "VME ISA Reg Mapping & VMEbus Slave Image 0 Settings" on page 6-9 and "DRAM Window Size and VMEbus Slave Image 1 Settings" on page 6-11.

   f. Reboot the client.
3. VME Hostname

   Manual changes to this field are not supported. The client configuration must be removed and re-created.

4. Ethernet Hostname

   Manual changes to this field are not supported. The client configuration must be removed and re-created.

5. IRQ levels

   To manually change this field perform the following steps:

   a. Update the field in the **`/etc/dtables/nodes.vmeboot`** table.

   b. Update the **`<virtual_rootpath>./client_profile`** variable CLIENT_IRQS.

   c. Update the appropriate system tunables described below using **`config(1M)`** and specifying "**`-r <virtual_rootpath>`**".

   d. After steps a, b and c, build a new kernel and boot image using **`mkvmebstrap(1m)`** specifying "**`-r unix`**", for example:

   ```
   mkvmebstrap -r unix <client_vmehostname>
   ```

   e. Reboot the client.

   System Tunables to adjust: (shown below)

VME_IRQ1_ENABLE	VME_IRQ2_ENABLE
VME_IRQ3_ENABLE	VME_IRQ4_ENABLE
VME_IRQ5_ENABLE	VME_IRQ6_ENABLE
VME_IRQ7_ENABLE	

   To reserve IRQ level X, set the corresponding tunable VME_IRQX_ENABLE to 1. To un-reserve an IRQ level Y set the corresponding tunable VME_IRQY_ENABLE to 0. Note that a specific IRQ level may be reserved by only one client in the cluster, but a client may reserve more than one level for its use.

   The client profile variable, CLIENT_IRQS, must be assigned within quotes. If more than one IRQ is to be reserved for the client, the levels must be separated by a space. For example, to reserve IRQ levels 1, 2 and 4, set the profile variable as follows:

   CLIENT_IRQS="1 2 4"

6. Virtual Root

   To manually change this field perform the following steps:

   a. Update the field in the **`/etc/dtables/nodes.vmeboot`** table.

   b. Update the **`<virtual_rootpath>/.client_profile`** variable, CLIENT_VROOT, with the new virtual root path

   c. Update the virtual root path specified in **`/etc/dfs/dfstab.diskless`** table. This is applicable only to NFS client configurations.

d. After step c, execute the **`shareall(1m)`** command on the file server. This is applicable only to NFS client configurations.

e. After steps a and b, rebuild the memfs component and boot image using **`mkvmebstrap(1m)`** and specifying "**`-r memfs`**", for example:

```
mkvmebstrap -r memfs <client_vmehostname>
```

f. Reboot the client.

In NFS client configurations the virtual root directory is NFS mounted on the client, therefore, the client must be given permission to access the new directory path by changing the pathname in the **`dfstab.diskless`** table and then executing the **`share(1m)`** or **`shareall(1M)`** commands. The **`.client_profile`** file is included in the memfs boot image, and because the virtual root field must be known during the early stages of booting, the boot image must be rebuilt.

7. Autoboot

To manually change this field, perform the following steps:

a. update the field in the **`/etc/dtables/nodes.vmeboot`** table

b. update the **`<virtual_rootpath>/.client_profile`** variable: CLIENT_AUTOBOOT

The autoboot field is read directly from the **`nodes.vmeboot`** table by the file server for the local cluster, or the boot server in a remote cluster. Therefore, there is no need to rebuild the boot image. The change will take effect the next time the boot server of the cluster is booted or shutdown.

8. Base Configuration

Changes to this field are not supported. The client configuration must be removed and re-created.

9. Boot interface

Changes to this field are not supported. The client configuration must be removed and re-created.

10. Platform

To manually change this field, perform the following steps:

a. Update the field in the **`/etc/dtables/nodes.vmeboot`** table.

b. Update the **`<virtual_rootpath>/.client_profile`** variable: CLIENT_PLATFORM.

c. Disable/enable the platform specific kernel drivers using **`config(1M)`** and specifying "**`-r <virtual_rootpath>`**".

d. After steps a, b and c, build a new kernel and boot image using **`mkvmebstrap(1m)`** specifying "**`-r unix`**", for example:

```
mkvmebstrap -r unix <client_vmehostname>
```

e. Reboot the client.

The current platform-specific kernel driver must be disabled and the new one enabled. For example if changing from a 2600 to a 4600 board, disable the **bsp2600** and enable the **bsp4600** kernel driver. Optionally, the **bspall** kernel driver may be used. This generic driver can be used with all Motorola architectures.

11. Size of Remote Swap -

To manually change this field, perform the following steps:

a. Update the field in the **`/etc/dtables/nodes.vmeboot`** table.

b. Bring down the client system.

c. After step a, create a new swap file (see instructions below).

d. Update the **`<virtual_rootpath>./client_profile`** variable: CLIENT_SWAPSZ.

e. Boot the client.

Remote swap is implemented as a file under the dev directory in the client’s virtual root directory. The file is named **`swap_file`**. To create a different sized swap file run the following command on the file server system. **`<virtual_rootpath>`** is the path to the client’s virtual root directory and **`<mgs>`** is the size of the swap in megabytes.

```
/sbin/dd if=/dev/zero of=<virtual_root>/dev    \
/swap_file bs=1024k count=<mgs>
```

12. Subnetmask - a change to this field requires the following steps:

a. Update the field in the **`/etc/dtables/nodes.vmeboot`** table.

b. Update the subnetmask field for the “dec” network interface entry in the file **`<virtual_root>/etc/confnet.d/inet/interface.`**

c. Update the **`<virtual_rootpath>/.client_profile`** variable: CLIENT_SUBNETMASK.

d. After steps a, b and c, rebuild the memfs component and boot image using **`mkvmebstrap`** and specifying “**`-r memfs`**”, for example:

```
mkvmebstrap -r memfs <client_vmehostname>
```

e. If the client is configured to boot over ethernet, then the NVRAM subnet network parameter may also need updating. See “Example PPCBUG NIOT Configuration” on page 6-21 for more information.

f. Reboot the client.

6.5.4. Launching Applications

Following are descriptions on how to launch applications for:

- Embedded Clients
- NFS Clients

6.5.4.1. Launching an Application (Embedded Client)

For diskless embedded clients, all the application programs and files referenced must be added to the memfs root file system via the **memfs.files.add** file. See "memfs.files.add Table" on page 6-40 for more information on adding files via the **memfs.files.add** file.

As an example, the command name **myprog** resides on the file server under the path **/home/myname/bin/myprog**. We wish to automatically have this command executed from the path **/sbin/myprog** when the client boots. This command reads from a data file expected to be under **/myprog.data**. This data file is stored on the server under **/home/myname/data/myprog.data**.

The following entries are added to the **memfs.files.add** table:

```
f   /sbin/myprog 0755   /home/myname/bin/myprog
f   /myprog.data 0444   /home/myname/data/myprog.data
```

The following entry is added to the client's start-up script:

```
#
#  Client's start-up script
#
/sbin/myprog
```

See "Custom Configuration Files" above for more information about the **memfs.files.add** table and the **S25client rc** script.

6.5.4.2. Launching an Application (NFS Client)

Clients configured with NFS support may either add application programs to the memfs root file system or they may access applications that reside on the file server across NFS. The advantage to using the memfs root file system is that the file can be accessed locally on the client system rather than across the network. The disadvantage is that there is only limited space in the memfs file system. Furthermore, this file system generally uses up physical memory on the client system. When the client system is booted from an image stored in flash ROM, this is not the case, since the memfs file system remains in flash ROM until the pages are accessed and brought into memory.

To add files to the memfs root file system follow the procedures for an embedded client above.

When adding files to the client's virtual root so that they can be accessed on the client via NFS, the easiest method is to place the file(s) in one of the directories listed below. This is because the client already has permission to access these directories and these directories are automatically NFS mounted during the client's system initialization.

Storage Path on File Server	Access Path on the Client
`/usr`	**`/usr`**
`/sbin`	**`/sbin`**
`/opt`	**`/opt`**
`<virtual_rootpath>/etc`	**`/etc`**
`<virtual_rootpath>/var`	**`/var`**

As an example, the command name **`myprog`** was created under the path **`/home/myname/bin/myprog`**. To have this command be accessible to all the diskless clients, on the file server we could **`mv(1)`** or **`cp(1)`** the command to the **`/sbin`** directory.

```
mv /home/myname/bin/myprog  /sbin/myprog
```

If only one client needs access to the command, it could be moved or copied to the etc directory in that client's virtual root directory.

```
mv /home/myname/bin/myprog <virtual_root>/etc/myprog
```

To access an application that resides in directories other than those mentioned above, the file server's directory must be made accessible to the client by adding it to the **`dfstab(4)`** table and then executing the **`share(1M)`** or **`shareall(1M)`** command on the file server. To automatically have the directories mounted during the client's system start-up, an entry must be added to the client's **`vfstab`** file. See "Custom Configuration Files" above for more information about editing the **`vfstab`** file.

6.6. Booting and Shutdown

This section deals with the following major topics pertaining to booting and shutdown:

- "The Boot Image" on page 6-51
- "Booting Options" on page 6-52
- "Creating the Boot Image" on page 6-54
- "VME Booting" on page 6-54
- "Net Booting" on page 6-55
- "Flash Booting" on page 6-58
- "Verifying Boot Status" on page 6-58
- "Shutting Down the Client" on page 6-59

6.6.1. The Boot Image

The boot image is the file that is loaded from the file server to a diskless client. The boot image contains everything needed to boot a diskless client. The components of the boot image are:

- unix kernel binary
- compressed cpio archive of a memory-based file system
- a bootstrap loader that uncompresses and loads the unix kernel

Each diskless client has a unique virtual root directory. Part of that virtual root is a unique kernel configuration directory (**`etc/conf`**) for each client. The boot image file (**`unix.bstrap`**), in particular two of its components: the kernel image (**`unix`**) and a memory-based file system (**`memfs.cpio`**), are created based on configuration files that are part of the client's virtual root.

The makefile, **`/etc/diskless.d/bin/bstrap.makefile`**, is used by **`mkvmebstrap(1m)`** to create the boot image. Based on the dependencies listed in that makefile, one or more of the following steps may be taken by **`mkvmebstrap(1m)`** in order to bring the boot image up-to-date.

1. Build the unix kernel image and create new device nodes.
2. Create and compress a cpio image of the files to be copied to the memfs root file system.
3. Insert the loadable portions of the unix kernel, the bootstrap loader, the compressed cpio image and certain bootflags into the **`unix.bstrap`** file. The unix kernel portion in **`unix.bstrap`** is then compressed.

When **`mkvmebstrap`** is invoked, updates to key system files on the file server (i.e. **`/etc/inet/hosts`**) will cause the automatic rebuild of one or more of the boot image components. In addition, updates to user-configurable files also affect the build of the boot image. A list of the user-configurable files and the boot image component that is affected when that file is modified are listed below in Table 6-8. These files are explained in detail in "Custom Configuration Files" on page 6-36.

Table 6-8. Boot Image Dependencies

Boot Image Component	User-Configurable File
unix kernel	**`kernel.modlist.add`**
memfs cpio	**`memfs.files.add`**
	`memfs.inittab`

	`K00client`
	`(embedded client configurations only)`

	`S25client`
	`(embedded client configurations only)`

For a standard diskless client, the boot image is created under **etc/conf/cf.d** in the client's virtual root directory. However, the location where the boot image is created on the file server for clients that are part of a remote cluster, and are configured to boot over VME, is different than the location of the boot image for a standard diskless client. For remote VMEboot clients, the first board in the remote cluster, acts as the boot server for other VMEboot clients in the cluster. In order to download the boot image, the boot server must have access to each client's boot image. For this reason, the boot image for a remote VMEboot client is created under the virtual root directory of the boot server of the remote cluster in the var/bootfiles directory. Under the remote client's virtual root, the boot image file **etc/conf/cf.d/unix.bstrap**, is created as a symbolic link pointing to its actual storage path under the boot server's virtual root directory.

6.6.2. Booting Options

Booting of diskless client systems is affected by user-defined parameters in the configuration files. This section details the affect of two fields in the **/etc/tables/nodes.vmeboot** file.

The boot interface parameter specifies the interface used to download the boot image and initiate the boot sequence on the diskless client. The autoboot parameter determines whether the client should be automatically shutdown and rebooted when the file server is booted. However, the setting of the boot interface field also affects whether the client can be automatically restarted from the file server. The use of the VMEbus as the boot interface facilitates the autoboot capability by allowing the boot server to directly access the memory and control registers of the client SBC via the VMEbus.

Following is a description of how the boot interface and autoboot parameters specified in the **/etc/dtables/nodes.vmeboot** table interact to affect the boot process.

Boot Interface = "eth", Autoboot = 'n'

The ethernet interface is used to download the boot image. The boot sequence cannot be initiated from the boot server, because there is no means to access the control registers of the client from file server. Instead, **PPCBug** commands must be executed on the client which specify the location of the download image, cause that image to be downloaded into DRAM and to either a) boot from DRAM or b) burn the boot image into flash and then boot from flash. Because the boot server cannot initiate a boot directly, the autoboot parameter has no effect when the selected boot interface is ethernet.

Boot Interface = "vme", Autoboot = 'y'

The VME backplane is used to download the image and initiate the boot sequence. Because the autoboot feature is selected, the client is automatically downloaded and booted when the fileserver is rebooted. The client may also be manually booted from either DRAM or FLASH by invoking **mkvmebstrap(1m)** on the file server with the appropriate boot options.

Boot Interface = “vme”, Autoboot = ‘n’

The VME backplane is used to download the image and initiate the boot sequence. Because the autoboot feature is not selected, the client must be manually booted from either DRAM or FLASH by invoking **`mkvmebstrap(1m)`** on the file server with the appropriate boot options.

Boot Interface = “vmeflash”, Autoboot = ‘y’

The boot sequence is initiated over the VME bus. The boot loader is executed from flash and causes the kernel to be decompressed and loaded into DRAM. Execution then is initiated in that kernel. Because the autoboot feature is selected, the client is automatically booted from the boot image that is currently burned into flash when the file server is booted. The client may also be manually booted from either DRAM or flash by invoking **`mkvmebstrap(1m)`** on the file server with the appropriate boot options.

Boot Interface = “vmeflash”, Autoboot = ‘n’

The boot sequence is initiated over the VME bus. The boot loader is executed from flash and causes the kernel to be decompressed and loaded into DRAM. Execution then is initiated in that kernel. Because the autoboot feature is not selected, the client must be manually booted from either DRAM or FLASH by invoking **`mkvmebstrap(1m)`** on the file server with the appropriate boot options.

If there are client systems that are configured to autoboot, a part of the boot server’s system initialization is to start a background boot process for each client system that is configured to autoboot. An administrator should not issue commands that would initiate a manual boot for clients that are in the process of autobooting. It is likely that this would cause a failure of the client boot process.

The autoboot process may also cause the boot image to be rebuilt prior to downloading of the client SBC. The boot image is rebuilt only when one of the dependencies of the boot image (listed above) cause the current boot image to be out of date, or if the boot image is not present.

The boot image is never automatically rebuilt in the case of a remote client. This is because the boot server (who initiates the autoboot) does not have access to the remote client’s configuration files residing on the file server.

In the case where the boot interface is defined as ‘vmeflash’, if the boot image is found to be out of date when the boot server is booted, the boot image will be automatically rebuilt. However, the client will not be automatically rebooted. Reloading of flash ROM with the new boot image must be performed manually by invoking **`mkvmebstrap(1m)`** with the appropriate boot options.

Any client which is configured to autoboot and which is also an NFS client, will be automatically shutdown when the boot server is shutdown.

6.6.3. Creating the Boot Image

The **mkvmebstrap(1m)** tool is used to build the boot image. This tool gathers information about the client(s) from the **/etc/dtables/nodes.vmeboo**t table and from the ksh-loadable file named **.client_profile** under the client's virtual root directory. The manual page for this command is included in Appendix C. Some example uses follow. Note that building a boot image is resource-intensive. When creating the boot image of multiple clients in the same call, use the **-p** option of **mkvmebstrap(1m)** to limit the number of client boot images which are simultaneously processed.

Examples:

Example 1.

Update the boot image of all the clients configured in the **nodes.vmeboot** table that are members of cluster id 1. Limit the number of clients processed in parallel to 2.

```
mkvmebstrap -p2 -c1 all
```

Example 2.

Update the boot image of clients *wilma_vme* and *fred_vme*. Force the rebuild of the unix kernels and configure the boot images to stop in **kdb** early during system initialization.

mkvmebstrap -r unix -b kdb *wilma_vme fred_vme*

Example 3.

Update the boot image of all the clients listed in the **nodes.vmeboot** table. Rebuild their unix kernel with the **kdb** module configured and the **rtc** kernel module de-configured. Limit the number of clients processed in parallel to 3.

```
mkvmebstrap -p 3 -k kdb -k "-rtc" all
```

6.6.4. VME Booting

VME booting is supported when the client is configured with "vme" as the boot interface (see "Booting Options" on page 6-52). **mkvmebstrap(1m)** may be used to boot a diskless client.

Invoked with the **-B** option, **mkvmebstrap(1m)** can be used to both update/create the boot image and boot local as well as remote clients. **Mkvmebstrap(1m)** must be executed on the file server system. It calls on **sbcboot(1m)** to perform the boot operations.

Once the boot image has been created, the **sbcboot(1m)** tool may be executed on the boot server of the cluster to boot a single client. Note that the boot image path, passed to **sbcboot(1m)** as an argument, differs depending on whether the client is a member of the local or a remote cluster. For local clients, **sbcboot(1m)** is executed on the file server and the boot image path includes the path to the virtual root directory. (i.e

<vroot_dir>/etc/conf/cf.d/unix.bstrap). For remote clients, the boot image is created in the **var/bootfiles** directory under the virtual root of the boot server of the cluster. The **<vroot_dir>/var** directory is NFS mounted by the boot server under **/var**. Therefore, on the boot server, a client's boot image can be referenced by the path **/var/bootfiles/<client_vmehostname>**.

Both local and remote vmeboot clients depend on the file server for the creation and storage of the boot image. Once booted, both local and remote clients configured with NFS support rely on the file server for accessing their system files across NFS. Clients configured as embedded, once up and running, do not depend on any other system.

In addition to its dependency on the file server system, a remote vmeboot client depends on the boot server of the cluster to boot over VME. A remote client relies on the boot server to download the boot image into the client's DRAM and trigger the client to start executing.

Prior to vme booting, verify that the following steps have been completed:

a. Verify that the file server is up and running in **run level 3**.

b. If the client is remote, verify that the boot server of the remote cluster is up and running.

Examples:

Example 1.

Update the boot image and boot all the clients in cluster id 1. Limit the number of clients processed in parallel to 2.

```
mkvmebstrap -B -c1 -p2 all
```

Examples 2.

Update the boot image and boot remote client, *betty_vme*. Execute **mkvmebstrap(1m)** on the file server system.

mkvmebstrap -B *betty_vme*

6.6.5. Net Booting

Net booting is supported when the client is configured with "eth" as the boot interface (see "Booting Options" on page 6-52).

Like vmeboot clients, both local and remote netboot clients depend on the file server for the creation and storage of the boot image. Once booted, both local and remote netboot clients configured with NFS support rely on the file server for accessing their system files across NFS. Clients configured as embedded, once up and running, do not depend on any other system.

Unlike remote vmeboot clients, the remote netboot client depends only on the file server to boot. The remote netboot client does not depend on the boot server of the cluster.

Prior to network booting, verify that the following steps have been completed:

a. Verify that the NVRAM network boot parameters have been set (see “Example PPCBUG NIOT Configuration” on page 6-21).

b. Verify that the boot image has been created (see Creating the Boot Image above).

c. Verify that the file server is up and running in **run level 3**.

Network auto boot may be selected using the **PPCBug env** command which instructs **PPCBug** to attempt network boot at any system reset, or optionally only at power-on reset. The **PPCBug env** command allows setting several types of auto boot modes. All other auto boot loaders (Auto Boot and ROM Boot) must be disabled for the network auto boot to function correctly.

Following is an example run of **PPCBug’s nbo** command and a listing of the boot error codes that **PPCBug** will display in the event that the network boot fails. The network information displayed when the **nbo** command is run had to be stored in NVRAM by an earlier invocation of the **PPCBug niot** command. See “Example PPCBUG NIOT Configuration” on page 6-21 for more information.

6.6.5.1. Testing Network Boot Using NBO

Use the **vmebootconfig(1m)** utility's boot-target menu bar option to generate the boot strap image. Once the boot image is generated and the File Server is accepting network requests (is “up” and is at **run level 3**), you can test the network boot using the PPCBug **nbo** command:

```
PPC1-Bug> nbo
Network Booting from: DEC21140, Controller 0, Device 0
Device Name: /pci@80000000/pci1011,9@e,0:0,0
Loading: <virtual_rootpath>/etc/conf/cf.d/unix.bstrap

Client IP Address           = 129.76.244.36
Server IP Address           = 129.76.244.105
Gateway IP Address          = 0.0.0.0
Subnet IP Address Mask      = 255.255.255.0
Boot File Name              = <VROOT>/etc/conf/cf.d/unix.bstrap
Argument File Name          =

Network Boot File load in progress... To abort hit <BREAK>
Bytes Received =&6651904, Bytes Loaded =&6651904
Bytes/Second =&246366, Elapsed Time =27 Second(s)
Motorola PowerMAX_OS Release x.x <==== start of kernel execution
```

Network Auto Boot may be selected using the PPCBug **ENV** command which instructs PPCBug to attempt network boot at any system reset, or optionally only at power-on reset. All other auto boot loaders (Auto Boot and ROM Boot) must be disabled.

6.6.5.2. Boot Error Codes

In the event that the **NBO** command fails, PPCBug will display an error **A5**

```
Network Boot Logic Error
Packet Status: XXYY
```

The status word returned by the network system call routine flags an error condition if it is not zero. The most significant byte of the status word reflects the controller-independent errors. These errors are generated by the network routines. The least-significant byte of the status word reflects controller-dependent errors. These errors are generated by the controller. The status word is shown in Figure 6-1.

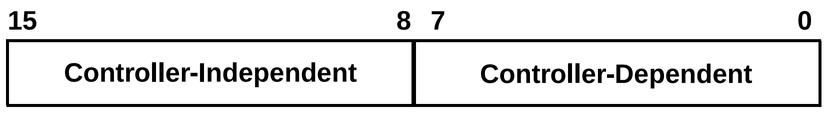

Figure 6-1. Command Packet Status Word

The Controller-Independent error codes are independent of the specified network interface. These error codes are normally some type of operator error. The Controller-Independent error codes are shown in Table 6-9.

Table 6-9. Controller-Independent Error Codes

Code	Description	Code	Description
$01	Invalid Controller Logical Unit Number	$0A	Time-Out Expired
$02	Invalid Device Logical Unit Number	$81	TFTP, File Not Found
$03	Invalid Command Identifier	$82	TFTP, Access Violation
$04	Clock (RTC) is Not Running	$83	TFTP, Disk Full or Allocation Exceeded
$05	TFTP Retry Count Exceeded	$84	TFTP, Illegal TFTP Operation
$06	BOOTP Retry Count Exceeded	$85	TFTP, Unknown Transfer ID
$07	NVRAM Write Failure	$86	TFTP, File Already Exists
$08	Illegal IPL Load Address	$87	TFTP, No Such User
$09	User Abort, Break Key Depressed	----	------------------------

The Controller-Dependent error codes relate directly to the specific network interface. These errors occur at the driver level out to and including the network. The Controller-Dependent error codes are shown in Table 6-10.

Table 6-10. Controller-Dependent Error Codes

Code	Description	Code	Description
$01	Buffer Not 16-Byte Aligned	$16	Transmitter Loss of Carrier
$02	Shared Memory Buffer-Limit Exceeded (Software)	$17	Transmitter 10Base T Link Fail Error
$03	Invalid Data Length (MIN <= LNGTH <= MAX)	$18	Transmitter No Carrier

Table 6-10. Controller-Dependent Error Codes

Code	Description	Code	Description
$04	Initialization Aborted	$19	Transmitter Time-out on PHY
$05	Transmit Data Aborted	$20	Receiver CRC Error
$06	PCI Base Address Not Found	$21	Receiver Overflow Error
$07	No Ethernet Port Available On Base-Board	$22	Receiver Framing Error
$10	System Error	$23	Receiver Last Descriptor Flag Not Set
$11	Transmitter Babble Error	$24	Receiver Frame Damaged by Collision
$12	Transmitter Excessive Collisions	$25	Receiver Runt Frame Received
$13	Transmitter Process Stopped	$28	Transmitter Time-Out During a Normal Transmit
$14	Transmitter Underflow Error	$29	Transmitter Time-Out During a Port Setup
$15	Transmitter Late Collision Error	$30	SROM Corrupt

The error codes are returned via the driver and they will be placed in the controller-dependent field of the command packet status word. All error codes must not be zero (an error code of $00 indicates No Error).

6.6.6. Flash Booting

Flash booting is supported when the client is configured with either "eth" or "vmeflash" as the boot interface (see Booting Options above).

For more information about Flash Booting, see Chapter 7, "Flash Boot System Administration".

6.6.7. Verifying Boot Status

If the client is configured with NFS support, you can verify that the client was successfully booted using any one of the following methods:

a. **`rlogin(1)`** or **`telnet(1)`** from the file server or remote boot server specifying the client's vme hostname.

b. attach a terminal to the console serial port and login.

You can also use the **`ping(1m)`** command and specify the VME hostname to verify that the network interface is running. Note, however, that this does not necessarily mean that the system successfully booted.

If the client does not boot, verify that the NFS daemons are running by executing the **`nfsping(1m)`** command on the file server. An example run of this command follows:

```
# nfsping -a
nfsping: rpcbind is running
nfsping: nfsd is running
nfsping: biod is running
nfsping: mountd is running
nfsping: lockd is running
nfsping: statd is running
nfsping: bootparamd is running
nfsping: pcnfsd is running
nfsping: The system is running in client, server, bootserver,
and pc server modes
```

If there is a console attached to the client and the client appears to boot successfully but cannot be accessed from any other system, verify that the **inetd(1m)** daemon is running on the client.

6.6.8. Shutting Down the Client

If a client is configured with NFS and the autoboot option is set to 'y', the client will automatically be shutdown whenever the boot server of the cluster is brought down.

A client configured with NFS can be shutdown from the file server using the **rsh(1)** command and specifying the VME hostname. For example, if the hostname used for VME networking is *wilma_vme*, the following **shutdown(1m)** command would bring the system *wilma_vme* to **init state 0** immediately.

```
rsh wilma_vme /sbin/shutdown -g0 -y -i0
```

By default, clients configured in Embedded mode do not require an orderly shutdown but an application may initiate it.

Chapter 7
Flash Boot System Administration

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7
Flash Boot System Administration

7.1. Overview

This chapter contains the following sub-sections:

- Introduction to Flash Booting (below)
- Vmeboot vs. Netboot (page 7-2)
- Configuring a Netboot Client to Flash Boot (page 7-3)
- Configuring a Vmeboot Client to Flash Boot (page 7-4)
- Example - Copying PPCBUG To FLASH B (page 7-6)
- Example - PPCBUG NIOT Configuration (page 7-7)
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- Tutorial - Configure a Netboot Client to Flashboot (page 7-10)

Note

The **PPCBug** examples in this chapter describe **PPCBug** Version 3.3 running on a PowerStack II (MTX). Minor differences may appear when running a different version of **PPCBug** or when running on a different platform (e.g. Power Hawk).

7.2. Introduction to Flash Booting

This chapter is a guide to configuring a diskless SBC to boot PowerMAX OS from flash memory. Flash booting is the preferred method of booting a diskless client in the production or deployed phase of an application. There are three advantages in booting from flash. First, flash boot allows very fast boot times because there are no rotational delays that would normally be associated with reading from disk. Second, the root file system is maintained as a read-only image in flash, providing much greater system stability because the root file system cannot be corrupted by unexpected system crashes which might leave a writable file system in an inconsistent state. Finally, when using flash, the memory based file system that is a part of the boot image, remains in flash with each page being paged into memory on demand. Only pages that are written will reside permanently in memory. This provides savings in memory usage on a diskless client system.

The boot image that is downloaded into flash is the same boot image that can be downloaded via the VME backplane or via an ethernet network connection. Therefore a developer can use one of the other download/boot techniques while actively modifying the boot image during the development phase, and then burn the final boot image into flash when deploying the final version of the application. The flash can be burned more than once. However, there is a lifetime limit on the number of times that flash can be burned.

The diskless system software is run on the file server system to create a client-private virtual root directory and a boot image that can be downloaded to the client and then burned into flash memory. The client may be configured as embedded or with NFS support. In the embedded configuration, all the files necessary to run an application must be resident in the boot image. An embedded flash boot client boots from the image in flash and runs independent of the file server. In the NFS case, the client relies on the file server for its system files that are mounted via NFS.

The diskless system software support for netboot (loosely-coupled) and vmeboot (closely-coupled) diskless system configurations supports the flash boot capability.

7.3. Vmeboot vs. Netboot

There are no tools specifically targeted towards creating boot images for flash booting. Instead, either the VME or network configuration tools are used for building the image. Depending on the hardware platform and the needs of the application, the client configuration may be created on the file server system using the netboot (loosely-coupled) or vmeboot (closely-coupled) configuration tools. Both of these tool sets are installed with the diskless software. Following are some guidelines for deciding which tool set to use.

vmeboot	The board must be one of the supported VME platforms. The board shares the VME backplane with the file server and optionally other diskless clients. An ethernet network connection between boards is optional, but not required.

Advantages of using the vmeboot configuration:

1. The steps to burn the flash memory and then boot from that image are issued remotely using commands executed on the file server system. This means there is no requirement for attaching a terminal to the diskless system.

2. Many forms of inter-process communication (IPC) between processes that are running on separate single board computers are available. These IPC mechanisms use the VMEbus for the communication medium.

3. An ethernet network connection is **not** required between the board and the file server. Optionally, the board may be configured to download the boot image over an ethernet connection, instead of VME. In this case an ethernet network connection **is** required.

netboot	All supported platforms can use this boot method. The board must be connected to the file server via an ethernet network connection. Inter-process communication between processes running on separate single board computers is limited to standard networking protocols across ethernet. Steps to download the boot image, burn the boot image into flash and boot from the image in flash are all done using **`PPCBug`** commands executed on the client.

Advantages of using the netboot configuration:

1. The board and client configuration is much more simple.
2. The unix kernel of these clients is smaller since it does not require the vme clustering kernel support.

7.4. Configuring a Netboot Client to Flash Boot

The following steps describe how to configure a system to boot from flash A using the netboot (Loosely-coupled) client configuration. A mini-tutorial, on page 7-10, gives an example session for configuring a netboot client to boot from flash A.

1. Follow the instructions in Chapter 5, Netboot System Administration to configure the client and build the boot image. However, when configuring the board's NVRAM, do not configure the board to network autoboot. Instead of answering ‘Y’ as instructed in that chapter, enter an ‘N’ as follows:

   ```
   PPC1-Bug> env
   ...
   Network Auto Boot Enable [Y/N] = Y? N
   ...
   Update Non-Volatile RAM (Y/N)? Y
   ```

2. Verify that **`PPCBug`** is in flash B

   Motorola boards support two flash banks. The boot image must be copied into flash A, since it is the larger flash bank. **`PPCBug`** must run from the smaller flash: flash B. If **`PPCBug`** is currently running from flash A, steps must be taken to copy **`PPCBug`** to flash B. Failure to keep **`PPCBug`** in at least one of the flashes means that the board will have to be returned to the factory for reprogramming. See “Example - Copying PPCBUG To FLASH B” on page 7-6 for instructions on how to determine from which flash **`PPCbug`** is currently executing and how to copy it to flash B.

3. Download and burn the boot image into flash A.

   This is accomplished using two separate **`PPCBug`** commands. Command **`nbh`** is used to download the boot image into memory. Once the boot image is in memory, it can be burned into flash A using the **`pflash`** command. Both commands are executed on the client system. A description of the commands follows and sample sessions are included later in this chapter. See “Example - Net Load Using NBH” on page 7-8 and “Example - Burning Flash Using PFLASH” on page 7-9.

Warning

Before executing the command which causes the boot image to be burned into flash A, verify that **`PPCBug`** can be booted from flash B. See step 2 above. The board cannot be booted if there is no valid version of **`PPCBug`** resident on the board. Failure to keep a valid **`PPCBug`** in at least one of the flashes means that the board will have to be returned to the factory for reprogramming.

`nbh`	**`PPCBug`** command used to connect with the specified server and download, via TFTP, the client's kernel image. Note that prior to downloading, the network parameters should have been set and saved in NVRAM using **`PPCBug's niot`** command. See "Example - PPCBUG NIOT Configuration" on page 7-7.
`pflash`	This command copies the designated range of memory into the specified flash memory device. It is used here for burning a PowerMAX OS boot image into flash.

4. Boot from the image in flash A

   `PPCBug's gd` command is used to jump to the first byte of the boot image. See "Example - Booting From Flash Using GD" on page 7-9.

5. Configure the client to automatically boot (autoboot) from the boot image in flash A. Once the boot image has been burned into flash A, the system may be configured to autoboot from flash whenever the system is powered up, or when it is reset. See "Example - Autobooting From Flash" on page 7-10.

7.5. Configuring a Vmeboot Client to Flash Boot

The following steps describe how to configure a system to boot from flash A using the vmeboot (Closely-coupled) client configuration.

1. Follow the instructions in Chapter 6, "VME Boot System Administration" to configure the client and build the boot image. When adding an entry for the client to the **`/etc/dtables/nodes.vmeboot`** table, consider the choices for the following fields:

Boot Interface	Specifies the interface used to download the boot image and initiate the boot sequence on the diskless client. The value of this field is specified as a string. The following values are meaningful for a flashboot system:

"vmeflash"	This value is specified when the download of the boot image and the boot operation are performed via com-

mands entered on the file server system. The boot image might be downloaded from the file server over VME and then burned into flash, or it might be directly loaded from an image that had been previously loaded into flash.

“eth”

This value is specified when the download of the boot image and the boot operation are performed via commands entered on the client system via **PPCBug**. The boot image might be downloaded from the file server over ethernet and then burned into flash, or it might be directly loaded from an image that had been previously loaded into flash. This type of configuration is different from the netboot configuration discussed in section 7.4 above because VME-based interprocess communication mechanisms are supported.

Autoboot

Indicates whether the client should be automatically rebooted and, for NFS clients, shutdown each time the boot server is rebooted. This field may be set to ‘y’ or ‘n’.

‘y’ - if the boot interface is set to “vmeflash” and the fileserver is rebooted, the client is automatically booted from the image previously copied into FLASH. However, if the boot image is found to be out-of-date with its components, a new boot image is created and the client boot is aborted. This field does not apply to clients configured with “eth” as the boot interface, since in that case, the client is expected to initiate the boot.

‘n’ - no attempt is made to boot the client when the file server is rebooted.

2. Verify that **PPCBug** is in flash B

   Motorola boards support two flash banks. The boot image must be copied into flash A, since it is the larger flash bank. **PPCBug** must run from the smaller flash: flash B. If **PPCBug** is currently running from flash A, steps must be taken to copy **PPCBug** to flash B. Failure to keep **PPCBug** in at least one of the flashes means that the board will have to be returned to the factory for reprogramming. See “Example - Copying PPCBUG To FLASH B” on page 7-6 for instructions on how to determine from which flash **PPCbug** is currently executing and how to copy it to flash B.

3. Download and burn the boot image into flash A.

   For clients configured with boot interface of:

   “vmeflash” - both the download and burn into flash steps can be done using the **-F** option of **mkvmebstrap(1M)**, executed on the file server system.

   “eth” - **PPCBug**’s **nbh** command is used to download the boot image into memory and the pflash command is used to burn the boot image in flash A. Both commands are executed on the client-system. See “Example - Net Load Using NBH” on page 7-8 and “Example - Burning Flash Using PFLASH” on page 7-9.

Warning

Before executing the command which causes the boot image to be burned into flash A, verify that **`PPCBug`** can be booted from flash B. See step 2 above. The board cannot be booted if there is no valid version of **`PPCBug`** resident on the board. Failure to keep a valid **`PPCBug`** in at least one of the flashes means that the board will have to be returned to the factory for reprogramming.

4. Boot from the image in flash A

   For clients configured with boot interface of:

"vmeflash"	the client may be booted via the **`-X`** option of **`mkvmebstrap(1M)`**.
"eth"	**`PPCBug`**'s **`gd`** command is used to jump to the first byte of the boot image. See "Example - Booting From Flash Using GD" on page 7-9.

5. Configure the client to Autoboot from the boot image in flash A. Once the boot image has been burned into flash A, the system may be configured to autoboot from flash whenever the system is powered up, or when it is reset. See "Example - Autobooting From Flash" on page 7-10.

7.6. Example - Copying PPCBUG To FLASH B

Failure to keep a valid **`PPCBug`** in at least one of the flashes means that the board will have to be returned to the factory for reprogramming. Before copying the boot image to Flash A , make sure that **`PPCBug`** is not running in the Flash which is being overwritten. This is easy to determine and fix:

Reboot the machine, or scroll back to the last **`PPCbug`** startup message.

Observe the **`PPCbug`** startup messages that scroll by on the screen.

Look for a one of the following two messages:

```
Reset          Vector Location:        ROM Bank B
Reset          Vector Location:        ROM Bank A
```

The correct answer is ROM Bank B. If ROM Bank B is displayed, **`PPCBug`** is executing from the correct Flash and nothing needs to be done.

If ROM Bank A is displayed (and it usually is since that is the way most boards are shipped), then **`PPCBUG`** must be copied from Flash A into Flash B and a jumper must be changed on the board. Use the **`pflash`** command to copy the first megabytes of FLASH A (located at **`0xff000000`**) to FLASH B (**`0xff800000`**) as follows:

```
PPC1-Bug> pflash ff000000:100000 ff800000
```

To verify the copy, display the memory in Flash A and Flash B and compare. In the following commands the first 0x20 words of Flash A, then Flash B are displayed.

```
PPC1-Bug> md ff000000:20

PPC1-Bug> md ff800000:20
```

Now that Flash B contains a copy of **PPCBug**, the client must be configured to run **PPCBug** from that Flash. This is done by changing a jumper. Refer to the table below for board type, jumper number and applicable figure and page reference.

MTX	Jumper J37	Figure 2-3 on page 2-5
MTX II	Jumper J24	Figure 2-3 on page 2-5
MCP750	Jumper J6	Figure 4-2 on page 4-4
MVME2600	Jumper J10	Figure 3-4 on page 3-7
MVME4600	Jumper J2	Figure 3-7 on page 3-10

7.7. Example - PPCBUG NIOT Configuration

The following is an example **PPCBug** setup for network booting and network loading. The example assumes that the File Server's Ethernet IP address is 129.76.244.105 and the netboot client's Ethernet IP address is 129.76.244.36 and the client is called "orbity" and the path to its virtual root is **/home/vroots/orbity**.

```
PPC1-Bug> niot
Controller LUN    =00? 0
Device LUN        =00? 0
Node Control Memory Address =03FA0000?
Client IP Address      =0.0.0.0? 129.76.244.36
Server IP Address      =0.0.0.0? 129.76.244.105
Subnet IP Address Mask =255.255.255.0? 255.255.255.0
Broadcast IP Address   =255.255.255.255? 129.76.244.255
Gateway IP Address     =0.0.0.0? 0.0.0.0
```

Note: A gateway IP address is necessary if the server and the netboot client do not reside on the same network. Otherwise, it should be left as `0.0.0.0`

```
Boot File Name ("NULL" for None) =?
/home/vroots/orbity/etc/conf/cf.d/unix.bstrap
Argument File Name ("NULL" for None) =? NULL
Boot File Load Address              =001F0000? 1000000
Boot File Execution Address         =001F0000? 1000000
Boot File Execution Delay           =00000000? 0
Boot File Length                    =00000000? 0
Boot File Byte Offset               =00000000? 0
BOOTP/RARP Request Retry            =00? 0
TFTP/ARP Request Retry              =00? 0
Trace Character Buffer Address      =00000000? 0
BOOTP/RARP Request Control: Always/When-Needed (A/W)   =W? W
BOOTP/RARP Reply Update Control: Yes/No (Y/N)          =Y? Y
Update Non-Volatile RAM (Y/N)? Y
PPC1-Bug>
```

7.8. Example - Net Load Using NBH

When the goal is to place a boot image into Flash, then Net Loading must be used instead of Net booting. Net Loading may be thought of as identical to Net Booting except that the final step, execution of the loaded boot image, is not performed. This provides the user with the opportunity to execute other **PPCBug** commands that, for example, copy the image into Flash Memory.

NBH uses the same setup information created by **NIOT** that **NBO** uses. Assuming that the **NIOT** setup is the same as described above. What follows is the results of a sample invocation of the **NBH** command:

```
    PPCBug> nbh
     Network Booting from: DEC21140, Controller 0,
     Device 0
     Device Name:
     /pci@80000000/pci1011,9@e,0:0,0
     Loading:
     /home/vroots/orbity/etc/conf/cf.d/unix.bstrap
Client IP Address      = 129.76.244.36
Server IP Address      = 129.76.244.105
Gateway IP Address     = 0.0.0.0
     Subnet IP Address Mask = 255.255.255.0
     Boot File Name =
     /home/vroots/orbity/etc/conf/cf.d/unix.bstrap
     Argument File Name =
Network Boot File load in progress... To abort hit <BREAK>
Bytes Received =&3428371, Bytes Loaded =&3428371
Bytes/Second   =&426232, Elapsed Time =8 Second(s)
IP   =01000000 MSR  =00003040 CR   =00000000 FPSCR =00000000
R0   =00000000 R1   =03F78000 R2   =00000000 R3    =00000000
R4   =00000000 R5   =49504C01 R6   =00007000 R7    =01000000
R8   =03FF9124 R9   =03FF8F24 R10  =03FF8F59 R11   =03FF9024
R12  =03FF9024 R13  =00000000 R14  =00000000 R15   =00000000
R16  =00000000 R17  =00000000 R18  =00000000 R19   =00000000
R20  =00000000 R21  =00000000 R22  =00000000 R23   =00000000
R24  =00000000 R25  =00000000 R26  =00000000 R27   =00000000
R28  =00000000 R29  =00000000 R30  =00000000 R31   =00000000
SPR0 =00000000 SPR1 =00000000 SPR8 =00000000 SPR9  =00000000
01000000 480000C1  BL          $010000C0
```

The IP value, above, is the address in memory where the boot image was loaded (`0x01000000`). Likewise, the Bytes Loaded value (`3428371`) is the boot image size. Both of these values will be needed in the next section, where the boot image is copied into Flash Memory.

7.9. Example - Burning Flash Using PFLASH

Warning

Before proceeding with this section, verify that you have followed the steps described in “Example - Copying PPCBUG To FLASH B” above. Failure to keep **`PPCBug`** in at least one of the Flashes means that the board will have to be returned to the factory for reprogramming

After loading the boot image into DRAM using the **`NBH`** command, the boot image may be burned into Flash. Two pieces of information are necessary for this: the address where the boot image was loaded into memory, and the size of the image. Both of these are displayed as part of the output of the **`NBH`** command (see above). Unfortunately, the size is displayed as a decimal value and needs to be converted to a hexadecimal value. One way to convert is to use **`awk(1)`** from a PowerMAX OS shell prompt. For example:

```
$ echo 3428371 | awk ‘{printf “%x\n”,$1}’
```

In the previous and following example, it is assumed that the load address of the boot image is **`0x1000000`** and its length is **`0x345013`**.

```
PPC1-Bug> PFLASH 1000000:345018 ff000000
```

This copies **`0x345018`** bytes from physical address **`0x1000000`** to physical address **`0xff000000`**. Several observations can be made about this copy. First, note that the number of bytes to copy is **`0x345018`**, not the actual size **`0x345013`**. The **`PFLASH`** command requires sizes to be modulo 8, or it may not copy accurately. Second, the second address (**`0xff000000`**) must be associated with a Flash Memory device or the copy will fail.

7.10. Example - Booting From Flash Using GD

Once Flash A contains a copy of the boot image, all subsequent boots may be done from Flash. If performing a manual boot from **`PPCBug`**, just jump to the first byte of the boot image:

```
    GD ff000000
```

Alternately, **`PPCBug`** may be configured to automatically do this jump each time it is powered up, or reset. That configuration is done with the **`PPCBug ENV`** command. See “Example - Autobooting From Flash” below.

7.11. Example - Autobooting From Flash

Once the boot image has been burned into Flash A, the **PPCBug ENV** command may be used to configure the system to autoboot the system from the Flash whenever the system is powered up, or when it is reset. To do this,

1. Execute the **ENV** command:

   ```
   PPC1-Bug> ENV
   ```

2. Hitting the `space` bar will leave a parameter set at the default value. Space on down, answering only the following **ENV**-generated questions:

   ```
   NVRAM BOOT LIST(GEV.fw-boot-path)Boot Enable[Y/N]- N? N
       ...
   Auto Boot Enable [Y/N]           - N? N
       ...
   ROM Boot Enable [Y/N]            - N? Y
   ROM Boot at powerup only [Y/N]   - N? N
   ROM Boot Abort Delay             - 5? 5
   ROM Boot Direct Starting Address - FFF00000? FF000004
   ROM Boot Direct Ending Address   - FFF00000? FF001004
       ...
   Network Auto Boot Enable [Y/N]   - N? N
       ...
   Update Non-Volatile RAM (Y/N)? Y
   ```

3. The purpose of step 2, above, is to make sure every type of autobooting supported by **PPCBug** is answered "**No**" except ROM Booting, which is answered "**Yes**" with supporting parameters.

4. Reset the machine. Observe if the Flashed PowerMAX OS boots by carefully observing the **PPCBug** startup messages, and then the PowerMAX OS startup messages that will scroll on the screen.

7.12. Tutorial - Configure a Netboot Client to Flashboot

This tutorial assumes that the netboot diskless client working environment has been created on the file server following the instructions in Chapter 5, Netboot System Administration. The operation consists of 7 major steps which are described below.

1. Undoing the Autoboot Setup:

   If you, the user, had really implemented the steps described in Chapter 5, then every time your test client powers up it will automatically boot a PowerMAX OS system from your host. This feature must now be <u>turned off</u>.

   a. Power cycle (turn off, then on) the client.

   b. Observe the **PPCBug** start-up messages as it scrolls by.

c. Look for a specific message:

```
Network about to Begin... press <Esc> to Bypass, <SP>
to Continue.
```

d. When that message appears, hit the `<Esc>` key. If you don't hit the `<Esc>` key in time (you have about 2 seconds to do so), power cycle the client and try again. If you hit the `<Esc>` key in time, the **PPCBug** prompt (`PPC1-Bug>`) will appear.

e. Disable autobooting using the following **PPCBug** command sequence. Enter values only for the questions listed below. Hit the space bar for all other questions to leave the default value unchanged.

```
PPC1-Bug> env
...
Network Auto Boot Enable [Y/N] = Y? N
...
Update Non-Volatile RAM (Y/N)? Y
```

f. Power cycle the machine. Verify that it stops at the **PPCBug** prompt without continuing on with the autoboot.

2. Checking if Flash A is Available:

   The next step is to make sure that the factory has placed **PPCBug** in Flash B (remember that Flash A must be used to hold any boot image that is to be placed into Flash). If **PPCBug** is already in Flash B, nothing more needs to be done and you may proceed to step 5 below. If **PPCBug** is in Flash A, then **PPCBug** must be copied to Flash B.

   To find out which Flash - A or B, **PPCBug** is being run from:

   a. Power cycle the machine.

   b. Watch the **PPCBug** start-up messages scrolls by. Look for a message of the form:

   ```
   Reset Vector Location: ROM Bank B
   ```

   This message signifies all is well. **PPCBug** is located in and is running from the correct Flash (Flash B). Skip steps 3 and 4 below and go to step 5.

   If instead, there is a message of the form:

   ```
   Reset Vector Location: ROM Bank A
   ```

   Then **PPCBug** is located in and running in Flash A; **PPCBug** will have to be moved out.

3. Copy PPCBug to Flash B:

   If **PPCBug** is currently being run from Flash A, then it must be copied to Flash B. Use the pflash command below to copy the first megabyte of data from Flash A to Flash B:

   ```
   PPC1-Bug> pflash ff000000:100000 ff800000
   ```

To verify the above copy, use the **`md`** command to display the memory contents of Flash A and Flash B.

```
PPC1-Bug> md ff000000:20
PPC1-Bug> md ff800000:20

The start of both Flashes should look the same:

FF800000  7C3043A6 7C2802A6 7C3143A6 48004115  |0C.|(..|1C.H.A.
FF800010  00000000 00000000 00000000 00000000  ................
FF800020  00000000 00000000 00000000 00000000  ................
FF800030  00000000 00000000 00000000 00000000  ................
```

4. Forcing the Client to Utilize the Copy of PPCBug now in Flash B:

   Now that Flash B contains a copy of **`PPCBug`**, the client must be configured to run **`PPCBug`** from that Flash. This is done by changing a jumper. Refer to the table below for board type, jumper number and applicable figure and page reference.

MTX	Jumper J37	Figure 2-3 on page 2-5
MTX II	Jumper J24	Figure 2-3 on page 2-5
MCP750	Jumper J6	Figure 4-2 on page 4-4
MVME2600	Jumper J10	Figure 3-4 on page 3-7
MVME4600	Jumper J2	Figure 3-7 on page 3-10

   a. Power down the client and change this jumper referring to the applicable chapter.

   b. Next, powerup the system. The correct **`PPCBug`** initialization message should appear.

5. Downloading a Boot Image Without Executing it:

   Now that the client has been properly prepared to hold a Flash boot image, you can burn that image into Flash A of this client. Only Flash A may be used since only Flash A is large enough to hold a boot image (Flash B is 1 megabyte, Flash A is at least 4 megabytes).

   a. The first step is to download the boot image without executing it. This is done with the **PPCBug NBH** command. It is assumed that the client's network parameters have been saved in NVRAM (see "Example - PPCBUG NIOT Configuration" on page 7-7) prior to invoking the NBH command.

```
PPC1-Bug> nbh
Network Booting from: DEC21140, Controller 0, Device 0
Device Name: /pci@80000000/pci1011,9@e,0:0,0
Loading: /home/vroots/netboot/orbity/etc/conf/cf.d/unix.bstrap
Client IP Address      = 129.134.35.21
```

```
Server IP Address      = 129.134.35.20
Gateway IP Address     = 0.0.0.0
Subnet IP Address Mask = 255.255.255.0
Boot File Name = /home/vroots/netboot/orbity/etc/conf/cf.d/unix.bstrap
Argument File Name  =

Network Boot File load in progress... To abort hit <BREAK>

Bytes Received =&2058178, Bytes Loaded =&2058178
Bytes/Second   =&343029, Elapsed Time =6 Second(s)
IP   =01000000 MSR  =00003040 CR   =00000000 FPSCR =00000000
R0   =00000000 R1   =03F78000 R2   =00000000 R3    =00000000
R4   =00000000 R5   =49504C01 R6   =00007000 R7    =01000000
R8   =03FF9124 R9   =03FF8F24 R10  =03FF8F59 R11   =03FF9024
R12  =03FF9024 R13  =00000000 R14  =00000000 R15   =00000000
R16  =00000000 R17  =00000000 R18  =00000000 R19   =00000000
R20  =00000000 R21  =00000000 R22  =00000000 R23   =00000000
R24  =00000000 R25  =00000000 R26  =00000000 R27   =00000000
R28  =00000000 R29  =00000000 R30  =00000000 R31   =00000000
SPR0 =00000000 SPR1 =00000000 SPR8 =00000000 SPR9  =00000000
01000000 480000C1  BL          $010000C0
```

Note

There are two useful pieces of information in the above display. One is the IP value (**`0x01000000`**). This is where the boot image was loaded into the client's physical memory. The other is the number of bytes loaded (`=2058178`). This is boot image size, in decimal.

b. The next step is to convert the #bytes loaded from decimal (`2058178`) to hexadecimal. If you don't have a hexadecimal calculator handy, the following UNIX shell script can be used on your host system.

```
$ echo 2058178 | awk '{printf "%x\n", $1}'
```

This will print out the echoed value in hexadecimal. For the above, that is `1f67c2`.

6. Copying the Boot Image now in the Client’s Memory to Flash A:

   Using the **PPCBug PFLASH** command, the above boot image, now located in physical memory at address `0x1000000` with a size of 1f67c2 bytes, is copied to Flash A, located at `0xff000000` and its size is `1f67c2` bytes:

```
PPC1-Bug> pflash 1000000:1f67c2 ff000000
```

7. Setting up the Client to Autoboot From the Flashed Boot Image:

a. The final step is to set up the client to autoboot this Flashed image each time it powers up, or is reset:

```
PPC1-Bug> env
...
ROM Boot Enable [Y/N]            = N? Y
ROM Boot at power-up only [Y/N]  = N? N
```
(continue next page)

```
ROM Boot Enable search of VMEbus [Y/N] = N?
ROM Boot Abort Delay             = 2? 2
ROM Boot Direct Starting Address = 0? FF000004
ROM Boot Direct Ending Address   = 0? FF001004
Network Auto Boot Enable [Y/N]           = N? N
...
Update Non-Volatile RAM (Y/N)? Y
```

b. Power cycle the client. The console messages should show it is autobooting from Flash.

Chapter 8
Modifying VME Space Allocation

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8
Modifying VME Space Allocation

8.1. Overview

Material is this chapter is applicable to closely-coupled systems only.

On Power Hawk platforms, accesses to VME space that are issued by the processor are accomplished through a special range of processor physical addresses. The hardware on Power Hawk platforms translates this range of processor physical addresses into PCI bus addresses that fall into the PCI Memory Space range on the PCI Bus. Additional hardware on Power Hawk platforms is set up to translate these PCI Memory Space addresses into VMEbus addresses which the hardware will place upon the VMEbus.

8.2. Default VME Configuration

The Power Hawk defines a 1.4GB space that maps processor bus read/write cycles into PCI memory space. All but 5MB of this area is used to allow master programmed I/O access to PMC/PCI devices, VME A32 devices, and the closely-coupled master shared memory interfaces.

The user configurable memory area resides between processor addresses 0xA0000000 and 0xFCAFFFFF which map directly to PCI memory space addresses 0 to 0x5CAFFFFF. Two sets of kernel tunables define additional mapping between the PCI memory space and VMEbus A32 space. Any PCI memory space not mapped to the VMEbus is available for use by PMC/PCI add on cards which may be attached to the Power Hawk's PMC expansion slot.

The default configuration for processor to PCI to VME address translations on Power Hawk platforms is shown in Table 8-1.

NOTE

The PH620 tunables are also used to configure the PH640 VME space. Therefore, references to "PH620" are also applicable to "PH640".

Table 8-1. Default Processor/PCI/VME Configuration

Processor Address	PCI Address	VME Address	VME Type	Window Size	VME Driver Tunables
`0xA0000000` `0xBFFFFFFF`	`0x00000000` `0x1FFFFFFF`			`0x20000000` `512MB`	PMC/PCI Add-Ons See Note.
`0xC0000000` `0xFAFFFFFF`	`0x20000000` `0x5AFFFFFF`	`0xC0000000` `0xFAFFFFFF`	`A32`	`0x3B000000` `944MB`	PH620_VME_A32_START PH620_VME_A32_END
`0xFB000000` `0xFCAFFFFF`	`0x5B000000` `0x5CAFFFFF`	`Variable`	`A32`	`0x01B00000` `27MB`	PH620_SBCMMAP_START PH620_SBCMMAP_END PH620_SBCMMAP_XLATE PH620_SBCMMAP_TYPE
`0xFCB00000` `0xFCBFFFFF`	`0x5CB00000` `0x5CBFFFFF`			`0x00100000` `1MB`	N/A - Fixed Mapping Tundra Universe Chip
`0xFCC00000` `0xFCFEFFFF`	`0x5CC00000` `0x5CFEFFFF`	`0xC00000` `0xFEFFFF`	`A24`	`0x003F0000` `4MB-64KB`	N/A - Fixed Mapping
`0xFCFF0000` `0xFCFFFFFF`	`0x5CFF0000` `0x5CFFFFFF`	`0x0000` `0xFFFF`	`A16`	`0x00010000` `64KB`	N/A - Fixed Mapping

NOTE

PMC/PCI add-on address space is defined by addresses which reside in the configurable PCI memory address space between `0` through `0x5CAFFFFF` which are NOT defined by the other configurable windows (as defined by the **`PH620_VME_A32_START/END`**, and **`PH620_SBCMMAP_START/END t`**unables.

8.3. Reasons to Modify Defaults

There are several reasons why a system administrator may want to modify the default VME space configuration on Power Hawk platforms. Some possible reasons are listed below:

- There are one or more VME devices configured in the system that have a large amount of on-board memory and/or require that their VME space be configured on certain address boundaries.

  For example, an A32 VME device might contain 1GB of on-board memory. It would not be possible to configure this device into the system using the default VME configuration address space.

- There are one or more VME devices configured in the system that respond to a fixed VME A32 address range that is outside the standard supported VME A32 address range. A translation option exists to allow mapping standard processor/PCI memory space addresses to non-standard VMEbus addresses.

For example, a Power Hawk 620 is being used to monitor an existing VME base processor which must reside in the VME A32 addresses 0x00000000 through 0x3ffffff (the first 64MB).

- There is a need to share more than 27MB (the default allocation) between closely-coupled processors using the Master MMAP shared memory interface.
- Although PCI devices can be configured to respond to PCI I/O Space addresses, PCI devices can also be configured to respond to PCI Memory Space addresses. Therefore, it is possible that there may be a mix of PCI and VME devices in the system that both want to share PCI Memory Space. In this situation, it may be desirable to reduce the amount of VME space within the PCI Memory Space in order to allow more of the PCI Memory Space to be used for PCI devices.

8.4. Limitations

The Power Hawk platform hardware and to some lesser extent, the PowerMAX OS place certain restrictions on the configuration ability of VME address space and its accessibility from the processor's point of view. The restrictions on configuring VME space on Power Hawk platforms under PowerMAX OS are:

- The location and size of the A16 and A24 VME windows shown in Table 8-1 may not be modified.
- The range of PCI Memory Space is `0x00000000` to `0x5cffffff` (PCI Bus Addresses). This restriction yields a possible total VME mapping size of `0x5cffffff` (approximately 1.4 GB). Note that within this PCI address range, `0x5cb00000` through `0x5cffffff` are dedicated to VMEbus A16 and A24 mapping. The remaining PCI addresses, `0x00000000` through `0x5cafffff`, are configurable by the system administrator.
- If one or more PCI devices have been configured to respond to the PCI Memory Space range, then accesses to this PCI address space must be coordinated between VME and PCI devices, such that the VME windows and PCI device ranges do not overlap.
- The VME address range from 0 to `0x7fffffff` is set aside for local and remote SBC DRAM memory space, and therefore should not normally be used for VME devices. However, it is possible to map a single contiguous local bus address range into this VME address range if care is taken to ensure that the VME device being mapped does not overlap the local closely-coupled computer's DRAM mapping.

8.5. Changing The Default VME Configuration

Within the bounds of the restrictions that were mentioned in the previous section on Limitations, the system administrator may modify certain system defaults involving the VME to PCI configuration, and the placement of VME windows for A32 devices. This configuration of VME space on Power Hawk platform may be accomplished by modifying the following tunables via the **`config(1M)`** utility:

```
PH620_VME_A32_START
PH620_VME_A32_END
PH620_SBCMMAP_START
PH620_SBCMMAP_END
PH620_SBCMMAP_XLATE
PH620_SBCMMAP_TYPE
```

As stated earlier, any available space not mapped to the VMEbus by one, or both, of the register sets, are available for add-on PMC/PCI devices.

8.5.1. PH620 VME A32 Window

The **`PH620_VME_A32_START`** and **`PH620_VME_A32_END`** tunables define the standard programmed I/O master window interface to VME A32 space. The window defined by these tunables must not overlap the PH620 SBC MMAP VME window (described below).

These tunables define processor local bus addresses which, when accessed through read/write cycles on the local processor, generate corresponding read/write cycles on the VMEbus in VME A32 space.

This window cannot be disabled.

8.5.2. PH620 SBC MMAP VME Window

In addition to the VME A32 window, there is a second VME A32 master window that allows **`mmap(2)`**, and in some cases **`shmbind(2)`**, access to VME A32 memory. This second window can: be disabled, provide SBC Master MMAP shared memory support or be programmed to provide the same type of functionality as provided by the PH620 VME A32 window with the addition of address translation.

The PH620 SBC Master MMAP tunables are described below:

`PH620_SBCMMAP_TYPE`

0	Window is disabled, no PCI space used. The remaining three tunables are ignored.

1	Master MMAP Type 1 Shared Memory - (Refer to Appendix A, Master MMAP Type 1 Shared Memory, in the *Closely-Coupled Programming Guide* for more details). The **PH620_SBCMMAP_XLATE** tunable is ignored.
2	Master MMAP Shared Memory - (Refer to Chapter 3, Shared Memory, in the *Closely-Coupled Programming Guide* for more details.) Standard A32 mapping w/translation. The remaining three tunables are all used.

PH620_SBCMMAP_START

Tunable only used when **PH620_SBCMMAP_TYPE > 0**. This defines the upper 16bits of the local processor bus address used in the mapping. For type 1 mapping, this also defines the VMEbus address “mapped to”. The lower 16 bits are forced to 0x0000.

PH620_SBCMMAP_END

Defines the ending address of the Map Memory Range. Tunable is only used when **PH620_SBCMMAP_TYPE > 0**. Defines the upper 16 bits of the local processor bus address used in the mapping. The lower 16 bits are assumed to be: `0xFFFF`.

PH620_SBCMMAP_XLATE

Used when **PH620_SBCMMAP_TYPE = 2**. For type 2 Master MMAP mapping, this value is added to **PH620_SBCMMAP_START** to form the effective upper 16 bits of the VME address to be accessed. Note that high order bit carries are ignored. For example, `0xA000 + 0x7000` = `0x1000` (not `0x11000`).

This window is disabled by default and should only be enabled in a closely-coupled configuration where the SBC kernel driver is to be used for **mmap(2)**ing remote SBC DRAM memory (i.e. type 1), or when VMEbus address translation is necessary to access VMEbus slave devices which are not accessible through the standard PH620 VME A32 window (i.e type 2).

Refer to Chapter 3, Shared Memory, in the *Closely-Coupled Programming Guide* and Appendix A, Master MMAP Type 1 Shared Memory, in the same manual, for more details on configuring SBC **mmap(2)** remote memory functionality.

8.5.3. Closely-Coupled Slave Window Considerations

When configuring your VME A32 space, you must provide a VMEbus master mapping through the PH620 VME A32 window to allow access to two slave windows which are used by the closely-coupled software. The tunables that define the slave windows are:

VME Tunable	Default Value	VMEbus Addressing
VME_VMEISA_BASEADDR	`0xEFFC`	Start = `0xEFFC0000` (Size=256KB)
VME_SLV_WINDOW_BASE	`0xF000`	Start = `0xF0000000`
VME_SLV_WINDOW_SIZE	`1`	Size = 1*64KB = 64KB

The **`VME_VMEISA_BASEADDR`** tunable defines the upper 16 bits of the base address of a 256KB VME A32 segment which allows closely-coupled boards to find each other during system initialization. Each closely-coupled processor board opens a slave window in a predefined 8KB slot within the 256KB area as defined by the PPCbug "VMEbus Slave Image 0" setting (see Chapter 3). The default value defines the ISA windows to reside at `0xEFFC0000-0xEFFFFFFF` in VME A32 address space. This tunable is set by the **`vmebootconfig`** utility based on the value defined in the **`/etc/dtables/clusters.vmeboot`** table.

The **`VME_SLV_WINDOW_BASE`** tunable defines the upper 16 bits of base address of an array of windows. Each closely-coupled processor board opens a slave window in a predefined slot in this array. The size of each slot is determined by the **`VME_SLV_WINDOW_SIZE`** tunable which defines the number of 64KB pages that are mapped by EACH processor. Due to the granularity of the VMEbus slave mapping register, this window size must be in multiples of 64KB; hence, the tunable defines the number of 64KB pages mapped, not the actual size of the window. The space that must be reserved for the slave windows is calculated as follows:

`Slave Window Area = (Max Board Id + 1) * VME_SLV_WINDOW_SIZE * 64KB`

As an example, the slave area for a cluster with 3 boards configured as board numbers 0, 1, and 12 is:

`Slave Window Area = (12 + 1) * 1 * 64KB = 832KB`

If the boards were configured sequentially, i.e. 0, 1, 2, the slave area is:

`Slave Window Area = (2 + 1) * 1 * 64KB = 192KB`

See Chapter 3, Shared Memory, in the *Closely-Coupled Programming Guide* for more information on these tunables.

8.6. Example Configurations

This section provides a few examples of non-default VME space configurations.

8.6.1. Example 1

In this example, an A32 VME memory module with 1GB of on-board memory is being installed. The module is strapped to respond to addresses `0xA0000000` to `0xDFFFFFF`. This example further assumes that there are no PMC/PCI add-ons and no other VME devices on the VMEbus.

Since there are no PMC/PCI devices, the area usually reserved for them (`0xA0000000-0xBFFFFFFF`), can be coalesced into the VME A32 area by changing the tunable:

`PH620_VME_A32_START` to `0xA000`

The new VME A32 area is now large enough to accommodate the 1GB memory module and the closely-coupled slave windows that must reside in this region (see Closely-Coupled Slave Window Considerations above). The default value for the **PH620_VME_A32_END** tunable (0xFAFF) does not need to change.

This yields the following configuration:

Table 8-2. Large 512MB VME Space Example Configuration

Processor Address	PCI Address	VME Address Space	VME Type	Window Size
0xA0000000 0xFAFFFFFF	0x00000000 0x5AFFFFFF	0xA0000000 0xFAFFFFFF	A32	0x5B000000 1.4GB

8.6.2. Example 2

Assume that the memory module from **Example 1** above had a hardware restriction that it's base address had to be aligned on a 1GB address boundary (i.e. at 0, 0x40000000, 0x80000000, or 0xC0000000). The mapping shown in **Example 1** would not work.

We can use the SBC Master MMAP (type 2) address translation functionality to open a 1GB window between 0x80000000 and 0xBFFFFFFF. We also need to adjust the **PH620_VME_A32_START** tunable to prevent window overlap.

1. Define a 1GB window which maps the start of the processors configurable address space (i.e. 0xA0000000) to the VMEbus A32 address 0x80000000.
   The translation offset was calculated as follows:

   XLATE = (VME_ADDR - START) & 0xFFFF.

   Specifically:

   XLATE = (0x8000 - 0xA000) & 0xFFFF = 0xE000.

   - set **PH620_SBCMMAP_TYPE** to 2
   - set **PH620_SBCMMAP_START** to 0xA000
   - set **PH620_SBCMMAP_END** to 0xDFFF
   - set **PH620_SBCMMAP_XLATE** to 0xE000

2. Reclaim the remaining configurable processor address space and map it to the corresponding VME A32 address space.
   - set **PH620_VME_A32_START** to 0xE000
   - set **PH620_VME_A32_END** to 0xFCAF

Note that we had to alter **PH620_VME_A32_START** since the address range we defined with the **PH620_SBCMMAP** tunables overlapped the default **PH620_VME_A32** address space. If we did not do this, the system would detect the window overlap at runtime and fail the SBCMMAP setup (the VME_A32 setup always takes precedence). Also, in this example, we moved the **`PH620_VME_A32_END`** defined address up to reclaim the 27MB space that was reserved for the **`PH620_SBCMMAP`** default mapping.

The above changes yield the following VME space configuration:

Table 8-3. Using All Available VME Mapping Space

Processor Address	PCI Address	VME Address Space	VME Type	Window Size
`0xA0000000` `0xDFFFFFFF`	`0x00000000` `0x3FFFFFFF`	`0x80000000` `0xBFFFFFFF`	`A32`	`0x40000000` `1GB`
`0xE0000000` `0xFCAFFFFF`	`0x40000000` `0x5CAFFFFF`	`0xE0000000` `0xFCAFFFFF`	`A32`	`0x1CB00000` `459MB`

Chapter 9
Debugging Tools

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9
Debugging Tools

9.1. System Debugging Tools

This chapter covers the tools available for system debugging on a diskless client. The tools that are available to debug a diskless client depend on the diskless system architecture. Tools covered in this include the following:

- kdb (page 9-2)
- crash (page 9-2)
- savecore (page 9-3)
- sbcmon (page 9-3)

In a closely-coupled system architecture, members of a cluster, referred to as vmeboot clients, are connected to a common VME backplane. Each client's memory is accessible to the boot server and to other clients via a mapping in VME space. This mapping may be accessed via the sbc device driver interface (**`sbc(7)`**). A vmeboot client is configured via an entry in the **`nodes.vmeboot`** table using the **`vmebootconfig(1m)`** tool.

In the loosely-coupled architecture, the only attachment between the file server and the diskless client is via an ethernet network connection. There is no way to remotely access a diskless system's memory in a loosely-coupled configuration. A client is referred to as a netboot client and is configured via an entry in the **`nodes.netboot`** table using the **`netbootconfig(1m)`** tool.

The state of a diskless system may be examined as follows:

vmeboot and netboot clients:

a. Enter **`kdb`** by typing a **`~k`** sequence on the console. The client's boot image must have been built with **`kdb`** support.

vmeboot clients only:

b. create a system dump using **`savecore(1m)`** or **`sbcmon(1m)`** and then examine the system dump with **`crash(1m)`**.

c. examine the system directly using **`crash`** and specifying the **`/dev/target[1-14]`** file to the **`-d`** option.

When **`kdb`** is configured into a client's kernel, the **`~k`** sequence will cause the system to drop into **`kdb`**. The sequences **`~b`**, **`~i`**, and **`~h`** all cause the system to drop into the board's **`PPCBug`** firmware.

9.2. kdb

The **kdb** package is provided with the kernel base package. A client kernel may be configured with **kdb**, and its boot image may be configured to enter **kdb** early in the boot process. A console terminal must be connected to the client board to interact with **kdb**.

On client boards, the console debugger support is not present. However, if system level debugging on a client is desired, then it is possible to use **kdb**. To use **kdb**, the **kdb** and **kdb_util** kernel drivers must be configured into the client’s unix kernel. Except for the **kdb consdebug** command, which is not available on clients, **kdb** operates without any differences from a normal system when executing on a client. A terminal should be connected to the console terminal port on the client being debugged in order to use **kdb**.

The default client kernel configuration does not have **kdb** support. The **kdb** kernel modules may be configured into the client’s kernel via the **-k** option and the system may be programmed to stop in **kdb** via the **-b** option. Both these options are supported by the boot image generating tools **mkvmebstrap(1m)** for closely-coupled and **mknetbstrap(1m)** for loosely-coupled.

When **kdb** is configured into a client’s kernel, the **~k** sequence will cause the system to drop into **kdb**.

9.3. crash

The **crash(1m)** utility may be run from the file server system to examine the memory of a client board in the local cluster. **Crash(1m)** may also be invoked on a diskless client to examine the memory of another member of the cluster. In the case where **crash** is invoked on a diskless client, rather than on the file server, steps must be taken to gain read access to the unix file of the client whose memory is to be probed.

The **crash** utility may be run from the file server system to examine the memory of a client board in the local cluster as follows:

```
crash -d /dev/target<1-14> -n <virtual_rootpath>/etc    \
/conf/cf.d/unix
```

For example, the following command may be used for a client configured as board id # 1, whose virtual root was created under **/vroots/client**

```
crash -d /dev/target1 -n /vroots/client/etc/conf/cf.d/unix
```

To use **crash** on remote clusters, see “System Debugging on Remote Clusters” on page 9-3.

9.4. savecore

The **savecore(1m)** system utility is used to save a memory image of the system after the system has crashed. **Savecore(1m)** supports the '**-t**' option to identify the client system that should be saved. This option allows **savecore(1m)** to be run on the file server, to create a crash file from the memory of a diskless client. **Savecore(1m)** saves the core image in the file **vmcore.n** and the namelist in **unix.n** under the specified directory. The trailing ``**.n**" in the pathnames is replaced by a number which is incremented every time **savecore(1m)** is run in that directory.

The **savecore(1m)** utility may be run from the file server system to create a system memory dump of a client board in the local cluster. The following series of commands would be used to save a memory image and then analyze that image. The system dump created by **savecore(1m)** under the directory **<dirname>** and given the numerical suffix **<n>** may then be examined using crash.

```
savecore -f -t <board_id> <dirname> <virtual_rootpath>/etc \
/conf/cf.d/unix
```

```
cd <dirname>
```

```
crash -n <n>
```

To use **savecore** on remote clusters, see “System Debugging on Remote Clusters” below.

9.5. sbcmon

sbcmon(1m) is a utility provided by the diskless package. It enables the host system to detect when another board in the cluster panics. When a panic is discovered, the **savecore(1m)** utility may be used to capture a dump file for future crash analysis or to shutdown the local system. This utility is documented in the **sbcmon(1m)** man page provided in the diskless package. Note that prior to executing **sbcmon(1m)** on a remote cluster with the system dump option (**-d**), the unix file of the clients being monitored for panics must be made accessible. To use **sbcmon** on remote clusters, see “System Debugging on Remote Clusters” below.

9.6. System Debugging on Remote Clusters

All of the tools described in this chapter are also available for debugging remote clusters. However, to run **crash**, **savecore** and **sbcmon** with the dump option, you must first acquire read access to the unix file of the client whose memory you want to examine. By default, diskless clients do not have read access to the virtual root directories of the other members in the cluster. There are two ways in which a diskless client, configured with NFS support, can get access to another client’s unix file. If there is enough space in the client’s virtual root partition (on the file server), then the other client’s unix file can be copied in and the unix file can be accessed across NFS. Another way is for the client system to NFS mount the other client's virtual root partition.

An example of acquiring access to another client's unix file appears below. In the following examples, the memory of client *c1*, residing in a remote cluster, will be examined from another diskless client, *c0*, in the same cluster. The following labels are used in the examples:

fserver	nodename of the file server system
c0	nodename of the client system on which **`crash(1m)`** will be executed
`/vroots/`*c0*	virtual root path, on the file server system, of client *c0*
c1	nodename of the client whose memory is to be examined; this board is configured with a board id value of 1 in the remote cluster.
`/vroots/`*c1*	virtual root path, on the file server system, of client *c1*

<u>Example 1</u>:

Access client *c1*'s unix file by copying it into any of the subdirectories under the client *c0*'s virtual root.

a. On the file server, copy the file into the virtual root of *c0*

```
cp /vroots/c1/etc/conf/cf.d/unix /vroots/c0/tmp/unix.c1
```

b. On client *c0*, you can now run **`savecore`**, **`crash`** or **`sbcmon`** and specify **`/tmp/unix.c1`** for the unix file

c. On client *c0*, clean-up when you are done

```
rm /tmp/unix.c1
```

<u>Example 2:</u>

Access client *c1*'s unix file by mounting via NFS, the kernel configuration directory of client *c1*.

a. Since the **`/vroots/c1`** directory is, by default, already shared with client *c1*, we must first run the **`unshare(1m)`** command. After adding client *c0* to the list of systems sharing the **`/vroots/c1`** directory in the **`dfstab.diskless`** file, the **`shareall(1m)`** command must be executed to process the change.

   On the file server system, perform the following steps:

   1. **`unshare /vroots/c1`**
   2. edit **`/etc/dfs/dfstab.diskless`** and change the line:

```
/usr/sbin/share -F nfs -o rw=c1,root=c1 -d /vroots/c1
```

to:

```
/usr/sbin/share -F nfs -o rw=c1:c0,root=c1:c0 -d /vroots/c1
                                ^^          ^^
```

(note to reader, `^^` denotes “`c0`” text changes/additions)

3. **`shareall -F nfs`**

b. On client *c0*, mount via NFS, client *c1*’s kernel configuration directory under the virtual root.

```
mount -F nfs fserver:/vroots/c1/etc/conf/cf.d /mnt
```

c. On client *c0*, you can now run **`savecore(1m)`**, **`crash(1m)`** or **`sbcmon(1m)`** and specify **`/mnt/unix`** for the unix file

d. On client *c0*, clean-up when you are done

```
umount /mnt
```

A
vmebootconfig(1m)

NAME

`vmebootconfig` – configuration tool used to create, remove or update a diskless client's environment and modify the file server's kernel to run in Closely-Coupled mode.

SYNOPSIS

`/usr/sbin/vmebootconfig`
`-h`
`-C` [**`-t`**] [**`-a`** *subsys*] [**`-c`** *clid*] [**`-m`** *addr,sz*] [**`-p`** *n*] **`all`** | *node ...*
`-R` [**`-st`**] [**`-c`** *clid*] [**`-p`** *n*] **`all`** | *node ...*
`-U` [**`-tv`**] [**`-ar`** *subsys*] [**`-m`** *addr,sz*] [**`-p`** *n*] **`all`** | *node ...*

DESCRIPTION

`vmebootconfig` is used to create, remove or update the environment needed to support one or more diskless clients in a Closely-Coupled system configuration. It is also used to add or remove clustering kernel support to/from the file server system. For more information on Closely-coupled systems, see the **`CCS(7)`** manual page and the *Diskless Systems Administrator's Guide*.

`vmebootconfig` must be invoked from the system configured as the file server and you must be logged in as root to execute.

One or more *nodes* or **`all`** must be specified. *node* may refer to the file server or a diskless client. If specified, *node* must match the hostname used for VME networking. If **`all`** is specified all of the nodes listed in the **`/etc/dtables/nodes.vmeboot`** table will be processed. When the **`-c`** option and **`all`** are both specified, all of the nodes listed in the **`nodes.vmeboot`** table which are members of the cluster id *clid* are processed.

One of the three options **`-C`**, **`-R`**, **`-U`** must be specified. When the create option (**`-C`**) is used, it is expected that prior to invoking this tool the **`/etc/dtables/clusters.vmeboot`**, **`/etc/dtables/nodes.vmeboot`** and **`/etc/hosts(4)`** tables have been updated with configuration information. The **`clusters.vmeboot`** table must have an entry describing each cluster referenced in the **`nodes.vmeboot`** table. The **`nodes.vmeboot`** table must have an entry for each *node* specified in the command line. The **`/etc/hosts`** table should have a entry for each networking interface supported by each *node*, that is, an entry for the vme networking and optionally an entry for the ethernet networking interface. Each hostname in the **`nodes.vmeboot`** must have a matching entry in the **`hosts`** table.

The file server system is identified as the system on which this tool is executed. Only the **`-C`**, **`-R`**, **`-U`** and **`-m`** apply to the file server system. The **`-C`** and **`-R`** options are used to respectively add and remove clustering support from the file server's kernel configuration. The **`-m`** option may be invoked in the create (**`-C`**) or update (**`-U`**) mode. All other options do not apply to the server system and are ignored. Note that after modifying the kernel configuration, a new kernel must be built and the server rebooted in order for the changes to take effect. No progress report or log file is produced for the file server; only error messages are sent to *stderr*.

The **`-m`** option may be used to reserve a local memory region to be shared with the other members of the cluster via the Slave Shared Memory interface. This option is supported for both the file server and diskless clients. The memory reservation maybe dynamic or static. With static allocations the starting address must be specified. Both **`mmap(2)`** and **`shmop(2)`** operations are supported. With dynamic memory allocations the kernel automatically reserves contiguous DRAM memory but **`shmop(2)`** operations are not supported.

All members of a cluster, with the exception of the file server, are referred to as clients or diskless clients. The rest of this section applies only to diskless clients.

The environment needed to support a diskless client is created using the **`-C`** option. A virtual root directory is generated on the server's disk for each client specified and the system tables **`/etc/dfs/dfstab`** and **`/etc/dfs/dfstab.diskless`** are updated. The **`shareall(1M)`** command is executed to give a diskless client permission to access the server's files. The lock file **`/etc/dfs/.dfstab.lock`** is used to synchronize updates to these tables. Note that these tables should not be edited directly while this command is running. Client configuration information in a **`ksh(1)`**-loadable format is stored in the file **`.client_profile`** under the client's virtual root directory. After the diskless environment is created, **`mkvmebstrap(1M)`** may be invoked to generate the boot image.

When the remove (**`-R`**) or update (**`-U`**) options are used, it is expected that the diskless environment already exists for each client specified. Configuration information needed to process the request is obtained from the **`nodes.vmeboot`** table and from the file **`.client_profile`** stored under each client's virtual root directory.

When the remove option (**`-R`**) is specified, the virtual root directory is renamed and removed in the background and the client name is removed from the resource-sharing tables.

The client configuration may be modified by using the update (**`-U`**) option. Note that configuration changes are specified via additional options. Specifying the update option by itself is meaningless.

By default, client processing is executed in parallel, however, the **`-p`** option may be used to limit the number of clients that are processed at the same time.

Output from the processing of each client is appended to a client-private log file, **`/etc/dlogs/<`*`client`*`>`**. The output includes a progress report and any error messages. If the **`-t`** option is specified, the output is directed to *stdout* instead of the log file. In addition, as each client process terminates, a message stating whether processing was successful or errors were encountered is printed to *stderr*. Once all client processing is terminated, a summary report is also printed to *stderr*.

OPTIONS

The following options are supported.

`C` when *node* is a diskless client, the diskless environment is created. A virtual root directory is created for each client specified and entries are added to the resource sharing tables to give each client permission to remotely access, via NFS, the server's system files and private files under the client's virtual root directory. Prior to invoking this option client configuration information must be specified in the **`nodes.vmeboot`**, **`clusters.vmeboot`**, and the **`hosts`** tables.
when *node* is the file server, tunables are set in the server's kernel configuration enabling it to run in Closely-Coupled mode. A new kernel must then be built (see **`idbuild(1M)`**) and the system booted in order for the changes to take effect.

R when *node* is a diskless client, the diskless environment is removed. The virtual root directory and entries from the resource sharing tables are removed.
when *node* is the file server, the Closely-Coupled tunables are "unset" in the server's kernel configuration. A new kernel must then be built (see **`idbuild(1M)`**) and the system booted in order for the changes to take effect.

`U` update an existing client or server kernel configuration. This option is meaningless by itself.

`a` *subsys*
This option may be invoked multiple times in the command line, once for each subsys to be added.
when *node* is the file server this option is ignored. subsystems are added to the file server when software packages are installed on the system via **`pkgadd(1M)`**.
when *node* is a diskless client, the client environment is modified to support the subsystem *subsys*. Currently supported subsystems:

CCS_FBS
adds support for a timing device that is located on a system within a closely-coupled configuration to be used as a Closely-Coupled FBS timing device for some or all of the nodes in the cluster. For more information see the *PowerMAX OS Guide to Real-Time Services* manual and the "Inter-SBC Synchronization and Coordination" chapter in the in *Closely-Coupled Programming Guide.*

RCFBS
adds support for a distributed interrupt RCIM device to be used as a "RCIM Coupled FBS timing device" for some or all of the nodes in the cluster. The SBCs that connect to the same RCIM Coupled timing device may be made up of a mix of standalone SBCs, NFS clients and netbooted clients. However, embedded clients may not make use of RCIM Coupled timing devices due to the networking support that is required for proper functioning of these timing devices. For more information see the *PowerMAX OS Guide to Real-Time Service* `manual.`

CCS_IPC
adds support for remote message queues and/or remote semaphores that may be used to provide inter-board coordination and synchronization for nodes within a closely-coupled system. For more information refer to the "Real-Time Interprocess Communication" and "Interprocess Synchronization" chapters of the *PowerMAX OS Real Time Guide* and the "Inter-SBC Synchronization and Coordination" chapter in the in *Closely-Coupled Programming Guide.*

IWE
: adds support for an integrated VGA or Super VGA display adapter, keyboard, and serial or PS/2 style pointing device. For more details of the user visible programming facilities provided by the IWE, refer to the **`display(7)`**, **`keyboard(7)`** **`mouse(7)`** manual pages.

`c` *clid*
: Use with the all argument to specify all of the nodes which are members of cluster id *clid*.

`h` Help mode. Prints usage info.

`m` *addr,sz*
: reserve physical memory on each *node* specified, to be dedicated for Slave Shared memory. Only one shared memory segment is allowed per *node*; therefore, if there is an existing segment reserved when a new segment is configured, the existing configuration is first removed. To remove a currently reserved memory segment without adding another, specify zero for *sz* and for *addr* specify the upper 16 bits (hexadecimal) of the starting address if the memory was allocated statically or zero if the memory was allocated dynamically.
sz is specified in kilobytes and indicates the size of the local memory region that may be shared with other SBCs in the cluster. *sz* must be a multiple of a page(4kb). The actual amount of memory reserved is this value plus 4 kilobytes of kernel-dedicated area. The specified *sz*, in addition to the 4 kilobytes dedicated to the kernel must be equal or less to the VME area configured for the Slave Window Size field in the **`clusters.vmeboot`** table.
static memory allocation: *addr* specifies the upper 16 bits (hexadecimal) of the start of contiguous physical memory (DRAM) to be reserved. A reasonable start address value to use is 0x0100 (16Mb), however, the board DRAM size, which must be >= 32 Mb to use this value, and other user-reserved memory allocations must be taken into account. Both **`mmap(2)`** and **`shmop(2)`** operations are supported when the memory is allocated statically.
dynamic memory allocation: Is indicated by specifying *addr* as zero. The **`mmap(2)`** but not the s**`hmop(2)`** call is supported when the memory is allocated dynamically.

`p` *n*
: Process n number of client processes in parallel. Default is all in parallel.

`r` *subsys*
: This option may be invoked multiple times in the command line, once for each subsys to be removed.
when *node* is a diskless client: modify the client environment to remove support for subsystem *subsys*, previously added via the **`-a`** option.
when *node* is the file server: this option is ignored. subsystems are removed from the file server when software packages are removed via **`pkgrm(1M)`**.

`s` when *node* is a diskless client and the client diskless environment is being removed via the **`-R`**, this option protects the client-private custom files under **`/etc/diskless.d/custom.conf/client.private/<node>`** from being removed. This option is useful when the diskless environment is being removed with the intention of making configuration table changes and re-creating it.
when *node* is the file server, this option is ignored.

`t` Use this option to redirect output to *stdout* instead of to a log file. This is useful when only one client is specified or when processing is limited to one client at a time via the **`-p`** option. If this option is used and more than one client is processed in parallel the output from the various processes will be intermixed.

`v` when *node* is a diskless client, updates the system directories that reside under the client's virtual root. Files in these directories cannot all be shared. Files that can be shared exist as a symbolic link; files that cannot be shared are created as regular files. This option generates new links for files that have been created on the server after the virtual root directory was generated, and removes links for files that no longer exist. Private files under the virtual root directory are not touched. Files added to the server's kernel configuration directory, are copied to the client's virtual root with the exception of **`Driver.o`** files which can be shared and are therefore linked. Kernel modules are copied in but not configured into the kernel.
when *node* is the file server this option is ignored.

RETURN VALUES

On success vmebootconfig returns 0. On failure, vmebootconfig returns 1. On termination due to a signal, returns 128.

EXAMPLES

Create the diskless environment of all clients listed in the **`nodes.vmeboot`** table who are member of cluster id #1. Process one client at a time and send output to *stdout* instead of to a log file.

```
vmebootconfig -C -p 1 -t -c 1 all
```

Create the diskless environment for client whose VME networking name is *wilma_vme*. Add support for subsystems CCS_FBS and CCS_IPC and reserve physical memory for Slave Shared Memory starting at 16 megabytes and of size 128 kilobytes.
`vmebootconfig -C -a`CCS_FBS **`-a`**CCS_IPC **`-m`** `0x0100,128` *wilma_vme*

Update the diskless environment of client *wilma_vme*. Remove support for subsystem CCS_IPC and replace current static memory reservation with a dynamic reservation of size 128 kilobytes.
`vmebootconfig -U -r`CCS_IPC **`-m`** `0,128` *wilma_vme*
Update the diskless environment of client *wilma_vme*. Remove the current dynamic memory reservation.
`vmebootconfig -U -m` `0,0` *wilma_vme*

Increase the value of the *VME Slave Window Size* field in the **`clusters.vmeboot`** table to 320. Since changes to this table affect all the members of the cluster, re-create the diskless environments of all the clients in the cluster. First remove the diskless configurations. Specify the **`-s`** option so that each client's private custom configuration directory is not removed.
`vmebootconfig -R -s -c 1 all`

Re-create the diskless environments of all the members of the cluster.
`vmebootconfig -C -c 1 all`
Update the diskless environment of *wilma_vme* to make use of the increased Slave Shared Memory size.
`vmebootconfig -U -m` `0x0100,256` *wilma_vme*

FILES

`/etc/dfs/dfstab`
`/etc/dfs/dfstab.diskless`
`/etc/dlogs/`*`<node>`*
`/etc/dtables/nodes.vmeboot`
`/etc/dtables/clusters.vmeboot`
`/etc/hosts`
`/etc/diskless.d/custom.conf/client.private/`*`<node>`*
***`<vroot_dir>`*`/.client_profile`**

REFERENCES

`shareall(1M)`, **`dfstab(4)`**, **`ksh(1)`**, **`mmap(1M)`**, **`shmop(1M)`**, **`mkvmebstrap(1m)`**
Power hawk Series 600 Diskless Systems Administrator's Guide
Power hawk Series 600 Closely-Coupled Programming Guide

CAVEATS

`vmebootconfig` is part of the diskless software package. The diskless package must be installed in order to use this command.

B
netbootconfig(1m)

NAME

netbootconfig – configuration tool used to create, remove or update a diskless client's environment in a Loosely Coupled system configuration.

SYNOPSIS

/usr/sbin/netbootconfig
-h
-C [**-t**] [**-a** *subsys*] [**-p** *n*] **all** | *client...*
-R [**-st.**] [**-p** *n*] **all** | *client...*
-U [**-tv**] [**-ar** *subsea*] [**-p** *n*] **all** | *client...*

DESCRIPTION

netbootconfig is used to create, remove or update the environment needed to support one or more diskless clients in a Loosely-Coupled system configuration.

A Loosely-Coupled system consists of one file server and one or more diskless clients which download the boot image using TFTP over an ethernet connection. For more information on Loosely-coupled systems, refer to the **LCS(7)** manual page and the *Diskless Systems Administrator's Guide*.

netbootconfig must be invoked from the system configured as the file server and you must be logged in as root to execute.

One or more *client* or **all** must be specified. If specified, *client* must match the hostname used for the ethernet networking interface. If **all** is specified all the clients listed in the **/etc/dtables /nodes.netboot** table will be processed.

One of the three options **-C**, **-R**, **-U** must be specified. When the create option (**-C**) is used, it is expected that prior to invoking this tool the **/etc/dtables/nodes.netboot** and **/etc/hosts(4)** tables have been updated with client configuration information. The **nodes.netboot** table must have an entry for each *client* specified in the command line. The **/etc/hosts** table should have an entry for the ethernet hostname of each client.

The environment needed to support a diskless client is created using the **-C** option. A virtual root directory is generated on the server's disk for each client specified and the system tables **/etc/dfs/dfstab** and **/etc/dfs/dfstab.diskless** are updated. The **shareall(1M)** command is executed to give a diskless client permission to access the server's files. The lock file **/etc/dfs/.dfstab.lock** is used to synchronize updates to these tables. Note that these tables should not be edited directly while this command is running. Client configuration information in a **ksh(1)**-loadable format is stored in the file **.client_profile** under the client's virtual root directory.

After the diskless environment is created, **mknetbstrap(1M)** may be invoked to generate the boot image.

When the remove (**-R**) or update (**-U**) options is used, it is expected that the diskless environment already exists for each client specified. Configuration information needed to process the request is obtained from the **nodes.netboot** table and from the file**.client_profile** stored under each client's virtual root directory.

When the remove option (**-R**) is specified, the virtual root directory is renamed and removed in the background and the client name is removed from the resource-sharing tables.

The client configuration may be modified by using the update (**-U**) option. Note that configuration changes are specified via additional options. Specifying the update option by itself is meaningless.

By default, client processing is executed in parallel, however, the **-p** option may be used to limit the number of clients that are processed at the same time.

Output from the processing of each client is appended to a client-private log file, **/etc/dlogs/<client>**. The output includes a progress report and any error messages. If the **-t** option is specified, the output is directed to *stdout* instead of the log file. In addition, as each client process terminates, a message stating whether processing was successful or errors were encountered is printed to *stderr*. Once all client processing is terminated, a summary report is also printed to *stdout.*

OPTIONS

The following options are supported.

`C` create the diskless environment. A virtual root directory is created for each client specified and entries are added to the resource sharing tables to give each client permission to remotely access, via NFS, the server's system files and private files under the client's virtual root directory. Prior to invoking this option client configuration information must be specified in the **`nodes.netboot`**, and the **`hosts`** tables.

`R` remove the diskless environment. Removes the virtual root directory and entries from the resource sharing tables.

`U` update an existing client configuration. This option is meaningless by itself.

`a` *subsys*
modify the client environment to support the subsystem *subsys*. Currently supported subsystems:

IWE
adds support for an integrated VGA or Super VGA display adapter, keyboard, and serial or PS/2 style pointing device. For more details of the user visible programming facilities provided by the IWE, refer to the **`display(7)`**, **`keyboard(7)`** **`mouse(7)`** manual pages.

RCFBS
adds support for a distributed interrupt RCIM device to be used as a "RCIM Coupled FBS timing device". For more information see the *PowerMAX OS Guide to Real-Time Service* manual.

`h` Help mode. Prints usage info.

`p` *n*
Process n number of client processes in parallel. Default is **`all`** in parallel.

`r` *subsys*
modify the client environment to remove support for the subsystem *subsys* previously added via the **`-a`** option.

`s` when removing a client's diskless environment (**`-R`** option), do not remove custom configuration files under **`/etc/diskless.d/custom.conf/client.private/<client>`**. This option is useful when the diskless environment is being removed with the intention of making configuration table changes and re-creating it.

`t` Use this option to redirect output to stdout instead of to a log file. This is useful when only one client is specified or when processing is limited to one client at time via the **`-p`** option. If this option is used and more than one client is processed in parallel the output from the various processes will be intermixed.

`v` update the system directories that reside under the client's virtual root. Files in these directories cannot all be shared. Files that can be shared exist as a symbolic link; files that cannot be shared are created as regular files. This option generates new links for files that have been created on the server after the virtual root directory was generated, and removes links for files that no longer exist. Private files under the virtual root directory are not touched. Files added to the server's kernel configuration directory, are copied to the client's virtual root with the exception of **`Driver.o`** files which can be shared and are therefore linked. Kernel modules are copied in but not configured into the kernel.

RETURN VALUES

On success netbootconfig returns 0. On failure, **`netbootconfig`** returns 1. On termination due to a signal, returns 128.

EXAMPLES

Create the diskless environment of all clients listed in the nodes.netboot table. Process one client at a time and send output to *stdout* instead of to a log file.

```
netbootconfig -C -p 1 -t all
```

Create the diskless environment for client whose ethernet hostname is *wilma*. Add support for subsystem IWE.

```
netbootconfig -C -a IWE wilma
```

Update the diskless environment of client *wilma*. Remove support for subsystem IWE.

```
netbootconfig -U -r IWE wilma
```

To change a client's configuration, first remove the diskless environment specifying the **-s** option so that each client's private custom configuration directory is not removed.

netbootconfig ***-R -s*** *wilma*

Change the client's configuration parameters in the nodes.netboot and/or the /etc/hosts table and then re-create the diskless environment

netbootconfig **-C all**

FILES

/etc/dfs/dfstab
/etc/dfs/dfstab.diskless
/etc/dlogs/*<client>*
/etc/dtables/nodes.netboot
/etc/hosts
/etc/diskless.d/custom.conf/client.private/<client>
<vroot_dir>/.client_profile

REFERENCES

shareall(1M), **dfstab(4)**, **ksh(1)**, **mknetbstrap**
Power Hawk Series 600 Diskless Systems Administrator's Guide.

CAVEATS

netbootconfig is part of the diskless software package. The diskless package must be installed in order to use this command.

C
mkvmebstrap(1m)

NAME

mkvmebstrap – builds the bootstrap image used to boot a diskless single board computer in a Closely-Coupled System configuration.

SYNOPSIS

/usr/sbin/mkvmebstrap [**-BFXhlt**] [**-b** *bflags*] [**-c** *clid*] [**-k** "*[-]kmod*"] [**-p** *n*] [**-r** *comp*] **all** | *client ...*

DESCRIPTION

mkvmebstrap is used to generate the bootstrap image used in booting a diskless Single Board Computer (SBC) in a Closely-Coupled system configuration. Optionally, for clients configured to boot over the VME interface, it may download the boot image and start its execution or burn the boot image in Flash. For more information on Closely-coupled systems, refer to the **CCS(7)** manual page and the *Diskless Systems Administrator's Guide.*

mkvmebstrap must be invoked from the system configured as the file server and you must be logged in as root to execute.

One or more *clients* or **all** must be specified using the client's VME hostname. **all** indicates that all the clients listed in the **/etc/dtables/nodes.vmeboot** table should be processed. When the **-c** option and **all** are both specified, all the clients listed in the **nodes.vmeboot** table which are members of the cluster id *clid* are processed. Note that the file server of the cluster boots from disk, hence it is ignored when **all** is specified.

Each client specified must be listed in the **nodes.vmeboot** table and its diskless environment created on the server via **vmebootconfig(1M)**. Configuration information needed for generating the bootstrap image is obtained from the **nodes.vmeboot** table and from the file **.client_profile** stored under each client's virtual root directory.

By default, client processing is executed in parallel, however, the -p option may be used to limit the number of clients that are processed at the same time.

Output from the processing of each client is appended to a client-private log file, **/etc/dlogs/<*client*>**. The output includes a progress report and any error messages. If the **-t** option is specified, the output is directed to *stdout* instead of the log file. In addition, as each client process terminates, a message stating whether processing was successful or errors were encountered is printed to *stderr*. Once all client processing is terminated, a summary report is also printed to *stderr*.

mkvmebstrap invokes **make(1M)** and uses the makefile **/etc/diskless.d/bin /bstrap.makefile** to generate the boot image. The two components used to build the the boot image, **unix** and **memfs.cpio** and the bootstrap file itself, **unix.bstrap** are generated in the **etc/conf/cf.d** directory under each client's virtual root directory.

The **memfs.cpio** file is a cpio image of all the files that will be installed in the memfs file system used in the initial boot phase, before the client is running NFS. The **memfs.cpio** file is automatically rebuilt when global system configuration files or client-private configuration files under the /etc/diskless.d/custom.conf directory are updated or when a new unix kernel is generated.

The **memfs.cpio** file is compressed using the random access compressor **rac(1)**. To list the contents of this image, you can use the **-d** option of rac. For example; ***rac -d < memfs.cpio*** | ***cpio -itcv***

The unix kernel is automatically rebuilt when the unix *file* is missing, when kernel configuration is modified via the **-k** and **-b** options, or when additional modules are added to the **kernel.modlist.add** configuration file under the **/etc/diskless.d/custom.conf** directory. Other kernel modifications, such as changing the values of tunables, may be done using the **config(1M)** tool by specifying the virtual root directory path to the **-r** option. Note that if the **-r** option is omitted on the call to **config**, the server's kernel configuration directory, instead of the client's, will be modified. After changing the kernel configuration via **config** a new kernel and boot image must be forced to be rebuilt by invoking **mkvmebstrap** with the **-r** unix option. The unix kernel is compressed using **sbczipimage(1M)**.

OPTIONS

The following options are supported. **`sbcboot(1M)`** is called by this tool but may be invoked directly to execute the download options (**`-B`**, **`-F`**, **`-X`**, **`-l`**). Note that if the client is configured to boot via an ethernet connection then the client itself must initiate the boot sequence and the download options do not apply.

`B` Download the boot image and boot the client. This option only applies to clients configured to boot over VME.

`b` *bflags*
Set boot flags. Used to dynamically alter the normal boot process. By default *bflags* is set to zero indicating that no special actions are to be performed during the boot process. Note that these flags are not persistent and must be specified for each boot. These flags are passed via the boot command for clients configured to boot over VME. However, for targets configured to boot over the ethernet interface, the flags must be written into the bootstrap image. For these clients, **`mkvmebstrap`** automatically builds a new boot image each time the flags are specified or need to be reset. *bflags* may be set to:

`kdb`
Enter the kernel debugger during the client's system boot. This is useful for debugging. If not already configured, the required **`kdb`** kernel modules will be turned on and a new kernel will be automatically rebuilt.

`c` clid
Use with the **`all`** argument to specify all the clients in cluster id clid.

`F` Burn boot image into Flash. This option only applies to clients booting over VME. This is like the load only option (**`-l`**) but, in addition, the boot image is burned into Flash. The client may subsequently be booted from local Flash via the **`-X`** option. Note that if the client is configured with NFS support, then the client still relies on the file server for its files.
WARNING: This option overwrites Flash 'A' which may be the Flash used for **`PPCBug`**. Refer to The *Diskless Systems Administrator's Guide* before using this option.

`h` Help mode. Prints usage info.

`k` *"[-]kmod"*
This option may be invoked multiple times in the command line, once for each kernel module to be specified. Configure or deconfigure the kernel driver module *kmod*. To deconfigure a module, the module name must be prefixed with a minus sign and the name must be within quotes. For example specify **`-k`** ***`kdb -k`*** *"**`-fbs`**"* to turn on **`kdb`** and turn off the **`fbs`** kernel module. If the specified kernel module depends on other kernel modules then those modules will also be configured. If the specified module is already in the requested state the request is silently ignored; otherwise a new kernel and boot image is generated.

`l` Download the boot image but do not boot the client. The boot image is brought up-to-date and downloaded but the client is not booted. Booting may be resumed by typing the command ***`go <load address>`*** at the **`PPC1-Bug`** prompt on the client SBC. The *load address* is the first value in the address range printed when the image is downloaded. By default, the load address is `0x01000000`.

`p` *n*
Process *n* number of client processes in parallel. Default is **`all`** in parallel.

`r` *comp*
Rebuild new boot image. This option is used to force the building of a new **`unix.bstrap`** file and its dependents. The component to be rebuilt, *comp*, must be specified. *comp* may be set to:

`unix`
after kernel configuration changes.

`memfs`
after updates to user files invoked in the early init states, before the client is running NFS.

`bstrap`
when the unix.bstrap appears to have been corrupted.

`all`
to rule out file corruption when a boot fails.

`t` Use this option to redirect output to stdout instead of to a log file. This is useful when only one client is specified or when processing is limited to one client at at time via the **`-p`** option. If this option is used and more than one client is processed in parallel the output from the various processes will be intermixed.

X Boot client from Flash instead of DRAM. The boot image must have been previously burned into FLASH using the **-F** option. This option only applies to clients booting over VME.

RETURN VALUES

On success **mkvmebstrap** returns 0. On failure, **mkvmebstrap** returns 1. On termination due to a signal returns 128.

EXAMPLES

Update the boot image and boot all the clients configured in the **nodes.vmeboot** table that are members of cluster id 1.

```
mkvmebstrap -B  -c 1 all
```

Invoke **config(1M)** to change the value of tuneables in client wilma_vme's kernel. Then invoke **mkvmebstrap** to force the build of a new unix and boot image and boot the client. Have the client stop in **kdb** during system initialization.

```
config -r /home/vroots/wilma
mkvmebstrap  -B -r unix -b kdb  wilma_vme
```

Build a new kernel and boot image with kdb configured and the **gd** kernel module deconfigured. Download the boot image but do not execute it for all clients listed in the **nodes.vmeboot** table. Process only one client at a time and have the output directed to stdout instead of to a log file.

```
mkvmebstrap  -l -k kdb -k "-gd"  -t -p 1  all
```

FILES

/etc/diskless.d/bin/bstrap.makefile
/etc/diskless.d/custom.conf
/etc/dtables/nodes.vmeboot
<vroot_dir>/.client_profile
<vroot_dir>/etc/conf/cf.d/unix
<vroot_dir>/etc/conf/cf.d/memfs.cpio
<vroot_dir>/etc/conf/cf.d/unix.bstrap

REFERENCES

vmebootconfig(1M), **sbcboot(1M)**, **sbc(7)**, **sbcextract(1M)**, **sbcmkimage(1M)**, **sbczipimage(1M)**, **rac(1)**
Power Hawk Series 600 Diskless Systems Administrator's Guide.

D mknetstrap(1m)

NAME

mknetbstrap – builds the bootstrap image used to boot a diskless single board computer in a Loosely-Coupled System configuration.

SYNOPSIS

/usr/sbin/mknetbstrap [**-ht**] [**-b** *bflags*] [**-k** "*[-]kmod*"] [**-p** *n*] [**-r** *comp*] all | *client...*

DESCRIPTION

mknetbstrap is used to generate the bootstrap image used in booting a diskless Single Board Computer (SBC) in a Loosely-Coupled system configuration.

A Loosely-Coupled system consists of one file server and one or more diskless clients which download the boot image using TFTP over an ethernet connection. For more information on Loosely-coupled systems, refer to the **LCS(7)** manual page and the *Diskless Systems Administrator's Guide*.

mknetbstrap must be invoked from the system configured as the file server and you must be logged in as root to execute.

One or more *clients* or all must be specified using the client's hostname. all indicates that all the clients listed in the **/etc/dtables/nodes.netboot** table should be processed.

Each client specified must be listed in the nodes.netboot table and its diskless environment created on the server via **netbootconfig(1M)**. Configuration information needed for generating the bootstrap image is obtained from the **nodes.netboot** table and from the file **.client_profile** stored under each client's virtual root directory.

By default, client processing is executed in parallel, however, the **-p** option may be used to limit the number of clients that are processed at the same time.

Output from the processing of each client is appended to a client-private log file, **/etc/dlogs/<*client*>**. The output includes a progress report and any error messages. If the **-t** option is specified, the output is directed to *stdout* instead of the log file. In addition, as each client process terminates, a message stating whether processing was successful or errors were encountered is printed to *stderr*. Once all client processing is terminated, a summary report is also printed to *stderr*.

mknetbstrap invokes **make(1M)** and uses the makefile **/etc/diskless.d/bin/bstrap.makefile** to generate the boot image. The two components used to build the boot image, unix and **memfs.cpio** and the bootstrap file itself, **unix.bstrap** are generated in the **etc/conf/cf.d** directory under each client's virtual root directory.

The **memfs.cpio** file is a cpio image of all the files that will be installed in the memfs file system used in the initial boot phase, before the client is running NFS. The **memfs.cpio** file is automatically rebuilt when global system configuration files or client-private configuration files under the **/etc/diskless.d/custom.conf** directory are updated or when a new unix kernel is generated.

The **memfs.cpio** file is compressed using the random access compressor rac(1). To list the contents of this image, you can use the **-d** option of rac. For example; ***rac -d*** < ***memfs.cpio*** | ***cpio -itcv***

The unix kernel is automatically rebuilt when the unix file is missing, when kernel configuration is modified via this tool or when the **kernel.modlist.add** configuration file under the **/etc/diskless.d/custom.con**f directory is updated. Other kernel modifications, such as changing the values of tunables, may be done using the **config(1M)** tool by specifying the virtual root directory path to the **-r** option. Note that if the **-r** option is omitted on the call to **config**, the server's kernel configuration directory, instead of the client's, will be modified. After changing the kernel configuration via **config** a new kernel and boot image must be forced to be rebuilt by invoking mknetbstrap with the **-r *unix*** option. The unix kernel is compressed using **sbczipimage(1M)**.

OPTIONS

The following options are supported.

b *bflags*
Set boot flags. Used to dynamically alter the normal boot process. By default *bflags* is set to zero indicating that no special actions are to be performed during the boot process. These flags are written into the bootstrap image, therefore, a new boot image is automatically rebuilt each time the flags are specified or need to be reset. Note that these flags are not persistent and must be specified for each boot. *bflags* may be set to:

kdb
Enter the kernel debugger during the client's system boot. This is useful for debugging. If not already configured, the required kdb kernel modules will be turned on and a new kernel will be automatically rebuilt.

h Help mode. Prints usage info.

k *"[-]kmod"*
Configure or deconfigure the kernel driver module *kmod*. To deconfigure a module, the module name must be prefixed with a minus sign and the name must be within quotes. For example specify **-k** ***kdb*** **-k** "*-fbs*" to turn on kdb and turn off the fbs kernel module. If the specified kernel module depends on other kernel modules then those modules will also be configured. If the specified module is already in the requested state the request is silently ignored; otherwise a new kernel and boot image is generated.

p *n*
Process *n* number of client processes in parallel. Default is all in parallel.

r *comp*
Rebuild new boot image. This option is used to force the building of a new unix.bstrap file and its dependents. The component to be rebuilt, *comp*, must be specified. *comp* may be set to:

unix
after kernel configuration changes.

memfs
after updates to user files invoked in the early **init** states, before the client is running NFS.

bstrap
when the **unix.bstrap** appears to have been corrupted.

all
to rule out file corruption when a boot fails.

t Use this option to redirect output to *stdout* instead of to a log file. This is useful when only one client is specified or when processing is limited to one client at time via the **-p** option. If this option is used and more than one client is processed in parallel the output from the various processes will be intermixed.

RETURN VALUES

On success mknetbstrap returns 0. On failure, **mknetbstrap** returns 1. On termination due to a signal returns 128.

EXAMPLES

Update the boot image of all the clients configured in the nodes.netboot table.
mknetbstrap *all*
Invoke **config(1M)** to change the value of tunables in client *fred's* kernel. Then invoke **mknetbstrap** to force the build of a new unix and boot image. Have the client stop in kdb during system initialization.
config -r /home/vroots/fred
mknetbstrap -r unix -b kdb *fred*
Build a new kernel and boot image with **kdb** configured and the **gd** kernel module deconfigured. Process only one client at a time and have the output directed to *stdout* instead of to a log file.
mknetbstrap -k kdb -k "**-gd**" **-t -p** 1 *all*

FILES

/etc/diskless.d/bin/bstrap.makefile
/etc/diskless.d/custom.conf
/etc/dtables/nodes.netboot
<vroot_dir>/.client_profile
<vroot_dir>/etc/conf/cf.d/unix

<vroot_dir>/etc/conf/cf.d/memfs.cpio
<vroot_dir>/etc/conf/cf.d/unix.bstrap

REFERENCES

netbootconfig(1M), **sbcboot(1M)**,**sbc(7)**, **sbcextract(1M)**, **sbcmkimage(1M)**, **sbczipimage(1M)**, **rac(1)**
Power Hawk Series 600 Diskless Systems Administrator's Guide.

E
Adding Local Disk

By default, clients are configured as diskless systems. It may be desirable to connect a local disk drive which is used to store application-specific data. The following example demonstrates how to configure a disk assuming that the disk has been formatted, file systems have been created on the appropriate partitions and the disk has been connected to the client. Note that these instructions apply to both loosely/closely coupled systems. Refer to the *System Administration* manual (Volume 2) for guidelines on how to accomplish these pre-requisite steps.

The kernel configuration may be modified using the **`config(1M)`** tool and specifying the client's virtual root directory. For example, if the client's virtual root path is **`/vroots/elroy`**:

```
config -r /vroots/elroy
```

1. If necessary, add an entry to the adapters table -

   Adapter information must be added to the adapters table for VME adapters (i.e., via). PCI adapters (i.e., ncr) are auto-configurable and should not be added to the adapters table. If this is a VME adapter, add an entry for it in the adapters table using the Adapters/Add menu option of **`config(1m)`**.

2. Configure kernel modules -

   Use the Modules function of the **`config(1M)`** tool to enable the following modules:

gd	(generic disk driver)
scsi	(device independent SCSI interface support)
ncr	(internal SCSI adapter interface driver)
ufs	(unix file system)
sfs	(unix secure file system)

   If a Resilient File System (XFS) is required for a client, instead of enabling ufs and sfs, enable:

   xfs (resilient file system)

   xfsth (resilient file system threaded)

   Note that the kernel.modlist.add table placed in the client's private **`custom.conf`** directory (**`/usr/etc/diskless.d/custom.conf/client.private/<client.dir>`** may instead be used to enable the kernel modules.

Note: The procedural steps below differ depending whether the client was configured with NFS support or as embedded.

NFS Clients (steps #3 - #6):

3. Configure Disk Device Files

   Check that an appropriate device node entry (**Node(4)**) exists and is uncommented for the disk being added. The following is such an entry from the Node file **/vroots/elroy/etc/conf/node.d/gd**:

   ```
   gd  dsk/0  D  ncr  0  0  0  0  3  0640  2
   ```

4. Add mount point directory entries to the memfs root file system via the **memfs.files.add** custom file. For example, to add the directories arbitrarily named **/dsk0s0** and **/dsk0s1**:

   ```
   # cd /usr/etc/diskless.d/custom.conf/client.private \
   /<client_dir>
   # [ ! -f ./memfs.files.add ] && cp /usr/etc/diskless.d \
   /custom.conf/client.shared/nfs/memfs.files.add .
   # vi memfs.files.add
   ```

   Example entries:

   ```
   d   /dsk0s0     0777
   d   /dsk0s1     0777
   ```

5. Enable Automatic Mounting of a Disk Partition by adding entries to the client's **vfstab** file. Note that the mount point directory name must match the directory name specified in the **memfs.files.add** file in step 4 above.

   ```
   # cd /usr/etc/diskless.d/custom.conf/client.private \
   /<client_dir>
   # [ ! -f ./vfstab ] && cp /usr/etc/diskless.d \
   /custom.conf/client.shared/nfs/vfstab .
   # vi vfstab
   ```

   Example entries:

```
/dev/dsk/0s0   /dev/rdsk/0s0   /dsk0s0  ufs    1    yes   -
/dev/dsk/0s1   /dev/rdsk/0s1   /dsk0s1  ufs    1    yes   -
```

6. Generate a new boot image.

   For a closely-coupled system you can optionally use the **-B** option to also boot the client:

```
mkvmebstrap -B -r all <client>
```

For a loosely-coupled system:

```
mknetbstrap -r all <client>
```

Embedded clients (steps #3 - #5):

3. The disk management tools must be added to the memfs file system. The list of tools is documented in the file **/usr/etc/diskless.d/sys.conf /memfs.d/add_disk.sh**. In executing the following commands, we grep the list of file entries from this script and append them to the **memfs.files.add** tables.

```
# cd /usr/etc/diskless.d/custom.conf/client.private \
/<client_dir>
# [ ! -f ./memfs.files.add ] && cp /usr/etc/diskless.d \
/custom.conf/client.shared/nfs/memfs.files.add .
# /sbin/grep "^#f" /usr/etc/diskless.d/sys.conf \
/memfs.d/add_disk.sh | cut -c2- >> ./memfs.files.add
```

Verify that the following entries were appended to **memfs.files.add**.

```
f    /sbin/expr          0755
f    /usr/bin/devcfg     0755
f    /usr/bin/cut        0755
f    /sbin/mknod         0755
f    /usr/bin/mkdir      0755
f    /sbin/fsck          0755
f    /etc/fs/ufs/fsck    0755
f    /etc/fs/xfs/mount   0755
f    /etc/fs/ufs/mount   0755
f    /sbin/df            0755
```

4. Embedded client systems do not have access to the kernel configuration directory, which is needed to generate the device node entries. However, the device node must be created on the client system because it’s minor number carries information that is unique to the running system. For this reason, special steps must be taken during client boot-up to create the device nodes.

   The sample script below will do the necessary steps to add a local disk on an embedded client. This script may be found on the File Server system under the path **/usr/etc/diskless.d/sys.conf/memfs.d/add_disk.sh**. Note that you must set the variables “FSTYPE” and “PARTITIONS” to the appropriate values.

```
# cd /usr/etc/diskless.d/custom.conf/client.private \
/<client_dir>
# [ ! -f ./S25client ] && cp /usr/etc/diskless.d/ \
custom.conf/client.shared/nfs/S25client .
# cat /usr/etc/diskless.d/sys.conf/memfs.d  \
/add_disk.sh >> ./S25client
# vi ./S25 client
```

Verify that the script (**illustrated on the next page after step #5**) was appended to `S25client` and set the variables FSTYPE and PARTITIONS.

5. Generate a new boot image.

   For a closely-coupled system you can optionally use the **`-B`** option to also boot the client:

   `mkvmebstrap -B -r` *all <client>*

   For a loosely-coupled system:

   `mknetbstrap -r` *all <client>*

```
----------- Beginning of Script --------------------

#
#  Start-up script to mount a local disk on a client configured
#  as embedded.
#
#  The variables FSTYPE and PARTITIONS should be set to the
#  appropriate values.
#
#  To be able to run this script, the following binaries must be
#  added to the memfs file system via the memfs.files.add custom
#  table. Example entries follow.
#
#f   /sbin/expr        0755
#f   /usr/bin/devcfg   0755
#f   /usr/bin/cut      0755
#f   /sbin/mknod       0755
#f   /usr/bin/mkdir  0755
#f   /sbin/fsck      0755
#f   /etc/fs/ufs/fsck0755
#f   /etc/fs/xfs/mount0755
#f   /etc/fs/ufs/mount 0755
#f   /sbin/df          0755
#
# Set FSTYPE and PARTITIONS
#
FSTYPE=ufs                   # file system type (ufs, xfs)
PARTITIONS="0 1 2 3 4 5 6"   # disk partitions to be mounted

#
# Initialize
#
> /etc/mnttab
> /etc/vfstab
disk=0

#
#  Create the device directories
#
/usr/bin/mkdir -p /dev/dsk
/usr/bin/mkdir -p /dev/rdsk
```

```
#
#  In this loop, the device nodes are created based on
#  major/minor device information gathered from the call
#  to devcfg.  The fsck(1m) utility is executed for each
#  file system, a mount point directory is created, and
#  the file system is mounted and then verified using df.
#
/usr/bin/devcfg -m disk | /usr/bin/cut -f3 | while read majmin
do
     maj=`echo $majmin | /usr/bin/cut -f1 -d” “`
     min=`echo $majmin | /usr/bin/cut -f2 -d” “`
     #
     # Creates, fsck and mounts the partition.
     #
     for i in $PARTITIONS
     do

          #
          # create the device nodes
          #
          minor=`/sbin/expr $min + $i`
          echo “===>Creating nodes /dev/dsk/${disk}s${i} \c”
          echo “and /dev/rdsk/${disk}s${i}”
          /sbin/mknod /dev/dsk/${disk}s${i} b $maj $minor
          /sbin/mknod /dev/rdsk/${disk}s${i} c $maj $minor

          #  fsck (ufs only) and mount each partitions.
          #
          if [ “$FSTYPE” != “xfs” ]
          then
          echo “===>Fsck’ing partition /dev/rdsk/${disk}s${i}”
               /etc/fs/$FSTYPE/fsck -y /dev/rdsk/${disk}s${i} \
                    > /dev/null
          fi

          #
          # create a mount point directory
          #
          /usr/bin/mkdir /${disk}s${i}

          #
          #  mount the partition
          #
          echo  “===>Mounting  /dev/dsk/${disk}s${i} /${disk}s${i}\n”
          /etc/fs/$FSTYPE/mount /dev/dsk/${disk}s${i} /${disk}s${i}

     done
     break
     disk=`/sbin/expr $disk + 1`
done
#
# verify the partitions are mounted
#
echo “===>Verifying mounted file systems”
/sbin/df -kl

-------------- End of Script --------------------
```

F
Make Client System Run in NFS File Server Mode

To become an NFS server, a client system must have an attached local disk. In becoming an NFS server, the client can share the data in the local disk partitions with other nodes in the cluster. Note that these instructions apply to both loosely-coupled and closely-coupled systems. See Appendix E "Adding Local Disk" for instructions on how to add a local disk to a diskless client.

We will refer to the client that has a local disk attached as the disk_server and the node(s) that want to share this disk as disk_clients.

First we must enable the **nfssrv** kernel module which, by default, is disabled in a diskless client configuration. We must also give the disk_client node(s) permission to access the partitions. The following commands are to be run on the node configured as the File Server of the loosely or closely-coupled system.

1. Enable the **nfssrvr** kernel module for the client that has the local disk attached (disk_server). This may be accomplished in several ways, either by using **config(1M)** and using the **-r** option to specify the virtual root directory or by adding it to the **kernel.modlist.add** custom file.

   ```
   # cd /usr/etc/diskless.d/custom.conf/client.private \
   /<client_dir>
   # [ ! -f ./kernel.modlist.add ] && cp /usr/etc/diskless.d \
   /custom.conf/client.shared/nfs/kernel.modlist.add .
   # vi kernel.modlist.add
   ```

   Add the following entry:

   ```
   nfssrv
   ```

2. For each partition to be shared, add an entry similar to the example entry shown below. Note that "`disk_client_1:disk_client_n`" refers to a list of nodes that want to share this partition. See the **dfstab(4)** manpage for more information. **disk_server_vrootpath** is the path to the virtual root directory of the node with the local disk attached.

   ```
   # vi <disk_server_vrootpath>/etc/dfs/dfstab
   ```

   Example entry:

```
share -F nfs -o rw,root=disk_client_1:disk_client_n -d "/disk0s0" /disk0s0 disk0s0
```

3. Generate a new boot image for the disk_server node by executing the command:

   If this is a closely-coupled system you may use the **-B** option to also boot the disk_server node:

```
mkvmebstrap -B -r all <disk_server>
```

If this is a loosely-coupled system:

```
mknetbstrap -r all <disk_server>
```

On each disk_client node that wants to share the disk partitions, we need to generate a mount point directory for each partition to be mounted across NFS. These partition can also be automatically mounted and unmounted during the system's boot/shutdown if desired. If the disk_client node is another diskless client, the mount points may be added to the memfs root file system via the **memfs.files.add** table and the automatic mounting may be achieved via the node's **vfstab** file or the **rc** scripts shown below.

1. Add directories to be used for mount points to the memfs filesystem.

```
# cd /usr/etc/diskless.d/custom.conf/client.private \
/<client_dir>
# [ ! -f ./memfs.files.add ] && cp /usr/etc/diskless.d \
/custom.conf/client.shared/nfs/memfs.files.add .
# vi memfs.files.add
```

Example entry:

```
d   /rem_0s0    0755
```

2. Add an entry to the client’s **startup** script to automatically mount the partition.

```
# cd /usr/etc/diskless.d/custom.conf/client.private \
/<client_dir>
# [ ! -f ./S25client ] && cp /usr/etc/diskless.d \
/custom.conf/client.shared/nfs/S25client .
# vi S25client
```

Example entry:

```
#
# if the disk_server is up, mount remote file system
# mount point /rem_0s0
#
if ping <disk_server>  > /dev/null
then
     /sbin/mount -F nfs  <disk_server>:/disk0s0  /rem_0s0
fi
```

3. Add an entry to the client's **`shutdown`** script to automatically unmount the partition

```
# cd /usr/etc/diskless.d/custom.conf/client.private \
/<client_dir>
#[ ! -f ./K00client ] && cp /usr/etc/diskless.d \
/custom.conf/client.shared/nfs/K00client .
# vi K00client
```

Example entry:

```
umount /rem_0s0
```

Glossary

Abbreviations, Acronyms, and Terms to Know

10base-T

See twisted-pair Ethernet (10base-T).

100base-T

See twisted-pair Ethernet (100base-T).

ARP

Address Resolution Protocol as defined in RFC 826. ARP software maintains a table of translation between IP addresses and Ethernet addresses.

AUI

Attachment Unit Interface (available as special order only)

asynchronous

An event occurring in an unpredictable fashion. A signal is an example of an asynchronous event. A signal can occur when something in the system fails, but it is not known when the failure will occur.

asynchronous I/O operation

An I/O operation that does not of itself cause the caller to be blocked from further use of the CPU. This implies that the caller and the I/O operation may be running concurrently.

asynchronous I/O completion

An asynchronous read or write operation is completed when a corresponding synchronous read or write would have completed and any associated status fields have been updated.

block data transfer

The method of transferring data in units (blocks) between a block device such as a magnetic tape drive or disk drive and a user program.

block device

A device, such as a magnetic tape drive or disk drive, that conveys data in blocks through the buffer management code. Compare `character device`.

block driver

A device driver, such as for a magnetic tape device or disk drive, that conveys data in blocks through the buffer management code (for example, the `buf` structure). One driver is written for each major number employed by block devices.

block I/O

A data transfer method used by drivers for block access devices. Block I/O uses the system buffer cache as an intermediate data storage area between user memory and the device.

block

The basic unit of data for I/O access. A block is measured in bytes. The size of a block differs between computers, file system sizes, or devices.

board ID

All SBCs in the same cluster (i.e. reside in the same VME chassis) are assigned a unique board identifier or "BID". The BID's range from 0 to 14 in any given cluster. Every cluster must define a BID 0. Additional SBC's installed in a cluster may assign any remaining unused BID. By convention, BID's are allocated sequentially but this is not mandatory.

boot

The process of starting the operating system. The boot process consists of self-configuration and system initialization.

boot device

The device that stores the self-configuration and system initialization code and necessary file systems to start the operating system.

boot image file

A file that can be downloaded to and executed on a client SBC. Usually contains an operating system and root filesystem contents, plus all bootstrap code necessary to start it.

boot server

A system which provides a boot image for other client systems.

bootable object file

A file that is created and used to build a new version of the operating system.

bootstrap

The process of bringing up the operating system by its own action. The first few instructions load the rest of the operating system into the computer.

bootp

A network protocol that allows a diskless client machine to determine it's own IP address, the address of the server host and the name of a file to be loaded into memory and executed.

Boot Image

This is the object that is downloaded into the memory of a diskless client. It contains a UNIX kernel image and a memory-based root file system. The memory-based file system must contain the utilities and files needed to boot the kernel. In the case of an NFS client, booting must proceed to the point that remote file systems can be mounted. For an embedded kernel, the memory-based file system is the only file system space that is available on the diskless system. Users may add their own files to the memory-base file system.

Boot Server

The boot server is a special SBC in a Closely-Coupled system, because it is the SBC that downloads a boot image to all other clients in the same cluster across the VMEbus. This is known as VMEbus booting.

buffer

A staging area for input-output (I/O) processes where arbitrary-length transactions are collected into convenient units for system operations. A buffer consists of two parts: a memory array that contains data from the disk and a buffer header that identifies the buffer.

cache

A section of computer memory where the most recently used buffers, i-nodes, pages, and so on are stored for quick access.

character device

A device, such as a terminal or printer, that conveys data character by character.

character driver

The driver that conveys data character by character between the device and the user program. Character drivers are usually written for use with terminals, printers, and network devices, although block devices, such as tapes and disks, also support character access.

character I/O

The process of reading and writing to/from a terminal.

client

A SBC board, usually without a disk, running a stripped down version of PowerMAX OS and dedicated to running a single set of applications. Called a client since if the client maintains an Ethernet connection to its server, it may use that server as a kind of remote disk device, utilizing it to fetch applications, data, and to swap unused pages to.

client board

The single-computer board (SBC) of a client system.

client boot image

A file which contains a UNIX kernel, memory file system image and bootstrap. A client system executes the bootstrap, which transfers control to the kernel, which then creates a root filesystem from the memory filesystem image.

client system

A client system is a system which runs its own copy of the operating system, but does not have its own UNIX system disk. It may utilize file systems located on the file server via NFS. It is booted by a boot server or receives a boot image from the boot server.

Closely-Coupled System

A Closely-Coupled System (CCS) is a set of Single Board Computers (SBCs) which share the same VMEbus. The first board must have an attached system disk and acts as the file server for the other boards in the VMEbus. The VMEbus can be used for various types of inter-board communication.

cluster

A cluster is one or more SBC(s) which reside on the same VMEbus. In general, a cluster may be viewed as a number of SBCs which reside in the same VME chassis. Note that "cluster" and "Closely-Coupled system" are synonymous.

Multiple clusters (VME chassis) can be configured together in the same LCS using Ethernet.

controller

The circuit board that connects a device, such as a terminal or disk drive, to a computer. A controller converts software commands from a driver into hardware commands that the device understands. For example, on a disk drive, the controller accepts a request to read a file and converts the request into hardware commands to have the reading apparatus move to the precise location and send the information until a delimiter is reached.

cyclic redundandancy check (CRC)

A way to check the transfer of information over a channel. When the message is received, the computer calculates the remainder and checks it against the transmitted remainder.

datagram

Transmission unit at the IP level.

data structure

The memory storage area that holds data types, such as integers and strings, or an array of integers. The data structures associated with drivers are used as buffers for holding data being moved between user data space and the device, as flags for indicating error device status, as pointers to link buffers together, and so on.

data terminal ready (DTR)

The signal that a terminal device sends to a host computer to indicate that a terminal is ready to receive data.

data transfer

The phase in connection and connection-less modes that supports the transfer of data between two DLS users.

DEC (dec)

Internal DEC Ethernet Controller (DEC 21040 Ethernet chip) located on SBC.

device number

The value used by the operating system to name a device. The device number contains the major number and the minor number.

diagnostic

A software routine for testing, identifying, and isolating a hardware error. A message is generated to notify the tester of the results.

DLM

Dynamically Loadable Modules.

DRAM

Dynamic Random Access Memory.

driver entry points

Driver routines that provide an interface between the kernel and the device driver.

driver

The set of routines and data structures installed in the kernel that provide an interface between the kernel and a device.

embedded

The host system provides a boot image for the client system. The boot image contains a UNIX kernel and a file system image which is configured with one or more embedded applications. The embedded applications execute at the end of the boot sequence.

ENV - Set Environment

ENV commands allows the user to view and/or configure interactively all PPCBug operational parameters that are kept in Non-Volatile RAM (NVRAM).

error correction code (ECC)

A generic term applied to coding schemes that allow for the correction of errors in one or more bits of a word of data.

FDDI

Fiber Distributed Data Interface.

flash autobooting

The process of booting a client from an image in its Flash memory rather than from an image downloaded from a host. Flash booting makes it possible to design clients that can be separated from their hosts when moved from a development to a production environment. On SBC boards, Flash autobooting is configured with the 'ROM Enable' series of questions of the **`PPCBug ENV`** command.

flash booting

See definition for **flash autobooting**.

flash burning

The process of writing a boot or other image into a Flash memory device. On SBC boards, this is usually accomplished with the **`PFLASH PPCBug`** command.

flash memory

A memory device capable of being occasionally rewritten in its entirety, usually by a special programming sequence. Like ROM, Flash memories do not lose their contents upon powerdown. SBC boards have two Flash memories: one (Flash B) to hold **`PPCBug`** itself, and another (Flash A) available for users to utilize as they see fit.

FTP (ftp)

The File Transfer Protocol is used for interactive file transfer.

File Server

The File Server has special significance in that it is the only system with a physically attached disk(s) that contain file systems and directories essential to running the PowerMAX OS. The File Server boots from a locally attached SCSI disk and provides disk storage space for configuration and system files for all clients. All clients depend on the File Server since all the boot images and the system files are stored on the File Server's disk

function

A kernel utility used in a driver. The term function is used interchangeably with the term kernel function. The use of functions in a driver is analogous to the use of system calls and library routines in a user-level program.

GEV (Global Environment Variables)

A region of an SBC boards NVRAM reserved to hold user and system data in environment variable format, identical to the environment variable format available in all Unix-derived operating systems. They may be accessed from **`PPCBug`** with the **`GEV`** command, from the Unix shell using the **`gev(1)`** command, and from Unix applications using **`nvram(2)`** system calls, and from UNIX kernel drivers using **`nvram(2D)`** kernel services. Data saved in GEVs will be preserved across system reboots, and thus provides a mechanism for one boot of a client to pass information to the next boot of the same client.

host

Generic term used to describe Board ID 0 in any cluster (see definition of File Server and Boot Server).

host board

The single board computer of the file server.

host name

A name that is assigned to any device that has an IP address.

host system

A term used for the file server or boot server. It refers to the prerequisite Power Hawk system.

Init Level

A term used in UNIX-derived systems indicating the level of services available in the system. Those at "**init level 1**" are single user systems which in turn is typical of embedded systems running on client SBCs. Those at "**init level 3**" have full multi-user, networking, and NFS features enabled, and is typical of client SBCs that run as netboot clients. See **`init(1M)`** for complete details.

interprocess communication (IPC)

A set of software-supported facilities that enable independent processes, running at the same time, to share information through messages, semaphores, or shared memory.

interrupt level

Driver interrupt routines that are started when an interrupt is received from a hardware device. The system accesses the interrupt vector table, determines the major number of the device, and passes control to the appropriate interrupt routine.

interrupt vector

Interrupts from a device are sent to the device's interrupt vector, activating the interrupt entry point for the device.

ICMP

Internet Control Message Protocol, an integral part of IP as defined in RFC 792. This protocol is part of the Internet Layer and uses the IP datagram delivery facility to send its messages.

IP

The Internet Protocol, RFC 791, is the heart of the TCP/IP. IP provides the basic packet delivery service on which TCP/IP networks are built.

ISO

International Organization for Standardization

kernel buffer cache

A set of buffers used to minimize the number of times a block-type device must be accessed.

kdb

Kernel debugger.

loadable module

A kernel module (such as a device driver) that can be added to a running system without rebooting the system or rebuilding the kernel.

loosely-coupled system

A Loosely-Coupled System (LCS) is a network of Single-Board Computers (SBCs). One of the SBCs must have a system disk and is referred to as the File Server and all other SBCs are generally referred to as clients. An ethernet connection between the file server and the client systems provides the means for inter-board communication.

MTU

Maximum Transmission Units - the largest packet that a network can transfer.

memory file system image

A cpio archive containing the files which will exist in the root file system of a client system. This file system is memory resident. It is implemented via the existing *memfs* file system kernel module. The kernel unpacks the cpio archive at boot time and populates the root memory file system with the files supplied in the archive.

memory management

The memory management scheme of the UNIX operating system imposes certain restrictions on drivers that transfer data between devices.

modem

A contraction of modulator-demodulator. A modulator converts digital signals from the computer into tones that can be transmitted across phone lines. A demodulator converts the tones received from the phone lines into digital signals so that the computer can process the data.

NBH

A variant of the **`PPCBug NBO`** command that downloads a boot image without subsequently executing it. This allows the **`PPCBug`** operator to perform other operations on the image (for example, burning it into (Flash) before executing it.

netboot

The process of a client loading into its own memory a boot image file fetched from a host, via the standard BOOTP and TFTP network protocols, and then executing that image. On SBC boards, netbooting is set up with the **`PPCBug NIOT`** command, and then invoked either with the **`PPCBug NBO`** command or set up to subsequently autoload and boot with the **`PPCBug ENV`** command.

netload

The process of a client loading a boot image as discussed under netboot, but without subsequently executing it. On SBC boards, netloading is invoked with the **`PPCBug NBH`** command.

netstat

The **`netstat`** command displays the contents of various network-related data structures in various formats, depending on the options selected.

network boot

See definition for **netboot**.

network load

See definition for **netload**.

networked client

In a networked configuration, the client kernel is configured with the capability of networking using the VME bus. Clients may communicate with each other and/or the host system using standard networking protocols which run over the VME bus. Embedded applications may utilize standard network services for inter-board communication.

NFS

Network File System. This protocol allows files to be shared by various hosts on the network.

NFS client

In a NFS client configuration, the host system provides UNIX file systems for the client system. A client system operates as a diskless NFS client of a host system.

NIS

Network Information Service (formerly called yellow pages or yp). NIS is an administrative system. It provides central control and automatic dissemination of important administrative files.

NVRAM

Non-**V**olatile **R**andom **A**ccess **M**emory. This type of memory retains its state even after power is removed.

panic

The state where an unrecoverable error has occurred. Usually, when a panic occurs, a message is displayed on the console to indicate the cause of the problem.

PDU

Protocol Data Unit

PowerPC 604^{TM}

The third implementation of the PowerPC family of microprocessors currently under development. PowerPC 604 is used by Motorola Inc. under license by IBM.

PowerPC Debugger (PPCBug)

A debugging tool for the Motorola PowerPC microcomputer. Facilities are available for loading and executing user programs under complete operator control for system evaluation.

PPP

Point-to-Point protocol is a method for transmitting datagrams over point-to-point serial links

prefix

A character name that uniquely identifies a driver's routines to the kernel. The prefix name starts each routine in a driver. For example, a RAM disk might be given the **`ramd`** prefix. If it is a block driver, the routines are **`ramdopen`**, **`ramdclose`**, **`ramdsize`**, **`ramdstrategy`**, and **`ramdprint.`**

protocol

Rules as they pertain to data communications.

RFS

Remote File Sharing.

random I/O

I/O operations to the same file that specify absolute file offsets.

raw I/O

Movement of data directly between user address spaces and the device. Raw I/O is used primarily for administrative functions where the speed of a specific operation is more important than overall system performance.

raw mode

The method of transmitting data from a terminal to a user without processing. This mode is defined in the line discipline modules.

rcp

Remote copy allows files to be copied from or to remote systems. rcp is often compared to ftp.

read queue

The half of a STREAMS module or driver that passes messages upstream.

Remote Cluster

A cluster which does not have the File Server as a member. In large configurations, multiple Remote Clusters can be configured. Remote Clusters rely on an ethernet network connection back to the File Server for boot loading and NFS mounting of system disk directories.

rlogin

Remote login provides interactive access to remote hosts. Its function is similar to telnet.

routines

A set of instructions that perform a specific task for a program. Driver code consists of entry-point routines and subordinate routines. Subordinate routines are called by driver entry-point routines. The entry-point routines are accessed through system tables.

rsh

Remote shell passes a command to a remote host for execution.

SBC

Single Board Computer

SCSI driver interface (SDI)

A collection of machine-independent input/output controls, functions, and data structures, that provide a standard interface for writing Small Computer System Interface (SCSI) drivers.

sequential I/O

I/O operations to the same file descriptor that specify that the I/O should begin at the "current" file offset.

SLIP

Serial Line IP. The SLIP protocol defines a simple mechanism for "framing" datagrams for transmission across serial line.

server

See definition for **host**.

SMTP

The Simple Mail Transfer Protocol, delivers electronic mail.

small computer system interface (SCSI)

The American National Standards Institute (ANSI) approved interface for supporting specific peripheral devices.

SNMP

Simple Network Management Protocol

Source Code Control System (SCCS)

A utility for tracking, maintaining, and controlling access to source code files.

special device file

The file that identifies the device's access type (block or character), the external major and minor numbers of the device, the device name used by user-level programs, and security control (owner, group, and access permissions) for the device.

synchronous data link interface (SDLI)

A UN-type circuit board that works subordinately to the input/output accelerator (IOA). The SDLI provides up to eight ports for full-duplex synchronous data communication.

system

A single board computer running its own copy of the operating system, including all resources directly controlled by the operating system (for example, I/O boards, SCSI devices).

system disk

The PowerMAX OS^{TM} requires a number of “system” directories to be available in order for the operating system to function properly. These directories include: **`/etc`**, **`/sbin`**, **`/dev`**, **`/usr`**, **`/var`** and **`/opt`**.

system initialization

The routines from the driver code and the information from the configuration files that initialize the system (including device drivers).

System Run Level

A netboot system is not fully functional until the files residing on the file server are accessible. **`init(1M)`** ‘init state 3’ is the initdefault and the only run level supported for netboot systems. In init state 3, remote file sharing processes and daemons are started. Setting initdefault to any other state or changing the run level after the system is up and running, is not supported.

swap space

Swap reservation space, referred to as ‘virtual swap’ space, is made up of the number of real memory pages that may be used for user space translations, plus the amount of secondary storage (disk) swap space available. Netboot clients in the NFS configuration utilize a file accessed over NFS as their secondary swap space.

TELNET

The Network Terminal Protocol, provides remote login over the network.

TCP

Transmission Control Protocol, provides reliable data delivery service with end-to-end error detection and correction.

Trivial File Transfer Protocol(TFTP)

Internet standard protocol for file transfer with minimal capability and minimal overhead. TFTP depends on the connection-less datagram delivery service (UDP).

twisted-pair Ethernet (10base-T)

An Ethernet implementation in which the physical medium is an unshielded pair of entwined wires capable of carrying data at 10 Mbps for a maximum distance of 185 meters.

twisted-pair Ethernet (100base-T)

An Ethernet implementation in which the physical medium is an unshielded pair of entwined wires capable of carrying data at 100 Mbps for a maximum distance of 185 meters.

UDP

User Datagram Protocol, provides low-overhead, connection-less datagram delivery service.

unbuffered I/O

I/O that bypasses the file system cache for the purpose of increasing I/O performance for some applications.

upstream

The direction of STREAMS messages flowing through a read queue from the driver to the user process.

user space

The part of the operating system where programs that do not have direct access to the kernel structures and services execute. The UNIX operating system is divided into two major areas: the user programs and the kernel. Drivers execute in the kernel, and the user programs that interact with drivers execute in the user program area. This space is also referred to as user data area.

VMEbus Boot

A master/slave kernel boot method by which the Boot Server resets, downloads and starts an operating system kernel on a client which is attached to the same VMEbus. Note that the client does not initiate the boot sequence.

VMEbus networking

The capability of a system to utilize network protocols over the VME bus to communicate with other systems in the VME cluster.

VME cluster

The set of systems which share a common VME bus.

volume table of contents (VTOC)

Lists the beginning and ending points of the disk partitions specified by the system administrator for a given disk.

yellow pages

See NIS (Network Information Services).

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Spine for 1” Binder

Product Name: 0.5" from top of spine, Helvetica, 36 pt, Bold

Volume Number (if any): Helvetica, 24 pt, Bold

Volume Name (if any): Helvetica, 18 pt, Bold

Manual Title(s): Helvetica, 10 pt, Bold, centered vertically within space above bar, double space between each title

Bar: 1" x 1/8" beginning 1/4" in from either side

Part Number: Helvetica, 6 pt, centered, 1/8" up

PowerMAX OS

Admin

Power Hawk Series 600 Diskless Systems Administrator’s Guide

0891080