Technote 1189

The Monster Disk Driver Technote

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Summary

This Technote is both a summary and review of existing disk driver information and a description of disk driver features that until now have not been generally documented.

This Note is directed at developers of disk drivers and disk formatting utilities. There is also a section specifically aimed at application developers who need to operate on disks directly.

Introduction

The Mac OS disk driver architecture has not been comprehensively documented since *Inside Macintosh II* (1985). In the intervening years, disk technology has changed radically, from 400 KB floppy disks to FireWire, visiting two different SCSI Managers and four versions of ATA Manager on the way. Many of these technological changes have been accompanied by architectural changes for which the documentation is in obscure places, was not generally released, or was just never written.

The technote is an attempt to rectify that oversight. It serves both to bring together the existing documentation and to fill in the missing pieces. You can use this technote as either a reference, an introduction to writing disk drivers, or just to bring yourself up-to-date on the latest disk driver advances.

If you are new to Mac OS disk drivers, you should start with the Disk Driver Basics section. If you're already familiar with the basics of the Mac OS disk driver architecture, you may want to start with the two high-level summaries, one for disk driver writers and one for application developers.

Existing Information

The existing documentation for disk drivers is scattered through many different Apple documents, interface files, and code samples. The section classifies these references based on their usefulness.

Core References

These large works cover information that you will definitely need in your driver. Don't start a disk driver without being familiar with these works:

- *Inside Macintosh: Devices* , SCSI Manager is the core reference for the classic SCSI Manager programming interface, introduced with the Mac Plus. It also describes the Apple partition map format, used by all Macintosh computers since the Mac Plus.
- *Inside Macintosh: Devices* , SCSI Manager 4.3 is the core reference for the SCSI Manager 4.3 programming interface, introduced with the Quadra 840av. All SCSI drivers written today should use the SCSI Manager 4.3 programming interface.
- ATA Device Software for Macintosh Computers (previously known as the *ATA Device Software Guide*) is the core reference for the ATA Manager, which allows you to find and control ATA devices connected to the computer. The "ATA Driver Reference" chapter offers a useful summary of the Control and Status requests relevant to a modern Mac OS hard disk driver, although some of the information is inaccurate and has been updated in this document.
- ATA 0/1 Software Developers Guide is a supplement to the above, and describes the changes required to support device 0/1 (master/slave) on ATA buses.
- Inside Macintosh: Files describes the drive queue, a key data structure used by all disk drivers.
- Technote 1041, "Inside Macintosh: Files Errata" comprises corrections to the core *Inside Macintosh: Files* document.
- The Shared Device Access Protocol specification.
- DTS sample code RAM Disk implements the basic framework for a disk driver. Unfortunately, it does not demonstrate how to handle requests asynchronously, which is one of the trickiest things to get right in a disk driver.
- DTS sample code TradDriverLoaderLib shows how to correctly install a Mac OS driver `'DRVR'`.
- DTS sample code SCSI Driver Example demonstrates a fully fledged SCSI driver that supports both classic SCSI Manager and SCSI Manager 4.3. It is a useful sample, although it has decayed a bit in the years since it was last updated (1994).
- DTS sample code ATA_Demo demonstrates how to read blocks from both ATA and ATAPI disks.
- "DriverGestalt.h" (from the latest Universal Interfaces) always contains the most up-to-date list of Driver Gestalt selectors.
- The MoreDisks module from the DTS sample code library MoreIsBetter contains a comprehensive list of all the currently defined disk driver Control and Status requests, and where to get more information on how to support them.

Additional Information

These smaller documents contain information that supplements the above in certain key areas.

- Technote 1098, "ATA Device Software Guide: Additions and Corrections" is the latest errata for the ATA Device Software for Macintosh Computers.
- Technote DV 17 Sony Driver: What your Sony Drives For You documents the Control and Status requests supported by Apple's standard floppy disk driver. This is a key reference for disk driver developers. Floppy disk driver writers should also read the "MFM Disk Device

Driver" chapter of Apple Logic Board Design LPX-40 Developer Note (hardware developer note), which includes information on floppy disk Control and Status requests that is missing from DV 17.

- Technote DV 22, "CD-ROM Driver Calls" documents the Control and Status requests supported by Apple's standard CD-ROM driver. This is a key reference for CD-ROM driver developers.
- Technote 1104, "Interrupt-Safe Routines" answers the perennial question, can I do X at interrupt time?
- Technote 1067, "Traditional Device Drivers: Sync or Swim" addresses a common misconception of device driver writers.
- Technote 1040, "Write Cache Flushing: Techniques for Properly Handling System Shutdown" describes how disk drivers should handle system shutdown.
- Technote ME 09, "Coping with VM and Memory Mappings" is probably the best place for information on ensuring that your device driver is compatible with virtual memory.
- Technote 1094, "Virtual Memory Application Compatibility" contains a description of the Mac OS VM architecture as a whole, which is useful background material for device driver writers.
- Designing PCI Cards and Drivers for Power Macintosh Computers, pages 110 through 117, documents the Driver Gestalt mechanism and some new Control requests. This technote provides clarifications and corrections on Driver Gestalt and the mechanism used to boot from a partition. In addition, the File Exchange section of this technote completely replaces the PC Exchange description in the book.
- Guide to the File System Manager contains useful background information about how FSM interacts with disk drivers; however, the specific recommendations for driver writers are covered in the File Exchange section of this technote.
- DTS Q&A OPS 22, "Notification Manager Reinitialized During Boot" is an important tidbit for disk driver developers.
- DTS Q&A DV 34, "Secondary Interrupts on the Page Fault Path" describes the dangers of using secondary interrupts in software that must service page faults. While the Q&A was written for SIM developers, its warning is also important for other page fault path software, such as disk drivers. *Disk drivers must not use secondary interrupts (or, for that matter, deferred tasks) on the page fault path.*
- Data Structure to Aid Security and Recovery Software, David Shayer and Marvin Carlberg, 1991
- The InterruptSafeDebug module of the DTS sample code library MoreIsBetter can be useful when tracking down nasty crashing problems in a device driver, especially those that happen early at startup time.

Obsolete

These documents, as they pertain to disk drivers, are considered obsolete. This list is provided for completeness only. You should read the recommended material instead.

- *Inside Macintosh II* , "The Disk Driver", page 211 through 219, documents the basic interface to a disk driver, include the `kEject` (7) Control request, the `kSetTagBuffer` (8) Control request, and the `kDriveStatus` (8) Status request.
- *Inside Macintosh IV* , "The Disk Driver", page 223 through 224, documents the `kVerify` (5), `kFormat` (6), `kTrackCache` (9), and `kDriveIcon` (21) Control requests.
- *Inside Macintosh IV* , "The SCSI Manager", page 292 through 293 describes the original partitioning format used on the Mac Plus and goes on to say, "Since the driver is called to install itself, it must contain code to set up its own entry in the unit table and to call its own Open routine. An example of how to do this can be obtained from Developer Technical Support." This example was part of the "SCSI Driver Developer Kit". All of the information in the kit is available elsewhere. The specific sample code referenced by the book evolved into SCSI Driver Example.
- *Inside Macintosh V* , "The Disk Driver", page 470 through 471, documents the `kDriveIcon` (21), `kMediaIcon` (22), and `kDriveInfo` (23) Control requests.
- Technote DV 2, "_AddDrive, _DrvrInstall, and _DrvrRemove" documented the `AddDrive`, `DriverInstall`, and `DriverRemove` system routines. This technote is now obsolete. `AddDrive` is documented in Inside Macintosh: Files, and `DriverInstall`, and `DriverRemove` are covered by Inside Macintosh: Devices, along with `DriverInstallReserveMem`. Moreover, developers

of 68K drivers should use TradDriverLoaderLib to install their drivers.

- Technote DV 12, "Our Checksum Bounced" documents a misfeature of the code used by the ROM to checksum disk drivers. The technote is now obsolete. The ROM checksum behavior is described in Inside Macintosh: Devices and this technote describes the checksum algorithm itself.
- Technote DV 13, "_PBClose the Barn Door" still contains valid advice for general device driver writers, although this technote deals with this topic as it applies to disk drivers.
- Technote DV 18, "CD-ROM Notes (Most Excellent)" contains some interesting historical information about CD-ROM devices, although much of the information is now obsolete or covered elsewhere.
- Power Macintosh 9500 Computers (hardware developer note) describes many aspects of the large volume support (greater than 4 GB support) introduced with that machine. The large volume support aspects of that developer note are now obsolete. This technote discusses large volume support as it applies to disk drivers. DTS Q&As FL 07 and FL 08 discuss large volume support from the application perspective.
- The following documents were never released generally. Their developer-oriented content has been rolled into this technote.
  - "Chainable Drivers and Patches"
  - "Ruby Slipper Lite ERS" (large volume support)
  - "Bootable CD Developer Kit (Software Developer Note)"
  - "PC Exchange and Large Volume Drivers"

Checklist for Disk Driver Writers

All of the above is probably overwhelming, so here is a summary of the most important steps to take to improve the reliability and compatibility of your disk driver:

- If you do nothing else, you should support Driver Gestalt.
- You should support the partition map entry features documented in Secrets of the Partition Map. Specifically, you should ensure that your driver is checksummed, supports booting from a partition, and write your driver signature to the `pmPad` field.
- Your driver should support large volumes, including booting from large volumes on machines without large volume support in the ROM by means of the `'ruby'` patch.
- You should follow the rules when installing and removing your driver and its drive queue elements. You should also support close to allow other developers to remove your driver cleanly.
- If your driver uses SCSI Manager 4.3 or ATA Manager, it must register itself with the manager. The documentation for each manager describes how this is done. If you're using SCSI Manager 4.3, use `SCSICreateRefNumXref`. If you're using ATA Manager, use `kATAMgrDriveRegister`.
- You should support the File Exchange interface. This will allow foreign file systems to access your disks without any skullduggery.
- You should check that your private Control and Status requests follow the rules, both with respect to Driver Gestalt and virtual memory. This is harder than you might think.
- You should support read-verify mode. This technote explains how to do it easily.
- You may want to support target mode in your ATA driver.
- You may want to support color icons. Woo hoo!

For Application Writers

The purpose of a disk driver is to support a generic interface for accessing block devices. The primary client of this interface is the File Manager, although it can be used by other programs. If you're writing a foreign file system, or just an application that needs something beyond the standard File Manager programming interface, parts of this technote may be of interest to you.

- If you need to interrogate a driver about its capabilities, you should read the section Driver Gestalt for Applications.
- If you need to read arbitrary blocks on a volume, you should read the discussion of the XIOParam block for applications, along with the accompanying hints and tips.
- If you need to read arbitrary blocks outside of a volume -- for example, the partition map, or a non-Mac OS partition -- you should investigate the File Exchange section of this technote,

especially the section on using the File Exchange interface.
- If you need to verify that you have written data to the disk correctly, you should check out the read-verify mode section which describes the easiest way to do this. [Hint: Think "MoreFiles"!]
- If you need to get color icons for a drive, you can now call the disk driver to get them -- although you should probably just call Icon Services instead.

In addition, if you're writing a disk formatting utility, this technote contain invaluable information on the partition map, chaining drivers, patch partitions, and "hostile" takeovers.

Disk Driver Basics

Mac OS communicates with attached devices through **device drivers**, which are software plug-ins that conform to a well-defined structure. The Device Manager is the original system component used to install, find, manage, and communicate with device drivers. It exports routines that can be called by higher level system software, and by applications. Most of these routines translate directly into requests to the underlying device driver.

In order to identify different drivers, the Device Manager assigns each installed driver a unique negative number, referred to as a **driver reference number**. When calling the Device Manager, clients pass a driver reference number to tell it which driver they are dealing with.

For a block device to be available to the system, it must have a **disk driver**. This is either in the ROM (for the built-in floppy drive), or loaded at system startup from a special partition on the disk (SCSI, ATA, and FireWire devices), or loaded from a system extension (USB and FireWire devices). In addition, a disk driver can be loaded when a device is plugged in by either an I/O family expert (ATA, USB, and FireWire), or by a special utility program (SCSI). Finally, software can install a disk driver for a virtual block device which has no obvious physical presence, such as a RAM disk or disk image. Regardless of how they are installed, all disk drivers roughly follow the same rules.

It is important to note the difference between a disk and a device. A **block device** is the entity which reads and writes data on a disk. A **disk** is the medium which actually stores the data. This distinction is unimportant for fixed disk devices (such as hard disks), but is critical for removable disk devices (such as floppy drives and removable cartridge disk devices).

Mac OS always directs block I/O to a software entity known as a **drive**. Each disk driver creates one or more drives and puts them in a system structure called the **drive queue**. Each **drive queue element** represents a drive, and contains both the driver reference number and the drive number. The **drive number** is a positive number that uniquely identifies the drive; it is assigned when the drive is added to the drive queue.

A drive does not necessarily correspond directly to a given physical device. Rather, the driver decides which drives to create for the device it controls. In some cases, there is one drive per physical device. For example, the built-in floppy disk driver creates a drive for each attached floppy disk device. However, it is also common for a driver to create multiple drives for a single device. For example, the driver for a partitioned hard disk device creates a drive for each file system partition on the disk.

When the system performs I/O to a drive, it supplies the driver reference number of the device driver and the drive number of a drive created by that driver. The Device Manager uses the driver reference number to find the device driver and call its entry point. The device driver then uses the drive number to determine which drive is the target of the I/O request.

All drive I/O is done is terms of 512-byte logical blocks. Therefore, all transfers must start at multiple of 512 bytes and be a multiple of 512 bytes long. This is regardless of the underlying device's block size.

File Manager and Drives

To allow the flexibility of storage required by the user interface (a hierarchy of folders and files), Mac OS implements another layer of abstraction, known as the File Manager, on top of the Device Manager and the drive queue.

A **file system** is a mechanism for storing fine-grained data (files) and meta-data (folders, Finders attributes, and so on) on a drive. The file system defines the way this data is stored and the rules for manipulating it. The File Manager includes built-in support for two file systems (HFS and HFS Plus) and a plug-in architecture (File System Manager) for others (AppleShare, DOS FAT, ProDOS , UDF, and third-party FSM plug-ins).

The File Manager exports a programming interface defined in terms of volumes, which contain directories, files, and meta-data. A **volume** is an instance of a file system on a drive. Each volume is uniquely identified by a negative **volume reference number**, which is stored, along with other data to operate the volume, in a **volume control block** (VCB) that is linked into the system **VCB queue**. The VCB also contains the drive number and the driver reference number of the drive on which the volume is mounted.

The process of making the contents of a drive available via the File Manager is called **mounting** a volume. When the File Manager attempts to mount a volume on a drive, it calls each of the file systems in turn to determine which one understands the logical format of the data on the disk in the drive. It then creates a VCB for that file system on that drive.

The File Manager takes requests to operate on the volume and passes them to the appropriate plug-in file system, which reduces them to basic block operations and passes them to the drive via the Device Manager (using the drive number and driver reference number stored in the VCB). As far as the file system is concerned, the drive is its own logical disk, even though it may only represent a small part of the real disk.

A drive can exist without having a volume mounted on it. This happens, for example, if the data format on the drive is incomprehensible to the installed file systems, or the volume on the drive has been unmounted. You can still access the data on a drive that has no volume mounted on it, but only via the Device Manager interface.

Terminology

In any technical document, it is very important to get your terminology straight. This is especially important when talking about disk drivers, where much of the terminology has been extended over the long, confusing history of the Mac OS block storage architecture. This technote uses the following terms throughout.

disk driver
: A software plug-in that implements a hardware abstraction layer for block devices, like hard disks, floppy drives, and CD-ROM drives. In Mac OS, a disk driver must be a Device Manager driver (either a 68K driver or a native driver).

68K driver
: A disk driver implemented using the traditional 68K driver architecture, as documented in Inside Macintosh: Devices. A 68K driver is commonly stored in a resource of type `'DRVR'` or in a driver partition.

native driver
: A disk driver implemented using the native driver model, introduced with the first generation of PCI Power Macintosh computers and documented in Designing PCI Cards and Drivers for Power Macintosh Computers. A native driver is commonly stored in a file of type `'ndrv'`, although native drivers have started appearing in driver partitions as well.

driver reference number
: An `SInt16` that uniquely identifies a Device Manager driver to the system. Driver reference numbers are not persistent -- they are assigned when the driver is added to the unit table -- but some driver reference numbers are assigned to certain well-known drivers. Driver reference numbers occupy the same "name space" as file reference numbers (which identify an open file). Driver reference numbers are always negative, while file reference numbers are always positive. Zero is an invalid driver reference number and an invalid file reference number.

unit table

A Device Manager data structure that lists the installed device drivers (both 68K and native).

block device
: A block-oriented storage device.

real block device
: A block device that has some obvious physical presence, such as a floppy drive or a SCSI hard disk device.

virtual block device
: A block device this has no obvious physical presence, such as a RAM disk, a disk image, or a network block device.

device
: Some hardware attached to the computer. In this context of this technote, this typically means a block device although, in some places, the term may be used for any type of device.

disk
: The actual physical media which holds data. A disk is made up of blocks, each of which holds a fixed number of bytes (typically 512). A disk is distinct from a block device because, in the case of removable disk devices, the user can insert one of many different disks into the device.

disc
: A synonym for "disk" that is only used in the context of CD or DVD discs (where the disk is actually a disc).

media
: See disk.

drive
: A Mac OS software construct used to represent a block storage entity. A volume is always mounted on a drive. There may be multiple drives corresponding to a single disk. Exception: some removable disk devices have been historically known as drives (for example, floppy drive, CD-ROM drive). This technote continues to use "drive" in these contexts, rather than the more cumbersome "floppy disk device." However, if the word "drive" appears unqualified, it always refers to the primary definition.

drive queue
: A OS queue which contains all the drive queue elements known to the system. You can get the head of the drive queue using the routine `GetDrvQHdr`. See Inside Macintosh: Files for more details of the drive queue and its elements.

drive queue element
: The specific data structure used to represent a drive. A drive queue element is a structure of type `DrvQEl` allocated in the system heap and placed in the drive queue.

drive number
: An `SInt16` which uniquely identifies a drive. Drive numbers are not persistent; they are assigned when the drive is added to the drive queue. Drive numbers occupy the same "name space" as volume reference numbers. Drive numbers are always positive, while volume reference numbers are always negative.

partition
: A disk may be divided into a set of contiguous blocks, each known as a partition. Partitions are typically either file system partitions (which hold file system data) or meta-data partitions (which hold information about the disk, such as the partition map or the disk's device driver). Not all disks are partitioned, although a disk must be partitioned to support booting (except for floppy disks, because the driver for the built-in floppy disk drive is in the ROM).

partition map
: A data structure, typically at the beginning of the disk, which describes the partitions on the disk. Most Mac OS disks are partitioned using the Apple partition map format, described in Secrets of the Partition Map.

partition map entry
: The Apple partition map describes each partition on the disk using a partition map entry data structure (of type `Partition`).

startup partition
: The partition which the user has designated as the one from which they prefer to boot the system, or the partition from which the system booted.

driver partition
: A partition which contains a disk driver.

file system partition
: A partition which contains file system data.

meta-data partition
: A partition which holds information about the disk, such as the partition map or the disk's device driver.

partition-based driver
: A driver that is loaded from a partition.

file system-based driver
: A driver that is loaded from a file in the file system, typically in the Extensions folder.

disk-based driver
: Either a partition-based driver or a file system-based driver. This term is ambiguous and to be avoided.

ghost partitioning
: A system used on non-512 byte block devices where partition map entries appear at both 512-byte boundaries and device block boundaries so that they can be seen by software using either physical or device blocks.

I/O family
: A component of the Mac OS I/O subsystem that is responsible for a particular category of devices. A driver can work within multiple I/O families. Each family requires certain attributes of the driver (for example, how it is packaged and the programming interface it provides to upper layer software) and provides services for the driver. For example, a FireWire disk driver must be packaged as a native driver which responds to the standard disk driver programming interface, and FireWire provides services to the disk driver, such as SBP-2 utility routines.

I/O family expert
: A component of an I/O family that seeks out devices of a particular type and registers them with the I/O family.

volume
: A File Manager software construct that represents a single, user-visible storage device. Each volume appears as a icon on the desktop. Each volume is mounted on a drive, so if the disk has multiple file system partitions it will also have multiple drives and hence multiple volumes.

volume reference number
: An `SInt16` which uniquely identifies a volume. Volume reference numbers are not persistent; they are assigned when the volume is mounted. Volume reference numbers occupy the same 'name space' as drive numbers. Drive numbers are always positive, while volume reference numbers are always negative.

refNum
: This contraction of "reference number" is ambiguous and is not used in this document. In other documents, it commonly means either a driver reference number or a file reference number, depending on context.

vRefNum
: A contraction of volume reference number.

logical blocks
: The block numbering scheme used to access blocks on a drive. Each logical block contains 512 bytes and the first block accessible through the drive is block 0. See Block Translation for details.

physical blocks
: The block numbering scheme used to access blocks on a disk. You can derive a physical block number from a logical block number by adding to it the start block number of the partition. If the disk is not partitioned, logical blocks and physical blocks are identical. Each physical block contains 512 bytes. See Block Translation for details.

device blocks
: The actual block numbering scheme used by the device hardware to access data on the disk. Device blocks are not necessarily 512 bytes big, and the device driver is responsible for blocking and deblocking to present the illusion of 512-byte physical blocks to the system. See Block Translation for details.

blocks
: When used without qualification in this technote, blocks means logical blocks.

sectors
: Depending on context, this can either mean device blocks (for a floppy drive), physical blocks (for a hard disk device), or logical blocks (in a volume format specification). To avoid confusion, this technote avoids the term "sector" in favor of its more specific synonyms.

chaining driver

A driver loaded from a partition which performs some action and then loads the next driver in the driver chain. The most common chaining driver is Apple's patch driver.

driver chain

A sequence of drivers, each in its own driver partition, that can all be loaded for a particular expansion bus type (for example, SCSI or ATA). Each driver chain consists of one or more chaining drivers and a real driver for the disk. A disk may contain more than one driver chain if it can be accessed through more than one expansion bus type.

patch driver

A chaining driver which applies the patches from a patch partition and then chains to the next driver.

patch partition

A meta-data partition containing patches that must be applied to the system before it can boot. The patches in the patch partition are applied by the patch driver before it chains to the real disk driver.

target mode

PowerBook computers can be placed in target mode, where the PowerBook's internal hard disk device is accessible as a hard disk device to other computers on an expansion bus (typically SCSI).

SCSI disk mode

See target mode.

request

When the Device Manager calls a driver entry point (Open, Close, Prime, Control, or Status for a 68K driver, `DoDriverIO` for native drivers), it passes the address of a parameter block which describes the requested operation. This is known as a request. A request is different from a simple function call in that the driver may return from this initial call without completing the request. Specifically, for queued requests, the request is not complete until the driver explicitly tells the system so (by calling `IODone` for 68K drivers, or by calling `IOCommandIsComplete` for native drivers).

queued request

Synchronous and asynchronous requests are collectively known as queued requests. This is because they are queued in the driver's queue (on the `dCtlQHdr`) and the driver is marked as busy while the request is being processed.

immediate request

Immediate requests are distinct from queued requests in that they are not placed in the driver's queue and do not mark the driver as busy.

Driver Gestalt

All disk drivers should support Driver Gestalt. Driver Gestalt is a mechanism whereby the system can query your driver to determine whether it supports advanced driver features. In many ways it is similar to the Mac OS Gestalt Manager, except that the system is querying your driver, not the other way around.

Your driver should support Driver Gestalt. If you don't support Driver Gestalt, the system is in the dark as to which advanced driver features your driver supports.

Driver Gestalt Reference

The basic reference for Driver Gestalt is Designing PCI Cards and Drivers for Power Macintosh Computers, specifically the "Driver Gestalt" section starting on page 106. However, Driver Gestalt is useful even on non-PCI computers. Your driver must support Driver Gestalt regardless of what computer or OS version it is running on.

Designing PCI Cards and Drivers for Power Macintosh Computers does not document all of the selectors associated with Driver Gestalt. The only official, up-to-date list of Driver Gestalt selectors is the "DriverGestalt.h" header file, provided as part of Universal Interfaces. When Apple defines a new Driver Gestalt selector, we add the selector to "DriverGestalt.h", along with comments that describe how to implement it.

In the event of a conflict between the written documentation and "DriverGestalt.h", "DriverGestalt.h" is correct and the written documentation is wrong. For example, Designing PCI Cards and Drivers for Power Macintosh Computers describes the response of the `'purg'` selector as a `Boolean` (page 111), whereas "DriverGestalt.h" correctly describes the response to be of type `DriverGestaltPurgeResponse`.

Driver Gestalt Guarantees

By saying that it supports Driver Gestalt, your driver guarantees certain things to the system, including:

1. Your driver will return `controlErr` in response to a Control request with an unrecognized `csCode`.
2. Your driver will return `statusErr` in response to a Status request with an unrecognized `csCode`.
3. Your driver will return `controlErr` in response to a Driver Configure request with an unrecognized selector.
4. Your driver will return `statusErr` in response to a Driver Gestalt request with an unrecognized selector.
5. Your driver will not use any `csCodes` below 128 for private Control or Status requests.

Items 3 and 4 in the list above are not documented clearly in Designing PCI Cards and Drivers for Power Macintosh Computers, although they are implemented by all Apple drivers and are clearly shown in the various Driver Gestalt samples. This technote serves to officially document these two additional requirements.

Driver Gestalt for Applications

Probably the best way to understand how to issue Driver Gestalt queries from an application is to look at some sample code. "Driver Gestalt Demo" is a simple sample that shows how to issue a few queries. "DriverGestaltExplorer" is a more comprehensive sample, which is also useful as a simple test and investigation tool. Both samples are available as DTS sample code.

Summary of Driver Gestalt

All disk drivers should support Driver Gestalt.

Secrets of the Partition Map

A number of features have been added to the Apple partition map since it was documented in Inside Macintosh: Devices. This section describes those features in detail.

Partition Field Relevance

The description of the `Partition` data type in Inside Macintosh: Devices does not explicitly call out that some fields of the data structure are only relevant for driver partitions (those whose partition name contains "Apple" and "Driver"). Specifically, the fields from `pmLgBootStart` through to `pmProcessor` are only relevant for driver partitions. Non-driver partitions should set these fields to zero.

pmParType Possibilities

Inside Macintosh: Devices documents the well known values for the `pmParType` field of the partition map entry, namely "Apple_partition_map", "Apple_Driver", "Apple_Driver43", "Apple_MFS", "Apple_HFS", "Apple_Unix_SVR2", "Apple_PRODOS", "Apple_Free", and "Apple_Scratch". This technote describes a number of additional partition types.

- "Apple_Driver_ATA" -- Holds the device driver for an ATA device.
- "Apple_Driver_ATAPI" -- Holds the device driver for an ATAPI device. When it discovers a device on an ATA bus, the ATA Manager identifies whether a device is ATA or ATAPI and automatically loads the corresponding driver.
- "Apple_Driver43_CD" -- A SCSI CD-ROM driver suitable for booting.
- "Apple_FWDriver" -- Holds a FireWire driver for the device. See Loading FireWire Drivers for details.
- "Apple_Void" -- A dummy partition map entry, used to pad out a partition map to ensure the correct alignment of partition map entries in a bootable CD-ROM.
- "Apple_Patches" -- Holds a patch partition. The patch partition architecture is described in Chaining Drivers and Patch Partitions.

IMPORTANT:
Apple reserves all partition types beginning with "Apple". Apple expects to add a number of new partition types in the near future, and your software should handle these new, reserved partition types cleanly.

pmPartStatus Revealed

Inside Macintosh: Devices says that the `pmPartStatus` field of the `Partition` data structure is only used by A/UX, bits 0 through 7 having a defined meaning and all others being reserved. This is no longer true.

The following flags are defined in `pmPartStatus` field of the `Partition` structure. All bits not defined here are reserved (you should initialize them to 0 and ignore their value).

```
enum {
    kPartitionAUXIsValid                        = 0x00000001,
    kPartitionAUXIsAllocated                    = 0x00000002,
    kPartitionAUXIsInUse                        = 0x00000004,
    kPartitionAUXIsBootValid                    = 0x00000008,
    kPartitionAUXIsReadable                     = 0x00000010,
    kPartitionAUXIsWriteable                    = 0x00000020,
    kPartitionAUXIsBootCodePositionIndependent  = 0x00000040,

    kPartitionIsWriteable                       = 0x00000020,
    kPartitionIsMountedAtStartup                = 0x40000000,
    kPartitionIsStartup                         = 0x80000000,

    kPartitionIsChainCompatible                 = 0x00000100,
    kPartitionIsRealDeviceDriver                = 0x00000200,
    kPartitionCanChainToNext                    = 0x00000400,
};
```

Bits 0 through 4 and 6 are still defined as documented in Inside Macintosh: Devices. A Mac OS formatting utility should always set these bit to 1 for file system partitions and clear them for other partition types.

The second group of bits is used by Apple Mac OS disk drivers to hold information about file system partitions.

`kPartitionIsWriteable`
: This bit indicates whether the partition is writeable (1) or write-protected (0). If the bit is clear and your driver creates a drive queue element to represent this partition, it should mark the drive queue element as write-protected. Note that mask has the same value (and the same semantics) as `kPartitionAUXIsWriteable`.

`kPartitionIsMountedAtStartup`
: This bit indicates whether the partition is mounted at system startup (1) or not (0). If your driver would otherwise create a drive queue element to represent this partition at system startup and this bit is clear, it should not create the drive.

`kPartitionIsStartup`
: This bit indicates whether this is the startup partition (1) or not (0). This bit must be set for at most one partition. See A Partition of Your Imagination below.

Note:
Some third-party disk drivers reverse the sense of the `kPartitionIsMountedAtStartup` bit of `pmPartStatus`. This is a bug. Unfortunately, we cannot retroactively fix that bug on all installed disks, so it is not possible to look at this flag and determine whether the partition will be mounted. The most reliable way to work out whether a partition will be mounted at startup is by using the partition attribute Control and Status requests.

The third group of bits provides information about driver partitions. You may need to read Chaining Drivers and Patch Partitions to understand these descriptions.

`kPartitionIsChainCompatible`
: The driver in this partition supports being loaded by a chaining driver.

`kPartitionIsRealDeviceDriver`
: This partition contains a driver that actually knows how to drive the device. Contrast this with the patch driver, which is chain compatible, but which can only load patches and then chain to the next driver; it does not actually contain a disk driver.

`kPartitionCanChainToNext`
: This partition contains a driver that can chain to another driver. Typically, all drivers in the chain must have this bit set, except the last one where it is clear.

IMPORTANT:
Some Apple and most third-party drivers do not have the chaining flags set correctly, so it is virtually impossible for your software to rely on their semantics.

Partition Attributes

There are a number of Control and Status requests that modify the attributes of a partition. A disk driver must support these requests as described below. A formatting application can use these requests to modify partition attributes.

Note:
Many of these Control and Status requests were previously documented in Designing PCI Cards and Drivers for Power Macintosh Computers, page 113 through 114, and ATA Device Software for Macintosh Computers. The description herein replaces both of these documents. The old documents fail to describe the `DeviceIdent` parameter to these routines, nor do they clarify that `csParam[0..1]` is a partition map entry address.

Setting the Startup Partition

Trap	`_Control`
Mode	Synch, Async

`csCode`	`SInt16`	->	`kSetStartupPartition` (44)
`ioVRefNum`	`SInt16`	->	The drive number of the new startup partition, or 0 if you wish to specify the startup partition by block number.
`csParam[0..1]`	`UInt32`	->	If `ioVRefNum` is 0, this is the physical block number of the partition map entry of the new startup partition. If `ioVRefNum` is not 0, this is ignored.
`csParam[2..3]`	`DeviceIdent`	->	If `ioVRefNum` is 0, this is the device containing the new startup partition. This is in the same format as the `SCSIID` field of the `partInfoRec`. If `ioVRefNum` is not 0, this is ignored.

In response to this request, your disk driver must set the partition described by `ioVRefNum` and `csParam[0..3]` as the startup partition. Typically this involves setting `kPartitionIsStartup` in `pmPartStatus`, which in turn causes your disk driver to place the drive queue element for this partition first in the drive queue at system startup.

IMPORTANT:
When your driver sets the `kPartitionIsStartup` bit for one partition, it must clear it for all other partitions. This bit must be set for at most one partition.

Determining Whether a Partition is the Startup Partition

Trap	`_Status`
Mode	Synch, Async

csCode	SInt16	->	kGetStartupStatus (44)
ioVRefNum	SInt16	->	The drive number of the partition to query, or 0 if you wish to query the partition by block number.
csParam[0..1]	UInt32	->	If ioVRefNum is 0, this is the physical block number of the partition map entry of the partition to query. If ioVRefNum is not 0, this is ignored.
csParam[2..3]	DeviceIdent	->	If ioVRefNum is 0, this is identifies the device containing the partition to query. This is in the same format as the SCSIID field of the partInfoRec. If ioVRefNum is not 0, this is ignored.
csParam[0]	UInt16	<-	Your disk driver must set this to either 0 (this is not the startup partition) or 1 (this is the startup partition).

In response to this request, your disk driver must set csParam[0] to indicate whether the partition described by ioVRefNum and csParam[0..3] is the startup partition. Typically this involves testing kPartitionIsStartup in pmPartStatus.

The request returns the status that is currently recorded in the partition map, not whether the system actually started from this partition.

Specifying That a Partition Should Be Mounted at Startup

Trap	_Control
Mode	Synch, Async

csCode	SInt16	->	kSetStartupMount (45)
ioVRefNum	SInt16	->	The drive number of the partition, or 0 if you wish to specify the partition by block number.
csParam[0..1]	UInt32	->	If ioVRefNum is 0, this is the physical block number of the partition map entry of the partition. If ioVRefNum is not 0, this is ignored.
csParam[2..3]	DeviceIdent	->	If ioVRefNum is 0, this is the device containing the partition. This is in the same format as the SCSIID field of the partInfoRec. If ioVRefNum is not 0, this is ignored.

In response to this request, your disk driver must set the partition described by ioVRefNum and csParam[0..3] to be mounted at startup. Typically this involves setting kPartitionIsMountedAtStartup in pmPartStatus, which in turn causes your disk driver to place a drive queue element for this partition in the drive queue at system startup.

This request modifies the partition map, and hence only takes effect the next time the system is started. It does not affect the state of any volume currently mounted on the partition.

Specifying That a Partition Should Not Be Mounted at Startup

Trap	_Control
Mode	Synch, Async

csCode	SInt16	->	kClearPartitionMount (48)
ioVRefNum	SInt16	->	The drive number of the partition, or 0 if you wish to specify the partition by block number.
csParam[0..1]	UInt32	->	If ioVRefNum is 0, this is the physical block number of the partition map entry of the partition. If ioVRefNum is not 0, this is ignored.
csParam[2..3]	DeviceIdent	->	If ioVRefNum is 0, this is the device containing the partition. This is in the same format as the SCSIID field of the partInfoRec. If ioVRefNum is not 0, this is ignored.

In response to this request, your disk driver must set the partition described by ioVRefNum and csParam[0..3] to not be mounted at startup. Typically this involves clearing kPartitionIsMountedAtStartup in pmPartStatus, which in turn causes your disk driver to not place a drive queue element for this partition in the drive queue at system startup.

This request modifies the partition map and hence only takes effect the next time the system is started. It does not affect the state of any volume currently mounted on the partition.

Determining Whether a Partition is to be Mounted

Trap	_Status
Mode	Synch, Async

csCode	SInt16	->	kGetMountStatus (45)
ioVRefNum	SInt16	->	The drive number of the partition to query, or 0 if you wish to query the partition by block number.
csParam[0..1]	UInt32	->	If ioVRefNum is 0, this is the physical block number of the partition map entry of the partition to query. If ioVRefNum is not 0, this is ignored.
csParam[2..3]	DeviceIdent	->	If ioVRefNum is 0, this is identifies the device containing the partition to query. This is in the same format as the SCSIID field of the partInfoRec. If ioVRefNum is not 0, this is ignored.
csParam[0]	UInt16	<-	Your disk driver must set this to either 0 (this partition is not to be mounted) or 1 (this partition is to be mounted).

In response to this request, your disk driver must set csParam[0] to indicate whether the partition described by ioVRefNum and csParam[0..3] is to be mounted at system startup. Typically this involves testing kPartitionIsMountedAtStartup in pmPartStatus.

The request returns the status that is currently recorded in the partition map, not whether the partition was actually mounted at startup.

Mounting a Partition Immediately

Trap	_Control
Mode	Synch, Async

csCode	SInt16	->	kMountVolume (60)
ioVRefNum	SInt16	->	The drive number of the partition, or 0 if you wish to specify the partition by block number.
csParam[0..1]	UInt32	->	If ioVRefNum is 0, this is the physical block number of the partition map entry of the partition. If ioVRefNum is not 0, this is ignored.
csParam[2..3]	DeviceIdent	->	If ioVRefNum is 0, this is the device containing the partition. This is in the same format as the SCSIID field of the partInfoRec. If ioVRefNum is not 0, this is ignored.

In response to this request, your disk driver must create a drive queue element for the partition described by ioVRefNum and csParam[0..3] (if it doesn't already have one) and post a "disk inserted" event for it. It must do this regardless of the state of the kPartitionIsMountedAtStartup bit in the partition's pmPartStatus; however, the kPartitionIsWriteable bit still controls whether the drive is writeable.

If there is already a volume mounted on the partition, the system will ignore the "extra disk inserted" event this request generates.

Locking a Partition

Trap	_Control
Mode	Synch, Async

csCode	SInt16	->	kLockPartition (46)
ioVRefNum	SInt16	->	The drive number of the partition, or 0 if you wish to specify the partition by block number.
csParam[0..1]	UInt32	->	If ioVRefNum is 0, this is the physical block number of the partition map entry of the partition. If ioVRefNum is not 0, this is ignored.
csParam[2..3]	DeviceIdent	->	If ioVRefNum is 0, this is the device containing the partition. This is in the same format as the SCSIID field of the partInfoRec. If ioVRefNum is not 0, this is ignored.

In response to this request, your disk driver must lock the partition described by ioVRefNum and csParam[0..3]. Typically this involves:

- clearing kPartitionIsWriteable in pmPartStatus, which in turn causes your disk driver to create a read-only drive queue element for this partition at system startup, and
- making the drive queue element associated with this partition read-only. A read-only drive queue element has bit 7 of the writeProt field of the drive queue element set, as described in Inside Macintosh: Files, page 2-85.

Unlocking a Partition

Trap	_Control
Mode	Synch, Async

csCode	SInt16	->	kUnlockPartition (49)
ioVRefNum	SInt16	->	The drive number of the partition, or 0 if you wish to specify the partition by block number.
csParam[0..1]	UInt32	->	If ioVRefNum is 0, this is the physical block number of the partition map entry of the partition. If ioVRefNum is not 0, this is ignored.
csParam[2..3]	DeviceIdent	->	If ioVRefNum is 0, this is the device containing the partition. This is in the same format as the SCSIID field of the partInfoRec. If ioVRefNum is not 0, this is ignored.

In response to this request, your disk driver must unlock the partition described by ioVRefNum and csParam[0..3]. Typically this involves:

- setting kPartitionIsWriteable in pmPartStatus, which in turn causes your disk driver to create a read/write drive queue element for this partition at system startup, and
- making the drive queue element associated with this partition read/write.

Determining Whether a Partition is Locked

Trap	_Status
Mode	Synch, Async

csCode	SInt16	->	kGetLockStatus (46)
ioVRefNum	SInt16	->	The drive number of the partition to query, or 0 if you wish to query the partition by block number.
csParam[0..1]	UInt32	->	If ioVRefNum is 0, this is the physical block number of the partition map entry of the partition to query. If ioVRefNum is not 0, this is ignored.
csParam[2..3]	DeviceIdent	->	If ioVRefNum is 0, this is identifies the device containing the partition to query. This is in the same format as the SCSIID field of the partInfoRec. If ioVRefNum is not 0, this is ignored.
csParam[0]	UInt16	<-	Your disk driver must set this to either 0 (this partition is not locked) or 1 (this partition is locked).

In response to this request, your disk driver must set csParam[0] to indicate whether the partition described by ioVRefNum and csParam[0..3] is locked. Typically this involves testing kPartitionIsWriteable in pmPartStatus.

IMPORTANT:
The polarity of this test is opposite to the other partition attribute Status requests. If the partition is locked, kPartitionIsWriteable is clear in pmPartStatus.

The request returns the status that is currently recorded in the partition map, not whether the partition was actually locked at startup. You can determine whether a drive is currently write-protected by looking at bit 7 of the writeProt field of the drive queue element, as described in Inside Macintosh: Files, page 2-85.

pmPad Pearls

A previously undocumented feature of the Partition structure is the use of the pmPad field. The first four bytes of this field is a **driver signature**, a Mac OS four- character code that uniquely identifies the driver. Developers must fill out this field with either a registered creator code (which is strongly recommended) or zero. Drivers that use a registered creator code in this driver signature field may then use the remainder of `pmPad` to hold driver-specific configuration parameters.

Apple currently uses the following driver signatures:

```
enum {
    kPatchDriverSignature   = 'ptDR',
    kSCSIDriverSignature    = 0x00010600,
    kATADriverSignature     = 'wiki',
    kSCSICDDriverSignature  = 'CDvr',
    kATAPIDriverSignature   = 'ATPI',
    kDriveSetupHFSSignature = 'DSU1'
};
```

The values have the following meaning:

`kPatchDriverSignature`
: The Apple patch driver.

`kSCSIDriverSignature`
: The Apple SCSI hard disk driver. [The significance of this value has been lost in the mists of time.]

`kATADriverSignature`
: The Apple ATA hard disk driver.

`kSCSICDDriverSignature`
: The Apple SCSI CD-ROM driver.

`kATAPIDriverSignature`
: The Apple ATAPI CD-ROM driver.

`kDriveSetupHFSSignature`
: Drive Setup sets the first four bytes of the `pmPad` field of "Apple_HFS" partitions to this value. While this is not, in the strictest sense, a driver signature, it is documented here for completeness.

Remember that your disk driver should use its own driver signature; do not use these values for your own driver.

New Driver Types

Inside Macintosh: Devices describes how a Mac OS driver is tagged by having `ddType` set to 1 in the driver descriptor map (DDM). There is a constant for this, `sbMac`, defined in "SCSI.h". However, there are other useful constants for this field.

```
enum {
    kDriverTypeMacSCSI          = 0x0001,
    kDriverTypeMacATA           = 0x0701,
    kDriverTypeMacSCSIChained   = 0xFFFF,
    kDriverTypeMacATAChained    = 0xF8FF
};
```

The following constants are defined for the `ddType` field of the DDM:

`kDriverTypeMacSCSI`
: This is a Mac OS SCSI driver, equivalent to `sbMac`. Typically this is only used for the first driver (the patch driver) in a SCSI driver chain.

`kDriverTypeMacATA`
: This is a Mac OS ATA driver. Typically this is only used for the first driver (the patch driver) in an ATA driver chain.

`kDriverTypeMacSCSIChained`
: This is a chained Mac OS SCSI driver. This is used for the second and subsequent drivers in a driver chain.

`kDriverTypeMacATAChained`
: This is a chained Mac OS ATA driver. This is used for the second and subsequent drivers in a driver chain.

The driver type for a chained driver is always the two's complement of the driver type for the patch driver. For more information about this relationship, see Chaining Drivers and Patch Partitions.

Driver Checksums

Inside Macintosh, Volume V (page 580) contains an assembly language description of the checksum algorithm used for the `pmBootCksum` field of the partition map, but this algorithm was somehow dropped from Inside Macintosh: Devices. As it is now quite difficult to obtain copies of *Inside Macintosh , Volume V* , the algorithm is included below.

```
; Inputs:
;   a0.l -> pointer to driver code
;   d1.w -> length of driver code in bytes
; Outputs:
;   d0.w -> driver checksum

DoCksum
        moveq.l     #0,d0        ; initialize sum register
        moveq.l     #0,d7        ; zero extended byte
        bra.s       CkDecr       ; handle 0 bytes
CkLoop
        move.b      (a0)+,d7     ; get a byte
        add.w       d7,d0        ; add to checksum
        rol.w       #1,d0        ; and rotate
CkDecr
        dbra        d1,CkLoop    ; next byte
        tst.w       d0           ; convert a checksum of 0
        bne.s       @1           ; into $FFFF
        subq.w      #1,d0        ;
@1
```

The following is a C equivalent.

```
static UInt32 ChecksumDriver(void *start, UInt16 bytesToSum)
{
    UInt8  *cursor;
    UInt16 result;

    cursor = (UInt8 *) start;
    result = 0;

    while ( bytesToSum != 0 ) {
        result = result + *cursor;
        result = ((result <<  1) & 0x0FFFE) |
                 ((result >> 15) & 0x00001);
        cursor += 1;
        bytesToSum -= 1;
    }
    if (result == 0) {
        result = 0x0FFFF;
    }
    return result;
}
```

One minor mystery of the `pmBootCksum` field is that the field is 32 bits wide but the checksum algorithm only calculates a 16-bit value. The checksum is always stored in the least significant 16 bits of `pmBootCksum` and the most significant bits are always set to zero.

Inside Macintosh, Volume V also states that driver checksumming is only done for if the first four bytes of the driver's partition map entry `pmPartName` field is "Maci". This is only true for SCSI disk drivers. Other, partition-based disk drivers are always checksummed.

The above algorithm is known as the **16-bit driver checksum algorithm**. This is because the ROM decrements and tests `bytesToSum` using a `DBRA` instruction (which effectively makes `bytesToSum` a `UInt16`), so only the first `bytesToSum` modulo 64 K bytes of the driver are checksummed. This is not a problem if your driver is smaller than 64 K bytes. If your driver is larger, you must be careful for two reasons.

1. The code you use to calculate `pmBootCksum` must mimic the incorrect behavior and only checksum your driver up to the driver size modulo 64 K.
2. You may want to include your own checksum in the driver to ensure that the driver code is intact.

Note:
The 16-bit driver checksum algorithm is identical to the algorithm used by AppleTalk's Datagram Delivery Protocol (DDP).

In some situations where the ROM loads a driver, it does not use the 16-bit checksum algorithm. Specifically, later versions of ATA Manager use a **32-bit driver checksum algorithm**, shown below.

```
static UInt16 ATALoadDoCksum(void *start, UInt32 bytesToSum)
{
    UInt8  *startAsBytes;
    UInt32 result;
    UInt32 i;

    startAsBytes = (UInt8 *) start;
    result = 0;

    for (i = 0; i < bytesToSum; i++) {
        result += startAsBytes[i];
        result <<= 1;
        result |= (result & 0x00010000) ? 1 : 0;
    }
    return (UInt16) result;
}
```

The key difference is that `bytesToSum` is now expressed as a 32-bit quantity, and the algorithm correctly checksums bytes beyond 64 KB. Further, the 16-bit algorithm never returns a checksum of 0 (it is mapped to $FFFF), while the 32-bit algorithm can return a checksum of 0.

Your formatting utility must set `pmBootCksum` appropriately, depending on which version of ATA Manager is loading your driver. Furthermore, the ATA driver loader mechanism is updated during the system startup process so that on machines with the old checksum algorithm in ROM, your driver will need a different checksum depending on whether it is loaded at start time or after system startup.

Overall, the best solution to this driver checksum conundrum is:

- make your driver's size less than 64 KB (if necessary, use a boot strap driver to load your main driver), and
- if your driver checksums to 0, add pad bytes until it doesn't.

IMPORTANT:
ATA disk drivers are also limited to a size of 255 * block size bytes (just under 128 KB for 512-byte block devices). This is because the ROM reads the entire driver using a single ATA request.

A Partition of Your Imagination

The original Mac Plus SCSI implementation did not allow the user to specify a startup partition. Obviously this is desired feature, and disk driver developers came up with a number of solutions for this problem. Over the years, Apple has introduced various stages of OS support for booting from a partition.

Developer-Only Solutions

Prior to Apple providing a solution, developers were responsible for engineering their own. Developers quickly noticed that, all things being equal, the Macintosh tends to boot from the first bootable drive in the drive queue. Therefore, disk driver writers arranged to add the startup partition's drive queue element to the drive queue before the non-boot partitions' element. The disk driver's formatting utility provided the user interface for specifying the boot partition.

This technique was relatively effective and stimulated user demand for a reliable mechanism for booting from a partition.

Partition Attribute Support

Eventually, Apple codified this approach and provided support for it in the Startup Disk control panel. The codification came in the form of the `kPartitionIsStartup` bit in the `pmPartStatus` field of the partition map, along with a driver Control request, `kSetStartupPartition`, which allows the Startup Disk control panel to instruct the driver to set that bit.

This standardized the previous non-standard behavior, although it still is not a perfect solution because of variances in the way the ROM startup code chooses a drive from which to start up.

SCSI Manager 4.3

Apple made further refinements to this solution with the introduction of SCSI Manager 4.3. SCSI Manager 4.3 presented new problems to the startup code because it allows for multiple SCSI buses, and it provides full support for SCSI LUNs. So, when SCSI Manager 4.3 was introduced, Apple also introduced a new technique for finding the startup partition, the `kdgBoot` Driver Gestalt selector.

IMPORTANT:
SCSI Manager 4.3 must be in ROM for the `kdgBoot` selector to be effective. On machines, such as the Quadra 700, that can run SCSI Manager 4.3 but do not have it in ROM, SCSI Manager 4.3 loads out of the System file, too late for it to affect the startup drive selection.

When the user chooses a drive in the Startup Disk control panel, Startup Disk sends the `kdgBoot` Driver Gestalt selector to the disk driver controlling that drive. Startup Disk then records the response in PRAM. When the Macintosh boots, it iterates through the drive queue, sending a `kdgBoot` request to each drive. When it finds a drive with a value matching the value in PRAM, it knows that this is the correct startup drive.

The `kdgBoot` Driver Gestalt selector is documented in Designing PCI Cards and Drivers for Power Macintosh Computers, page 113. This documentation is accurate for SCSI drivers. For ATA drivers, the `DriverGestaltBootResponse` response fields should be set as follows.

`extDev`
: The ATA bus number of the device.

`partition`
: The partition number on the bootable partition on the device. As described below, the format of this field is internal to your disk driver.

`SIMSlot`
: ATA devices must set this to `kDriverGestaltBootATASIMSlot` ($20). [This constant is not currently in Universal Interfaces, Radar ID 2314693.]

`SIMsRSRC`
: If your driver supports ATA 0/1, you must put 0 or 1 in this field to indicate the number of the

device on the ATA bus. If your driver does not support ATA 0/1, you must set this to zero. See ATA 0/1 Software Developers Guide for more details on ATA 0/1 support.

ROM-in-RAM (NewWorld)

The ROM-in-RAM architecture, introduced with the iMac, presents new challenges for the startup device selection process. On a ROM-in-RAM machine, Open Firmware is responsible for loading the Mac OS ROM file off the startup partition, and hence Open Firmware must define the startup partition well before Mac OS starts to execute. When the Mac OS ROM starts, it continues booting from the startup partition chosen by Open Firmware to avoid the potential user confusion of loading the Mac OS ROM from one disk and the system software from another.

Open Firmware synthesizes the traditional Macintosh startup process, including:

- Startup drive selection algorithm -- Open Firmware implements the traditional startup drive selection algorithm. It turns out that this algorithm is very complex, although the gist of it is:
  1. if a "snag" key is held down, try booting from the corresponding device,
  2. try booting from the default drive (if any),
  3. then try booting from other drives.
- CODS -- Holding down command-option-delete-shift (CODS) prevents the Open Firmware from booting from the default drive.
- C for CD-ROM -- Holding down the C key forces Open Firmware to boot from the CD-ROM device. This was previously implemented by the `"snag"` patch but is implemented by Open Firmware in ROM-in-RAM computers.
- Flashing question mark -- If no startup device is available, Open Firmware displays the traditional "flashing question mark" icon (although, in deference to the fact that ROM-in-RAM computers do not have floppy drives, it flashes the question mark inside a folder icon instead of a floppy disk icon).

On ROM-in-RAM computers, the selected default startup device is held in an Open Firmware configuration variable `boot-device`. This configuration variable holds an Open Firmware path to the default startup device. The Startup Disk control panel generates a path based on the disk driver's response to various Driver Gestalt queries.

It is impossible for Open Firmware to completely mimic the startup drive selection algorithm when it comes to selecting a startup partition. When booting from a partition, `boot-device` contains the Open Firmware partition number of the startup partition. Unfortunately, there is no reliable way to get this from a disk driver with commonly implemented Driver Gestalt queries.

Note:
You might think that the `partition` field of the `DriverGestaltBootResponse` would do the trick; however, this field is defined to be opaque to the system. "Designing PCI Cards and Drivers for Power Macintosh Computers" explicitly states:

> The `partition` field enables the selection of a single partition on a multiply partitioned device as the boot device. It is not interpreted by the ROM or the Startup Disk `'cdev'` [sic], so the driver can choose a meaning and a value for this field.

It turns out that different disk drivers use different values for the `partition` field. Apple disk drivers set this to be the block number of the partition map entry for the partition, but some third-party drivers use other techniques, such as recording 1 for the first HFS partition, 2 for the second HFS partition, and so on. The upshot of this is that Startup Disk is unable to use this field reliably to set the partition number in `boot-device`.

Prior to Mac OS 9.0, the Startup Disk control panel used tricky heuristics to allow booting from a partition with Apple disk drivers as a temporary measure to solving this problem. The long-term solution; however, is for disk drivers to support a set of new Driver Gestalt queries, which return exactly the information Startup Disk needs to set `boot-device`. The required Driver Gestalt selectors (`kdgDeviceReference`, `kdgNameRegistryEntry`, `kdgOpenFirmwareBootSupport`, and `kdgOpenFirmwareBootingSupport`) are described in "DriverGestalt.h" in Universal Interfaces 3.3.

Note:
Your driver only need support the `kdgNameRegistryEntry` Driver Gestalt selector if your device has an obvious Name Registry node. For devices with no Name Registry node (SCSI), or where the Name Registry node can be tricky to find (ATA), it is reasonable to just return `statusErr`.

Non-512 Byte Block Devices

The original Mac OS disk driver architecture assumed that all block devices would use 512-byte blocks. Supporting block devices with a different block size is relatively simple, although it gets more complicated if you want to boot from such a device. Non-512 byte block device support is most important for CD-ROM drivers, which use a 2-KB block size.

Just the Basics

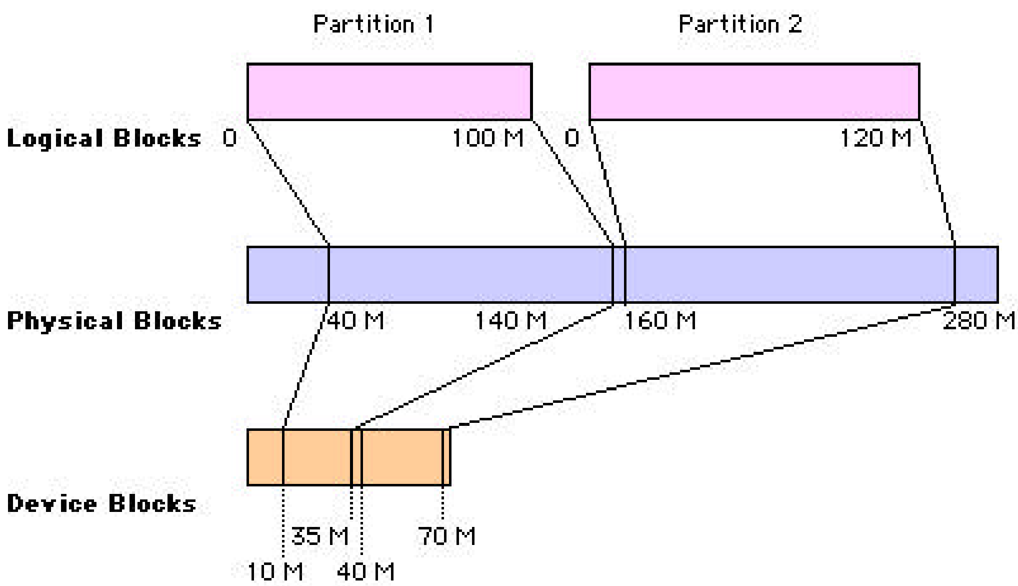
The basic rule for supporting non-512 block devices on Mac OS is that the disk driver is responsible for blocking and deblocking all I/O requests to a drive. This discussion assumes that the device block size is an integer multiple of 512, although similar algorithms work for weird device block sizes.

Block Translation

The File Manager makes an I/O request in terms of 512-byte **logical block numbers** on a particular drive. The disk driver is responsible for translating the logical block number of the request to an actual block number on the drive. If the disk is partitioned, the first step of this translation is to add the offset of the partition to the logical block number; this generates the **physical block number**. If the device uses 512-byte blocks, the physical block number is the actual block number of the data on the disk. If the device uses non-512 byte blocks, the disk driver must do a further translation, converting the physical block number to a **device block number** by dividing the physical block number by the number of 512-byte blocks in each physical block.

In addition, the disk driver must block/deblock the request. If the physical block number, or the number of blocks to transfer, is not evenly divisible by the device block size, the disk driver must transfer partial blocks to and from the disk.

The following diagrams shows the entire translation process for two partitions on a 2 KB block device. All numbers on the diagram are in the units labeled in the left column. For example, partition 1 is a 50 MB partition which extends from 0 to 100 mega logical blocks (512-byte blocks), 40 to 140 mega physical blocks (also 512-byte blocks), and 10 to 35 mega device blocks (2 KB byte blocks).



Implementation Notes

A disk driver typically deblocks a request by breaking it into three components. The **leading** component consists of all the requested physical blocks up to the first device block boundary. The leading component is empty if the requested physical blocks start on a device block boundary.

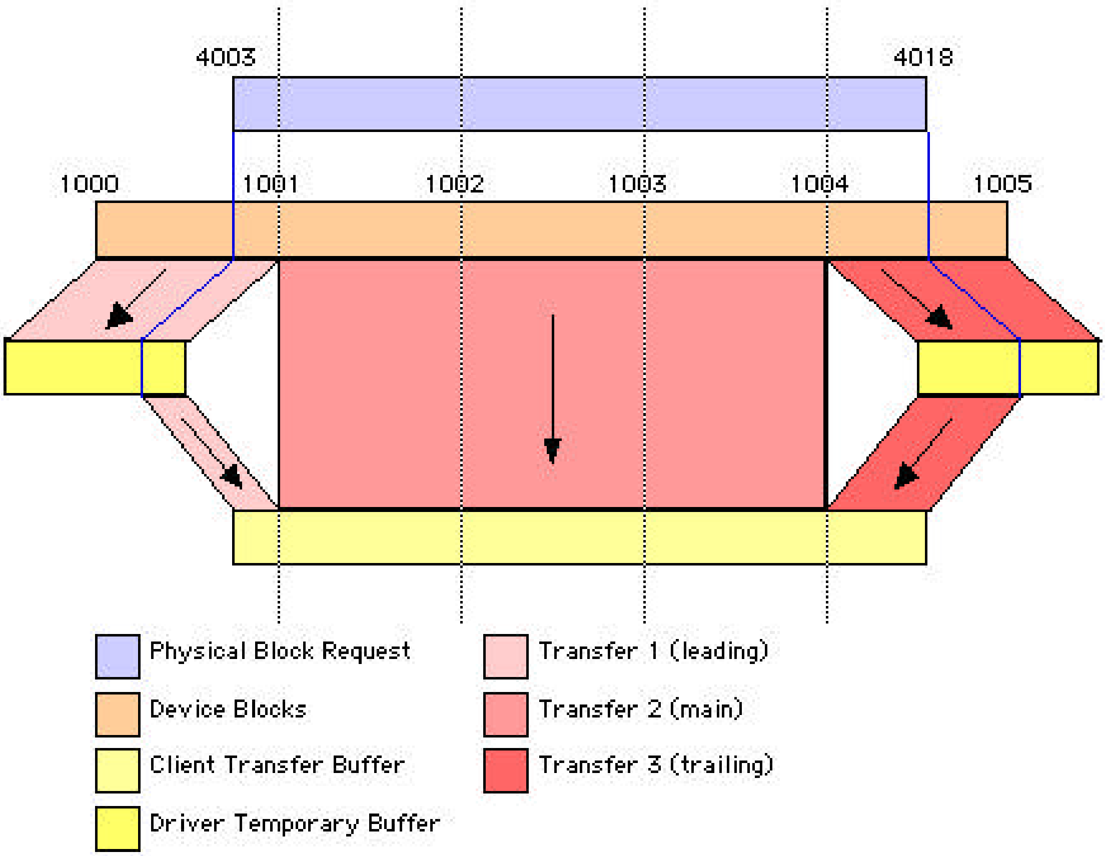
The **main** component consists of all the requested physical blocks which are fully encompassed by device blocks. The main component may be empty if the transfer is short. The main component is transferred directly from between the client buffer and the disk.

Finally, the **trailing** component consists of all the requested physical blocks of the transfer which fall after the last block of the main component. The trailing component is empty if the physical block number plus the number of physical blocks to transfer falls on a device block boundary.

Because you can't transfer a sub-block size request, the leading and trailing components must be transferred through a temporary buffer. You should allocate this temporary buffer when your driver is opened. As the leading and trailing components are always less than one device block (otherwise they would be part of the main component), the temporary buffer need only be as big as a device block. If your device driver is single threaded, you need only allocate a single temporary buffer. If your driver is multi-threaded, you must allocate as many temporary buffers as you allow threads of execution within your driver, or internally serialize the use of the temporary buffer.

The leading and trailing components are read by transferring the device block to the temporary buffer and then copying the appropriate data out of the temporary buffer to the client buffer. The leading and trailing components are written by first reading the current contents of the device to the temporary buffer, then copying the new data from the client buffer to the temporary buffer, then writing the temporary buffer to the device.

The following illustration shows how misaligned read is transferred to the client buffer:



Performance Considerations

The above algorithm is obviously inefficient if transfers are misaligned, that is, if the leading and trailing components are not empty. Misaligned writes are even more expensive than misaligned reads because the disk driver must do an extra I/O to pre-fill the temporary buffer with the existing contents of device block. Worse yet, a misaligned write that has both leading and trailing components takes *five I/O operations* (read leading, write leading, write main, read leading, write leading).

There are a number of ways to avoid misaligned transfers:

- Your formatting utility should always start partitions (especially file system partitions) on device block boundaries.
- File system clients can issue a Driver Gestalt `kdgMediaInfo` request to determine the device block size and ensure that transfers are aligned. This is particularly important for write requests.
- As a rule, volume formats should use the above technique to ensure that their allocation blocks are correctly aligned. At a minimum, volume formats should align allocation blocks on 2 KB boundaries to accommodate the most common cases, namely CD-ROM, DVD-ROM/RAM, and magneto-optical devices.

It is strongly recommended that your disk driver cache at least one device block. Many Mac OS programs will transfer data in sequential 512-byte chunks. By caching a single device block, your driver can radically reduce the average time taken to service these requests.

Booting From Non-512 Byte Block Devices

This section is not yet finished and has been omitted in the interests of shipping an initial version of the technote. A future revision of this technote will cover booting from a non-512 byte block device. If you are interested in this topic, please email DTS and ask for a prerelease draft of this section.

Large Volume Support

When Mac OS originally shipped, it supported volume sizes up to 2 GB. This limit was shared by a number of system components, including the File Manager and disk drivers. Large volume support was introduced in two phases.

1. System 7.5 introduced support for volumes larger than 2 GB, up to a size of 4 GB. The semantics of two programming interfaces were changed to accomplish this.
    - `PBHGetVInfo` does not return the true size of the volumes greater than 2 GB; the volume size and free space are always clipped to 2 GB or less.
    - The `dCtlPosition` field of the Device Control Entry (DCE) was redefined as an unsigned quantity.
2. System 7.5.2 introduced support for volumes larger than 4 GB, up to a size of a 2 TB. This required two new programming interfaces.
    - `PBXGetVolInfo` returns the volume size and free space as a 64-bit quantity.
    - The I/O parameter block passed to disk drivers was extended to include a 64-bit field, `ioWPosOffset`, which supplants `dCtlPosition`.

The changes to the File Manager programming interfaces are not relevant to this technote; they are documented in DTS Q&A FL 08, "Determining Volume Size." This section describes the changes to the disk driver interface.

Large Volume Interfaces

Supporting volumes between 2 GB and 4 GB was simply a matter of redefining the `dCtlPosition` field of the DCE and the `ioPosOffset` field of the `IOParam` structure to be unsigned longs (`UInt32`).

IMPORTANT:
While the semantics of these fields have been changed to unsigned, Universal Interfaces (as of the current version, 3.3) still define the fields as signed. Your code must type cast the fields as appropriate.

To support volumes larger than 4 GB, a new extended I/O parameter block (`XIOParam`) structure was defined. The original and extended I/O parameter blocks are distinguished by the `kUseWidePositioning` bit of the `ioPosMode` field (clear for original, set for extended).

The C definition of the extended I/O parameter block is given below. The key difference is the addition of the `ioWPosOffset` field, a signed 64-bit quantity which contains the offset of the request.

IMPORTANT:
The extended I/O parameter block must only be used for `_Read` or `_Write` requests to device drivers. It must not be used for accessing files. The following description assumes this restriction to simplify the text.

Note:
This structure was previously only documented in the Power Macintosh 9500 Computers hardware developer note. The description here is not only easier to find, but updated and more accurate.

```
struct XIOParam {
    QElemPtr            qLink;
    short               qType;
    short               ioTrap;
    Ptr                 ioCmdAddr;
    IOCompletionUPP     ioCompletion;
    OSErr               ioResult;
    StringPtr           ioNamePtr;
    short               ioVRefNum;
    short               ioRefNum;
    SInt8               ioVersNum;
    SInt8               ioPermssn;
    Ptr                 ioMisc;
    Ptr                 ioBuffer;
    long                ioReqCount;
    long                ioActCount;
    short               ioPosMode;
    wide                ioWPosOffset;
};
typedef struct XIOParam XIOParam;
typedef XIOParam *XIOParamPtr;
```

For software making extended I/O requests, the fields are defined as follows:

`qLink`
`qType`
`ioTrap`
`ioCmdAddr`
: Used internally by the Device Manager.

`ioCompletion`
: For asynchronous requests, you must either set this field to zero or set it to a universal procedure pointer for your completion routine. For synchronous requests, this field is ignored.

`ioResult`
: On completion this field contains the result of the request, which is either `noErr` (0) or a negative error code. The Device Manager guarantees that this field will be set to `ioInProgress` (1) until the request is complete.

`ioNamePtr`
: Ignored for `_Read` and `_Write` requests.

`ioVRefNum`
: You must set this field to the drive number of the drive you wish to read or write.

`ioRefNum`
: You must set this field to the driver reference number of the device driver controlling the drive you wish to read or write.

`ioVersNum`
`ioPermssn`
`ioMisc`
: Ignored for `_Read` and `_Write` requests.

`ioBuffer`
: You must set this to point to a data buffer from which data is written, or to which data is read.

`ioReqCount`
: You must set this field to the number of bytes you wish to read or write. For disk driver requests, this must be a multiple of 512 bytes.

`ioActCount`
: On completion this field contains the number of bytes of data that were actually transferred.

`ioPosMode`
: You must set this field to `kUseWidePositioning` to indicate that this is a wide request. All wide requests use a positioning mode of `fsFromStart`. You must not specify any other positioning mode (`fsAtMark`, `fsFromLEOF`, or `fsFromMark`). You may also specify `rdVerifyMask` for read-verify mode, `noCacheMask` to request that the data not be placed in the cache, or `pleaseCacheMask` to request that data be placed in the cache.

`ioWPosOffset`
: You must set this field to the offset (in bytes) from the beginning of the disk where the transfer should begin. For disk driver requests, this must be a multiple of 512 bytes.

For disk drivers servicing an extended I/O request, the fields are defined as follows:

`qLink`
`qType`
: Used internally by the Device Manager.

`ioTrap`
: Your driver must test bit 0 of this field to determine whether the request is a `_Read` (bit 0 clear) or a `_Write` (bit 0 set). It must also test `noQueueBit` (bit 9) to determine whether the request is immediate (bit 9 set) or not. If your driver does not support immediate requests, it must fail the request with a `paramErr`. Your driver *must not* test `asyncTrpBit` (bit 10) to determine whether the request is synchronous or asynchronous. Instead, it should handle all requests as if they were made asynchronously. See Technote 1067 Traditional Device Drivers: Sync or Swim for details.

`ioCmdAddr`
: Used internally by the Device Manager.

`ioCompletion`
: The Device Manager `IODone` routine will do the right thing with this field. Your driver should ignore this field and handle all requests as if they were made asynchronously. See Technote 1067 Traditional Device Drivers: Sync or Swim for details.

`ioResult`
: Your driver must not read or write this field. Your driver sets this field implicitly when it calls `IODone`. When your driver has finished a queued request, it should call `IODone` to signal that the request is complete. `IODone` performs a number of actions, one of which is to set this field to the error status you passed to the routine in register D0. **Your driver must pass a non-positive error status to `IODone`.**

`ioNamePtr`
: Your driver must ignore this field.

`ioVRefNum`
: Your driver must use this field to determine which drive is the target of the request. If your driver does not control a drive with this drive number, it must complete the request with `nsDrvErr`.

`ioRefNum`
: Your driver may look at this field to determine the driver reference number of the request. This may be useful if the same code is used for multiple device drivers (see Code Sharing).

`ioVersNum`
`ioPermssn`
`ioMisc`
: Your driver must ignore these fields.

`ioBuffer`
: Your driver must transfer data to or from the buffer pointed to by this field.

`ioReqCount`
: Your driver must attempt to transfer the number of bytes specified in this field. Your driver may fail a request (with `paramErr`) if this is not a multiple of 512 bytes.

`ioActCount`
: Before completing the request, your driver must set this field to the number of bytes that were actually transferred.

`ioPosMode`
: Your driver must test the `kUseWidePositioning` bit to determine whether this is a wide request, as described in the next section. If it is a wide request, your driver must ignore the bottom 2 bits of this field (that is, `fsFromStart`, `fsAtMark`, `fsFromLEOF`, and `fsFromMark`) and use `ioWPosOffset` to determine the offset into the drive for the transfer. Your driver may choose to honor the `rdVerifyMask`, `noCacheMask`, and `pleaseCacheMask` in the traditional way.

`ioWPosOffset`
: Your driver must transfer data from this offset (in bytes) into the drive. Your driver may fail a request (with `paramErr`) if this is not a multiple of 512 bytes. If `ioWPosOffset` is negative or `ioWPosOffset` plus `ioReqCount` is beyond the end of the drive, your driver must fail the request with a `paramErr`.

Supporting Large Volumes in Your Driver

To support large volumes correctly, your driver must implement the following:

- Your driver must return true in response to the `kdgWide` Driver Gestalt selector. You may want to use the `GetDriverGestaltBooleanResponse` macro to ensure that you set the correct response byte in the parameter block.
- When handling all `_Read` or `_Write` requests, your driver must check whether the `kUseWidePositioning` flag is set in `ioPosMode`. If it is, you must cast the parameter block to an `XIOParam` and do the I/O at the 64-bit offset specified in `ioWPosOffset`. This type of request is known as a **wide request**.
- If `kUseWidePositioning` is not set, your driver must do the I/O at the offset specified by `dCtlPosition`. You must cast this signed value to an unsigned quantity (`UInt32`) to correctly handle offsets from 2 GB to 4 GB. This type of request is known as a **narrow request**.

There are some important caveats of which you should be aware.

- There is no guarantee that the system will check with Driver Gestalt before issuing a wide request. The system expects that any driver controlling a drive larger than 4 GB will respond to wide request correctly. Similarly, the system expects that a driver controlling a drive whose size is between 2 GB and 4 GB is smart enough to treat `dCtlPosition` as unsigned.
- There is no guarantee that the system will always use wide requests when talking to a drive larger than 4 GB. In fact, the system currently decides on a request-by-request basis whether to use a wide or a narrow request, based on the request's offset on the drive. However, you must not rely on this behavior; you must handle wide requests to offsets less than 4 GB correctly.
- The `dCtlPosition` field of the DCE is a 32-bit quantity, thus it cannot accurately reflect the position of the current I/O beyond the 4 GB boundary. You should ignore `dCtlPosition` for wide requests and use it only for narrow requests.

Notes for Developers Calling Disk Drivers

If you're writing software that issues `_Read` or `_Write` requests to a disk driver, you must be careful to avoid some common pitfalls. Specifically, you should follow the recommendations given below.

- You should always use an `ioPosMode` of `fsFromStart` when calling a disk driver. Because `dCtlPosition` cannot accurately reflect the position beyond 4 GB, other positioning modes do not work as expected in all cases.
- Before issuing a wide request, you should call Driver Gestalt to determine whether the driver supports wide requests.
- If the driver supports wide requests, you may choose to always use wide requests for that driver. However, for maximum compatibility, DTS recommends that you take the same approach as the system by deciding to use a wide or narrow request based on the offset into the drive.

The following code snippet implements these recommendations.

```
static void SetWidePosOffset(UInt32 blockOffset, XIOParamPtr pb)
    // Set up ioPosMode and either ioPosOffset or ioWPosOffset for a
    // device _Read or _Write.
{
    pb->ioWPosOffset.lo = blockOffset << 9;  // convert block number
    pb->ioWPosOffset.hi = blockOffset >> 23; // to wide byte offset

    if ( pb->ioWPosOffset.hi != 0 ) {
        // Offset on drive is >= 4G, so use wide positioning mode
        pb->ioPosMode = fsFromStart | (1 << kWidePosOffsetBit);
    } else {
        // Offset on drive is < 4G, so use regular positioning mode,
        // and move the offset into ioPosOffset
        pb->ioPosMode = fsFromStart;
        ((IOParam *)pb)->ioPosOffset = pb->ioWPosOffset.lo;
    }
}
```

In addition, you should never call `PBReadImmed` or `PBWriteImmed` on a disk driver unless you know, in advance, that the disk driver supports such requests. Many disk drivers fail to handle `Immediate` requests properly. Because immediate requests result in the disk driver possibly being reentered, these problems are hard to detect and debug.

How the ROM Loads SCSI and ATA Drivers

This section describes how the ROM loads SCSI and ATA drivers from a driver partition. Understanding this process is critical to an understanding of the chaining driver architecture, and useful for general disk driver writers.

Note:
This discussion only applies to computers with built-in support for SCSI or ATA, and the drivers loaded from devices attached to those buses. It does not apply to the Macintosh 128 and 512, which can only boot through the floppy drive interface and do not support `partition-based drivers`. Nor does it apply to drivers for modern I/O buses, such as USB and FireWire.

When a Macintosh boots, code in the ROM scans each SCSI and ATA bus for block devices in a bus-specific manner. Once it has found a potentially bootable block device, the ROM attempts to load a driver from that device. The ROM executes the following procedure to load a driver.

1. It first reads device block 0 of the disk. This is the driver descriptor map (DDM) and is structured as the `Block0` data type defined in "SCSI.h". It checks that block 0 is a valid DDM by comparing the `sbSig` field to `sbSIGWord` ($4552 or `'ER'`). If the DDM is not valid, the ROM ignores the device.
2. It then reads device block 1 of the disk and looking for the first entry of the partition map. A partition map entry is represented by the `Partition` data structure in "SCSI.h". For the partition to be recognized, the `pmSig` field must be `newPMSigWord` ($5453 or `'PM'`). The ROM uses the `pmMapBlkCnt` field of this first partition to determine the size of the partition map as a whole.
3. The ROM then searches the DDM for the first driver that is compatible with this bootable bus. The DDM contains an array of `DDMap` structures. The key field in this structure is `ddType`, which identifies the type of driver defined by the structure. If the device is attached to a SCSI bus, the ROM looks for a `DDMap` whose `ddType` is `kDriverTypeMacSCSI`. If the device is attached to an ATA bus, the ROM looks for a `DDMap` whose `ddType` is `kDriverTypeMacATA`.
4. The ROM then searches (by reading consecutive device blocks) the partition map for the chosen driver's partition map entry (whose `pmParType` *starts with* "Apple_Driver" and whose `pmPyPartStart` equals the `ddBlock` field of the `DDMap` of the chosen driver). It stores this partition map entry in a temporary memory block.
5. The ROM then searches (by reading consecutive device blocks) the partition map for the first HFS partition (whose `pmParType` is "Apple_HFS"). It stores this partition map entry in a

temporary memory block.

6. The ROM then uses the driver's `DDMap` to read the driver into memory. It first allocates a pointer block in the system heap to hold the driver (the size of this block is the size of the driver in blocks (`ddSize`) multiplied by the disk's block size (`sbBlkSize`)) and then reads the driver off the disk (starting from `ddBlock`) into that buffer.
7. Next, the ROM checksums the driver to ensure its validity. For more information on the exact details of the checksum, see Driver Checksums.
8. The ROM then calls the driver's entry point. The exact calling conventions are described below. The driver is expected to install itself in the unit table, open itself, and create drive queue elements for each mountable partition on the disk. (The exact definition of "mountable" is covered in Cooperating with File System Manager.)

If any of these steps fail, the ROM assumes that the device is not bootable and attempts to boot from the next available device.

IMPORTANT:
The fact that the ROM requires an "Apple_HFS" partition to boot from a device is important to authors of non-standard disk drivers, such as RAID striping drivers. The RAID software must create a dummy "Apple_HFS" partition on the device so that the ROM will boot far enough to load the RAID driver.

Note:
The Macintosh Plus originally used an old style (*Inside Macintosh IV*) partition format, identified by a `pmSig` of `oldPMSigWord` ($5453 or `'TS'`). Chaining drivers are not supported on the old partition format. However, the new (*Inside Macintosh V*) partition map format will work on the Mac Plus, so it is possible to use chaining drivers on these venerable machines.

If you want to support the Macintosh Plus in your driver, you need to be aware of the subtle difference between it and later computers. Specifically the buffer pointed to by A0 when the Macintosh Plus ROM calls your driver contains the contents of the second block on the disk (the old style "device partition map"); on all subsequent computers, the buffer pointed to by A0 contains the first "Apple_HFS" partition map entry.

Each driver has two possible entry points. The **primary entry point** is at the beginning of the memory block holding the driver. The **secondary entry point** is 8 bytes into the memory block holding the driver. In general, the primary entry point is called when an "old" driver is loaded, or a "new" driver is loaded by an 'old' ROM, and the secondary entry point is used when a 'new' ROM load a "new" driver. The secondary entry point has extra parameters that make sense in the 'new' ROM environment.

The exact definition of "old" and "new" depends on the bootable bus. For SCSI, a "new" ROM is one that contains SCSI Manager 4.3, and a "new" driver is indicated by the bytes "43" in the two bytes following the "Apple_Driver" in `pmParType`. For ATA, an 'old' ROM is one that contains ATA Manager 1.0. All newer versions of ATA Manager use the secondary entry point. A 'new' ATA Manager will always call the secondary entry point of the driver.

Note:
Computers with ATA Manager 1.0 in ROM are listed in the table below:

Base Model	Introduced	and Derivatives?
Macintosh Performa 630	July 1994	yes
Macintosh PowerBook 150	July 1994	yes
Macintosh LC 580	Apr 1995	yes
Power Macintosh 5200	Apr 1995	yes
Power Macintosh 6200	May 1995	yes
Power Macintosh 5300	Aug 1995	yes
Power Macintosh 6300	Oct 1995	yes, except 6360

Both entry points use register-based calling conventions. The register usage is shown in the table below:

`A0`	`Partition *`	->	A pointer to the first "Apple_HFS" partition map entry in the partition map. See step 5 above. You do not own this memory and must neither change it nor free it. This memory is *not* guaranteed to be a standard Memory Manager pointer block. This parameter is generally ignored by drivers.
`D3`	n/a	->	See discussion below.
`D5`	bus dependent	->	A specification of the device from which the driver was loaded, in a format that is bootable-bus dependent. See the table and discussion below.
`D7`	`long`	->	The `sbData` field from the DDM. This parameter is generally ignored by drivers.
`D0`	`OSErr` or `SInt32`	<-	See discussion below.

Register D3

Old Apple SCSI drivers require that register D3 be set to a non-zero value in order to boot correctly. This bug was fixed in September 1996 although, if you are writing a SCSI disk -mounting utility, you may still encounter these old drivers.

Register D5

The data in register D5 depends on both the bootable bus and the entry point called. The following table indicates the possible combinations.

Bootable Bus	Entry Point	D5 Format
SCSI	Primary	0, 0, 0, SCSI ID
SCSI	Secondary	`DeviceIdent`
ATA	Primary	0, 0, 0, Bus
ATA	Secondary	`DeviceIdentATA`

The format of `DeviceIdentATA` is given below.

```
struct DeviceIdentATA {
    UInt8 diReserved;
    UInt8 busNum;
    UInt8 devNum;
    UInt8 diReserved2;
};
typedef struct DeviceIdentATA   DeviceIdentATA;
typedef DeviceIdentATA *        DeviceIdentATAPtr;
```

Note:
`DeviceIdentATA` is not the same as the `ataDeviceID` structure defined in ATA 0/1 Software Developers Guide, although it is easy to convert between the two.

The fields have the following meaning:

`diReserved`
: Reserved. When calling a disk driver, the ROM sets this to 0; however, in the case described below, this field contains meaningful data.

`busNum`
: The ATA bus number.

`devNum`
: If the machine has ATA 0/1 support, this is the device number of the device on that bus. Otherwise, it must be zero.

`diReserved2`
: Reserved. Set to 0.

In some cases (such as the entry point to a patch loaded by the Apple patch driver), the `diReserved` field is used to distinguish between a `DeviceIdent` and `DeviceIdentATA`. The appropriate values for this field are given below.

```
enum {
    kBusTypeSCSI        = 0,
    kBusTypeATA         = 1,
    kBusTypePCMCIA      = 2,
    kBusTypeMediaBay    = 3
};
```

IMPORTANT:
Values other than `kBusTypeSCSI` (which indicates a `DeviceIdent`) and `kBusTypeATA` (which indicates a `DeviceIdentATA`) are now deprecated. PC Card and media bay device are now handled through the ATA Manager, modern versions of which handle multiple buses.

Note:
In times past, it was accepted practice to use various high bits of register D5 to hold various pieces of state information. Specifically the following bits are used by various Apple and third party drivers.

```
enum {
    kSecondaryEntryPointCalled  = 29,    // 1 => secondary entry point called
    kDontMountVolumes           = 30,    // 1 => don't mount any partitions
    kAfterSystemStartupTime     = 31     // 1 => post-system startup load
};
```

However, in the circumstances described above, all bits in register D5 can be used to hold information. Therefore, DTS recommends that you discontinue the practice of storing flags in the high bit of D5 where practical.

A good substitute for the `kAfterSystemStartupTime` flag is described in Disk Drivers and the System Heap.

Register D0

The significance of register D0 on return from your driver's entry point varies depending on the manager that loaded your driver.

- For ATA Manager, your driver should return an error result in the low word of register D0 and, if the driver successfully installed, its driver reference number in the high word (or a high word of zero otherwise). If you return an error value other than `noErr`, ATA Manager will unload your driver code from memory.
- For SCSI Manager 4.3, the contents of register D0 are always ignored. SCSI Manager 4.3 will never unload your driver from memory. With some clever coding, you can unload the bulk of your driver code upon a failed installation, if you feel that level of polish is necessary.
- For old SCSI Manager, the situation varies depending on the particular ROM.
    - The Mac Plus will treat register D0 as an error result and unload your driver if you return a non-zero value.
    - Subsequent computers ignore the contents of register D0. If your driver fails to install and you want its code to be unloaded, you can return to the return address plus 4 bytes, which signals this to SCSI Manager. **Doing this on a computer running SCSI**

Manager 4.3 will crash the system.

Loading FireWire Drivers

This section is only available under non-disclosure agreement. Please contact DTS for details.

Chaining Drivers and Patch Partitions

Booting a computer is always a tricky exercise. One of the perennial challenges is working around problems in the ROM that prevent the OS from booting far enough to load patches in the normal way. On pre-ROM-in-RAM Macintosh computers, this problem is solved by means of chaining drivers and patch partitions. Patches loaded in this way have been used to:

- support booting from volumes larger than 2 GB on machines that don't have such support in the ROM (for example, NuBus-based Power Macintoshes),
- fix bugs in the ROM SCSI Manager that would otherwise prevent booting, and
- provide support for **snag booting**, where the user can hold down the C key to force the system to boot from the CD-ROM device.

This section explains how chaining drivers and patch partitions are implemented, and how you can license chaining drivers and patches suitable for inclusion in your own disk formatting utility.

Note:
The chaining driver architecture is only required for SCSI and ATA devices. All computers capable of booting from modern I/O buses (USB and FireWire) use the ROM-in-RAM architecture, where the ROM is loaded from the "Mac OS ROM" file in the System Folder. On such machines, ROM patches are effected by updating the "Mac OS ROM" file.

Background Material

This section presumes that you are familiar with the existing documentation on disk partitions and how Mac OS loads a driver from the disk at startup time. Specifically, you should be familiar with:

- Inside Macintosh: Devices, Chapter 3 "SCSI Manager" The Structure of Block Devices (page 3-12 through 3-15) and Data Structures, (page 3-23 through 3-27), and
- Inside Macintosh: Devices, Chapter 4 "SCSI Manager 4.3" Loading and Initializing a Driver (page 4-11)
- Secrets of the Partition Map, earlier in this document.

Architecture Overview

When it boots from a block device, Mac OS loads the driver from the device itself. This driver is held in a driver partition (whose `pmParType` starts with "Apple_Driver") and is referenced by an entry in the driver descriptor map (DDM), which is stored in the first device block on the disk. The ROM searches the DDM to find the appropriate driver, loads that driver into memory, and calls it.

The chaining driver architecture works by installing a special driver in place of the standard disk driver. This **chaining driver** performs its operation (typically it applies a patch to the ROM) and then loads the next suitable driver in the DDM, in exactly the same way as the ROM would have. The next driver may be a real disk driver, or yet another chaining driver.

The sequence of drivers loaded in this way is known as a **driver chain**. There may be more than one driver chain on the disk; often, there is one for each bootable bus possible for that disk. For example, a Zip disk may have a chain of SCSI drivers (whose `pmParType` is "Apple_Driver43") for use when the Zip disk is inserted in a SCSI Zip device, and a chain of ATA drivers (whose `pmParType` is "Apple_Driver_ATA") for use when the Zip disk is inserted in an ATA Zip device.

The last driver in a driver chain does not need to support chaining because there is nothing to chain to. This means that you don't need to modify your disk driver to support this architecture, as long as the disk driver is always installed last in the chain.

One special kind of chaining driver is the **patch driver**. This is a driver supplied by Apple that is responsible for loading and executing system patches out of a **patch partition**. Each patch has a **patch descriptor**, which contains a four character code that uniquely identifies the patch. Once it has loaded the patches, the patch driver chains to the next driver, as any other chaining driver would.

In general, you do not need to write a patch driver, or the patches it installs. However, your formatting utility must install the patch driver and the patch partition such that the right patches are loaded.

Available Patches

Apple supplies both patch drivers and patches to developers. The available patch drivers are listed below:

- "PatchChainDriver" -- This patch driver is used when booting from a SCSI device.
- "ATAPatchChainDriver" -- This patch driver is used when booting from an ATA device, such as an internal ATA hard disk.
- "ATAPIPatchChainDriver" -- This patch driver is used when booting from an ATAPI device, such as an ATAPI CD-ROM.

The following patches are available.

- `'mesh'` -- This patch fixes a bug in the ROM SCSI Manager's handling of the MESH chip. It is required to successfully boot on a machine with that chip.
- `'scsi'` -- This patch makes adjustments to the classic SCSI Manager to enable booting from CD-ROM devices.
- `'ruby'` -- This patch installs support for volumes larger than 2 GB on machines that don't have this support in the ROM.
- `'snag'` -- This patch implements the "To start up from this CD-ROM, hold down the C key as the computer starts up" functionality used in many bootable CD-ROM products. It is only necessary on pre-ROM-in-RAM computers; ROM-in-RAM computers implement snag booting in Open Firmware.

To legally include these patch drivers and patches in your formatting software, you must license the patches from Apple. Contact Apple Software Licensing for details.

Note:
For experimental and debugging use, you can extract the relevant patch resources from Apple's Drive Setup utility. Resources of type `'ptDR'` hold patch drivers, resources of type `'pDES'` hold patch descriptors, and resources of type `'ptch'` hold patch code. However, production software must license this resources from Apple for redistribution.

Advice for Formatting Utilities

The first thing that a formatting utility must do is decide how many driver chains need to be constructed. This is determined by the number of possible bootable buses for the disk. For example, a SCSI device can only be attached via SCSI, so the utility need only construct one driver chain. In contrast, an removable cartridge disk might be placed in either a SCSI or ATA mechanism, and therefore must contain two driver chains, one for SCSI and one for ATA. Moreover, a PowerBook internal ATA hard disk device needs to have a SCSI driver chain if it is to work in target mode.

For each driver chain constructed, the formatting utility must first create a partition for the patch driver and then create a partition for the disk driver itself. When creating partitions, the formatting utility must be careful to write the driver signature into the `pmPad` field of the `Partition` record. Chaining drivers (including the patch driver) need this signature to correctly find the next driver to load. The utility should also be sure to set up the `pmPartStatus` field according to the description in `pmPartStatus` Revealed.

In addition to creating the driver partitions, the formatting utility must also create entries in the DDM with the appropriate driver type. See New Driver Types for a list of driver types, and Architecture in Detail for an explanation of the relationship between them.

The formatting utility must also construct the "Apple_Patches" partition. Some rules must be observed when doing this.

- The `pmPartName` field of the partition map entry should be "Patch Partition".
- The `pmParType` field of the partition map entry must be "Apple_Patches".
- The first block of the patch partition contains a list of the patches in the partition.
- Patches are run in order, so it is necessary to place patches that are critical to the correct operation of later patches (like `'mesh'` and `'scsi'`) before the less critical ones (like `'snag'`).
- Patch descriptors contain a version number. The formatting utility should not replace a newer patch with an older one.
- Patch descriptors are variable length data structures. You cannot index the list of patches as an array.

There are also some non-obvious factors when deciding whether to install a particular patch on a particular disk.

- The MESH patch (`'mesh'`) should be installed on any disk which might be booted from via SCSI. In particular, the MESH patch is required on the internal ATA hard disk on PowerBooks, because it is possible they might be used to boot a machine while in target mode.
- The large volume support patch (`'ruby'`) is only required if any of the partitions on the disk are 2 GB or larger.
- Do not install the `'snag'` patch on hard disks! Doing so will prevent the user from snag booting a CD. This is because, if the C key is held down, the hard disk `'snag'` patch prevents booting from the CD, while the CD-ROM `'snag'` patch prevents booting from the hard disk.

Finally, formatting utilities should aim to leave some free space in the partition maps, driver partitions, and patch partitions. Drivers and patches grow over time and wasting a few KB now may radically ease the job of upgrading a driver or patch in the future.

IMPORTANT:
To be compatible with computers that have the classic SCSI Manager in ROM, all data that is read by the ROM must be within the first 1 GB of the disk. This is because the classic SCSI Manager driver loading code uses 6-byte SCSI commands to read the driver.

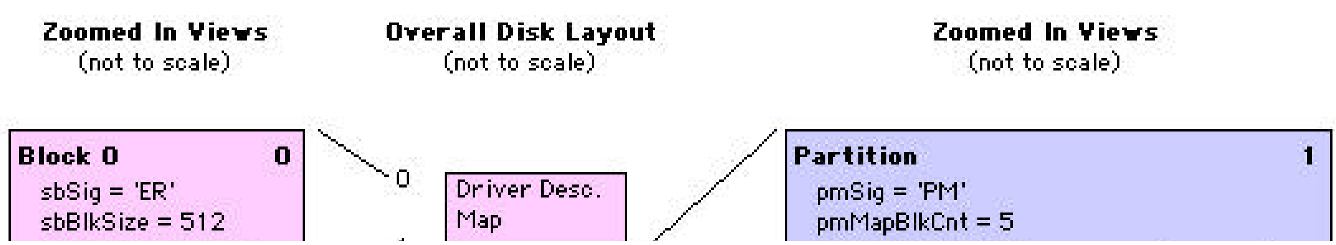
Architecture in Detail

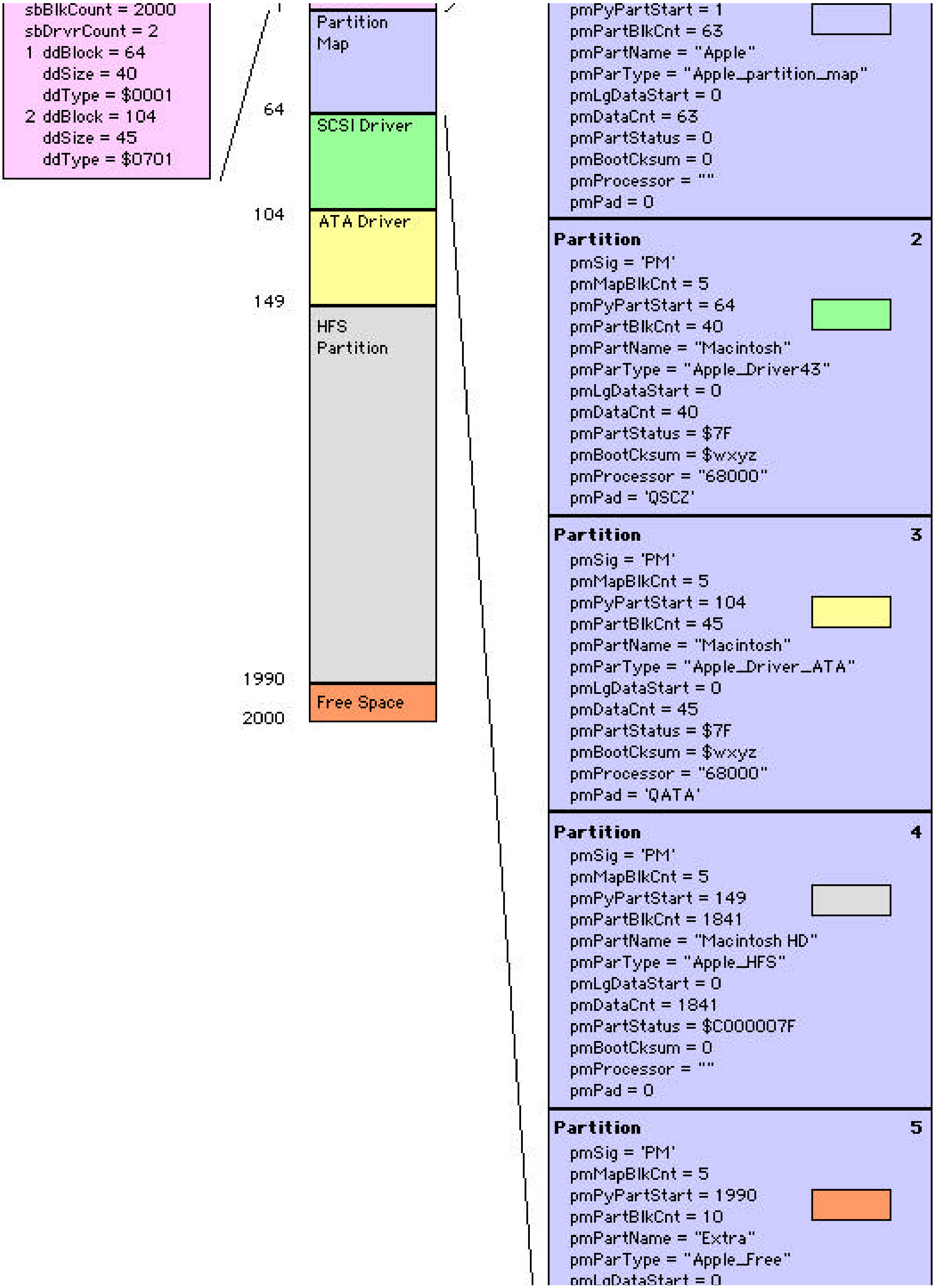
This section describes the chaining driver architecture in detail, including how chaining drivers intercept the driver loading process, the Apple patch driver, and the structure of the patches it loads. To understand this section, you need to understand how the ROM loads SCSI and ATA drivers.

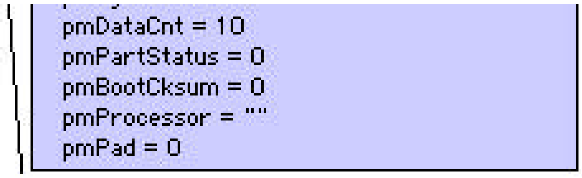
Pre-Chaining Example

The following diagram shows how a partition map might be laid out prior to the introduction of chaining drivers. This example includes both ATA and SCSI drivers, a setup which is useful for disks that can be mounted in both ATA and SCSI mechanisms. Some salient features are:

- The sample SCSI driver has a driver signature of `'QSCZ'`, and the sample ATA driver has a driver signature of `'QATA'`.




sbBlkCount = 2000
sbDrvrCount = 2
1 ddBlock = 64
ddSize = 40
ddType = $0001
2 ddBlock = 104
ddSize = 45
ddType = $0701
1
64
104
149
1990
2000
Partition Map
SCSI Driver
ATA Driver
HFS Partition
Free Space
pmPyPartStart = 1
pmPartBlkCnt = 63
pmPartName = "Apple"
pmParType = "Apple_partition_map"
pmLgDataStart = 0
pmDataCnt = 63
pmPartStatus = 0
pmBootCksum = 0
pmProcessor = ""
pmPad = 0
Partition 2
pmSig = 'PM'
pmMapBlkCnt = 5
pmPyPartStart = 64
pmPartBlkCnt = 40
pmPartName = "Macintosh"
pmParType = "Apple_Driver43"
pmLgDataStart = 0
pmDataCnt = 40
pmPartStatus = $7F
pmBootCksum = $wxyz
pmProcessor = "68000"
pmPad = 'QSCZ'
Partition 3
pmSig = 'PM'
pmMapBlkCnt = 5
pmPyPartStart = 104
pmPartBlkCnt = 45
pmPartName = "Macintosh"
pmParType = "Apple_Driver_ATA"
pmLgDataStart = 0
pmDataCnt = 45
pmPartStatus = $7F
pmBootCksum = $wxyz
pmProcessor = "68000"
pmPad = 'QATA'
Partition 4
pmSig = 'PM'
pmMapBlkCnt = 5
pmPyPartStart = 149
pmPartBlkCnt = 1841
pmPartName = "Macintosh HD"
pmParType = "Apple_HFS"
pmLgDataStart = 0
pmDataCnt = 1841
pmPartStatus = $C000007F
pmBootCksum = 0
pmProcessor = ""
pmPad = 0
Partition 5
pmSig = 'PM'
pmMapBlkCnt = 5
pmPyPartStart = 1990
pmPartBlkCnt = 10
pmPartName = "Extra"
pmParType = "Apple_Free"
pmLgDataStart = 0



Chaining Drivers

The basic idea behind chaining drivers is very simple. A chaining driver appears to the ROM as the actual disk driver. It has a DDM entry of the appropriate type (`kDriverTypeMacSCSI` for SCSI, `kDriverTypeMacATA` for ATA) and it has a partition with the appropriate type ("Apple_Driver43" for SCSI, "Apple_Driver_ATA" for ATA). The ROM finds, loads, and executes the chaining driver as if it was the real disk driver. The chaining driver does its operation (patching, password protection, and so on) and then finds, loads and executes the next driver in the driver chain. This process is repeated once for each driver in the chain.

The first chaining driver in a driver chain always has the `ddType` expected by the ROM (`kDriverTypeMacSCSI` for SCSI, `kDriverTypeMacATA` for ATA). Subsequent drivers in the driver chain have their `ddType` set to the two's complement of the standard value (`kDriverTypeMacSCSIChained` for SCSI, `kDriverTypeMacATAChained` for ATA).

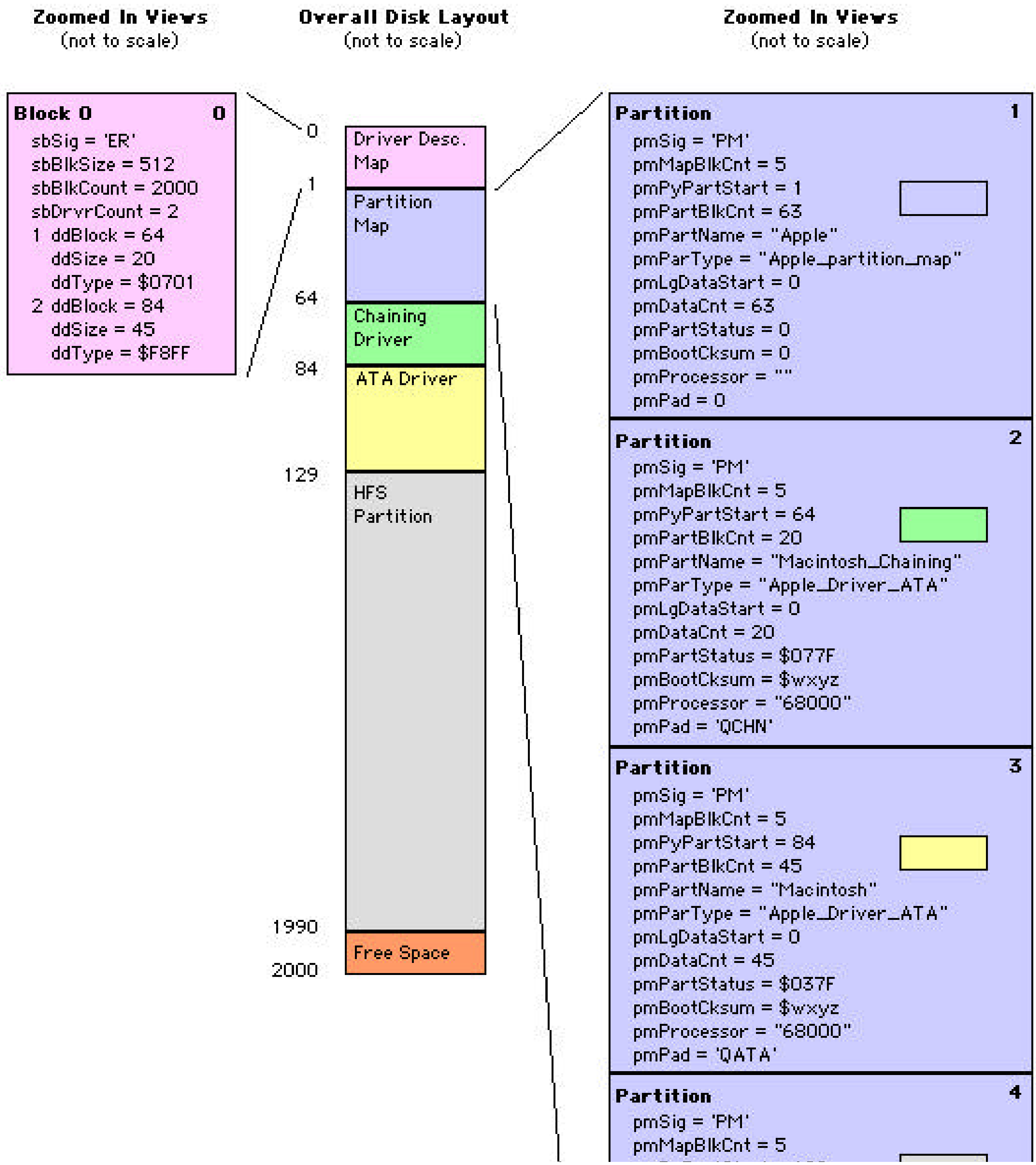
There are a number of important implementation details for chaining drivers.

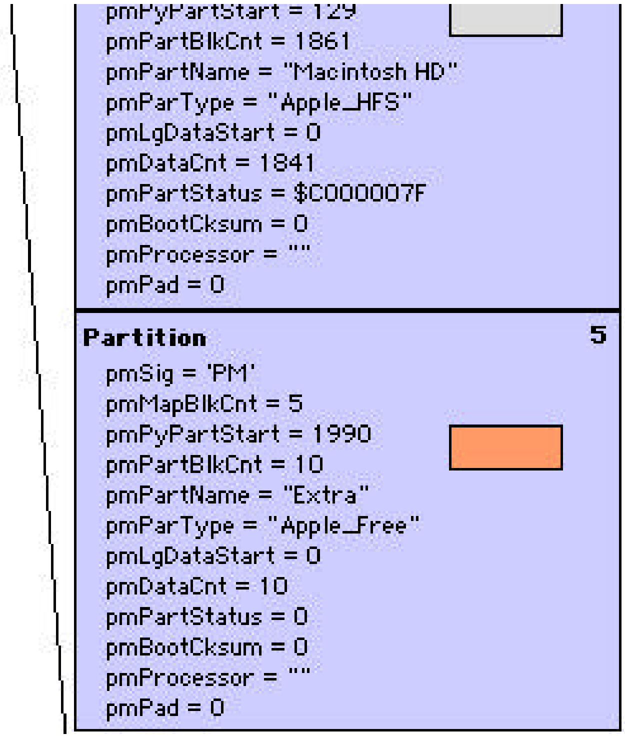
- All drivers in the chain, except the first, must have the `kPartitionIsChainCompatible` bit set in the `pmPartStatus` field of their partition map entries to indicate that they can be chained to (they don't have to be loaded directly by the ROM). The first driver may have this bit set, although it is not required.
- A chaining driver must always have the `kPartitionCanChainToNext` bit set in the `pmPartStatus` field of its partition map entry. While this bit is not actually needed for the chaining driver to be loaded, formatting utilities may use the bit to determine the required order of drivers in the DDM.
- A chaining driver may also contain the real disk driver. If it does, it should have the `kPartitionIsRealDeviceDriver` bit set in the `pmPartStatus` field of its partition map entry.
- The ROM loads the chaining driver exactly as it would a normal driver. Therefore, if a chaining SCSI driver wants to have its checksum validated by the ROM, it must set the first four bytes of its partition map entry `pmPartName` field to "Maci".
- A chaining driver must find the next driver to load using the following algorithm.
    1. First, the chaining driver should search the partition map for its own partition map entry. It can distinguish itself from other drivers by looking for its driver signature in the `pmPad` field.
    2. Then, the driver should look up its entry in the DDM. It can find itself by matching the `pmPyPartStart` field of its partition map entry to the `ddBlock` field of its `DDMap`.
    3. It can then find the `DDMap` of the next driver in the driver chain by searching onwards from its own `DDMap` for a `DDMap` with the appropriate `ddType`. In this case, appropriate is either the two's complement of the chaining driver's `ddType` (if the chaining driver is first in the chain), or the same `ddType` as the chaining driver (if the chaining driver is subsequent in the chain).
- There may be no next driver to load. The chaining driver should treat this as an error, and handle it as described below.
- A chaining driver must load and execute the next driver exactly as the ROM would have. The exact details are covered in the previous section. Note that the chaining driver must:
    1. checksum the driver, as described in Driver Checksums, and
    2. remember which of its entry point was called (primary or secondary) and call the same entry point for the next driver, and
    3. call the next driver with registers A0, D5, and D7 set exactly as they were when the chaining driver was called.
    4. handle any error returned by the next driver as described below.
- A chaining driver may need to increase the size of the system heap to allow it to allocate enough memory to load the next driver. See Disk Drivers and the System Heap for details on doing this.

How the chaining driver handles errors depends on whether the chaining driver precedes the disk driver in the driver chain. If the chaining driver precedes the disk driver, any error loading the next driver, or any error returned by the next driver's entry point, is fatal. The chaining driver should return `ioErr` from its entry point. However, if the chaining driver is the disk driver (both `kPartitionCanChainToNext` and `kPartitionIsRealDeviceDriver` are set in its `pmPartStatus`) or comes after the disk driver, any error loading the next driver is not fatal, and the chaining driver should return `noErr` regardless of any error loading the next driver in the chain.

The following diagram shows how a partition map might be laid out for a disk that can only be booted on an ATA bus and which has a chaining driver. Some salient features are:

- The DDM has the chaining driver first, followed by the disk driver (with a negated `ddType`).
- The chaining flags are set in the `pmPartStatus` fields of the chaining driver's and the disk driver's partition map entry.





The Apple Patch Driver

The Apple patch driver is a chaining driver supplied by Apple that loads patches from a special partition on the disk. You must license the patch driver and its accompanying patches for inclusion with your disk driver software. This section describes the operation of the patch driver insofar as is necessary for you to write a formatting utility that correctly installs the patches.

Typically, the patch driver is installed first in the driver chain. It finds the patch partition by searching the partition map for an entry whose type is "Apple_Patches". It then walks the patch partition, loading and executing the patches. Finally, it chains to the next driver.

The patch partition is structured to contain multiple patches. The first block of the patch partition contains a **patch list**, a description of all the patches in the partition. The patch list is defined by the `PatchList` structure.

```
struct PatchList {
    UInt16 numPatchBlocks;
    UInt16 numPatches;
    PatchDescriptor thePatch[1];
};
typedef struct PatchList    PatchList;
typedef PatchList *         PatchListPtr;
```

The fields have the following meaning:

`numPatchBlock`
: The number of *device blocks* used to hold the patch list. The patch driver must load this many blocks from the start of the patch partition to ensure that it has all the patch descriptors.

`numPatches`
: The number of patch descriptors contained in the patch list.

`thePatch`
: The patch descriptor describing the first patch in the patch list.

IMPORTANT:
Each patch descriptor is of variable size, so you can't index `thePatch` as an array.

Each patch in the patch list is described by the `PatchDescriptor` data type.

```
struct PatchDescriptor {
    OSType patchSig;
    UInt16 majorVers;
    UInt16 minorVers;
    UInt32 flags;
    UInt32 patchOffset;
    UInt32 patchSize;
    UInt32 patchCRC;
    UInt32 patchDescriptorLen;
    Str32  patchName;
    UInt8  patchVendor[1];
};
typedef struct PatchDescriptor  PatchDescriptor;
typedef PatchDescriptor *       PatchDescriptorPtr;
typedef PatchDescriptorPtr *    PatchDescriptorHandle;

enum {
    kRequiredPatch = 0x00000001;
};
```

The fields have the following meaning:

`patchSig`
: A four-character code that uniquely identifies the patch. If you create your own patches, you must use a registered creator code.

`majorVers`
: A major version number. Typically this is 1.

`minorVers`
: A minor version number. Typically this is 0. This combines with the major version number to indicate a version of the form 1.0, 1.1, and so on.

`flags`
: A set of flags for the patch. The only bit currently defined is `kRequiredPatch`. If this is set, the patch must succeed for the system to continue booting. See the section on error handling below. All other bits are reserved and must be set to zero.

`patchOffset`
: The offset, in *device blocks* , from the beginning of the patch partition to the patch code.

`patchSize`
: The actual size of the patch code in bytes.

`patchCRC`
: A checksum for the patch. This is calculated using the 16-bit driver checksum algorithm.

`patchDescriptorLen`
: The total length, in bytes, of this patch descriptor. The minimum value for this field is `sizeof(PatchDescriptor)`, which is 62 bytes. This value of this field must be even.

`patchName`
: A human-readable name for the patch. This name is never displayed to users or used by the system. It is present for debugging and diagnosis only.

`patchVendor`
: A human-readable description of the patch vendor. This name is never displayed to users or used by the system. It is present for debugging and diagnosis only. This string may be followed by an arbitrary amount of patch-specific data.

IMPORTANT:
Previous versions of the patch partition documentation described `patchName` as a `Str31` (actually, an array of 32 `UInt8s`), which implied that `patchVendor` started at offset 60 in the structure. This is incorrect. The `patchName` field is a `Str32` and `patchVendor` starts at offset 61. Note that this is an exception to the general rule that Pascal strings are not supposed to be placed at odd offsets in a structure.

In addition, because of the aforementioned error, the minimum value for the `patchDescriptorLen` field is 62, not 61 as previously documented.

IMPORTANT:
Previous versions of the patch partition documentation stated that `patchDescriptorLen` must be a multiple of 4. This is contradicted by observed behavior.

Note:
Apple patches generally use "\pApple Computer, Inc." in the `patchVendor` field and have no patch-specific data. This results in a `patchDescriptorLen` of 82, which is 62 + `PLstrlen(patchVendor)`.

When the patch driver executes a patch, it does so by creating a new pointer block in the system heap which is large enough to hold the patch, reading the patch code into that block, and then calling the patch entry point (the first byte of the memory block) using the calling conventions described in the next section.

As part of its operation, the patch driver increases the size of the system heap to accommodate the size of the patches loaded.

Patch Driver Error Handling

Error handling in the patch driver follows the general outline for error handling in chaining drivers. Specifically, an error is classified as either fatal or non-fatal. For a fatal error, the patch driver discards the current patch descriptor and patch code (if any) and returns `ioErr` from its entry point, which indicates to the system that this disk is unusable. Fatal errors include:

- failure to load a required patch (one whose patch descriptor's `flags` field has `kRequiredPatch` set),
- a positive result from a required patch,
- a negative error result from any patch, and
- failure to load the next driver (the patch driver is always loaded first in the driver chain, so a failure to load the next driver is always a fatal error).

For a non-fatal error, the patch driver simply discards the patch descriptor and patch code for the patch and continues trying to load the next patch (if any) or the next driver in the driver chain. Non-fatal errors include:

- inability to load a non-required patch, and
- a positive error result from a non-required patch.

Patch Execution

The prototype for a patch's entry point is given below.

```
extern pascal OSErr MyPatch(PatchDescriptorPtr myPatch,
                            DeviceIdent myDevID);
```

IMPORTANT:
Previous versions of the patch partition documentation incorrectly documented this prototype as using C calling conventions and having a `long` return result. This documentation is correct.

The parameters to the entry point are:

`myPatch`

A pointer to the patch's patch descriptor. The patch can use this pointer to extract patch-specific information from `patchVendor` part of the patch descriptor. The memory containing the patch descriptor will be deallocated after the patch returns; the patch is responsible for copying any information it needs to retain.

`myDevID`

A device identifier which identifies the device from which the patch was loaded. The `diReserved` field of this parameter can be used to distinguish whether this is a SCSI `DeviceIdent` or a `DeviceIdentATA`.

result

`noErr`, if the patch was successful. The patch driver will dispose of the patch descriptor but leave the patch code in memory. A positive error code, if the patch encountered a non-fatal error. A negative error code, if the patch encountered a fatal error. See the description of patch driver error handling for details.

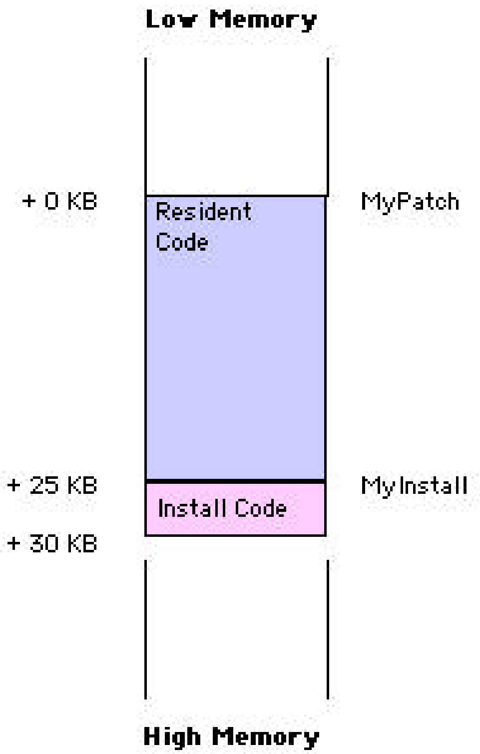
The patch's code is always loaded in the system heap. The patch's entry point is always called at system task time.

IMPORTANT:
A patch must try to minimize any assumptions about its environment. Specifically:

- A patch should not assume that it was loaded from an ATA or SCSI device. For example, a SCSI-specific patch should behave correctly if it is loaded from an ATA device. This can happen if the patch is installed on a removable cartridge disk that can be mounted in both ATA or SCSI devices.
- A patch should not assume the existence of optional system software capabilities. For example, a SCSI Manager 4.3 specific patch should not assume that SCSI Manager 4.3 is present. It is possible for an external device to be moved from a machine with SCSI Manager 4.3 to a machine without it, and vice versa.
- Because of the above, patches should avoid loading data from the disk. If your patch needs data, you should add the data after the `patchVendor` field of your patch descriptor.
- Patches are loaded very early in the startup sequence and must allocate memory as outlined in Disk Drivers and the System Heap.
- A patch should work correctly even if it is loaded twice. For example, if the same patch is installed on multiple SCSI devices, both patches will be executed at startup time and the patches must coordinate to avoid any conflicts.

Note:
The `myDevID` parameter is a true device identifier, even if the patch is being loaded on a system without SCSI Manager 4.3 in the ROM. In that case, the patch driver is responsible for synthesizing the device identifier from the SCSI ID. A full explanation of the driver's various entry points is given in an earlier section.

Because a patch's code is always loaded in a pointer block in the system heap, it can reduce its size in memory using clever code sorting and `SetPtrSize`. For example, imagine a patch that has 5 KB of install code and 25 KB of resident code. The patch can reduce its memory footprint by sorting the code as shown below.



The following code snippet shows how this might be achieved in C.

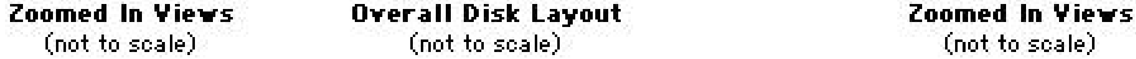
```
extern pascal OSErr MyPatch(PatchDescriptorPtr myPatch,
                            DeviceIdent myDevID)
{
    OSErr err;

    err = MyInstall(myPatch, myDevID);
    SetPtrSize( (Ptr) &MyPatch,
                (UInt32) &MyInstall - (UInt32) &MyPatch
              );
    return err;
}
```

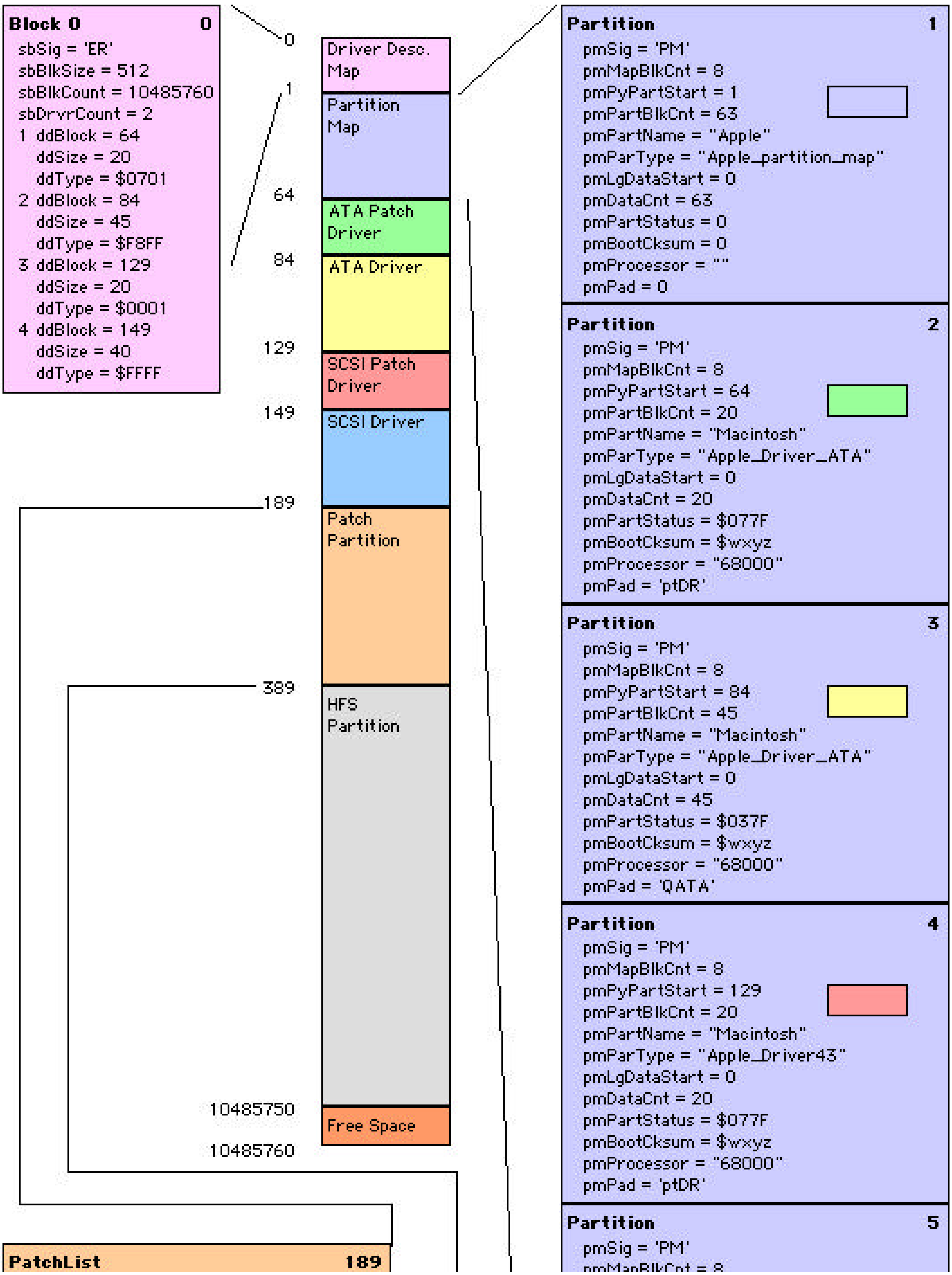
WARNING:
If you use this technique, be sure to generate a link map and check that the code order matches your expectations. Your development environment might reorder code in an unexpected way.

Putting It All Together

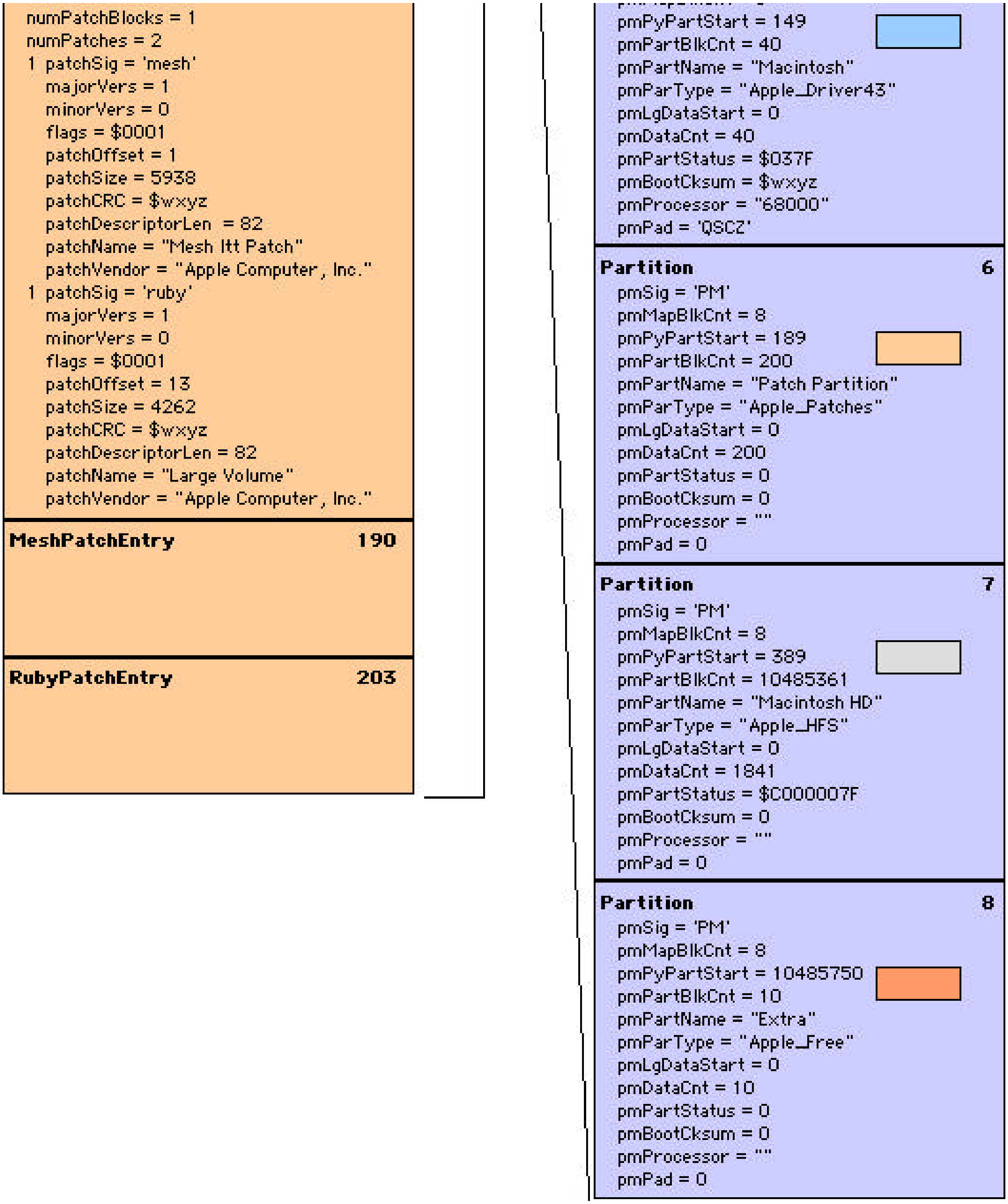
The following diagram shows the layout of a disk that can be booted via SCSI and ATA.

- The DDM has two patch chains, one for ATA booting and one for SCSI booting.
- Each patch chain starts with the appropriate Apple patch driver.
- The first block of the "Apple_Patches" partition contains a list of patches to be installed on the machine. The remaining blocks contain the code for the patches themselves.
- The `'mesh'` patch is installed to ensure correct operation when booted via SCSI on a machine with the MESH chip.
- The `'ruby'` patch is installed to allow booting on machines without large volume support in ROM. Note that the total disk size in this example is 5 GB. On the smaller disks used in the previous examples, the `'ruby'` patch would not be necessary.





Block 0 0
sbSig = 'ER'
sbBlkSize = 512
sbBlkCount = 10485760
sbDrvrCount = 2
1 ddBlock = 64
ddSize = 20
ddType = $0701
2 ddBlock = 84
ddSize = 45
ddType = $F8FF
3 ddBlock = 129
ddSize = 20
ddType = $0001
4 ddBlock = 149
ddSize = 40
ddType = $FFFF
0
1
64
84
129
149
189
389
10485750
10485760
Driver Desc. Map
Partition Map
ATA Patch Driver
ATA Driver
SCSI Patch Driver
SCSI Driver
Patch Partition
HFS Partition
Free Space
Partition 1
pmSig = 'PM'
pmMapBlkCnt = 8
pmPyPartStart = 1
pmPartBlkCnt = 63
pmPartName = "Apple"
pmParType = "Apple_partition_map"
pmLgDataStart = 0
pmDataCnt = 63
pmPartStatus = 0
pmBootCksum = 0
pmProcessor = ""
pmPad = 0
Partition 2
pmSig = 'PM'
pmMapBlkCnt = 8
pmPyPartStart = 64
pmPartBlkCnt = 20
pmPartName = "Macintosh"
pmParType = "Apple_Driver_ATA"
pmLgDataStart = 0
pmDataCnt = 20
pmPartStatus = $077F
pmBootCksum = $wxyz
pmProcessor = "68000"
pmPad = 'ptDR'
Partition 3
pmSig = 'PM'
pmMapBlkCnt = 8
pmPyPartStart = 84
pmPartBlkCnt = 45
pmPartName = "Macintosh"
pmParType = "Apple_Driver_ATA"
pmLgDataStart = 0
pmDataCnt = 45
pmPartStatus = $037F
pmBootCksum = $wxyz
pmProcessor = "68000"
pmPad = 'QATA'
Partition 4
pmSig = 'PM'
pmMapBlkCnt = 8
pmPyPartStart = 129
pmPartBlkCnt = 20
pmPartName = "Macintosh"
pmParType = "Apple_Driver43"
pmLgDataStart = 0
pmDataCnt = 20
pmPartStatus = $077F
pmBootCksum = $wxyz
pmProcessor = "68000"
pmPad = 'ptDR'
Partition 5
pmSig = 'PM'
pmMapBlkCnt = 8
PatchList 189



Disk Drivers and the System Heap

Disk drivers typically allocate their memory in the system heap. A disk driver must use one of three techniques to allocate system heap space, depending on the execution context. There are three relevant execution contexts for your driver:

1. Driver Load Time -- If you driver is bootable, it is called at driver load time to install itself in the unit table.
2. System Startup -- It is possible for your driver to be called at system startup time, after driver load time but before system startup is complete. For example, if your driver sets `dNeedTime` and some startup code (for example, an `'INIT'`) brings up a dialog, your driver will receive `accRun` requests.
3. After System Startup -- System startup time finishes when the Process Manager starts and launches the Finder.

The best way to detect whether system startup is complete is to compare the first byte (the length) of the Pascal string returned by `LMGetCurApName` to `$FF`. If the first byte is `$FF`, the system is still starting up. If it is any other value, system startup is complete.

There is no good way to distinguish between driver load time and system startup time. Your driver must remember internally whether it is executing as a result of its install routine being called.

Driver Load Time

At driver load time, a driver that needs to allocate a large amount of memory must grow the system heap using `SetApplBase`. This system routine is documented as Inside Macintosh: Memory, along with a warning that applications should not use it. However, it is expected that disk drivers which need to expand the system heap will use this routine.

A simple example of calling `SetApplBase` is shown below.

```
static void ExpandSystemHeap(Size bytesToGrow)
{
    THz currentZone;

    // Only try to expand the system heap if we're at startup time,
    // ie the CurApName is still filled with $FFs.

    assert( LMGetCurApName()[0] == 0xFF );    // from <assert.h>

    currentZone = GetZone();

    // Round up the request to 512 bytes.

    bytesToGrow = (bytesToGrow + 0x01FF) & ~0x01FF;

    // Set the system heap to the specified size.

    SetApplBase((Ptr)((UInt32) (LMGetSysZone())->bkLim + bytesToGrow));

    SetZone(currentZone);
}
```

IMPORTANT:
Disk drivers should not attempt to grow the system heap too much using this mechanism. How much is too much? It depends on a lot of factors, including the machine's ROM software, the system version, whether virtual memory is turned on, which patches are being loaded, and which other device drivers are installed.

For example, on Mac OS 8.1 the system heap can grow to a maximum of 4 MB during this early phase of the startup process and this limit was exceeded when certain PCI RAID cards were installed. While this problem was worked around before Mac OS 8.1 shipped, it is an important lesson for developers of software that runs during the early startup process. There *is* a system heap limit and there is no allocation policy for what memory is available.

In the absence of a formal policy, DTS recommends that each individual developer limit their system heap expansion to less than 256 KB during this early startup phase. This includes the expansion done by the system to load your code. If necessary, you must compromise on the speed of your driver to achieve this goal. If you need more memory to improve performance, you must either:

- install a system extension with an `'INIT'` resource, which grows the system heap (as described below), and turns that memory over to your driver, or
- wait until your driver receives an `accRun` Control request and allocate your extra memory then.

System Startup

Disk drivers that load as part of the `'INIT'` loading process should request that the system heap be grown using a `'sysz'` resource, as documented in Inside Macintosh: Memory and Inside Macintosh: Operating System Utilities, and amended in Technote IM 2 Inside Macintosh: Memory Errata.

IMPORTANT:
`'INIT'` resources should not expand the system heap using `SetApplBase`. The Start Manager has open resource files whose resource maps reside in the application zone and there is no supported way to close and reopen these resource files.

After Startup Time

After the system has started up, a disk driver should allocate its system heap memory using `NewPtrSys`, or `NewHandleSys`. The system heap will automatically expand to meet these requirements.

PowerPC Native Disk Drivers

Many developers wish to implement their disk drivers in PowerPC native code. However, there is no well-defined architecture for native disk drivers. There are a number of consequences and drawbacks, which this section discusses in detail.

The Need for Speed

Most drivers are I/O bound. They spend a small amount of time setting up an I/O request and a proportionally much larger amount of time waiting for the underlying hardware to complete that request. Such drivers receive very little benefit from executing as native code. Moreover, the benefit varies depending on the ratio of small I/O requests (which tend to be CPU bound) to large I/O requests (which tend to be I/O bound).

On the other hand, some drivers are CPU bound. For example, a driver that encrypts data as it transfers it to the disk may spend a significant amount of time executing driver code. This may even be true for a complex, but still I/O focused driver, such as a RAID driver or a caching disk driver. These drivers may receive significant benefit from "going native."

The only good way to tell whether your driver receives a benefit from conversion to native code, and that the benefit is enough to overcome the difficulties in doing so, is to actually profile the code. You may be able to do this quickly by profiling the driver code in an application framework before facing the challenges of creating a working native driver.

Difficulties with Taking Your Driver Native

The primary difficulty in creating a native disk driver is that there is no well-defined architecture for it. The PCI-native driver model has a number of drawbacks for disk driver developers.

1. It does not include a disk driver I/O family expert. It is possible to write a generic native driver (`kServiceCategoryNdrvDriver`) which acts as a disk driver, but it is not possible to do so within the native driver architecture. Specifically, a disk driver must link to InterfaceLib to access routines like `AddDrive`. Linking to InterfaceLib works just fine on the current Mac OS, but it is not legal within the native driver model and guarantees that your driver will not be compatible with any future Mac OS that emulates this model on a non-traditional framework.
2. The PCI native driver model is not available on older, non-PCI-based, Power Macintosh computers.

Another possible approach is to implement a partially native driver, where code that you know to take a long time is implemented as native code. This makes a lot of sense in some cases, such as an encryption driver, where the lengthy code is easily isolated from the rest of the driver.

It is also possible to implement a virtually fully native driver without the PCI native driver module, using only a tiny amount of 68K glue code to provide the driver header and an interface to `IODone`. In general, this approach is not recommended by DTS because of the complexities involved in transitioning from 68K to native code and back.

When taking a disk driver native, it is important to remember that the primary client of the disk driver is the File Manager, which is not native. While it is likely that a disk driver will incur Mixed Mode switches regardless of whether it is native or not (the SCSI Manager and ATA Manager are native), taking the driver native shifts the line where the switches occur, and may increase or decrease the number of switches depending on how your driver works. So, to guarantee an overall speed improvement, it is important that the native driver be significantly faster than the emulated one.

Native Drivers and accRun

Before implementing a disk driver as a native driver, you must read DTS Q&A DV 35, "Native Drivers (`'ndrv's`) and `dNeedTime`", which describes an incompatibility between native drivers and `dNeedTime`.

The rest of this technote assumes that you are building a 68K driver, and thus you can set `dNeedTime` in `dCtlFlags` to get system task time via the `accRun` Control request. If you are building a native driver and you need system task time, you must implement one of the alternative mechanisms described in the Q&A.

68K drivers should continue to use `dNeedTime` as always.

Recommendations

DTS does not recommend that developers implement disk drivers in PowerPC native code unless there is clear evidence that doing so improves the performance significantly. Typically this is only for drivers that are CPU bound, such as encrypting drivers. A standard SCSI or ATA driver is I/O bound, and receives little benefit from running native.

The easiest way to implement a PowerPC native driver is using the native driver model, introduced with the PCI-based Power Macintosh computers. However, this approach will not work on older Power Macintosh computers. Another recommended alternative is to implement a partially native driver, where core functionality (such as an encryption engine) is in native code.

Installing and Removing Drivers and Drives

Over the course of the past 15 years, Mac OS has evolved from a relatively static environment -- a Mac with one or two floppy drives that needed to be connected at startup time -- to a highly dynamic system, where devices and disks come and go at runtime. The Mac OS disk driver architecture has, to a large extent, coped with this evolution, as long as driver writers play by the rules. This section explains these rules in detail.

Installing and Removing Drivers

There are a number of ways to install your disk driver.

1. If you're writing a native driver that controls a real piece of hardware (a FireWire device, or a PCI RAM disk card, for example), you can set up your `DriverDescription` so that the system automatically finds and opens your device driver. See Designing PCI Cards and Drivers for Power Macintosh Computers for details.
2. If you're writing a native driver with no corresponding hardware, you can use DriverLoaderLib to install your driver directly. See Designing PCI Cards and Drivers for Power Macintosh Computers for details.
3. If you're writing a 68K driver, you should use TradDriverLoaderLib to install your driver. Installing a driver in the unit table is easy to do half right but tricky to do exactly right, which is why DTS strongly recommends that developers use TradDriverLoaderLib. The only exception is boot disk drivers, where the limited scope of the task makes the general nature of TradDriverLoaderLib seem a little too much. See Code Sharing for more details on this.

Note:
TradDriverLoaderLib is a DTS sample that provides similar functionality to DriverLoaderLib, except that it works for 68K drivers rather than native drivers. You can download the sample via FTP.

WARNING:
Disk drivers, which can be called at interrupt time, must never be installed as RAM-based drivers (`dRAMBased` must not be set in `dCtlFlags`); paradoxically, disk drivers are always "ROM-based." TradDriverLoaderLib takes care of this and many other details of loading a driver.

To remove a disk driver from the unit table, you have a number of choices.

1. If the driver is a native driver, you must use the DriverLoaderLib routine `RemoveDriver` to remove it.
2. If the driver is a 68K driver, you should have installed it using `TradDriverLoaderLib`. If so, you can remove it using the `TradRemoveDriver` routine provided by that library.
3. If the driver was not installed using TradDriverLoaderLib (either because it was a boot disk driver or because it wasn't installed by your software), you should follow the procedure described in the Hostile Takeovers section of this document.

WARNING:
You must **never remove a driver that has drives in the drive queue**. Doing so will cause the system to crash.

Code Sharing

Code sharing is a technique used by some third-party disk drivers to share the device driver code between multiple drivers in the unit table. Code sharing is a legal technique, although it is not implemented by Apple disk drivers and is not recommended by DTS. Before shipping a driver that uses code sharing, you need to understand the costs and benefits of the technique.

How Code Sharing Works

The basic algorithm for code sharing is as follows:

1. When your driver installs itself, it first scans the unit table to see whether another instance of it is already installed.
2. If there is an existing instance, you must check its version number to determine whether to use its code or replace its code with the code in your driver. You can get the driver's version using a Driver Gestalt `kdgVersion` request.
3. If the existing driver is older, you must somehow dispose of its code and replace it with yours. As there is no Apple-defined way of replacing `'DRVR'`s, you must use a private hand-off technique built in to your driver. Alternatively, you might consider not sharing code in this case.
4. If the existing driver is newer, you must somehow inform it that another instance of it is being created. Again, there is no Apple-defined technique for this; this information exchange is private to your driver.

In addition, drivers that implement code sharing must reference count the code in order to support close and purge correctly.

The Pros and Cons of Code Sharing

Code sharing has one big advantage: it reduces memory usage if two devices controlled by your driver are attached to the system. This may be especially significant for a complex device driver, such as a RAID driver.

The disadvantages of code sharing include:

- The standard library for installing `'DRVR'`s, TradDriverLoaderLib does not support code sharing. If you implement code sharing, you must do this leg work yourself.
- Supporting code sharing significantly complicates the installation code path of your driver. As the installation code is run very early in the startup sequence, bugs in that code are often very hard to debug.
- Drivers that use code sharing cannot be reopened.

Managing Drive Queue Elements

The Basics

The drive queue and its associated drive queue elements are documented in Inside Macintosh: Files, page 2-85. However, that document does not describe how drive queue elements are created, installed, removed, and destroyed.

Your disk driver must add a drive queue element for each file system partition on each disk it controls. The strategy you use for managing drive queue elements is largely up to you, within some basic constraints. Drive queue elements must be allocated in the system heap, primarily so that they persist throughout the life of the system but also, in the case of paging devices, so that they are held resident in memory. Typically, your driver is responsible for creating and disposing the drive queue elements under your control.

One popular technique for managing drive queue elements is to extend the `DrvQEl` data structure with the extra per-drive storage needed by your driver. This makes it easy for you to find your per-drive storage structure given either the `DrvQElPtr` (just cast the `DrvQElPtr` to a pointer to your per-drive storage structure) or the drive number (search the drive queue looking for that drive number, which gives you the `DrvQElPtr`, and then proceed as before).

Another important thing to remember about drive queue elements is that the system requires that you implement four flag bytes immediately before the first field of the `DrvQEl`. You can choose to either define these flags as part of your per-drive storage structure (which complicates the cast between it and a `DrvQElPtr`), or just handle those flags as a special case.

When creating a drive queue element, you must first decide on the drive number for the new drive. The algorithm to find a free drive number is very simple: start with drive number 5 (or, by convention, 8 if you're a hard disk driver), check to see whether it is in use, and if so, increment the number and try again.

IMPORTANT:
This algorithm must be run at system task time to work reliably.

Note:
Drive numbers below 5 are reserved. A third-party disk driver should not use drive numbers less than 5 except in special circumstances. As an example, a floppy disk driver that provides high-fidelity emulation of Apple's ".Sony" driver, might want to use drive number 1.

Once your driver has created a drive queue element, it can put it in the drive queue with the system routine `AddDrive`. `AddDrive` is a very thin wrapper around `GetDrvQHdr` and `Enqueue`. It is not strictly necessary to use this routine, but it may be convenient.

IMPORTANT:
Prior to Mac OS 8.5, the PowerPC glue for `AddDrive` in InterfaceLib was broken. The MoreInterfaceLib module of the DTS MoreIsBetter sample shows how to correctly call `AddDrive` from PowerPC code.

Once your driver has created a drive queue element, it should inform the system of its existence, as described in Cooperating with File System Manager.

Removing a Drive Queue Element

Removing a drive queue element is somewhat more convoluted than adding one. The basics are very simple. The system doesn't define a `RemoveDrive` routine; you must remove a drive queue element using the code shown below. Compilable source is available as part of the MoreDisks module of the DTS sample code library MoreIsBetter.

```
extern pascal OSErr MoreRemoveDrive(DrvQElPtr drvQEl)
{
    OSStatus err;

    if ( MoreVolumeMountedOnDrive(drvQEl->dQDrive, false) == 0 ) {
        err = Dequeue( (QElemPtr) drvQEl, GetDrvQHdr());
    } else {
        err = volOnLinErr;
    }
    return err;
}
```

WARNING:
You must **never remove a drive queue element for a drive which has mounted volumes**. Doing so will cause the system to crash, with possible data loss.

WARNING:
You should **never add or remove drive queue elements at interrupt time**. For a start, `AddDrive` is not documented to be interrupt safe. Furthermore, system task time code may be walking the drive queue, looking at elements in the queue. If your interrupt-time code removes the drive queue element while system task time code is looking at it, the system may crash.

It is also important to remember that, if your disk driver can be called asynchronously, it is possible for even synchronous requests to be executed at interrupt time. See Technote 1067, "Traditional Device Drivers: Sync or Swim."

Consequently, your driver should never add or remove a drive queue element except in its Open or Close entry point, or in response to an immediate request that it knows was made at system task time, such as an `accRun` Control request. In particular, it is **not safe for your disk driver to remove a drive queue element as part of handling an `kEject` Control request**.

If your disk driver needs to remove a drive queue element, it must mark the drive queue element as "to be removed" and set `dNeedTime` in its `dCtlFlags`. When it receives the `accRun` Control request, it must walk the drive queue looking for drives it owns that are marked as "to be removed" and remove them there. The DTS sample AsyncDriverSample shows a correct implementation of this.

Drive Queue Strategies

While removing a drive queue element is relatively simple, deciding on a strategy for when to remove the drive queue element is not. The key is how you handle the `kEject` Control request. The two common strategies are described below.

Real Block Device

If your disk driver controls some real piece of hardware (for example, a floppy drive, a SCSI ejectable disk device, a SCSI fixed disk device), you should not remove the drive queue element when the user ejects the disk. You should leave the drive queue element in the queue so that, when the user reinserts the disk, you can post a "disk inserted" event for it. This simplifies your life and ensures that your drive's drive number is relatively stable.

This approach may seem a little strange for fixed disks, but it works just fine. Fixed disks are typically not marked as ejectable, so the user can not really eject a fixed disk; they simply unmount the volume mounted on it. This is useful for programs (for example, a disk recovery program) which want to unmount a volume, perform some low-level activity on the disk, and then remount the volume. To remount the volume, the program can simply call `PBMountVol` for the old drive number. This technique would not be possible if the fixed disk driver removed its drive queue elements when the disk was ejected.

Note:
The Alias Manager remounts volumes in this way, which is very convenient for the user. The user can unmount a volume by dragging it to the Trash and later remount it by simply double-clicking an alias to the volume.

So leaving fixed disk drive queue elements in the drive queue is not only safe, it is also convenient.

IMPORTANT:
One important exception to the above is removable disks with multiple partitions. For example, if the users ejects a disk with three partitions and then inserts a disk with a single partition, you should remove the two extra drive queue elements (at system task time) before informing the system about the new disk.

Virtual Block Device

If you are writing a disk driver for some virtual block device (like a RAM disk, or a disk image, or a block-oriented network protocol), your job is more complex. In the simple case, if the disk is ejected when there is no volume mounted on it, you should remove the drive queue element, as explained in the previous section.

However, if the disk is ejected while there is still a volume mounted on it, you must take special action to avoid the disk switch dialog asking the user to insert the virtual disk. [The "Please insert disk RAM Disk" disk switch dialog is particularly amusing or annoying depending on how much caffeine you've had that day.] There are two common ways to prevent this:

1. Non-Ejectable -- You can mark your virtual drive as non-ejectable. This is probably the easiest and most sensible approach. It can; however, have problems when running with virtual memory enabled on older systems. Old versions of the Virtual Memory Manager assume that any local, non-ejectable drive is eligible for paging. This may not be true for your virtual block device driver (especially if it relies on the network). Modern versions of the Virtual Memory Manager (starting with Mac OS 8.1) query the drive, via Driver Gestalt (`kdgVMOptions`), to see whether the drive is really suitable for paging. However, for older systems, the only recourse you have is to make your drive as ejectable.
2. Auto Reinsert -- If you are forced to mark your virtual drive as ejectable, the following algorithm will ensure that you remove the drive queue element when appropriate and never have an ejected drive with a volume mounted on it:
   1. When you receive the `kEject` Control request, mark the drive as not having a disk in place and set the `dNeedTime` bit in the `dCtlFlags`.
   2. When the system sends you an `accRun`, walk the drive queue looking for any of your drives which are marked as not having a disk in place.
   3. For those drives, walk the system VCB queue looking for a volume that has been ejected but was previously mounted on that drive.
   4. If you find such a volume, post a "disk inserted" event for that drive. This will remount the volume back on the drive.
   5. If you don't find such a volume, remove the drive queue element for that drive.

   The DTS sample AsyncDriverSample implements this algorithm.

Hot Swapping

The Mac OS I/O subsystem is evolving towards more support for hot-swappable devices. Modern I/O buses, like USB and FireWire, fully support the addition and removal of devices while the system is running.

Unfortunately, other parts of Mac OS are not as friendly to the hot swapping of devices. For disk devices, hot swapping is a relatively new idea, and Mac OS support for hot swappable disk devices is limited. While it is possible to add new drives on the fly, removing a drive while there is a volume mounted on it will cause the system to crash, with possible loss of user data.

There are two basic strategies for handling a disk device being unplugged unexpectedly.

1. Put It Back -- If possible, your disk driver should stop the system and post a dialog telling the user to replace the disk device. This dialog should have no OK or Cancel buttons; the user must replace the device to continue using the system and the dialog should auto-dismiss when the device is reattached. This is tricky to implement, for the following reasons.
   - In most cases, the notification that a device has been removed happens at interrupt time, and it is unsafe to pose a standard Dialog Manager dialog at interrupt time. You can defer the dialog until your next `accRun`, but you may receive I/O requests before you are issued an `accRun`, and you must be prepared to handle those I/O requests at interrupt time.
   - Some I/O families are not capable of handling reconnections at interrupt time.
   - Some block devices are not tagged with a unique ID so, even if the device is reconnected, there is no way to guarantee that it is the same device.
2. Error Everything -- Your device driver should simply fail all I/O requests with the error `driverHardwareGoneErr` (-503). In Mac OS 9.0 and higher, the File Manager recognizes this error and responds in the following way.
   - It sets the `kVCBFlagsHardwareGoneBit` in the `vcbFlags` field of the Volume Control Block (`VCB`).

  - It posts a Notification Manager alert saying, "The device for disk 'MyDiskName' was unexpectedly disconnected. To prevent data loss, always use the Finder to 'Put Away' a disk before disconnecting its disk device."
  - At system task time, it walks the volume list looking for volumes that have the `kVCBFlagsHardwareGoneBit` bit set and puts them offline.
3. This approach is similar to that taken by the AppleShare external file system when the connection to the server tears.

In some cases, your I/O family may provide support for the hot unplugging of disk devices. For example, if your device is connected via the media bay, the system will automatically put up a "put it back" dialog for you, and if your device is connected via FireWire, you can use the `FWWaitForDeviceRePlug` routine to wait for a device to be reconnected.

Note:
The media bay uses the System Error Handler to display its dialogs. The system error codes used by the media bay are documented in "Errors.h", namely:

System Error Code	English Text (Mac OS 8.5)
`dsMBFlpySysError`	Please reinsert the Floppy Drive module now.
`dsMBATASysError`	Please reinsert the Disk Drive module now.
`dsMBATAPISysError`	Please reinsert the CD-ROM module now.
`dsMBExternFlpySysError`	Please reconnect the Floppy Drive module now.

You might think to use the same technique as the media bay but this is unsatisfactory for a number of reasons:

- It is not supported by DTS.
- The System Error Handler uses QuickDraw to display its dialogs. Calling QuickDraw at interrupt time is illegal, and therefore calling `SysError` at interrupt time is illegal. This is a known compromise in the design of `SysError` and is acceptable because, when you're handling a real system error, the system is already in a precarious state. However, using `SysError` as part of the standard operation of your disk driver is asking for trouble.

In the absence of an I/O family-specific solution, the best compromise solution is to implement the following algorithm:

- When you are notified of a device being disconnected, check whether there is a volume mounted on any of its drives. If there isn't a volume mounted on any of its drives, all is well; you can simply wait for the next `accRun` to remove the device's drive queue elements. If there is a volume mounted, set a flag in your per-drive storage.
- If you receive an I/O request while that flag is set, fail the request with `driverHardwareGoneErr` error. On Mac OS 9.0 or above, this is a sufficient response. On earlier systems, you should also:
  - At `accRun` time, look through for drives owned by your driver which have the flag set. For each missing device, post a Dialog Manager dialog that requires the user to reattach the device. Once the device is reattached, clear the flag and return from your `accRun` handler.
  - Post a Notification Manager alert like that described above.

Close and Purge

For maximum friendliness, your driver must support being closed. This section explains how to support the Close request properly in you disk driver and how a formatting utility might use this to allow a disk to be reformatted without rebooting.

Supporting Close in Your Driver

Your driver must support the Close request properly. This requirement was documented a long time ago and is as true today as it ever was.

Your driver's Close entry point should attempt to undo all the things that its Open entry point did, including the tasks listed below.

1. Check to see whether there are volumes mounted in any of the drives controlled by the driver. Code for doing this is shown below. If there are, the Close should fail with a `closErr`.

```
extern pascal SInt16 MoreVolumeMountedOnDrive(SInt16 drive,
                                    Boolean ejectedIsMounted)
{
    SInt16 result;
    VCBPtr thisVCB;

    result = 0;
    thisVCB = (VCBPtr) GetVCBQHdr()->qHead;
    while (thisVCB != nil && result == 0) {
        if (thisVCB->vcbDrvNum == drive ||
                (ejectedIsMounted &&
                 thisVCB->vcbDrvNum == 0 &&
                 thisVCB->vcbDRefNum == drive
                )
           ) {
            result = thisVCB->vcbVRefNum;
        } else {
            thisVCB = (VCBPtr) thisVCB->qLink;
        }
    }

    return result;
}
```

1. Terminate all asynchronous operations and remove any interrupt handlers. Your Close entry point is always called immediately at system task time, so it is safe to "spin wait" (that is, synchronously wait) for asynchronous operations to complete.
2. Remove all of its drive queue elements from the drive queue. The system supplies a routine for adding a drive queue elements (`AddDrive`), but not one to remove them. The code for removing a drive queue element is shown earlier.
3. Unregister with any system services with which it registered. Typically, this includes SCSI Manager or ATA Manager, Power Manager, and Shutdown Manager.
4. Free any memory allocated by the driver, including the `dCtlStorage`.

If it is absolutely impossible to complete any of these steps, the driver should return `closErr` and continue as if the close had not been requested.

In addition, your driver may choose to implement the `kdgPurge` Driver Gestalt selector. The response to this selector is a `DriverGestaltPurgeResponse`, as shown below.

```
struct DriverGestaltPurgeResponse {
    UInt16  purgePermission;
    UInt16  purgeReserved;
    Ptr     purgeDriverPointer;
};
typedef struct DriverGestaltPurgeResponse DriverGestaltPurgeResponse;
```

If your driver responds to this selector, it must fill out the fields of the response as follows:

`purgePermission`
: Three bits in this field are defined below. You should set them as appropriate for your driver. The remaining bits are reserved and must be set to zero.

`purgeReserved`
: Reserved. Must be set to zero.

`purgeDriverPointer`
: A pointer to the memory block containing your driver's code. You must set this to a valid Memory Manager pointer if you return `kmOkCloseOkPurge` in the `purgePermission` field.

The bits in the `purgePermission` field are defined as follows:

`kbCloseOk`
: Set this bit if your driver correctly handles the Close request, as described above.

`kbRemoveOk`
: Set this bit if your driver can be removed from the unit table with `DriverRemove`. Usually this is safe if you installed your driver using `DriverInstall` or `DriverInstallReserveMem` (assuming your driver is pointer based, which all disk drivers should be).

`kbPurgeOk`
: Set this bit if you can supply a pointer to a single Memory Manager pointer block that contains your driver code and that can be disposed to free the memory used by your driver's code. If you set this bit, you must set `purgeDriverPointer` to be that pointer. If your driver supports code sharing, you must only set this bit if there is only one instance of your driver remaining in the unit table.

Of the eight possible combinations of these three bits, only three make any real sense. There are symbolic constants for these three useful combinations (`kmNoCloseNoPurge`, `kmOkCloseNoPurge` and `kmOkCloseOkPurge`).

Note:
If you set `kbRemoveOk` without setting `kbPurgeOk`, anyone closing your driver is guaranteed to leak the memory containing your driver's code (unless you use code sharing).

Supporting Reopen

If your driver supports close, it should also support being reopened. There are circumstances under which third party software wants to close your driver, take control of the device, and then restore the normal function of your driver. This is only possible if your driver supports reopen.

IMPORTANT:
Most existing SCSI and ATA drivers do not support reopen. There is no well-documented way of determining whether a driver supports reopen. Software that relies on the ability to reopen disk drivers should warn the user that the reopen may not work, preferably before closing the driver.

Most existing disk drivers perform their driver initialization code in their Install routine and do nothing in their Open entry point. A typical SCSI driver's initialization code is as follows.

```
on install
                  install driver into unit table
    scan partition map
    create a drive queue element for each partition
    'open' driver by marking it open in the DCE
end install

on open
    return noErr
end open
```

The problem with this approach is that it does not allow clients to reopen the driver after closing it. A better approach is shown below.

```
on install
    install driver into unit table
    rename driver to a unique name
    open driver using OpenDriver
end install

on open
    scan partition map
    create a drive queue element for each partition
end open
```

WARNING:
SCSI disk driver lore requires that a driver's installation routine not use the `OpenDriver` routine to open the driver. Instead, the driver installation routine was expected to put the driver in the unit table and then mark the driver as open by setting the `dOpened` bit of the DCE's `dCtlFlags`. This was because the implementation of `OpenDriver` in old ROM's would touch the Resource Manager (and hence the File Manager) even when the driver already existed in the unit table. DTS believes that this is only necessary on ancient Macintosh ROMs and modern drivers should install themselves using `OpenDriver`.

Note:
Many device driver writers guard against their Open entry point being called multiple times. This is unnecessary for 68K drivers. Once your 68K driver is marked as open (bit `dOpened` is set in the DCE's `dCtlFlags`), further calls to `OpenDriver` will simply return `noErr` without calling your driver's Open entry point.

This is not true for native drivers, where opens and closes are reference counted by the Device Manager. For a native driver, a second call to `OpenDriver` will result in your driver being sent another `kOpenCommand` request.

Note:
If your driver uses code sharing, it is impossible to support reopen properly because all instances of your driver in the unit table will have the same name, and the `OpenDriver` routine only allows you to open a driver by name.

Hostile Takeovers

There are circumstances under which software wants to remove the driver for a disk at runtime. For example, a formatting utility might want to reformat a disk which was previously controlled by another driver. If the driver controlling the disk is written by you, it is easy to coordinate this takeover. On the other hand, if the driver controlling the disk is unknown to you, taking over the disk is tricky to do safely. This process is known as a **hostile takeover**.

Note:
Do not use the term "hostile takeover" in your user interface. It is likely to scare and confuse users.

To initiate a hostile takeover of a device, you must take the following steps.

1. Warn the user that you are attempting something that risks both crashing and data loss.
2. Verify that there are no volumes mounted on drives controlled by the device. Do this by iterating through the mounted volumes (by making indexed calls to `PBHGetVInfo`) checking that `ioVDRefNum` is not equal to the driver reference number of the driver in question. If there are volumes mounted using the driver, you may want to unmount the volumes yourself using `PBUnmountVol`.
3. If the driver supports Driver Gestalt, issue a `kdgPurge` Driver Gestalt request. If this succeeds, you can check the `purgePermission` to see whether the driver supports the Close request. If it doesn't, a hostile takeover is not possible without restarting.
4. Call `CloseDriver` to close the driver, which returns one of the following results.
    1. `noErr` -- The driver closed successfully. Continue with the next step.
    2. `closErr` (or any other error) -- The driver could not be closed. A hostile takeover is not possible without restarting.

Note:
Never close a driver with `FSClose` or `PBClose`. If you're closing a driver, always use `CloseDriver`. Similarly, if you're opening a driver, always use `OpenDriver`. These routines provide the correct glue to the `_Open` and `_Close` traps to ensure that you are acting on a driver, not a file, or a desk accessory, or a slot driver.

1. Just to be certain, you should check whether any drive queue elements belonging to the driver remain in the drive queue. If there are, the driver's implementation of the Close request is broken and a hostile takeover is not possible without restarting.
2. If you issued a `kdgPurge` request (step 3 above) and `kbRemoveOk` was set in the `purgePermission` response, you can call `DriverRemove` to remove the driver from the unit table. If the driver doesn't support Driver Gestalt, or `kbRemoveOk` is not set, the hostile takeover is complete. The driver is still installed in the unit table but it should be a relatively benign memory leak.
3. If you issued a `kdgPurge` request (step 3 above) and `kbPurgeOk` was set in the `purgePermission` response, you can call `DisposePtr` on `purgeDriverPointer` to remove the driver's code from memory. If the driver doesn't support Driver Gestalt, or `kbPurgeOk` is not set, the hostile takeover is complete. The driver code is still in memory but it should be a relatively benign memory leak.

Note:
You might think that you can just dispose `dCtlDriver`, but that is not correct. `dCtlDriver` may not be a valid Memory Manager pointer. Specifically, for SCSI and ATA drivers, `dCtlDriver` typically points some number of bytes into the pointer block.

If a hostile takeover is not possible without restarting -- or the user declines your offer to attempt one -- you are forced to restart the computer to take over the disk. You can overwrite the DDM to eliminate all foreign drivers from the disk and then restart the computer. Because there are no drivers in the DDM, the disk will not be mounted and you will be free to use it as you wish.

IMPORTANT:
Do not expect any data on the disk to survive this operation. While most drivers use the standard partition format, there are some non-standard partition formats (such as RAID striping) for which the driver is the only thing that "holds it all together". In those cases, eliminating the driver typically eliminates the data. The only way around this is to treat each of the common RAID formats as a special case in your hostile takeover software.

Note:
Some third-party formatting utilities implement a more powerful but less safe approach to hostile takeovers. Specifically, if the check for orphaned drive queue elements (step 5 above) fails, the utility simply dequeues the orphaned drive queue elements and unregisters the drives with the appropriate manager. This technique works in most cases, although it leaks memory (the orphaned drive queue elements) and may potentially cause a system crash. If you implement this technique, be sure to warn the user of the possible consequences.

File Exchange (né PC Exchange)

Foreign file systems (such as File Exchange) require your disk driver to do extra work to support the mounting of non-HFS volumes. While this extra work is not hard, it has been poorly documented. This section explains the correct way to support foreign file systems in your disk driver.

Note:
For an in-depth explanation of the whole volume mounting process, see Partition Handling: Background and Rationale later in this section.

Cooperating with File System Manager

There are two steps you must take to fully support File System Manager in your disk driver. The first step is to support the File Exchange interface, which is described in the next section. The second step is related to the way your disk driver scans a bus and creates drive queue elements for devices on that bus. Your current algorithm might look something like that shown below.

```
on scanForDevices
  scan bus for devices
  for each device found on the bus
    if the disk contains an Apple partition map
      for each partition on the disk
        if kPartitionIsMountedAtStartup is set in pmPartStatus
          if the partition is of type "Apple_HFS"
            create a drive queue element with FSID of 0
            post a "disk inserted" event
          end-if
        end-if
      end-for
    end-if
  end-for
end scanForDevices
```

To cooperate with FSM, you should modify this algorithm to the one shown below.

```
on scanForDevices
  clear InformFSM flag
  scan bus for devices
  for each device found on the bus
    if the disk contains an Apple partition map
      for each partition on the disk
        if kPartitionIsMountedAtStartup is set in pmPartStatus
          if the partition is of type "Apple_HFS"
            create a drive queue element with FSID of 0
            post a "disk inserted" event
          else if the partition is of a known non-disk type
            do nothing
          else
            create a drive queue element with FSID of fsmGenericFSID
            set InformFSM flag
          end-if
        end-if
      end-for
    else
      create a drive queue element with FSID of fsmGenericFSID \
             that encompasses the entire drive
      set InformFSM flag
    end-if
  end-for
  if InformFSM flag
    call InformFSM(fsmDrvQElChangedMessage)
  end-if
end scanForDevices
```

IMPORTANT:
`InformFSM` is a generic utility routine by which your disk driver can send messages to FSM. It is documented in Guide to the File System Manager.

The basic algorithm, as shown above, is surprisingly easy. However, complications arise if your disk driver might load before FSM. This can happen in the following circumstances:

1. If your disk driver is loaded out of a driver partition in a partition map.
2. If your disk driver loads from a system extension on an old system. Systems prior to System 7.5 did not have FSM in the System file, so FSM loaded at INIT time. The system extension which loads your driver might run before the one loading FSM.

Note:
There are two common cases where FSM might load from a system extension:

1. Early versions of PC Exchange contain an equally early version of FSM embedded in the extension. When PC Exchange loads, it checks to see whether FSM is already present in the system. If it isn't, it loads the embedded version of FSM.
2. FSM plug-in developers can license a system extension, "File System Manager", to install with their FSM plug-in on older systems.

If your disk driver loads before FSM, the above algorithm has a number of problems. Firstly, `InformFSM` is not implemented until FSM loads, so calling it would be bad. Secondly, the support for `fsmGenericFSID` is implemented by FSM, so creating a drive queue element with that FSID is a bad idea unless FSM is installed.

The solution to this is to defer both activities until FSM loads. If system startup completes without FSM loading, you simply do not perform these steps. You can poll for both of these events in your driver's `accRun` handler. The new algorithm is shown below.

```
on scanForDevices
  determine whether FSM is installed
  clear InformFSM flag
  scan bus for devices
  for each device found on the bus
    if the disk contains an Apple partition map
      for each partition on the disk
        if kPartitionIsMountedAtStartup is set in pmPartStatus
          if the partition is of type "Apple_HFS"
            create a drive queue element with FSID of 0
            post a "disk inserted" event
          else if the partition is of a known non-disk type
            do nothing
          else
            if FSM available
              create a drive queue element with FSID of fsmGenericFSID
            end-if
            set InformFSM flag
          end-if
        end-if
      end-for
    else
      if FSM available
        create a drive queue element with FSID of fsmGenericFSID \
               that encompasses the entire drive
      end-if
      set InformFSM flag
    end-if
  end-for
  if InformFSM flag
    if FSM available
      call InformFSM(fsmDrvQElChangedMessage)
    else
      set gPollForFSM
      set dNeedTime in dCtlFlags
    end-if
  end-if
end scanForDevices

on accRun
  if gPollForFSM
    if FSM available then
      call scanForDevices again
      clear gPollForFSM
      clear dNeedTime in dCtlFlags (unless you need it for other reasons)
    else if startup time is over
      clear gPollForFSM
      clear dNeedTime in dCtlFlags (unless you need it for other reasons)
    end-if
  end-if
end accRun
```

Note:
You can determine whether system startup is complete using the technique described in Disk Drivers and the System Heap.

For more information about why this algorithm is necessary, see Partition Handling: Background and Rationale.

Finally, if you mount a large number of disks simultaneously, you may run afoul of the system event queue's size limit. On current systems (Mac OS 9.0), the system event queue is limited to 48 events. If the system event queue is full and you post a "disk inserted" event, the event is ignored. There are two aspects to this problem:

1. If you explicitly posted the "disk inserted" event by calling `PostEvent`, you will find that an event posted while the event queue is full will cause the first event in the queue to be dropped. `PostEvent` will not return an error to indicate that an event was dropped.
2. You also receive no notification that the event queue is full if you implicitly post "disk inserted" events by calling `InformFSM` with the `fsmDrvQElChangedMessage` selector.

There is a simple algorithm that handles both of these cases:

1. When a drive is ready for operation (its disk has just been inserted, or you detected it during your initial scan for devices), set a flag in your per-drive storage to indicate that a "disk inserted" event is pending.
2. Inform the system that the disk was inserted as described above (either by posting a "disk inserted" event or by calling `InformFSM` with the `fsmDrvQElChangedMessage` selector).
3. When any I/O is done to the drive, clear the disk inserted pending flag. I/O to the drive indicates that some file system has queried the drive to determine whether to mount a volume on it, which implies that the "disk inserted" event was successfully processed.
4. At `accRun` time, check for any drives with the disk inserted pending flag still set. If you find one it is likely that the "disk inserted" event was lost, so you should reinform the system of the disk insertion.

Implementing File Exchange Support

This section describes how you should implement the File Exchange interface in your disk driver.

Note:
The requests described here have been documented in a number of places, including Designing PCI Cards and Drivers for Power Macintosh Computers, page 114, and "PCX and Large Volume Drivers." However, none of the previous descriptions are sufficiently detailed for you to implement the requests correctly.

Implementing Driver Gestalt kdgAPI

A disk driver that supports the following Control and Status requests must implement the `kdgAPI` selector to indicate that it does. For more information about Driver Gestalt, see the Driver Gestalt section of this technote.

Partition Information Record

The partition information record (`partInfoRec`) is a structure used to store information about a partition on a disk. The fields of the structure are:

`SCSIID`
: If the underlying device is connected via a SCSI interface, this field holds the SCSI Manager `DeviceIdent` of the device. If the device is connected via an ATA interface, this field holds the ATA Manager `ataDeviceID` (a structure defined in ATA 0/1 Software Developers Guide). Devices connected via other interfaces can use whatever value makes sense to uniquely identify the device on that bus (typically this is the same 32-bit number returned by the `kdgDeviceReference` Driver Gestalt selector). If no value makes sense, a driver must clear this field.

`physPartitionLoc`
: The block number of the first block in the partition.

`partitionNumber`
: The physical block number of the partition map entry of this partition.

Note:
You can determine the interface used by the device issuing the `kdgInterface` Driver Gestalt query. Drivers that support File Exchange should also support this Driver Gestalt selector.

Note:
For more information about the `ataDeviceID` structure, consult the ATA Device 0/1 Software Developer Guide. This structure is not the same as the `DeviceIdentATA` structure, defined above.

Creating a New Drive Queue Element

Trap	`_Control`
Mode	Synch, Async, Immediate

`csCode`	`SInt16`	->	`kGetADrive` (51)
`csParam[0..1]`	`DrvQElPtr *`	->	On input, contains the address of a drive queue element pointer. The request creates a new drive queue element based on the supplied drive queue element and places a pointer to the new drive queue element in the supplied address.

In response to this request, your disk driver must create a new drive queue element. The fields of the new drive queue element must be filled out as described below.

drive flags (the 4 bytes prior to `qLink`)
: Inherited from the supplied drive queue element.

`qLink`
: Set up when you add the drive to the drive queue using `AddDrive`.

`qType`
: Inherited from the supplied drive queue element.

`dQDrive`
: Must be set to a new unique drive number.

`dQRefNum`
: Must be set to your driver's reference number.

`dQFSID`
: Inherited from the supplied drive queue element.

`dQDrvSz`
: Inherited from the supplied drive queue element.

`dQDrvSz2`
: Inherited from the supplied drive queue element.

partition offset (typically held in extra bytes beyond `dQDrvSz2`)
: Inherited from the supplied drive queue element.

Your driver must return the new drive queue element in the memory pointed by `csParam[0..1]`. You must not post a "disk inserted" event for the new drive, or send the `fsmDrvQElChangedMessage` message to FSM.

IMPORTANT:
This request is typically issued as a synchronous request, which can cause problems if your driver needs to allocate memory to create the new drive queue element. To avoid this problem, DTS recommends that all clients issue this as an immediate request. However, to work with old clients, your driver should be prepared to handle all possible request modes.

IMPORTANT:
Your driver should be prepared for the incoming value of the drive queue element pointed to by `csParam[0..1]` being nil, or some other value which is not a pointer to one of your driver's drive queue elements. In that case, your driver should initialize the fields of the new drive queue element to default values.

Changing the Partition of a Drive Queue Element

Trap	`_Control`
Mode	Synch, Async

`csCode`	`SInt16`	->	`kRegisterPartition` (50)
`csParam[0..1]`	`DrvQElPtr`	->	The drive queue element whose partition is to be changed
`csParam[2..3]`	`UInt32`	->	The block number of the first block in the partition
`csParam[4..5]`	`UInt32`	->	The size (in blocks) of the partition

In response to this request, your disk driver must retarget the specified drive queue element to represent the given partition on the disk. After this request, the drive queue element must represent a partition that starts at the block specified by `csParam[2..3]` and is of the size specified by `csParam[4..5]`.

You must not post a "disk inserted" event for the drive, or send the `fsmDrvQElChangedMessage` message to FSM.

IMPORTANT:
The effects of this request are limited to the drive queue element in memory. This request must not change the partitioning scheme on the disk.

Preventing a Partition from Mounting

Trap	`_Control`
Mode	Synch, Async

`csCode`	`SInt16`	->	`kProhibitMounting` (52)
`csParam[0..1]`	`partInfoRec *`	->	A pointer to a `partInfoRec` that describes the partition which is not to be mounted at startup

In response to this request, your disk driver must mark the partition specified `csParam[0..1]` such that it isn't mounted at system startup.

IMPORTANT:
The effects of this request are permanently applied to the partition map on the disk.

Note:
Modern versions of File Exchange do not require your driver to support this request (partly because it is functionally equivalent to kClearPartitionMount). If you decide not to support it, make sure to return `controlErr`.

Note:
The partition is completely determined by the fields of the partition information record, not by the `ioVRefNum` field of the parameter block.

Determining the Partition of a Drive

Trap	`_Status`
Mode	Synch, Async

`csCode`	`SInt16`	->	`kGetPartInfo` (51)
`ioVRefNum`	`SInt16`	->	The drive number of the drive whose partition information is requested
`csParam[0..1]`	`partInfoRec *`	->	A pointer to a `partInfoRec` where the partition information is placed

In response to this request, your disk driver must place partition information about the specified drive in the partition information record pointed to by `csParam[0..1]`.

Note:
Your driver's response to this request has a non-obvious effect on the Disk Initialization Package, especially the `DIReformat` call. The Disk Initialization Package prevents the user changing the file system on a drive that exists on a partitioned disk. It does this to prevent the data on the partition getting out of sync with the partition type (`pmParType`) in the partition map entry. For example, if the user could reformat an existing HFS partition to be in DOS FAT format, the partition data would be in DOS FAT format while the `pmParType` would still be "Apple_HFS". This is obviously not a good thing (the ROM might attempt to boot from a DOS FAT partition!), so the Disk Initialization Package prevents it.

This raises the question, how does the Disk Initialization Package know whether a drive is a partition on a disk. The algorithm used is shown below.

```
on driveIsAPartition drive
  if drive's driver supports File Exchange requests (kdgAPI)
          and kGetPartInfo on drive succeeds then
    return physPartitionLoc != 0
  else
    return drive's driver's unit number in [32..39]
  end-if
end driveIsAPartition
```

The gist of this algorithm is that, if your driver supports File Exchange requests, the drive's partition must start at the beginning of the disk for the Disk Initialization Package to allow a change of format. Alternatively, if your driver does not support File Exchange requests, it is considered to have partitions if its unit number falls in the range reserved for classic SCSI Manager drivers.

If other demands on your driver prevent it from being reformatted by the above algorithm, you will probably need to include reformat support in your formatting utility.

DTS has requested a better solution to this problem [Radar ID 2287925].

Determining Whether a Partition is Mounted

Trap	`_Status`
Mode	Synch, Async

`csCode`	`SInt16`	->	`kGetPartitionStatus` (50)
`csParam[0..1]`	`partInfoRec *`	->	A pointer to a `partInfoRec` that describes the partition to be queried
`csParam[2..3]`	`SInt16 *`	->	A pointer to an `SInt16`. On return, this holds the `vRefNum` of the volume represented by this partition, or 0 if no volume is represented by this partition.

In response to this request, your disk driver must determine whether the partition described by the partition information record pointed to by `csParam[0..1]` is mounted and return the volume reference number of the volume in the `SInt16` pointed by `csParam[2..3]`, or 0 if the partition is not mounted.

Note:
The partition is completely determined by the fields of the partition information record, not by the `ioVRefNum` field of the parameter block.

Using These Requests

This section explains how you might utilize the File Exchange driver requests in your application (or FSM plug-in) to access portions of a partitioned disk that lie outside of the HFS partitions.

WARNING:
Many of the File Exchange driver requests require you to pass a pointer to a buffer. As explained in Private Requests and Virtual Memory, you must hold these buffers (in the VM sense) to prevent fatal page faults.

Note:
This section contains a number of routines which demonstrate the use of the File Exchange interface. Some of the details have been removed for brevity. Moreover, the routines rely on other utility routines that are not included here. The full source code for these routines is available in the MoreDisks module of the DTS MoreIsBetter sample code library.

The first step of using the File Exchange interface is to create a drive queue element that targets the section of the disk you wish to read or write. The following code snippet shows how this might be done.

```
extern pascal OSErr MoreCreateNewDriveQueueElement(SInt16 driveToClone,
UInt32 firstBlock, UInt32 sizeInBlocks, SInt16 *newDrive)
    // See comment in interface part.
{
    OSErr err;
    CntrlParam pb;
    DrvQElPtr drvQEl;

    // First check that the driver supports the File Exchange
    // interface.

    err = noErr;
    if ( ! MoreDriveSupportFileExchange(driveToClone) ) {
        err = controlErr;
    }

    // Find the drive queue element associated with
    // driveToClone.  This is an input parameter to
    // kGetADrive.

    if (err == noErr) {
        err = MoreUTFindDriveQ(driveToClone, &drvQEl);
    }

    // Make the kGetADrive request to the driver.  Because
    // we pass a pointer to memory outside of the parameter
    // block (drvQEl) and the driver might be a paging device,
    // we must hold drvQEl (and make sure to unhold it later!).

    if (err == noErr) {
        err = SafeHoldMemory(&drvQEl, sizeof(drvQEl));
        if (err == noErr) {
            pb.ioVRefNum = driveToClone;
            pb.ioCRefNum = MoreGetDriveRefNum(driveToClone);
            pb.csCode = kGetADrive;
            *((DrvQElPtr **) &pb.csParam[0]) = &drvQEl;

            err = PBControlSync((ParmBlkPtr) &pb);
            if (err == noErr) {
                *newDrive = drvQEl->dQDrive;
            }
            (void) SafeUnholdMemory(&drvQEl, sizeof(drvQEl));
        }
    }

    // Now retarget the new drive to the partition on the
    // disk specified by firstBlock and sizeInBlocks.  We do
    // this in the create call because some disk drivers
    // don't always inherit the partition information from
```

```
    // the drive that was cloned.

    if (err == noErr) {
        err = MoreSetDrivePartition(*newDrive, firstBlock, sizeInBlocks);
    }

    return err;
}
```

This routine works in two parts. First, it finds the drive queue element associated with `driveToClone` and clones it using a `kGetADrive` request to the driver. Then, it sets the new drive's partition location and size using `MoreSetDrivePartition`, which is shown below.

```
     extern pascal OSErr MoreSetDrivePartition(SInt16 drive, UInt32 firstBlock,
     UInt32 sizeInBlocks)
    // See comment in interface part.
{
    OSErr err;
    CntrlParam pb;
    DrvQElPtr drvQEl;

    // First check that the driver supports the File Exchange
    // interface.

    err = noErr;
    if ( ! MoreDriveSupportFileExchange(drive) ) {
        err = controlErr;
    }

    // Find the drive queue element associated with
    // drive.  This is an input parameter to
    // kRegisterPartition.

    if (err == noErr) {
        err = MoreUTFindDriveQ(drive, &drvQEl);
    }

    // Make the kRegisterPartition Control request.  We
    // don't need to hold any memory because all the
    // parameters to this Control request are entirely
    // contained within the parameter block.

    if (err == noErr) {
        pb.ioVRefNum = drive;
        pb.ioCRefNum = MoreGetDriveRefNum(drive);
        pb.csCode = kRegisterPartition;
        *((DrvQElPtr *) &pb.csParam[0]) = drvQEl;
        *((UInt32 *) &pb.csParam[2]) = firstBlock;
        *((UInt32 *) &pb.csParam[4]) = sizeInBlocks;

        err = PBControlSync((ParmBlkPtr) &pb);
    }

    return err;
}
```

Once you have a drive queue element that spans the blocks you're interested in, you can read and write those blocks using standard Device Manager routines, for example, `PBReadSync`. The next listing shows how this might be done.

```
static OSErr ReadBlock(SInt16 drive, UInt32 blockNumber, void *blockBuffer)
{
    OSErr err;
    IOParam pb;

    pb.ioVRefNum = drive;
    pb.ioRefNum = MoreGetDriveRefNum(drive);
    pb.ioBuffer = blockBuffer;
    pb.ioReqCount = 512;
    pb.ioPosMode = fsFromStart;
    pb.ioPosOffset = blockNumber * 512;
    err = PBReadSync( (ParmBlkPtr) &pb );
    return err;
}
```

Partition Handling: Background and Rationale

To understand the current disk driver architecture, you really need to understand the history of how it evolved, starting with the floppy disk drives on the Mac 128.

Mac 128 Disk Driver

When the original Mac shipped all disks were floppy disks, which did not support partitions. The floppy disk driver would create a single drive queue element that represented the entire disk, and the File Manager used this drive as the entire volume. There was a one-to-one translation between logical blocks on the volume (blocks that the File Manager requests) and physical blocks on the disk.

For example, on a floppy disk, if the File Manager requests block 64, the disk driver would simply return block 64.

Disk insertion was handled with the following algorithm:

1. The disk driver created a drive queue element for each physically attached floppy drive.
2. When the user inserted a disk in a drive, the driver posted a disk inserted (`diskEvt`) event for that drive.
3. The next time the application called `GetNextEvent` (a predecessor to `WaitNextEvent`), the (Toolbox) Event Manager got the "disk inserted" event and called `_MountVol`.
4. `_MountVol` only recognized built-in file systems, such as MFS and HFS. An attempt to mount an unsupported file system would cause `_MountVol` to return an error.
5. The (Toolbox) Event Manager put the error result from `_MountVol` into the high word of the `message` field of the `EventRecord`, and returned the "disk inserted" event to the application.
6. The application saw the "disk inserted" event and examined the high word of the event's `message` field. If the value was not zero, the "disk inserted" event was "bad" and the application called the Disk Initialization Package's `DIBadMount` routine. `DIBadMount` would give the user the opportunity to initialize or eject the disk.

SCSI and Partitions

The introduction of SCSI hard disk devices on the Mac Plus made this situation more complex. Hard disk devices support multiple partitions. The File Manager was not changed to recognize these partitions, so the burden of supporting partitions fell on the disk driver. When a disk is partitioned, the disk driver must read the partition map and creates a drive queue element for each HFS partition (a partition whose `pmParType` is "Apple_HFS") on the disk.

Thus, each drive queue element on a partitioned disk contains an implicit translation from logical blocks to physical blocks. For example, if you have a partition that starts at block 1024 and continues for 4096 blocks, the driver creates a drive queue element for a drive whose size is 4096 blocks. When the system reads logical block 64 on that volume, the driver knows that it must translate that to physical block 1088 (that is, 1024 + 64) on the disk.

The new disk insertion algorithm was:

1. The ROM or a system extension loaded the disk driver.
2. The disk driver parsed the partition map looking for all the partitions of type "Apple_HFS". For each found partition, the driver would create a drive queue element and post a "disk inserted" event.
3. If the driver was being loaded at system startup, the Start Manager would call `_MountVol` to mount the startup volume. It would then boot from that volume. Later, when the Finder launched and started calling `GetNextEvent`, the "disk inserted" events for other partitions would be processed.
4. If the driver was being loaded after system startup, the process would proceed as from step 3 above.

This works just fine for disks with the Apple partition map and HFS partitions, where the driver recognizes both the partition map format and the "Apple_HFS" partition map entries, and creates the appropriate drive queue elements. However, it doesn't allow foreign disk formats to be handled correctly, in two important cases.

1. **The partition map contains non-HFS partitions** (such as "Apple_PRODOS" or "Apple_UNIX_SVR2" (A/UX) partitions) -- When confronted by a non-HFS partition, the driver has a difficult choice. If it creates a drive queue element for the partition and a suitable foreign file system is not installed, the system asks the user whether they want to initialize the partition. Probably not good. On the other hand, if it doesn't create a drive queue element for the partition, there is no way for a foreign file system to access the data on the partition. To safeguard user data, most drivers choose the second alternative.
2. **The partition map format is unrecognized** -- As Mac OS loads disk drivers from a partition on the disk, it is rare that a disk driver is loaded for a non-Apple partitioned disk. However, if a driver is loaded (by a system extension, for example) for a disk with an unrecognized partition map (such as a DOS partition map), it faces the same difficult choice described above. Most drivers resolve this issue by simply not creating any drive queue elements for disks with an unrecognized partition map.

A foreign file system (such as a File System Manager plug-in) is responsible for controlling a volume mounted on a particular drive (represented by a drive queue element). If there is no drive queue element for a partition, there is no obvious way to create one. Similarly, if there is no driver for a particular disk (because the disk doesn't have an Apple partition map to load it from), there is no easy way for the foreign file system to read from or write to the disk.

File System Manager

When File System Manager was introduced, it defined a new way for disk drivers to announce the arrival of new drive queue elements. This mechanism allows disk drivers to create drive queue elements for non-Apple partitions, free from the fear of the dreaded "This is not a Macintosh disk. Would you like to initialize it?" dialog.

The new algorithm works as described below:

1. When the disk driver loads, it parses the partition map. For each partition of type "Apple_HFS", the driver creates a drive queue element and posts a "disk inserted" event. For other partition types, the disk driver creates a drive queue element whose FSID is `fsmGenericFSID` and calls `InformFSM` with the `fsmDrvQElChangedMessage` message. If it can't recognize the partition map, the driver just creates a single drive queue element whose FSID is `fsmGenericFSID` and calls `InformFSM` with the `fsmDrvQElChangedMessage` message.
2. When `InformFSM` is called with the `fsmDrvQElChangedMessage` message, FSM posts a "disk inserted" event for the drive if all the following conditions are met:
   - the drive's FSID is not zero,
   - the drive's FSID is not `fsmIgnoreFSID`,
   - the drive does not already have a volume mounted on it, and
   - the drive's FSID is `fsmGenericFSID` or the drive's FSID matches the FSID of one of the

installed FSM plug-ins.
3. Each "disk inserted" event is handled as before, except:
    1. FSM passes `_MountVol` requests to external file systems, which have the opportunity to claim the drive as a foreign volume.
    2. FSM tail patches `_MountVol`. If `_MountVol` fails and the drive on which the mount was attempted has the FSID of `fsmGenericFSID`, FSM causes `_MountVol` to return `nsDrvErr`. This error code, when passed back to the application and hence on to `DIBadMount`, causes `DIBadMount` to not display the disk initialization dialog.

The effect of these changes is that disk drivers are now free to create a drive queue element for any partition and will not trigger the Disk Initialization Package as long as they set the FSID of the drive to `fsmGenericFSID`. This goes some way to addressing problem 1, described above.

File Exchange

The final part of the solution for problem 1 is the File Exchange interface for disk drivers, as defined above. To mount non-HFS partitions in an Apple partition map, File Exchange (and by extension any FSM plug-in) uses this interface in the following way.

1. It first creates a new drive queue element by cloning an existing drive queue element using `kGetADrive`.
2. It then retargets that drive queue element to represent the partition map for the disk using `kRegisterPartition`. For an Apple partition map, this is a two-step process. First it must set the partition to start at block 0 and be 2 blocks long. This gives access to the driver descriptor map (DDM) and to the first partition map entry. It then uses the first partition map entry to determine the size of the partition map. It then retargets the drive to represent the entire DDM and partition map.
3. It then reads through the partition map looking for the required partition type. For each found partition, it creates a new drive queue element (using `kGetADrive`) and sets that drive queue element to represent the partition's data. It can then mount a volume on that drive queue element.

A similar technique can be used for non-Apple partition maps.

File Exchange also includes a partial solution to problem 2 in that it contains a generic SCSI disk driver. At startup time, File Exchange scans the SCSI bus looking for devices that contain DOS partition maps. When it finds such a device, it loads its generic SCSI driver for the device. Obviously that driver supports the File Exchange interface, which File Exchange then uses (in a similar process to that described above) to read through the DOS partition map and create drives for all the mountable DOS partitions on the disk.

This is only a partial solution because (a) it only supports SCSI and ATA devices (the system includes a generic ATA device driver), but not any other block devices, and (b) the mechanism for loading the generic SCSI driver is not documented to developers. However, as a disk driver writer, you can craft your driver to guarantee a total solution to problem 2, as described in Cooperating with File System Manager.

Private Control and Status Requests

If you define private Control and Status requests for communication with your device driver, you must follow certain rules to ensure their reliable operation. This section outlines these rules.

Private csCode Selection

If your driver claims to supports Driver Gestalt, it must not use any `csCode` below 128 for a private Control or Status request. All private `csCodes` must be allocated from the range 128 to 32767.

Private Means Private

If you implement a Control or Status request that is private to your driver, you must issue it only to your driver. Do not issue your private Control and Status requests to other drivers, because the other driver might use the private `csCode` for a completely different purpose, one that is potentially fatal to user data (such as rewriting the partition map!).

At a minimum, you must check the driver name before issuing a private Control or Status request. You may also want to perform other checks (such as verifying a signature in the driver header, or issuing a private Driver Gestalt) just to be sure.

Synchronous != System Task Time

As described in DTS Technote 1067, "Traditional Device Drivers: Sync or Swim," calling a device driver synchronously does not guarantee that the driver's entry point will run at system task time. If you are defining a Control or Status request for which your driver must do something that is not interrupt safe, you must define the request to be executed immediately.

Private Requests and Virtual Memory

If your driver supports virtual memory (you can use the `kdgVMOptions` Driver Gestalt selector to indicate this), you must be careful to avoid fatal page faults when fielding private Control or Status requests. Specifically, your driver must not cause a page fault while it is fielding a queued (that is, synchronous or asynchronous) request.

The Virtual Memory Manager holds the entire `ParamBlockRec` (80 bytes) passed to all queued `_Read`, `_Write`, `_Control`, and `_Status` calls. In addition, VM holds the I/O buffer (pointed to by `ioBuffer`, for length `ioReqCount`) for `_Read` and `_Write` requests. Thus your driver can safely access this memory without causing a fatal page fault.

The problem comes when you define a private Control or Status request whose `ParamBlockRec` contains a pointer to another piece of memory. If your driver accesses that memory, it may cause a page fault. If your driver supports virtual memory, that page fault will be fatal (because a page fault while any paging device is busy is fatal).

There are a number of ways to avoid this problem.

1. Always include all information "inline" in the parameter block. Remember that the parameter block is automatically held for you by the Virtual Memory Manager.
2. If you must include pointers in your parameter block, define your private Control or Status interface to be called immediately. Immediate requests to a driver do not mark the driver as busy, and hence any page faults they cause will not be fatal. However, your driver must be written to support immediate requests of this kind.
3. If none of the above are suitable, you must require that your clients hold any buffers pointed to by the parameter block.

If you're making a queued Control or Status request to a device driver which supports paging and the parameter block contains pointers to other data structures, you should hold those data structures, just to be sure.

For more background about how the Mac OS Virtual Memory Manager prevents fatal page faults, see DTS Technote 1094, "Virtual Memory Application Compatibility."

Read-Verify Mode

Very few disk driver writers support read-verify mode in their drivers, perhaps on the mistaken assumption that it is difficult to do. This may be because the historical definition of read-verify mode in the ".Sony" driver is tricky to implement for any DMA-based peripheral. This section explains the current definition of read-verify mode, the best way to support it in your driver, and the best way for application software to use it.

Read-Verify Mode Explained

Read-verify mode is engaged by setting `rdVerifyMask` in the `ioPosMode` field of the I/O parameter block passed to a device driver. The original definition of read-verify mode is that the driver should do a byte-for-byte comparison of the data buffer (pointed to be `ioBuffer` and `ioReqCount`) with the data on disk. If they are the same, the operation would succeed. If they are different, the operation would fail with an `ioErr`.

This was easy to implement in the classic ".Sony" driver because the driver polled all bytes in to and out of memory. So implementing read-verify mode was a simple as changing the original copy loop:

```
while ( err == noErr && ioActCount != ioReqCount ) {
    err = GetByte(ioBuffer + ioActCount);
    if (err == noErr) {
        ioActCount += 1;
    }
}
```

to a verify loop:

```
while ( err == noErr && ioActCount != ioReqCount ) {
    err = GetByte(&tmp);
    if (err == noErr && tmp != *(ioBuffer + ioActCount)) {
        err = ioErr;
    }
    if (err == noErr) {
        ioActCount += 1;
    }
}
```

This form of read-verify mode is tricky to implement in modern disk drivers, which typically use a DMA engine to transfer the data. So the definition of read-verify mode has changed, as explained in the next section.

Implementing Read-Verify Mode in Your Driver

The new definition of read-verify mode is simple to explain, and to implement in your driver. If your driver gets a read-verify request, it should treat it exactly like a read request except that it must disable all caches for the request. The data transferred into memory must have originated from the physical medium itself.

This new definition of read-verify mode still allows applications to perform read-verify operations, as explained in the next section.

Using Read-Verify Mode in an Application

It is easy to write software that uses read-verify mode in way that is compatible with both the old and new definitions. The `FSWriteVerify` routine in the DTS sample "MoreFiles" is an excellent example. The basic algorithm is as follows.

1. Write the data to the disk in the traditional way.
2. Copy the data to a temporary buffer.
3. Read the data back into the temporary buffer.
4. Compare the temporary buffer to the original data.

This works because:

- if the driver implements read-verify mode in the old way, any errors will be detected at step 3, and
- if the driver implements read-verify mode in the new way, any errors will be detected at step 4.

Color Icons

A classic problem with disk drivers is that the mechanism for returning icons from a disk driver (Control requests `kDriveIcon` (21) and `kMediaIcon` (22), documented in Technote DV 17, "Sony Driver: What Your Sony Drives for You") is limited to black-and-white icons. In Mac OS 8, the Finder was changed to look at the drive and apply special-case color icons, but there was still no generic way for a disk driver to return a color icon.

Mac OS 8.5 and later allow disk drivers to return color icons. This is done through two new Driver Gestalt selectors, `kdgPhysDriveIconSuite` (equivalent to the `kDriveIcon` (21) Control request) and `kdgMediaIconSuite` (equivalent to the `kMediaIcon` (22) Control request). To give your drives a color icon, you must respond to these Driver Gestalt requests by putting a pointer to an icon family (`'icns'`) in `driverGestaltResponse`. The icon family allows you to return any number of icon sizes and depths in one data structure.

You can build an icon family in a number of ways.

- Manually -- The format is documented in "IconServices.r". This approach is most suitable for boot disk drivers which typically statically link the icon into the driver code resource.
- Resource Editor -- Modern resource editors have been updated to edit these structures directly.
- Programatically -- The Icon Services programming interface allows you to create an icon family from an icon suite, as shown in the code sample below. This approach is more suitable for disk drivers that are loaded after the machine has started to boot, for example, network or disk image drivers.

```
static IconFamilyPtr GetRamDiskIconFamily(void)
{
    OSErr err;
    OSErr junk;
    IconFamilyPtr result;
    IconSuiteRef iconSuite;
    IconFamilyHandle iconFamily;
    Size iconFamilySize;

    result = nil;
    iconSuite = nil;
    iconFamily = nil;

    err = GetIconSuite(&iconSuite, 128, kSelectorAllAvailableData);
    if (err == noErr) {
        err = IconSuiteToIconFamily(iconSuite, kSelectorAllAvailableData, &iconFamily);
    }
    if (err == noErr) {
        iconFamilySize = GetHandleSize( (Handle) iconFamily);

        result = (IconFamilyPtr) NewPtrSys(iconFamilySize);
        err = MemError();
        if (err == noErr && result == nil) {
            err = memFullErr;
        }
    }
    if (err == noErr) {
        BlockMoveData(*iconFamily, result, iconFamilySize);
    }

    // Clean up.

    if (iconSuite != nil) {
        (void) DisposeIconSuite(iconSuite, false);
    }
```

```
    if (iconFamily != nil) {
        DisposeHandle( (Handle) iconFamily);
    }

    return result;
}
```

IMPORTANT:
Icon Services always requests icons using an immediate request at system task time. Your driver can move or purge memory in response to these requests. Be warned; however, that this immediate request can cause your driver to be reentered.

IMPORTANT:
If an application issues these Driver Gestalt requests, it must follow Icon Services and issue them using an immediate request at system task time.

Disk Driver Power Management

This section is not yet finished and has been omitted in the interests of shipping an initial version of the technote. A future revision of this technote will cover disk driver power management. In the meantime, you can consult the following references:

- *Inside Macintosh: Devices* , Power Manager
- DTS Technote 1046, "Inside Macintosh: Devices, Power Manager Addenda"
- DTS Technote 1039, "File Access and the Power Manager"

Target Mode

Most PowerBooks support **target mode** (commonly known as "SCSI disk mode"), in which the attachment of a special cable causes the PowerBook to make its internal hard disk device available as a SCSI target device. For PowerBooks that use internal SCSI hard disk devices, support for target mode requires no special work by the disk driver. The PowerBook simply stays off of the SCSI bus and the host computer has free access to the PowerBook's internal hard disk device. However, for PowerBooks that use an internal ATA hard disk device, the implementation of target mode is somewhat more complex, and requires explicit support by the ATA disk driver.

When a PowerBook with an internal ATA hard disk device boots in target mode, the CPU runs special target mode software. This software loads the ATA driver for the internal hard disk device and then puts the built-in SCSI controller into target mode, listening for incoming SCSI requests. When such a request is made, the CPU services that request by interpreting the incoming SCSI command. If the command requires disk I/O, the CPU makes an appropriate I/O request to the ATA disk driver to satisfy that I/O.

In order to support target mode, your ATA disk driver must support some additional Control and Status requests that allow the target mode software to do its job. These requests are described in the remainder of this section.

Target Mode Checklist

If your ATA disk driver is having trouble when used in target mode, check that you support the following items.

- You must support the `kdgBoot` (`'boot'`) Driver Gestalt selector as described above.
- You must return `kdgDiskType` (`'disk'`) in response to the `kdgDeviceType` (`'devt'`) Driver Gestalt selector.
- You must support the `kPhysicalIOCode` (17) Control request, described below.
- You must support the `kGetDriveCapacity` (125) Status request, described below.
- You must support the `kSetPowerMode` (70) Control request, described in Designing PCI Cards and Drivers for Power Macintosh Computers.

- You may choose to support the `kGetErrorInfo` (123) and `kGetDriveInfo` (124) Status requests, although the system will accommodate you not supporting them. See below for details of how to support these Status requests.

Required Control and Status Requests

Your ATA driver must support the Control and Status requests described in this section in order to work in target mode.

Switching to Physical I/O Mode

Trap	`_Control`
Mode	Synch, Async

`csCode`	`SInt16`	->	`kPhysicalIOCode` (17)
`ioVRefNum`	`SInt16`	->	A drive number of a drive controlled by your driver
`csParam[0]`	`UInt16`	->	Contains either 1 to specify physical I/O mode, or 0 to specify logical I/O mode

In response to this request, your disk driver must change how it does logical-to-physical block translation on the drive specified by `ioVRefNum`. If `csParam[0]` is 1, your driver must disable logical-to-physical block translations on the drive for subsequent I/O requests. In this mode, an I/O request for logical block X will always access physical block X. If `csParam[0]` is 0, your driver must re-enable logical-to-physical block translation. In this mode, an I/O request for logical block X will access physical block X + Y, where Y is the offset from the beginning of the disk of the partition represented by the drive.

For more details on logical-to-physical block translation, see Block Translation.

If `ioVRefNum` is not a drive number controlled by your driver, it must return `nsDrvErr`.

Returning Disk Size

Trap	`_Status`
Mode	Synch, Async

`csCode`	`SInt16`	->	`kGetDriveCapacity` (125)
`ioVRefNum`	`SInt16`	->	The `ataDeviceID` of your device
`csParam[0]`	`UInt16`	<-	Your disk driver must set this to the bottom 16 bits of the number of physical blocks on the device
`csParam[1]`	`UInt16`	<-	Your disk driver must set this to the top 16 bits of the number of physical blocks on the device

In response to this request, your disk driver must return the physical size (in 512-byte blocks) of the disk in the device.

IMPORTANT:
In this request, `ioVRefNum` is an `ataDeviceID`, not the more typical drive number.

If `ioVRefNum` is not an `ataDeviceID` of a device controlled by your driver, it must return `nsDrvErr`.

Optional Status Requests

Your ATA driver may support the following Status requests to improve the fidelity of SCSI target emulation.

Returning Error Information

Trap	`_Status`
Mode	Synch, Async

`csCode`	`SInt16`	->	`kGetErrorInfo` (123)
`ioVRefNum`	`SInt16`	->	A drive number of a drive controlled by your driver
`csParam[2]`	`OSErr`	<-	Your disk driver must set this to the last error that occurred on the drive
`csParam[3..4]`	`UInt32`	<-	Your disk driver must set this to the number of bytes that were transferred in the I/O request that caused the last error on the drive

In response to this request, your disk driver must return the information described above about the last error that occurred on the drive.

If `ioVRefNum` is not a drive number controlled by your driver, it must return `nsDrvErr`.

Getting Information About the Drive

Trap	`_Status`
Mode	Synch, Async

`csCode`	`SInt16`	->	`kGetDriveInfo` (124)
`ioVRefNum`	`SInt16`	->	The `ataDeviceID` of your device
`csParam[0..1]`	`void *`	<-	Your disk driver must set this to a pointer to a 20-byte structure containing ASCII text describing the attached drive; the first 16 bytes should be the model number, the next 4 bytes should be the firmware revision number

In response to this request, your disk driver must return the information described above about the attached drive. The target mode software uses this information to satisfy a SCSI Inquiry (`$12`) command.

Note:
The Apple ATA driver extracts this information from the results of an ATA `kATAcmdDriveIdentify` (`$EC`) command to the device. The model number is extracted from bytes 27 through 42 of the response. The firmware revision number is extracted from bytes 23 through 26 of the response.

IMPORTANT:
In this request, `ioVRefNum` is an `ataDeviceID`, not the more typical drive number.

If `ioVRefNum` is not an `ataDeviceID` of a device controlled by your driver, it must return `nsDrvErr`.

Summary

When the war of the giants is over, the war of the pygmies will begin.

Winston S. Churchill

This technote *is* the summary!

Further References

- See the Existing Information section of the technote.

Downloadables

Acrobat version of this Note (K).

Data Structure to Aid Security and Recovery Software (49K).

PartitionExtras.h (49K).

MoreIsBetter (contains MoreDisks module) (486K).

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