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A METHOD FOR BASIC INPUT-OUTPUT SYSTEM (BIOS) CODE COMPRESSION/DECOMPRESSION DISPATCHER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention is related to personal computers and more particularly to an object-oriented basic input/output system using data compression.

Background Art

In IBM compatible personal computers a set of programs called basic input/output system (BIOS) are encoded in read-only memory (ROM). The BIOS facilitates the transfer of data and instructions between a central processing unit (CPU) and peripheral devices such as disk drives. Computer systems are designed to perform functional tests of the BIOS every time the computer is turned on. When the computer is turned on, BIOS is copied to an area of random access memory (RAM) set aside for it. Since a RAM is much faster acting than a ROM, accessing the BIOS code from RAM results in much faster initialization of the computer.

As more new features are designed into computers, more code has to be stored into the BIOS stored on the ROM. The size of the ROM must be increased to accommodate the additional code, resulting in additional manufacturing costs. It is desirable to decreases product cost by reducing the size of a ROM required to store the BIOS and all of its components. This can be done by decompressing the code as it is stored on the ROM and then decompressing the code at the time it is copied to the RAM.

SUMMARY OF THE INVENTION

Briefly, the present invention provides a method in which memory controller related components, a power on self test (POST) object, and a decompression dispatcher are stored in a read only memory (ROM). The method tests and initializes the memory controller related components;

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initializes the decompression dispatcher; dispatches the POST object resulting in uncompressed code, and, executes the uncompressed code.

More specifically, different basic input/output system (BIOS) functions are split into components, or objects, and are only decompressed and executed when needed. A decompression dispatcher software takes a request from currently executing BIOS code to decompress another portion of BIOS code that may be needed. The requester can specify whether or not to just decompress the portion of code into memory or to decompress and initialize the decompressed BIOS. The decompression dispatcher can be used to dispatch different portions of BIOS code to different processors in a mulit-processor system.

The BIOS stored in a read only memory (ROM) is organized into a set of components, each being dispatched as an independent executable object after being copied to a shadow memory portion of a random access memory (RAM). Three types of components are defined, initialization components, runtime components and functional components. The initialization components are dispatched during a Power On Self Test (POST) cycle such that the initialization components are active during initialization. The initialization components are terminated prior to loading an operating system. The runtime components are maintained decompressed and executable after loading of the operating system. The functional components are dispatched on an as needed basis. The components can be actively or passively dispatched. Control over a dispatched object is returned to a requester by the decompression dispatcher upon a condition that the component is to be passively dispatched and the passively dispatched component is recorded in a memory manager. Control over a dispatched object is passed to the decompressed component upon a condition that the component is to be actively dispatched. When dispatching components the decompression dispatcher works from a packing list provided in the ROM image by a BIOS build process. To optimize device usage, the binary images that comprise the different components are packed into the final ROM image.

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The packing list provides a detailed description of the packing as well as other important pieces of information regarding the types of components that have been packed into the ROM.

An advantage of this invention is that the decompression dispatcher can be used to embed option ROMs of add-in cards into the BIOS and, by virtue of auto-detection, associate those ROMs with the installed add-in card.

An advantage of this invention is that it provides a way to put more features into existing products and reduce the cost of future products.

A further advantage of this invention is that it provides a solution that is more comprehensive than the prior art by allowing all possible code and text to be compressed.

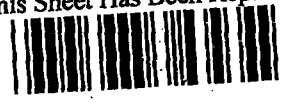
A further advantage of this invention is that it provides a way of customizing BIOSs without having to change individual binary images.

A further advantage of this invention is that it provides a way of distributing BIOS execution to other area of memory besides the standard 0F0000h, and onto multiple processors.

A further advantage of this invention is that it provides a mechanism for selling low-cost PCI add-in cards without having to ship a ROM on each card, because the ROM can be embedded into the BIOS of the mother board.

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention as illustrated in the accompanying drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram of a computer system in which the present invention is embodied;

FIGURE 2 is a flow diagram of a basic input/output system (BIOS) program in accordance with the present invention;

FIGURE 3 is a flow diagram of the decompression dispatcher of **FIGURE 2**;

FIGURE 4 is a flow diagram of how the decompression dispatcher of **FIGURE 2** is invoked;

FIGURE 5 is a flow diagram of how components are dispatched;

FIGURE 6 is a flow chart of the execution of the dispatched component;

FIGURE 7 is a flow diagram of the get component subclass identifier block (506) of **FIGURE 5**;

FIGURE 8 is a flow diagram of dispatching of components of a class that is protected having 4 gig limits;

FIGURE 9 is a flow diagram of dispatching of components of a class that is protected having 64 K limits;

FIGURE 10 is a flow diagram of removing a component from memory;

FIGURE 11 is a flow diagram of a function returns the size and address of any dispatched component;

FIGURE 12 is a flow diagram of the procedure for getting a specified component transferred and stored in RAM in an uncompressed and executable state; and,

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FIGURE 13 is a flow diagram of a BIOS build process that automates compressing and packing components into a final ROM binary image.

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DESCRIPTION OF THE PREFERRED EMBODIMENT

Refer to **FIGURE 1** which is a block diagram of a computer system in which the present invention is embodied. The computer includes a read only memory, or ROM, (10), a dynamic random access memory, or DRAM, (22), a system memory cache (24), a cache/DRAM controller (20), and central processing units (28, 30). A set of programs called basic input/output system (BIOS) are encoded in ROM (10). The BIOS facilitates the transfer of data and instructions between the central processing units (28, 30) and peripheral devices. In the present invention the BIOS is organized into a set of BIOS components (32 through 54), each of which is capable of being dispatched as an independent executable object. Each BIOS component is a self-contained (link independent) binary image that performs a certain task or function. The BIOS components fall into three major types: initialization components, runtime components and functional components.

The ROM (10) is a non-volatile device used to store the BIOS components, some in a compressed state and some in an uncompressed state. The DRAM (22) stores a shadow RAM binary image of selected components stored in the ROM which have been decompressed and stored in the shadow RAM. In Intel 80386 and 80486 computers, shadow RAM is a portion of upper memory area set aside for programs retrieved from ROM.

Compressed code is the code that resides in the ROM in a compressed state. Decompressed code is code that has been decompressed from its compressed state inside the ROM and now resides in DRAM (22) shadowed memory, in an uncompressed state. Uncompressed code is code that resides inside the ROM in an uncompressed state. This is code that was never compressed.

A component that has been decompressed and activated is an object that is manipulated with modular programming techniques.

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Stored in the ROM (10) are the following components: power-on self-test (POST) object (32); advanced power management (APM) object (34); video BIOS option ROM (36); runtime system BIOS object (38); peripheral component interconnect (PCI) BIOS object (40); small computer system interface (SCSI) option ROM (42); configuration utility (44); server management software object (46); miscellaneous optional ROM(48); component packing list (50); decompression dispatcher (52); and power-on self-test (POST) loader module (54).

The ROM (10) is connected to PCI to ISA Bridge Device (14) via Industry Standard Architecture (ISA) Bus (12). The PCI to ISA Bridge Device (14) is connected to the Peripheral Component Interconnect (PCI) Bus (16) which is connected to the host to PCI bridge device (18).

System random access memory, RAM, (22) and system memory cache (24) are connected to the Cache/DRAM Controller (20) via a local memory bus. The CPU 1 (28) and the CPU 2 (30) is connected to the host to PCI bridge device (18) via the Host CPU Bus (26).

FIGURE 13 is a flow diagram of a BIOS build process that automates compressing and packing components into a final ROM binary image. A list of binary images and associated attributes to include in the final ROM image (1300) and a number of binary image files (1302) are provided to a ROM Packing Utility (1304). The ROM Packing Utility (1304) creates a packed ROM image (1306) and a packing list (1308) that are merged by a merge utility (1310) into a final ROM image (1312) and a packing map (1314) that are stored in the ROM (10) shown in **FIGURE 1**.

Terminology

Compressed Code- Compressed code is the code that resides in the BIOS storage device in a compressed state.

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Decompressed Code- Decompressed code is code that has been decompressed from its compressed state inside the BIOS storage device and now resides in DRAM or Shadowed Memory in an uncompressed state.

Uncompressed Code- Uncompressed code is code that resides inside the BIOS storage device in an uncompressed state, code that never has been compressed.

Storage Device- The non-volatile device used to store the BIOS code (compressed or uncompressed). This may be a FLASH or EEPROM.

Component- A BIOS component is a self-contained (link independent) binary image that performs a certain task or function. A BIOS component could be something as simple as the decompression dispatcher itself or as complex as the entirety of Power On Self Test (POST) software.

Object- An object is a component that has been decompressed and activated.

Direct Dependency- A Direct Dependency is a dependency upon another object or component that is satisfied by a far call or absolute jump instruction.

Indirect Dependency- An Indirect Dependency is a dependency upon another object or component that is satisfied by an API such as an interrupt function or the decompression dispatcher.

Packing Utility- The Packing Utility is the utility used by the BIOS build process to automate compressing and packing Components into the final read only memory (ROM) image.

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Packing Script- The Packing Script is the script used by the Packing Utility to describe the packing order of the ROM image. The Packing Script facilitates the automated build process.

Packing List- The Packing List is generated by the Packing Utility and describes all the attributes of the packed ROM image. This list is used by the decompression dispatcher to dispatch components.

Decompression dispatcher- The decompression dispatcher is the component responsible for all decompression and dispatching activities.

Component Types

The BIOS is organized into a set of components, each being dispatched as an independent executable object. Components fall into three major types: initialization components, runtime components and functional components.

Initialization components are dispatched during what is commonly referred to as the Power On Self Test (POST) cycle. These components are active during initialization and terminated prior to loading the Operating System. Initialization components may contain direct runtime dependencies but these dependencies are limited to objects of the same Component Class. All initialization components must be segment relocatable.

Runtime components are objects that must remain decompressed and executable after loading of the Operating System. Typically, runtime components are combined to form the 64K System BIOS image located in the F0000h segment. Runtime components may not contain any direct dependencies to any other component regardless of its type or class, and indirect dependencies are allowed only to other runtime components.

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Functional components are dispatched on an as needed basis. A Functional component may not contain any direct dependencies to any other component regardless of type or class. An example of a Functional component is a Configuration Utility or a BIOS Setup program.

Component Dispatching

Components are dispatched through a utility called the decompression dispatcher. There two types of dispatching supported by the decompression dispatcher, active and passive.

Components are said to be passively dispatched when the binary image is decompressed into memory and control is returned to the requester by the decompression dispatcher. Passively dispatched components are recorded in the Memory Manager and must be disposed of prior to loading of the boot strap.

Components are said to be actively dispatched when the binary image is decompressed into memory and control is given to the decompressed object. Components must support Real mode execution to be actively dispatched. Control is given directly to the actively dispatched component by the decompression dispatcher.

Control may or may not be returned to the requester depending upon the Component being dispatched. The code segment (CS), instruction pointer (IP) and Flags of the requester remain on the stack when control is given to a actively dispatched component. That component may execute a ADD SP, 6 if it chooses to maintain control or execute an IRET instruction to return to the requester.

When dispatching components the decompression dispatcher works from a Packing List provided in the ROM image by the BIOS build process. To optimize device usage, the binary images that comprise the different components are packed into the final ROM image. The Packing List

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provides a detailed description of the packing as well as other important pieces of information regarding the types of components that have been packed into the ROM.

Class Identification

Each Component is identified by its Class and Sub-Class code. The Class / Sub-Class combination must be unique for each component and there must not be two components of the same Sub-Class within a given Class.

Packing Address

The Packing Address field specifies the offset inside the ROM image where the corresponding Component has been located. The Packing Address is typically provided by the Packing Utility unless specified in the Packing Script.

Unitialized Data components will have a Packing Address of zero (00000000h).

Compressed Size

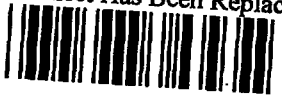
The Compressed Size field specifies the amount of space (in bytes) consumed by a component when it is in the ROM image.

Unitialized Data components use this field to specify the maximum amount of memory required and be aligned on a 64K boundary.

Decompressed Size

The Decompressed Size field specifies the amount of space (in bytes) consumed by a component after it has been dispatched. Components that are placed in the ROM uncompressed have identical Compressed and Decompressed sizes.

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Unitialized Data components specify this field to be identical to the Compressed Size field.

Load Address

The Load Address field specifies the 32 bit physical address of where the component is to be dispatched. This field must be specified even if the component is intended to be relocatable. Actively dispatched components must specify a Load Address that is below 1Mb and aligned on a paragraph (16 byte) boundary.

Unitialized Data components must specify a load address that is aligned on a 64K boundary. If the Load Address is arbitrary then a value of all FF's (FFFFFFFFh) may be specified. Components referencing Unitialized Data with an arbitrary Load Address must use the Get Unitialized Data Address function to determine the actual Load Address of the Unitialized Data. This function can only be called after the Unitialized Data has been dispatched. Refer to the Memory Management section described below for restrictions on fixed Load Address for Unitialized Data components.

Execution Offset

The Execution Offset field specifies a 16 bit offset into the component where execution is to begin. This offset must be specified for all components that satisfy direct dependencies of other components regardless of whether or not they are to be actively dispatched. Components that do not satisfy direct dependencies of other components should specify this field as FFFFh.

Unitialized Data components must specify an Execution Offset of FFFFh.

Relocation Type

The Relocation Type field specifies what type, if any, of component relocation is supported. Types are either: not relocatable; relocatable below 1MB only; relocatable above 1MB only; or relocatable anywhere.

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Dispatch Type

The Dispatch Type field specifies what type of dispatching is supported by the corresponding component. Types are either: passive dispatching; active dispatching; or both active and passive dispatching.

Component Organization

Though the flexibility of Component Type, Class, and Sub-Class allow unique customization of a particular BIOS, there are five components that must be supported in every BIOS. These five components are: decompression dispatcher, decompression dispatcher unitialized data, POST Loader, power on self test (POST), and system BIOS runtime executable. These five components are described in the following paragraphs.

Decompression Dispatcher

The decompression dispatcher component contains all the functions that comprise the decompression dispatcher. Access is gained through the interrupt interface defined in the decompression dispatcher Functions section described below. This component resides uncompressed in the ROM image.

Decompression Dispatcher Unitialized Data

This component is 128K in length and provides the memory buffers required by the decompression dispatcher.

POST Loader

The POST Loader component handles all hardware generated resets (i.e. power on, front panel, etc.) and software generated resets after being processed by the Shutdown Handler. This component resides uncompressed in the ROM image and may not be dispatched into DRAM.

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The primary responsibility of this module is to configure enough of the system to gain 2Mb of DRAM, activate the decompression dispatcher, and dispatch the main Power On Self Test.

Power On Self Test

The Power On Self Test component (24) is the main POST executable, and is responsible for dispatching all components required for initialization of the system.

System BIOS Runtime Executable

The System BIOS Runtime Executable component is responsible for all compatible System Services including Interrupt and Device Service Routines. This component must also contain the Shutdown Handler responsible for handling all software related resets and dispatching the POST Loader as needed.

Decompression Dispatcher Functions

Dispatch Component ()

The decompression dispatcher component (44) dispatches a Component into memory (12). Each Component is identified by a unique Class / Sub-Class code combination. Dispatched Components are recorded in an Allocation Table kept by the Memory Manager. The actual base address of a Component may be retrieved at any time by calling the Get Physical Address( ) function.

It is the responsibility of the caller to ensure that the Enter Flat Mod( ) has been called and 4G Data Segments are active (this implies that Gate A20 is enabled) before calling this function. Also, if dispatching is being done into shadowed memory (between C0000h-FFFFFh), then the caller must ensure that the appropriate range has been Read/Write enabled in DRAM.

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Unitialized Data Components are also dispatched using this function. All possible requests for Unitialized Data must be satisfied in the Packing List at build time in order for them to be dispatched by this function. Dynamic assigning of Unitialized Data Components is not supported by the decompression dispatcher.

Input:

AH 00h
AL 00h - Passive Dispatch
01h - Active Dispatch
BX Class Code
CX Sub-Class Code
EDI Relocation Address (00000000h if Relocation not Requested.)
ESI Unitialized Data Size (00000000h if Default)

Output - Success:

CF Clear (0)
AH 00h

Output - Failure:

CF Set (1)
AH Error Code
01h - Invalid Function.
02h - Component Packing List entry not found.
03h - Component does not support relocation
04h - Component cannot relocate above 1Mb
05h - Component does not support Active Dispatching
06h - Cannot Actively Dispatch above 1Mb
07h - Active Dispatch aborted because of invalid segment alignment
08h - Cannot allocate memory for component
09h - Decompression failed, dispatch aborted.

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Get Component Attributes( )

This function returns the information from the packing list corresponding to a given component.

Input:

AH	01h
BX	Class Code
CX	Sub-Class Code

Output - Success:

CF	Clear (0)
AH	Relocation Type
AL	Dispatch Type
EDX	Decompressed Size
SI	Execution Offset
EDI	Default Load Address

Output - Failure:

CF	Set (1)
AH	Error Code
	01h - Invalid Function.
	02h - Component Packing List entry not found.

Get Component SubClass( )

Return the Sub-Class code for entry ***n*** in the Packing List that corresponds to a given Component Class code. To find all components related to a given Class code call this function repeatedly incrementing the Entry Number until a failure is returned.

Input:

AH	02h
AL	Entry Number

BX Class Code

Output - Success:

CF Clear (0)
CX Sub-Class Code

Output - Failure:

CF Set (1)
AH Error Code
01h - Invalid Function.
02h - Component Packing List entry not found.

Enter Flat Mode( )

Enter Flat Mode execution. This function is provided for general component usage and places the system in a mode where the full 4G address range can be accessed through the general segment registers. Gate A20 must be set by the caller prior to using this function. CS and SS are unchanged and have 64K access.

Input:

AH 03h
Gate A20 Must be Enabled.

Output - Success:

CF Clear (0)
DS 0000h (4G Access)
ES 0000h (4G Access)
FS 0000h (4G Access)
GS 0000h (4G Access)

Output - Failure:

CF Set (1)
AH 01h - Invalid Function.

Leave Flat Mode( )

Leave Flat Mode execution. This function turns off the flat mode execution. It is the responsibility of the caller to track and change the state of the Gate A20. No A20 switching is done by this function.

Input:

AH	04h

Output - Success:

CF	Clear (0)
DS	0000h (64K Access)
ES	0000h (64K Access)
FS	0000h (64K Access)
GS	0000h (64K Access)

Output - Failure:

CF	Set (1)
AH	01h - Invalid Function.

Dispose Component( )

This function removes a component from memory based upon the Class and Sub-Class identifier provided by the caller. An error is returned to the caller if the given component does not have an entry in the Allocation Table. Components that have been disposed of by this function are removed from memory and the memory re-initialized to all zero's (0000h)

Input:

AH	05h
BX	Class Code
CX	Sub-Class Code

Output - Success:

CF	Clear (0)
AH	00h

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Output - Failure:

CF Set (1)
AH 01h - Invalid Function.
02h - Component Allocation Table entry not found.

Get physical Address( )

Return to the caller the base address and size of any dispatched Component identified by the given Class and Sub-Class code. An error is returned to the caller if the given Component does not have an entry in the Allocation Table.

Input:

AH 06h
BX Class Code
CX Sub-Class Code

Output - Success:

CF Clear (0)
AH 00h
EDI 32 bit Base Address of Component
EDX Size of Component in bytes (1K aligned)

Output - Failure:

CF Set (1)
AH 01h - Invalid Function.
02h - Component Allocation Table entry not found.

Memory Management

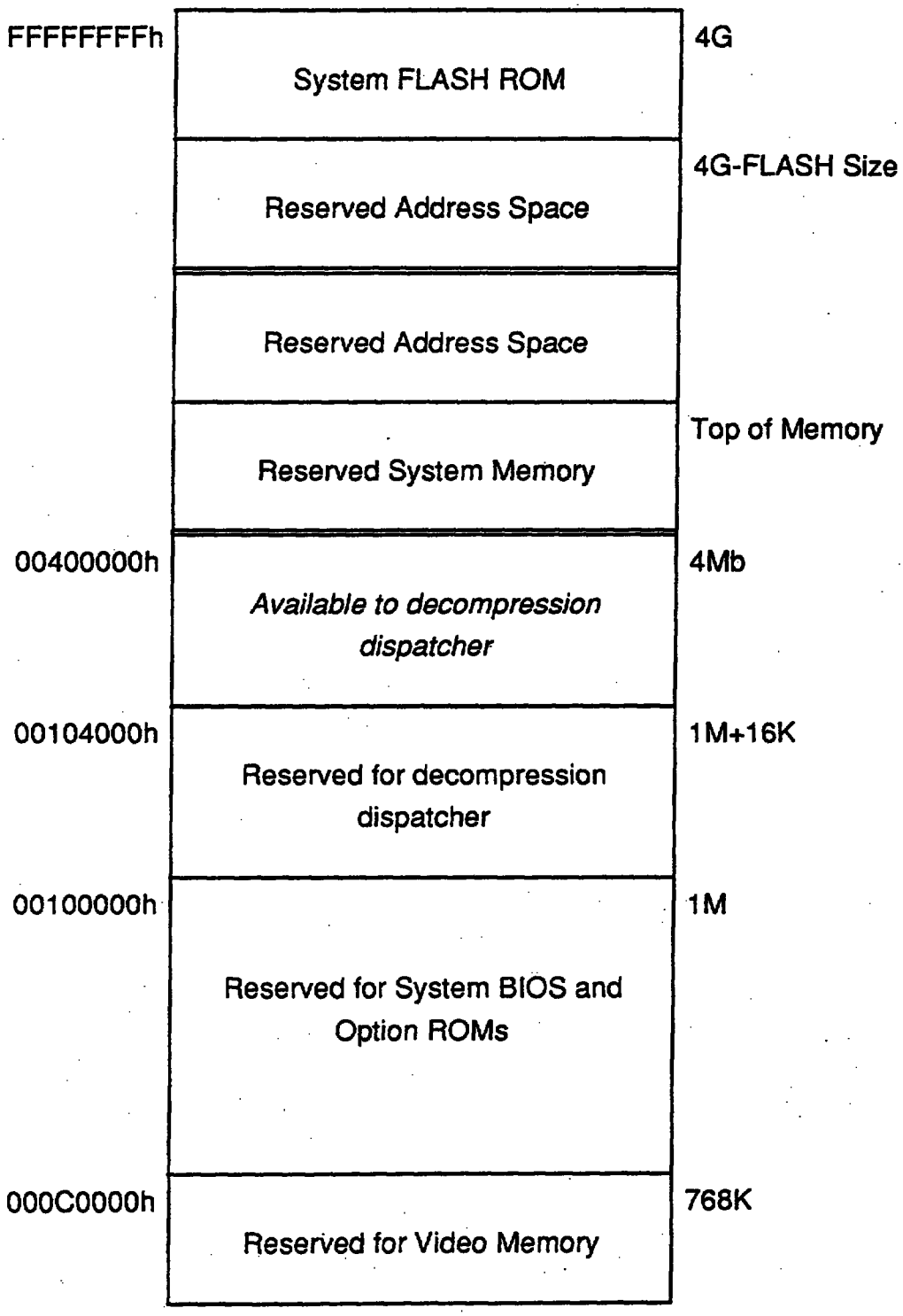
Memory testing and subsequent update of status to a video monitor are all done in 'Real Big' mode as opposed to constantly switching between Real and Protected Mode. 'Real Big' mode is a mode where the data segment registers of the processor are loaded with Protected Mode type

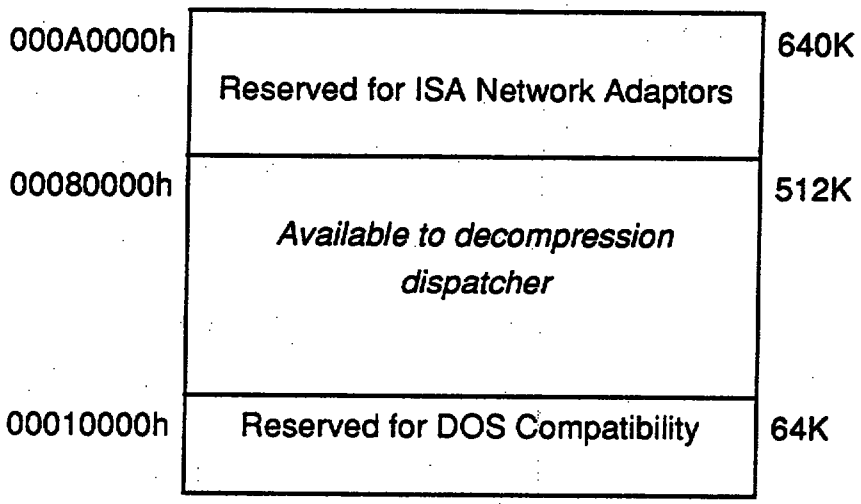
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characteristics while the code and stack segment registers retain their Real Mode characteristics. The processor essentially runs in Real Mode while allowing a full 4 GB access to memory.

Memory Map


FFFFFFFFh
System FLASH ROM
4G
Reserved Address Space
4G-FLASH Size
Reserved Address Space
Reserved System Memory
Top of Memory
00400000h
Available to decompression dispatcher
4Mb
00104000h
Reserved for decompression dispatcher
1M+16K
00100000h
Reserved for System BIOS and Option ROMs
1M
000C0000h
Reserved for Video Memory
768K



The Memory Manager tracks allocated memory blocks using a 4K byte map and a 6K allocation table. The Memory Manager uses the 4K byte map to specify the allocated blocks of memory. Each byte in the byte map represents a 1K block of memory starting at 0Mb and ending at 4Mb. A set byte (FFh) in a byte location means the represented 1K block of memory has already been assigned to a requester. A clear byte (00h) in a byte location means the represented 1K block of memory is available.

The Memory Manger uses the 6K Allocation Table to identify the assignee of each memory block. There is enough room in the Allocation Table to assign 512 blocks of memory to unique Components. Each entry in the Allocation Table has the following format:

Field	Offset	Length	Description
Class	0h	WORD	Class code of component using memory.
Sub-Class	2h	WORD	Sub-Class code of component using memory.
Base Address	4h	DWORD	32 bit Physical address of memory.
Size	8h	DWORD	32 bit Length of memory block.

When a request is being made for memory the Memory Manager searches the byte map for a block of memory large enough to satisfy the request. This search is conducted on a first fit algorithm. When a location is found, the corresponding byte is set in the byte map and then logged in the first available entry in the Allocation Table.

Interface Functions

Init Memory Manager( )

Alloc Memory Block( )

Reserve a block of memory for a given Component.

Input:

BX	Class Code
CX	Sub-Class Code
EDI	Physical Address (00000000h if not specified.)
ESI	Size of Block to allocate.

Output - Success:

CF	Clear (0)
AH	00h
EDI	Physical Address of allocated memory block

Output - Failure:

CF	Set (1)
AH	07h - Cannot allocate memory for component

Dealloc Memory Block( )

Un-Reserve a block of memory for a given Component.

Input:

BX	Class Code

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CX Sub-Class Code

Output:
None

Get Memory Block( )
Where am I function.

Input:
BX Class Code
CX Sub-Class Code

Output - Success:
CF Clear (0)
AH 00h
EDI Physical Base Address
EDX Size of Block

Output - Failure:
CF Set (1)
AH 07h - Cannot allocate memory for component

Description of Flow Charts
Refer to **FIGURE 2** which is a flow diagram of a basic input/output system (BIOS) program in accordance with the present invention. The program starts (200), and tests and initializes the memory controller related components (202). Next the program initializes the power on self test (POST) decompression dispatcher (204) shown in more detail in the flow diagram of **FIGURE 3**. Finally, the program dispatches and executes the POST (206) as shown in **FIGURES 4** and **5**, and stops (208).

Refer to **FIGURE 3** which is a flow diagram of a decompression dispatcher of **FIGURE 2**. The dispatcher data and executable code is copied (302) from the ROM to the RAM. The dispatcher interrupt vector is

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installed (304), the memory allocation table is cleared (306) and the component handle table is cleared (308). The compressed BIOS component information in the packing list is fetched from RAM (310). The relocation type field is examined to find what type of relocation is supported, below 1 meg.(312, 314) , above 1 meg. (316, 318), or anywhere (320). If the required size is not available (322) allocation error flags are set (324). If the specified load address is not available (326) allocation error flags are set (328).

If the required size is available (322), then the memory allocation table is updated (330). If the end of the component list in the packing list has not been reached (332), then the flow returns to block (310). If the end of the component list in the packing list has been reached (332), then the flow ends (334).

Refer to **FIGURE 4** which is a flow diagram of how the decompression dispatcher is invoked. The function to be dispatched requires the passing of and returning of parameters through a stack, which is an area of RAM set aside for temporary storage of the parameters. The portion of the stack holding local variables and parameters of a procedure is called a stack frame. The stack frame is set up (402) and a check is made to determine if the requested function is valid (404). If not, the procedure is halted (406). If yes, then the dispatcher function is executed (408). When the flow returns, the stack frame is restored (410) and the flow ends (412). **FIGURES 5** through **12** are flows for execution of the dispatcher function block (408) of **FIGURE 4**.

Refer to **FIGURE 5** which is a flow diagram of how components are dispatched. The dispatcher assumes only one component from a class is being loaded, and hence the count of components is set to 1. The counter is used as an index into the packing list. The component of a class might contain a number of components referenced by a subclass identifier. A check (504) is made to determine if all components of the class are to be loaded. If yes, then the first subclass identifier is fetched (506) as

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described in **FIGURE 7**. If the subclass is found in the packing list (508) then the count of the subclass index counter is incremented (510). If the subclass is not found in the packing list (508), then the count of the subclass index counter is not incremented and the flow proceeds to get packing information for the component indexed by the count of the component counter (512). The procedure next uncompresses the component at the index count and places the uncompressed code in RAM (514). The details of block (514) are shown in more detail in **FIGURE 12**. At the end of the uncompressing procedure, a check (516) is made to determine if there are more components in this class to uncompress. If yes, the component index counter is decremented (518). If no, a check (520) is made to determine if this is the last component actively dispatched or if an option ROM is present. If not, the flow ends (524). If yes, then the return address is adjusted to execute the dispatched component (522).

Refer to **FIGURE 6** which is a flow chart of the execution of the dispatched component. The list pointer for the packing list entries is fetched (602). The packing list pointer is checked (604) to determine if the end of the packing list is pointed to. If yes, a search failure flag is set (610). If no, a check (606) is made to determine if the pointer is pointing to the desired entry. If no, the list pointer is advanced (608). If yes, the flow proceeds to block (612). If the search of the packing list is successful (612), then the component decompression information is fetched (614). and this part of the procedure ends (616).). If the search of the packing list is not successful (612), an error is displayed (618) and the procedure is halted (620).

Refer to **FIGURE 7** which is a flow diagram of the get component subclass identifier block (506) of **FIGURE 5**. The sub class index is checked (702) to determine if it is valid. If not valid, an error is displayed (722) and the procedure is halted (724). If yes, the packing list pointer is checked (704) to determine if the end of the packing list is pointed to. If yes, a search failure flag is set (710). If no, a check (706) is made to

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determine if the packing list pointer is pointing to an entry from the desired class. If no, the packing list pointer is advanced (708). If yes, a check (712) is made to determine if the packing list pointer is referencing a desired sub component.. if no, the packing list pointer is advanced (708). If yes, the component code is fetched from the ROM (714) and this portion of the procedure stops (718).

Refer to **FIGURE 8** which is a flow diagram of dispatching of components of a class that is protected having 4 gig limits. The procedure loads the GDTR global descriptor table register (802) with the global descriptor table and then enters protected mode (804). The data segment (DS), extra segment (ES) , global segment (GS) , and general-purpose file segment (FS), registers are configured with 4 gig limits and protected mode is exited (808). The registers DS, ES, FS, and GS are loaded with a 0 base address (810) and the procedure stops (812).

Refer to **FIGURE 9** which is a flow diagram of dispatching of components of a class that is protected having 64 K limits. The procedure loads the GDTR global descriptor table register (902) with the global descriptor table and then enters protected mode (904). The data segment (DS), extra segment (ES) , global segment (GS) , and general-purpose file segment (FS), registers are configured with 64K limits and protected mode is exited (908). The registers DS, ES, FS, and GS are loaded with a 0 base address (910) and the procedure stops (912).

Refer to **FIGURE 10** which is a flow diagram of removing a component from memory. The procedure loads the pointer to the handle table (1002), and checks to see if it is pointing to the correct entry (1004). If not, it checks to see if it is at the end of the table (1006) and if so sets the not found flag (1010) and flow proceeds to block (1014). If it is not at the end of the table the pointer is incremented to the next entry (1008) and the flow returns to block (1004). If the handle pointer is at the correct entry, the not found flag is cleared (1012) and flow proceeds to block (1014). If the not found flag is set the procedure is exited (1022), otherwise the size

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and address arc retrieved (1018) and the corresponding entry is cleared from the memory allocation table (1018) and the handle entry is cleared from the handle table (1020).

Refer to **FIGURE 11** which is a flow diagram of a function which returns the size and address of any dispatched component. This function loads the pointer to the handle table (1102), and checks to see if it is pointing to the correct entry (1104). If not, it checks to see if it is at the end of the table (1106) and if so sets the not found flag(1110)and flow proceeds to block (1114). If it is not at the end of the table the pointer is incremented to the next entry (1108) and the flow returns to block (1104). If the handle pointer is at the correct entry, the not found flag is cleared(1112)and flow proceeds to block (l114). If the not found flag is set, an error is displayed (1120) and the function is halted (1122), otherwise the size and address are retrieved (l116) and the function is exited (1118).

Refer to **FIGURE 12** which is a flow diagram of the procedure for getting a specified component transferred and stored in RAM in an uncompressed and executable state.

A RAM memory block large enough to hold the specified component is found (1202) and allocated. After the memory space is allocated (1204), the size field in the packing list is accessed to get the size information (1206). The compressed and decompressed size information is obtained from the packing list entry (1206). The Compressed Size field specifies the amount of space (in bytes) consumed by a component when it is in the ROM image. Unitialized Data components use this field to specify the maximum amount of memory required and that they be aligned on a 64K boundary. The Decompressed Size field specifies the amount of space (in bytes) consumed by a component after it has been dispatched. Components that are placed in the ROM uncompressed have identical Compressed and Decompressed sizes. Unitialized Data components specify this field to be identical to the Compressed Size field.

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If the component is not compressed, then the component is copied (1212) to RAM from the non-volatile storage device used to store the compressed or uncompressed BIOS code. If the component is compressed, then the component is decompressed (1210), stored in an uncompressed state in the shadowed memory portion of RAM, and the procedure stops (1216).

In the event that memory cannot be allocated (1204) an error is displayed (1224) and the procedure halts (1226).

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and detail may be made therein without departing from the scope of the invention.

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What is claimed is:

1. In a data processing system in which are stored in a read only memory (ROM), memory controller related components, a power on self test (POST) object, and a decompression dispatcher,

a method comprising steps of:

A. testing and initializing said memory controller related components;

B. initializing said decompression dispatcher;

C. dispatching said POST object resulting in uncompressed code, and,

D. executing said uncompressed code.

2. The method in accordance with claim 1 wherein

said data processing system includes a random access memory (RAM) having stored therein a dispatcher interrupt vector, and a memory allocation table, and,

said ROM has stored therein dispatcher data, executable dispatcher code, and compressed basic input/output system (BIOS) component information,

said step of initializing said decompression dispatcher further comprising steps of:

A. copying said dispatcher data and executable dispatcher code from said ROM to said RAM;

B. installing said dispatcher interrupt vector;

C. clearing said memory allocation table;

D. getting said compressed BIOS component information from said ROM;

E. updating said memory allocation table;

F. setting up a stack frame;

G. executing said dispatcher code; and,

H. restoring said stack frame upon completion of execution of said dispatcher function.

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3. The method in accordance with claim 2 wherein

said computer system includes a component index counter,

said dispatcher information includes a packing list of component subclass identifiers, and,

said step of executing said uncompressed code includes steps of:

I. setting a default count of said component index counter to one;

J. getting one component subclass identifier of said component subclass identifiers;

K. searching said packing list for an instance of said one component subclass identifier;

L. incrementing said count of subclass components upon a condition that said sub class is found in said packing list;

M. getting packing information for an indexed component indexed by said count of components;

N. uncompressing said indexed component resulting in an uncompressed component;

O. storing said uncompressed component in said RAM;

P. decrementing said component index counter upon a condition that more components are to be uncompressed in said class.

4. The method in accordance with claim 3 wherein

said computer system includes a list pointer,

said step of getting one component subclass identifier of said component subclass identifiers includes steps of:

Q. advancing said list pointer until said list pointer points to an entry in said packing list from said one class; and,

R. getting a component code corresponding to said entry in said packing list.

5. The method in accordance with claim 4 comprising further steps of:

S. finding a RAM memory block large enough to hold said component code.

6. The method in accordance with claim 5 comprising further steps of:

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T. allocating said memory block;

U. getting size information from said entry in said packing list;

V. decompressing said component code resulting in decompressed code upon a condition that said component code is compressed; and,

W. storing said decompressed code in said RAM.

7. The method in accordance with claim 5 comprising further steps of:

T. allocating said memory block;

U. getting size information from said entry in said packing list; and,

V. copying said component code from said ROM to said RAM upon a condition that said component code is uncompressed;

W. storing said component code in said RAM.

8. In a data processing system in which,

basic input/output system (BIOS) is organized into three types of components, initialization components, runtime components and functional components,

each of said three types of components capable of being dispatched as an independent executable object,

initialization of said processor being controlled by a power on self test (POST),

general operation of said processor being controlled by an operating system,

a method comprising steps of:

A. dispatching said initialization components during said power on self test (POST) cycle such that said dispatching initialization components are active during said initialization;

B. terminating Initialization prior to loading said operating system;

C. loading said operating system;

E. maintaining said runtime components decompressed and executable after loading of said operating system;

F. dispatching said functional components on an as needed basis;

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G. decompressing a binary image of a component into memory thereby creating a decompressed object;

H. returning control to said requester by said decompression dispatcher upon a condition that said component is to be passively dispatched;

I. recording a passively dispatched component in a memory manager; and,

J. passing control to said decompressed component upon a condition that said component is to be actively dispatched;

9. The method in accordance with claim 8 wherein

said data processing system includes a random access memory (RAM) having stored therein a dispatcher interrupt vector, and a memory allocation table, and,

said ROM has stored therein dispatcher data, executable dispatcher code, and compressed basic input/output system (BIOS) component information,

said step of initializing said decompression dispatcher further comprising steps of:

A. copying said dispatcher data and executable dispatcher code from said ROM to said RAM;

B. installing said dispatcher interrupt vector;

C. clearing said memory allocation table;

D. getting said compressed BIOS component information from said ROM;

E. updating said memory allocation table;

F. setting up a stack frame;

G. executing said dispatcher code; and,

H. restoring said stack frame upon completion of execution of said dispatcher function.

10. The method in accordance with claim 9 wherein

said computer system includes a component index counter,

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said dispatcher information includes a packing list of component subclass identifiers, and,

said step of executing said uncompressed code includes steps of:

I. setting a default count of said component index counter to one;

J. getting one component subclass identifier of said component subclass identifiers;

K. searching said packing list for an instance of said one component subclass identifier;

L. incrementing said count of subclass components upon a condition that said sub class is found in said packing list;

M. getting packing information for an indexed component indexed by said count of components;

N. uncompressing said indexed component resulting in an uncompressed component;

O. storing said uncompressed component in said RAM;

P. decrementing said component index counter upon a condition that more components are to be uncompressed in said class.

11. The method in accordance with claim 10 wherein

said computer system includes a list pointer,

said step of getting one component subclass identifier of said component subclass identifiers includes steps of:

Q. advancing said list pointer until said list pointer points to an entry in said packing list from said one class; and,

R. getting a component code corresponding to said entry in said packing list.

12. The method in accordance with claim 11 comprising further steps of:

S. finding a RAM memory block large enough to hold said component code.

13. The method in accordance with claim 12 comprising further steps of:

T. allocating said memory block;

U. getting size information from said entry in said packing list;

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V. decompressing said component code resulting in decompressed code upon a condition that said component code is compressed; and,

W. storing said decompressed code in said RAM.

14. The method in accordance with claim 12 comprising further steps of:

T. allocating said memory block;

U. getting size information from said entry in said packing list; and,

V. copying said component code from said ROM to said RAM upon a condition that said component code is uncompressed;

W. storing said component code in said RAM.

15. In a data processing system in which are stored in a read only memory (ROM),

a plurality of basic input/output system (BIOS) components,

each one of said BIOS components being a self-contained, link independent, binary image of code that upon execution performs a certain task,

said BIOS components including a decompression dispatcher component a power on self test (POST) component,

a component packing list, said packing list describing all attributes of said packed ROM image; said packing list being used by said decompression dispatcher to dispatch said components;

compressed code in said non-volatile storage device in a compressed state, said compressed code being code that has been compressed,

said method comprising steps of:

A. executing said decompression dispatcher, said decompression dispatcher decompressing said compressed code resulting in decompressed code, said decompressed code being code that has been decompressed from its compressed state inside said non-volatile storage device;

B. storing said decompressed code in a shadowed memory in an uncompressed state as decompressed code; and,

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C. activating said decompressed code resulting in an object, said object being a component that has been decompressed and activated.

16. A BIOS build process comprising steps of:

A. providing a list of binary images and associated attributes to include in a final ROM image and a number of binary image files to a ROM Packing Utility;

B. invoking said ROM Packing Utility to create a packed ROM image and a packing list;

C. merging said packed ROM image and said packing list into a final ROM image and a packing map; and,

D. storing said final ROM image and said packing map in a ROM.

17. In a data processing system in which are stored in a read only memory (ROM),

a plurality of basic input/output system (BIOS) components,

each one of said BIOS components being a self-contained, link independent, binary image of code that upon execution performs a certain task,

said BIOS components including a decompression dispatcher component a power on self test (POST) component and a BIOS build process,

said build process including a packing utility used by said build process to automate compressing and packing components into a read only memory (ROM) binary image,

said packing utility including a packing script,

a method comprising steps of:

A. invoking said BIOS build process;

B. executing said packing script, said packing script being used by said packing utility to describe a packing order of components packed into said read only memory (ROM) image;

C. invoking said packing utility to generate a packing list, said packing list describing all attributes of said packed ROM image; said

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packing list being used by said decompression dispatcher to dispatch components;

D. storing uncompressed code in a non-volatile storage device in an uncompressed state, said uncompressed code being code that never has been compressed; and,

E. storing compressed code in said non-volatile storage device in a compressed state, said compressed code being code that has been compressed.

18. The method in accordance with claim 17 comprising further steps of:

F. executing said decompression dispatcher, said decompression dispatcher decompressing said compressed code resulting in decompressed code, said decompressed code being code that has been decompressed from its compressed state inside said non-volatile storage device;

G. storing said decompressed code in a shadowed memory in an uncompressed state as decompressed code; and,

H. activating said decompressed code resulting in an object, said object being a component that has been decompressed and activated.

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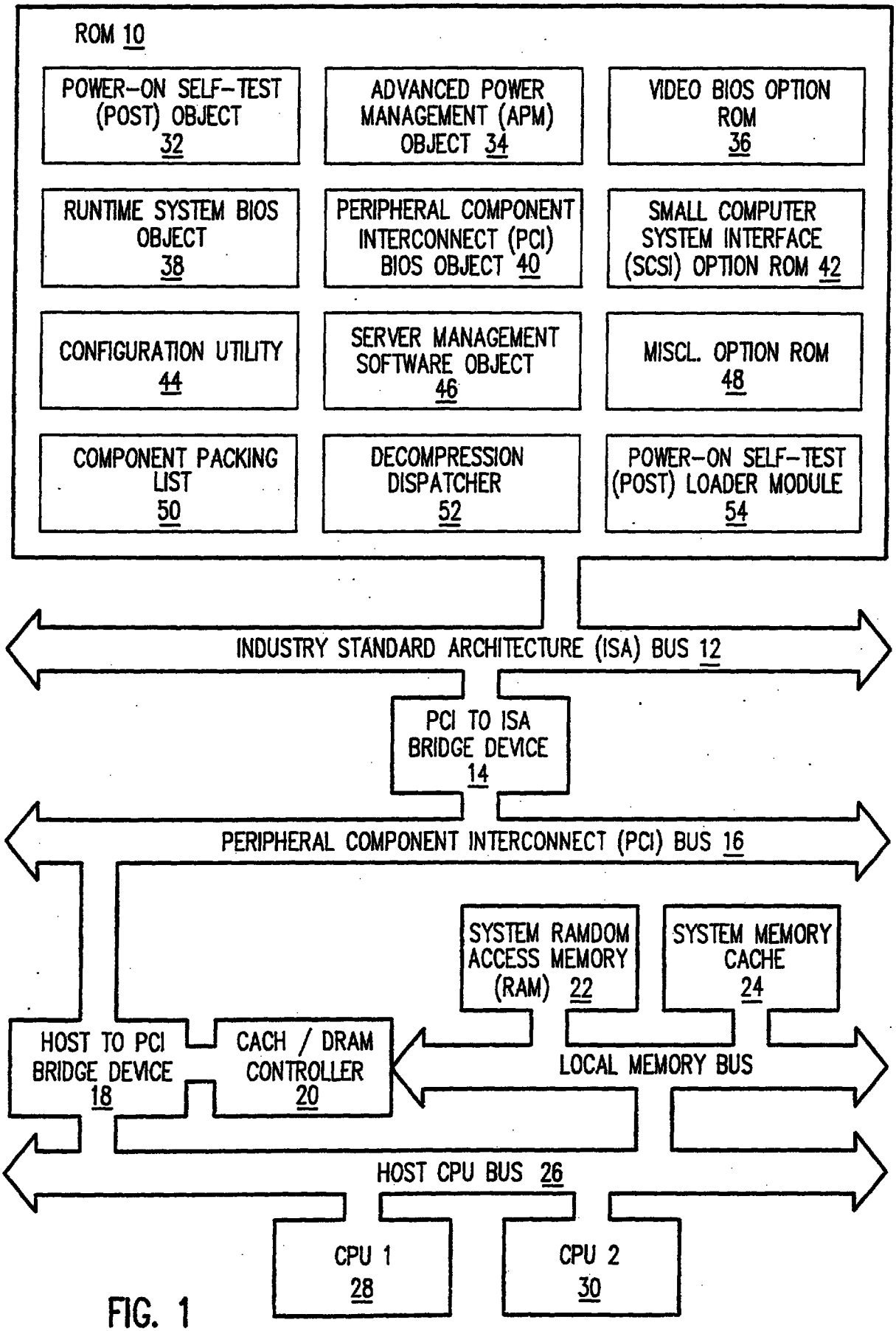

ROM 10
POWER-ON SELF-TEST (POST) OBJECT 32
ADVANCED POWER MANAGEMENT (APM) OBJECT 34
VIDEO BIOS OPTION ROM 36
RUNTIME SYSTEM BIOS OBJECT 38
PERIPHERAL COMPONENT INTERCONNECT (PCI) BIOS OBJECT 40
SMALL COMPUTER SYSTEM INTERFACE (SCSI) OPTION ROM 42
CONFIGURATION UTILITY 44
SERVER MANAGEMENT SOFTWARE OBJECT 46
MISCL. OPTION ROM 48
COMPONENT PACKING LIST 50
DECOMPRESSION DISPATCHER 52
POWER-ON SELF-TEST (POST) LOADER MODULE 54
INDUSTRY STANDARD ARCHITECTURE (ISA) BUS 12
PCI TO ISA BRIDGE DEVICE 14
PERIPHERAL COMPONENT INTERCONNECT (PCI) BUS 16
SYSTEM RAMDOM ACCESS MEMORY (RAM) 22
SYSTEM MEMORY CACHE 24
HOST TO PCI BRIDGE DEVICE 18
CACH / DRAM CONTROLLER 20
LOCAL MEMORY BUS
HOST CPU BUS 26
CPU 1 28
CPU 2 30

FIG. 1

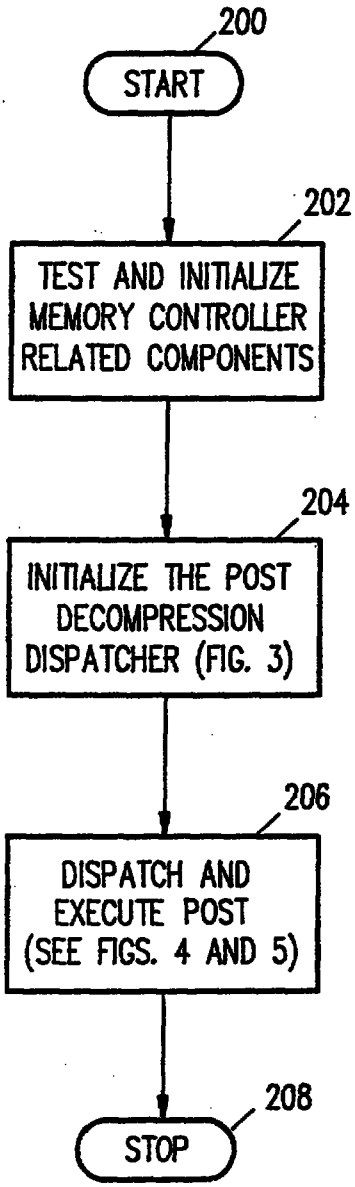

200
START
202
TEST AND INITIALIZE MEMORY CONTROLLER RELATED COMPONENTS
204
INITIALIZE THE POST DECOMPRESSION DISPATCHER (FIG. 3)
206
DISPATCH AND EXECUTE POST (SEE FIGS. 4 AND 5)
208
STOP

FIG. 2

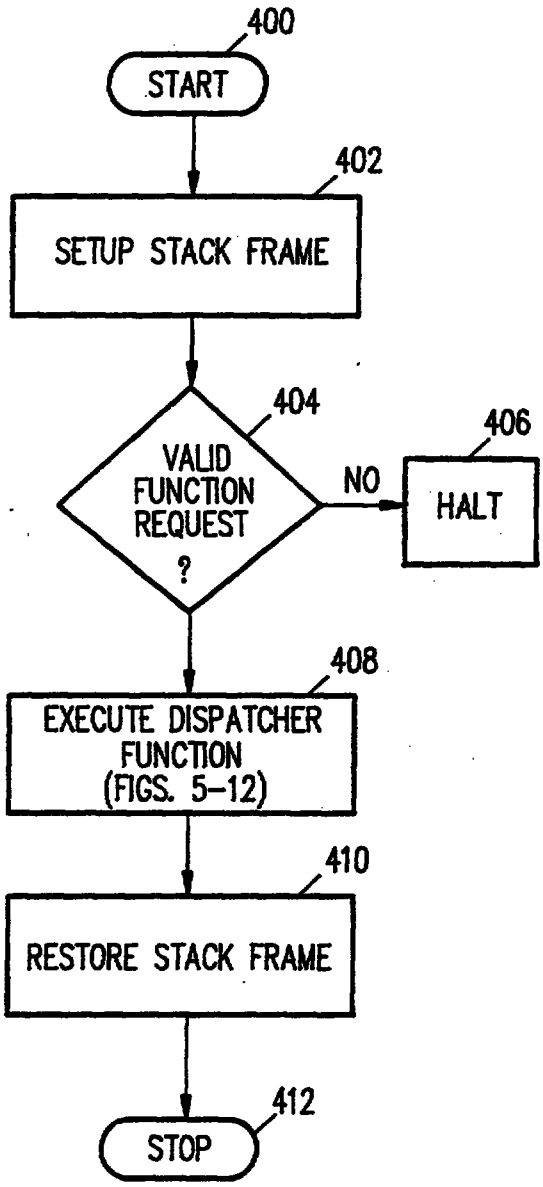

400
START
402
SETUP STACK FRAME
404
VALID FUNCTION REQUEST ?
NO
406
HALT
408
EXECUTE DISPATCHER FUNCTION (FIGS. 5–12)
410
RESTORE STACK FRAME
412
STOP

FIG. 4

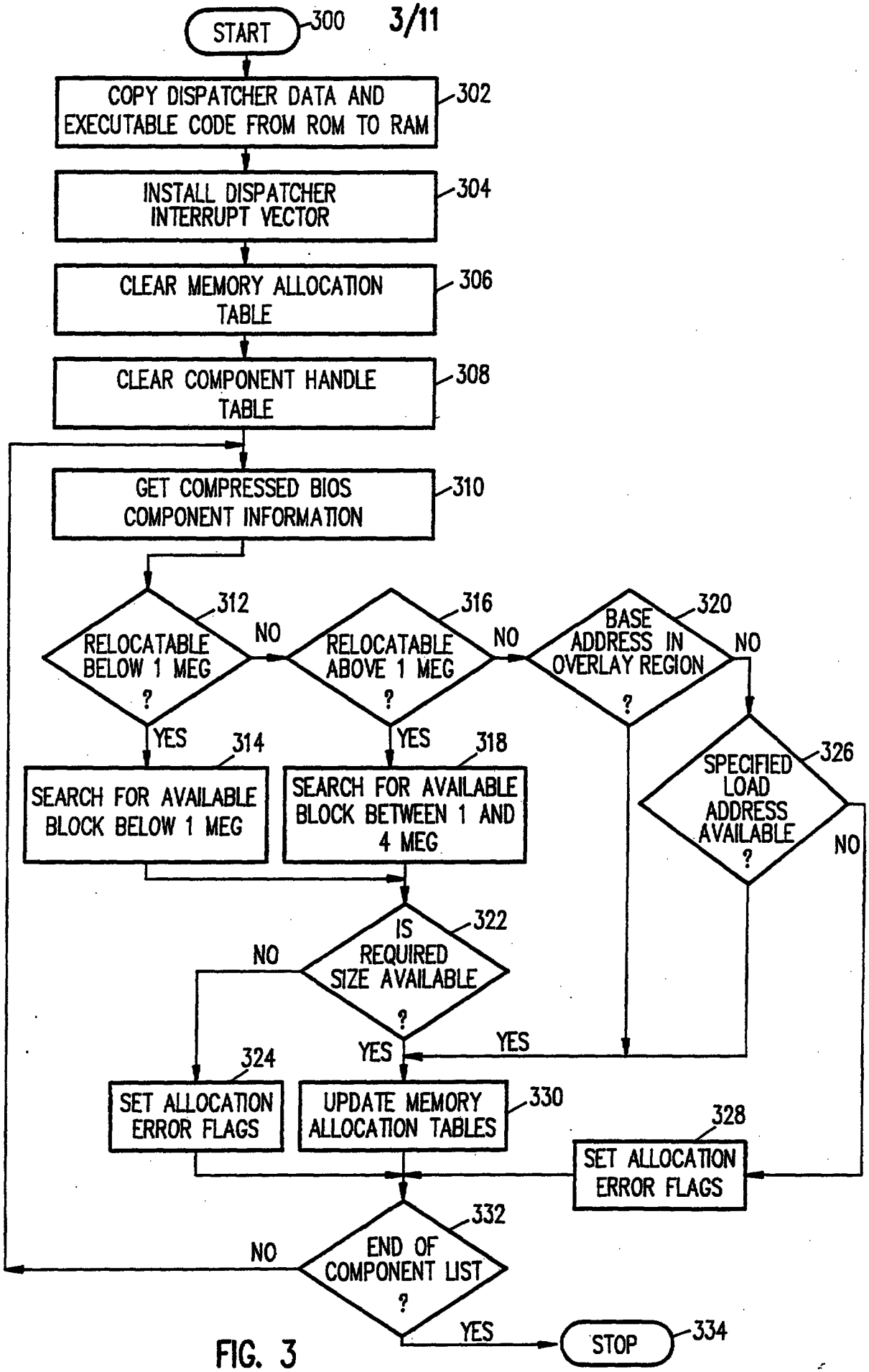

START
300
COPY DISPATCHER DATA AND EXECUTABLE CODE FROM ROM TO RAM
302
INSTALL DISPATCHER INTERRUPT VECTOR
304
CLEAR MEMORY ALLOCATION TABLE
306
CLEAR COMPONENT HANDLE TABLE
308
GET COMPRESSED BIOS COMPONENT INFORMATION
310
RELOCATABLE BELOW 1 MEG ?
312
NO
YES
SEARCH FOR AVAILABLE BLOCK BELOW 1 MEG
314
RELOCATABLE ABOVE 1 MEG ?
316
NO
YES
SEARCH FOR AVAILABLE BLOCK BETWEEN 1 AND 4 MEG
318
BASE ADDRESS IN OVERLAY REGION ?
320
NO
SPECIFIED LOAD ADDRESS AVAILABLE ?
326
NO
IS REQUIRED SIZE AVAILABLE ?
322
NO
YES
YES
SET ALLOCATION ERROR FLAGS
324
UPDATE MEMORY ALLOCATION TABLES
330
SET ALLOCATION ERROR FLAGS
328
END OF COMPONENT LIST ?
332
NO
YES
STOP
334

FIG. 3

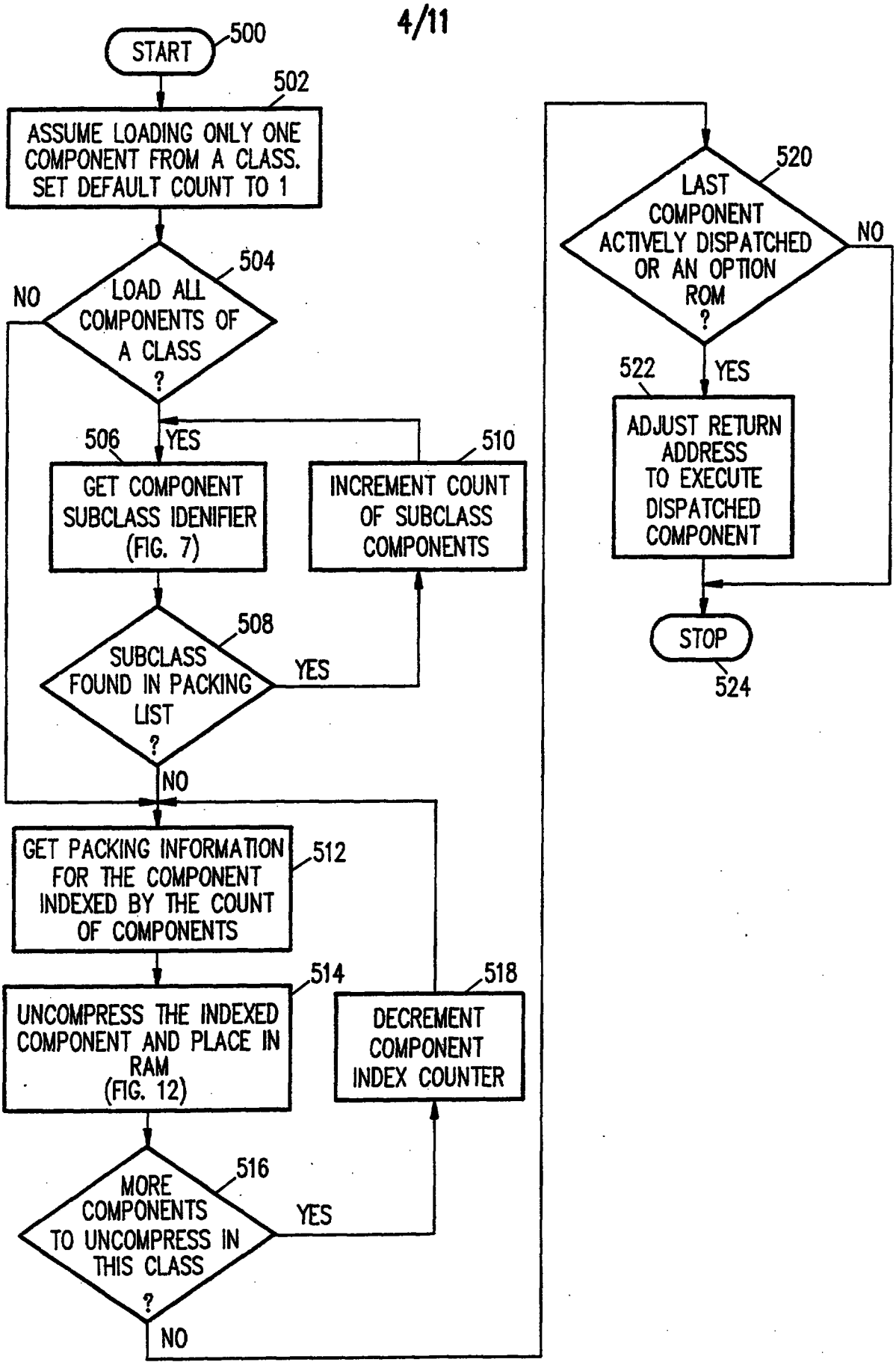

START
500
ASSUME LOADING ONLY ONE COMPONENT FROM A CLASS. SET DEFAULT COUNT TO 1
502
LOAD ALL COMPONENTS OF A CLASS ?
504
NO
YES
GET COMPONENT SUBCLASS IDENIFIER (FIG. 7)
506
INCREMENT COUNT OF SUBCLASS COMPONENTS
510
SUBCLASS FOUND IN PACKING LIST ?
508
YES
NO
GET PACKING INFORMATION FOR THE COMPONENT INDEXED BY THE COUNT OF COMPONENTS
512
UNCOMPRESS THE INDEXED COMPONENT AND PLACE IN RAM (FIG. 12)
514
DECREMENT COMPONENT INDEX COUNTER
518
MORE COMPONENTS TO UNCOMPRESS IN THIS CLASS ?
516
YES
NO
LAST COMPONENT ACTIVELY DISPATCHED OR AN OPTION ROM ?
520
NO
YES
ADJUST RETURN ADDRESS TO EXECUTE DISPATCHED COMPONENT
522
STOP
524

FIG. 5

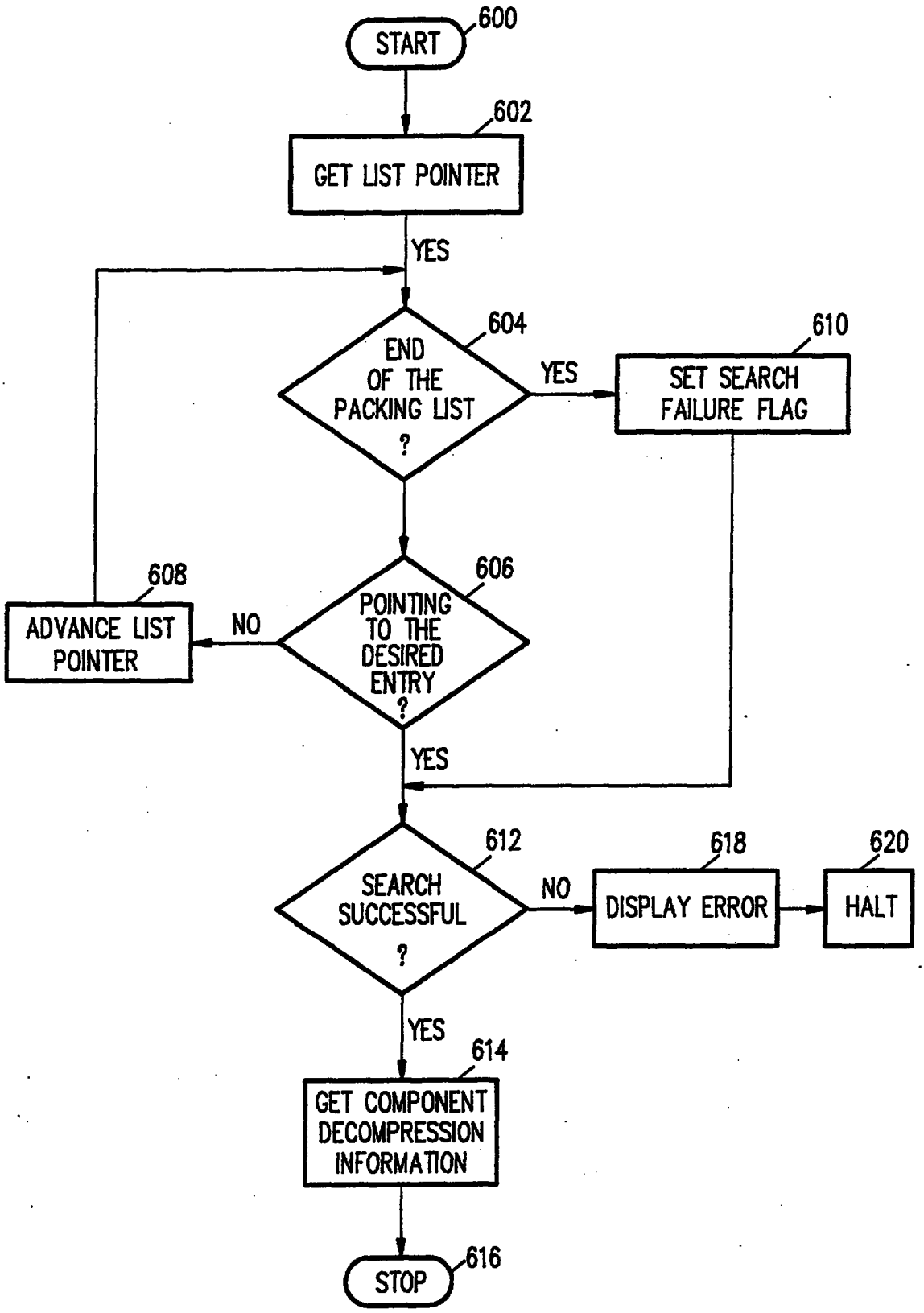

START
600
GET LIST POINTER
602
YES
END OF THE PACKING LIST ?
604
YES
SET SEARCH FAILURE FLAG
610
ADVANCE LIST POINTER
608
NO
POINTING TO THE DESIRED ENTRY ?
606
YES
SEARCH SUCCESSFUL ?
612
NO
DISPLAY ERROR
618
HALT
620
YES
GET COMPONENT DECOMPRESSION INFORMATION
614
STOP
616

FIG. 6

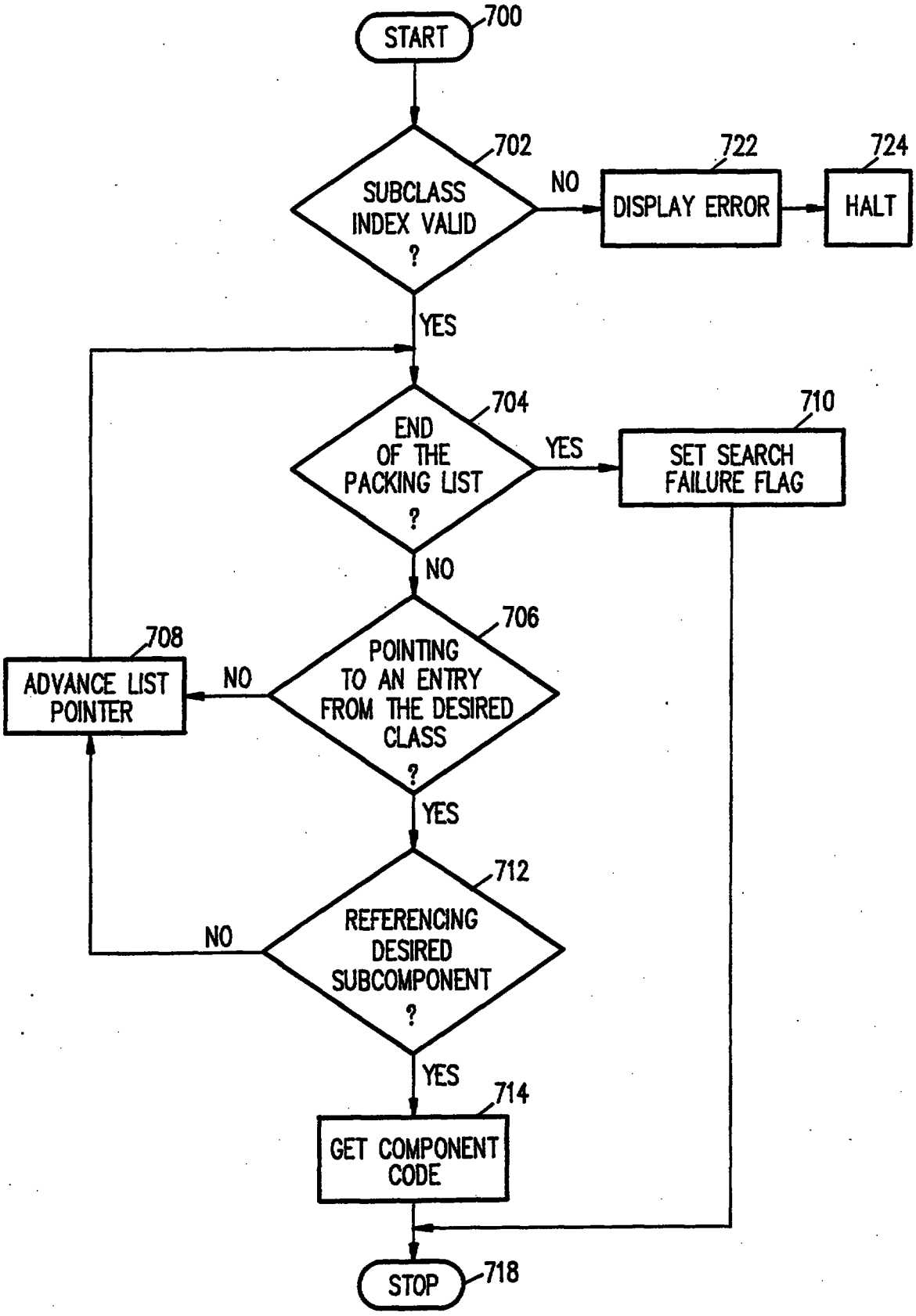

START
700
SUBCLASS INDEX VALID ?
702
NO
DISPLAY ERROR
722
HALT
724
YES
END OF THE PACKING LIST ?
704
YES
SET SEARCH FAILURE FLAG
710
NO
POINTING TO AN ENTRY FROM THE DESIRED CLASS ?
706
NO
ADVANCE LIST POINTER
708
YES
REFERENCING DESIRED SUBCOMPONENT ?
712
NO
YES
GET COMPONENT CODE
714
STOP
718

FIG. 7

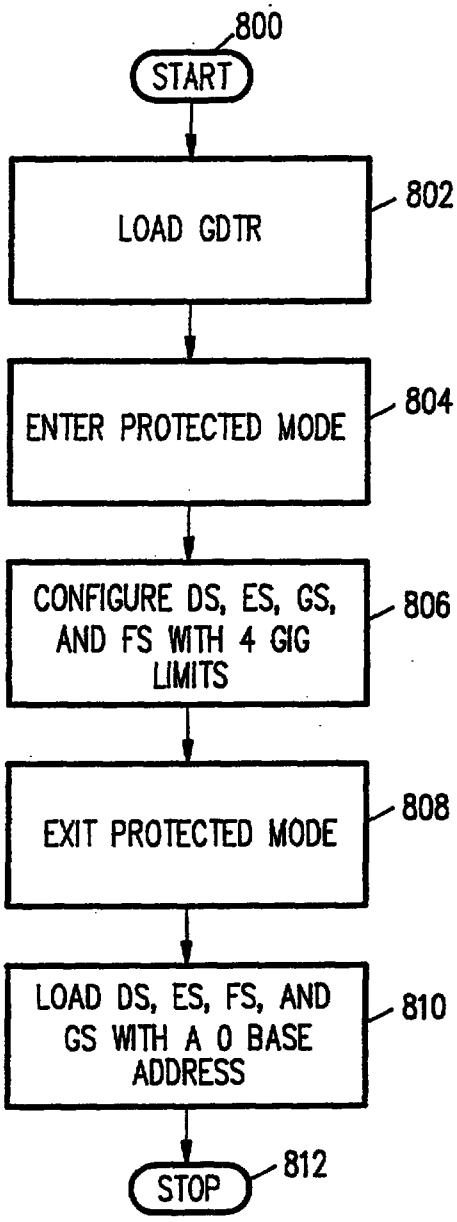

800
START
LOAD GDTR
802
ENTER PROTECTED MODE
804
CONFIGURE DS, ES, GS, AND FS WITH 4 GIG LIMITS
806
EXIT PROTECTED MODE
808
LOAD DS, ES, FS, AND GS WITH A 0 BASE ADDRESS
810
STOP
812

FIG. 8

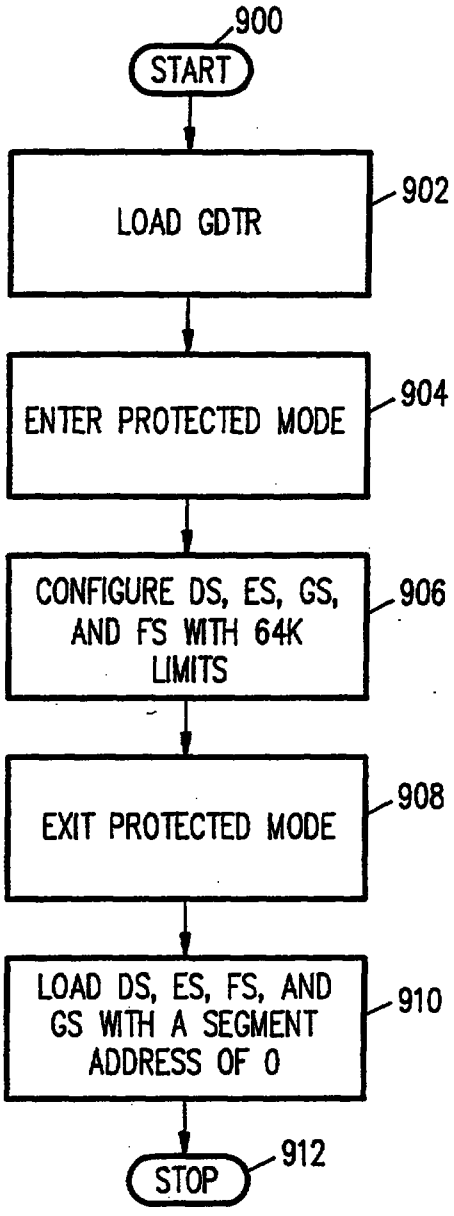

900
START
LOAD GDTR
902
ENTER PROTECTED MODE
904
CONFIGURE DS, ES, GS, AND FS WITH 64K LIMITS
906
EXIT PROTECTED MODE
908
LOAD DS, ES, FS, AND GS WITH A SEGMENT ADDRESS OF 0
910
STOP
912

FIG. 9

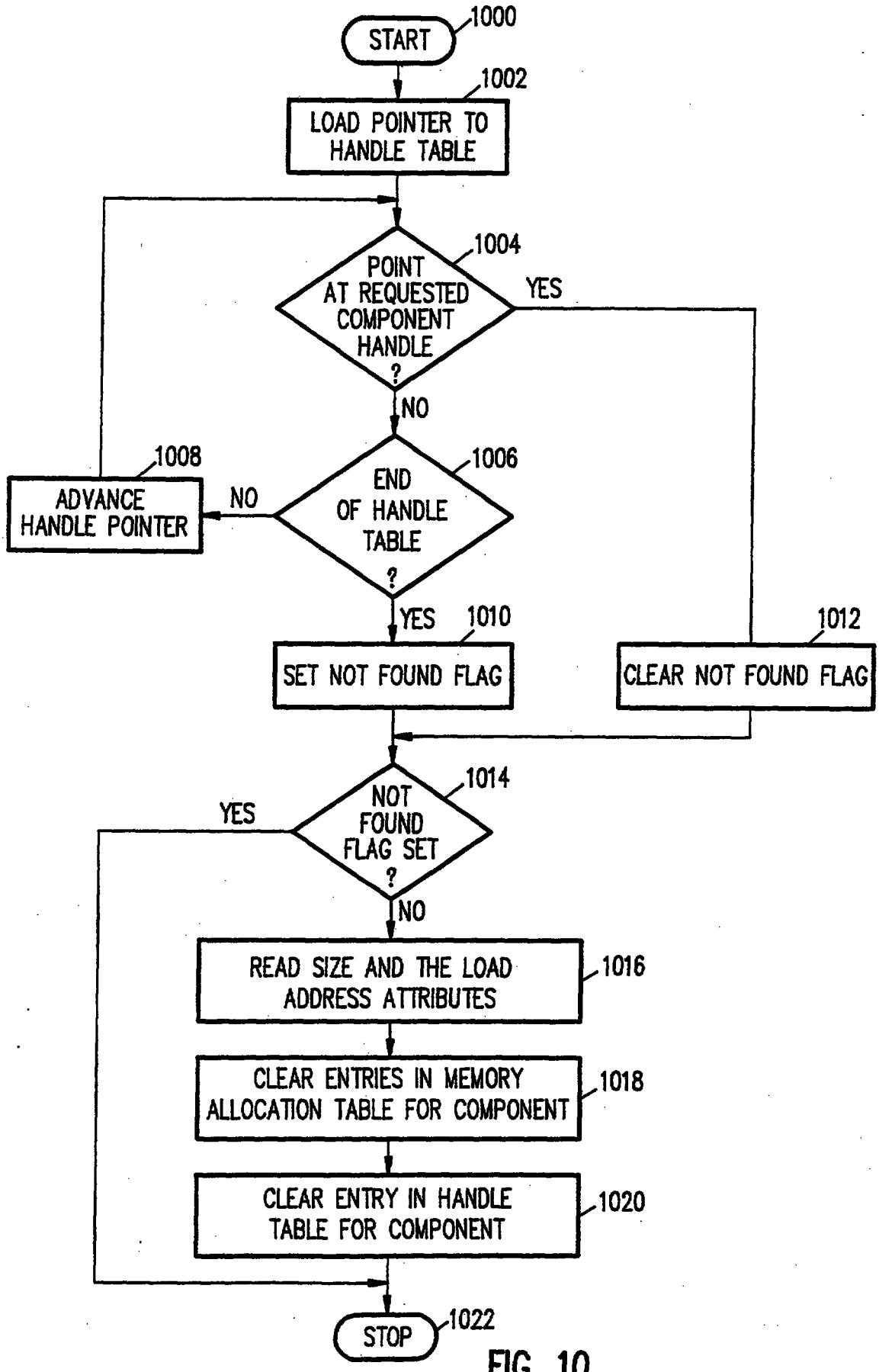

START
1000
LOAD POINTER TO HANDLE TABLE
1002
POINT AT REQUESTED COMPONENT HANDLE ?
1004
YES
NO
END OF HANDLE TABLE ?
1006
NO
ADVANCE HANDLE POINTER
1008
YES
SET NOT FOUND FLAG
1010
CLEAR NOT FOUND FLAG
1012
NOT FOUND FLAG SET ?
1014
YES
NO
READ SIZE AND THE LOAD ADDRESS ATTRIBUTES
1016
CLEAR ENTRIES IN MEMORY ALLOCATION TABLE FOR COMPONENT
1018
CLEAR ENTRY IN HANDLE TABLE FOR COMPONENT
1020
STOP
1022

FIG. 10

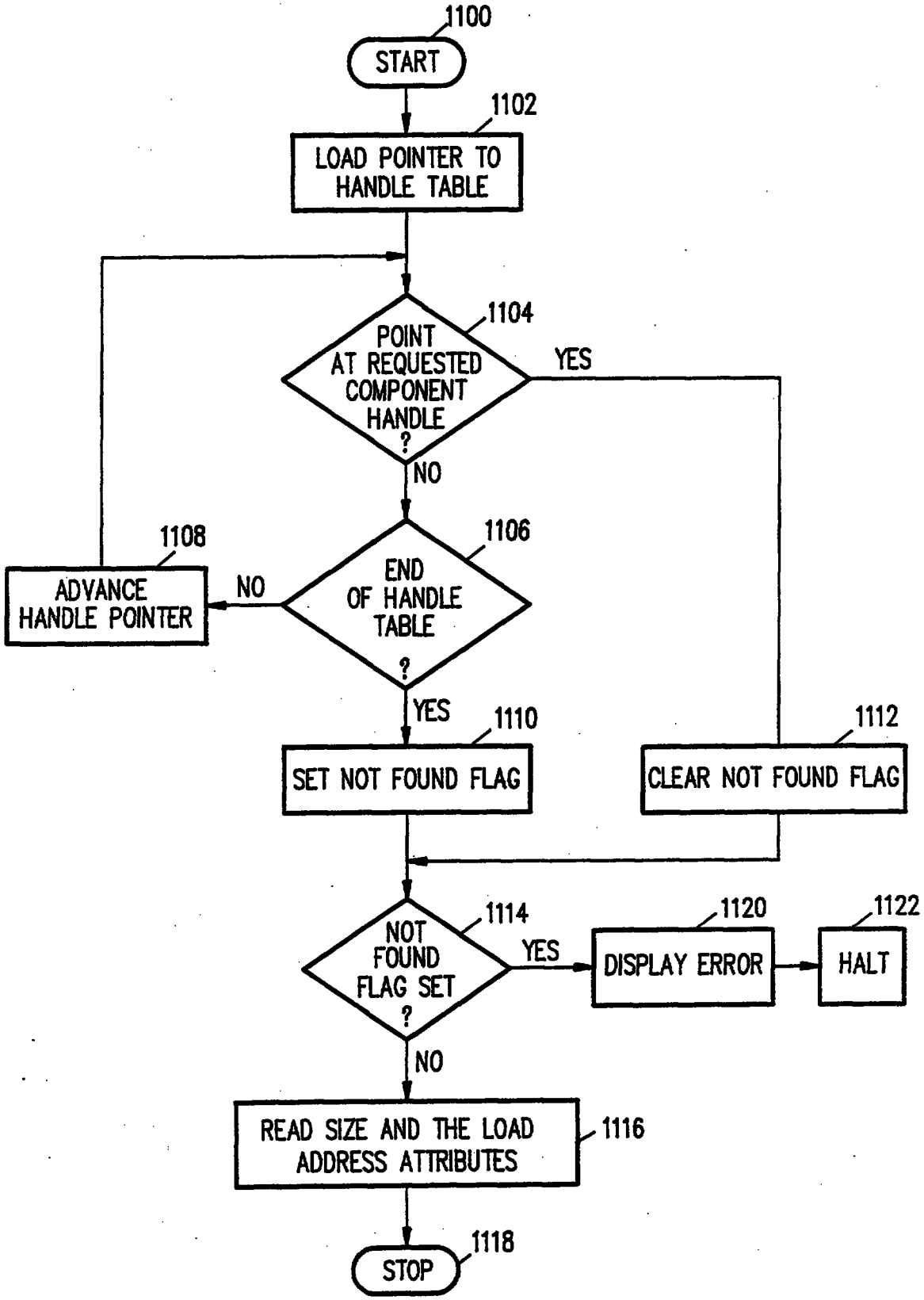

1100
START
1102
LOAD POINTER TO HANDLE TABLE
1104
POINT AT REQUESTED COMPONENT HANDLE ?
YES
NO
1106
END OF HANDLE TABLE ?
NO
1108
ADVANCE HANDLE POINTER
YES
1110
SET NOT FOUND FLAG
1112
CLEAR NOT FOUND FLAG
1114
NOT FOUND FLAG SET ?
YES
1120
DISPLAY ERROR
1122
HALT
NO
READ SIZE AND THE LOAD ADDRESS ATTRIBUTES
1116
1118
STOP

FIG. 11

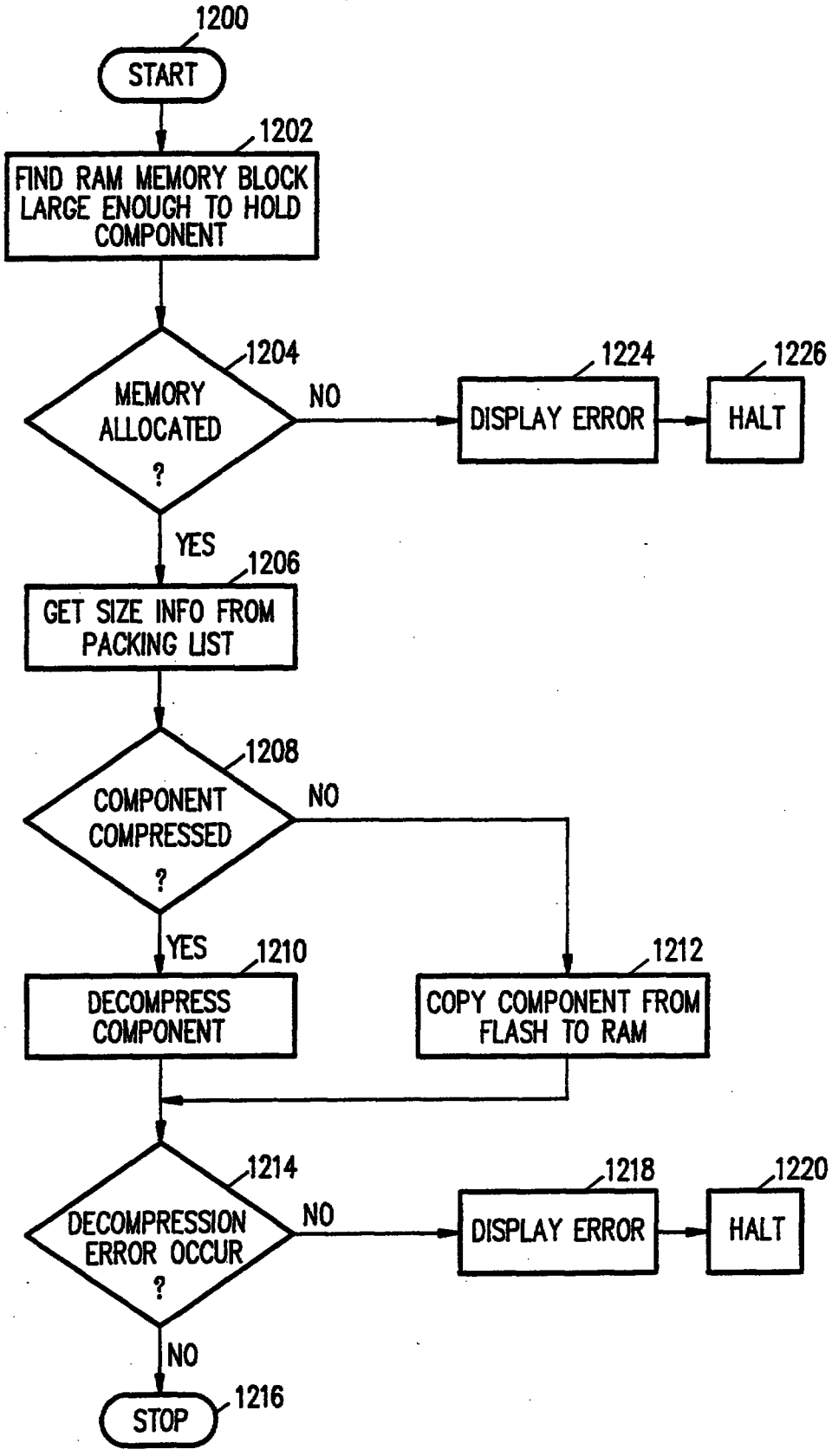

1200
START
1202
FIND RAM MEMORY BLOCK LARGE ENOUGH TO HOLD COMPONENT
1204
MEMORY ALLOCATED ?
NO
1224
DISPLAY ERROR
1226
HALT
YES
1206
GET SIZE INFO FROM PACKING LIST
1208
COMPONENT COMPRESSED ?
NO
YES
1210
DECOMPRESS COMPONENT
1212
COPY COMPONENT FROM FLASH TO RAM
1214
DECOMPRESSION ERROR OCCUR ?
NO
1218
DISPLAY ERROR
1220
HALT
NO
1216
STOP

FIG. 12

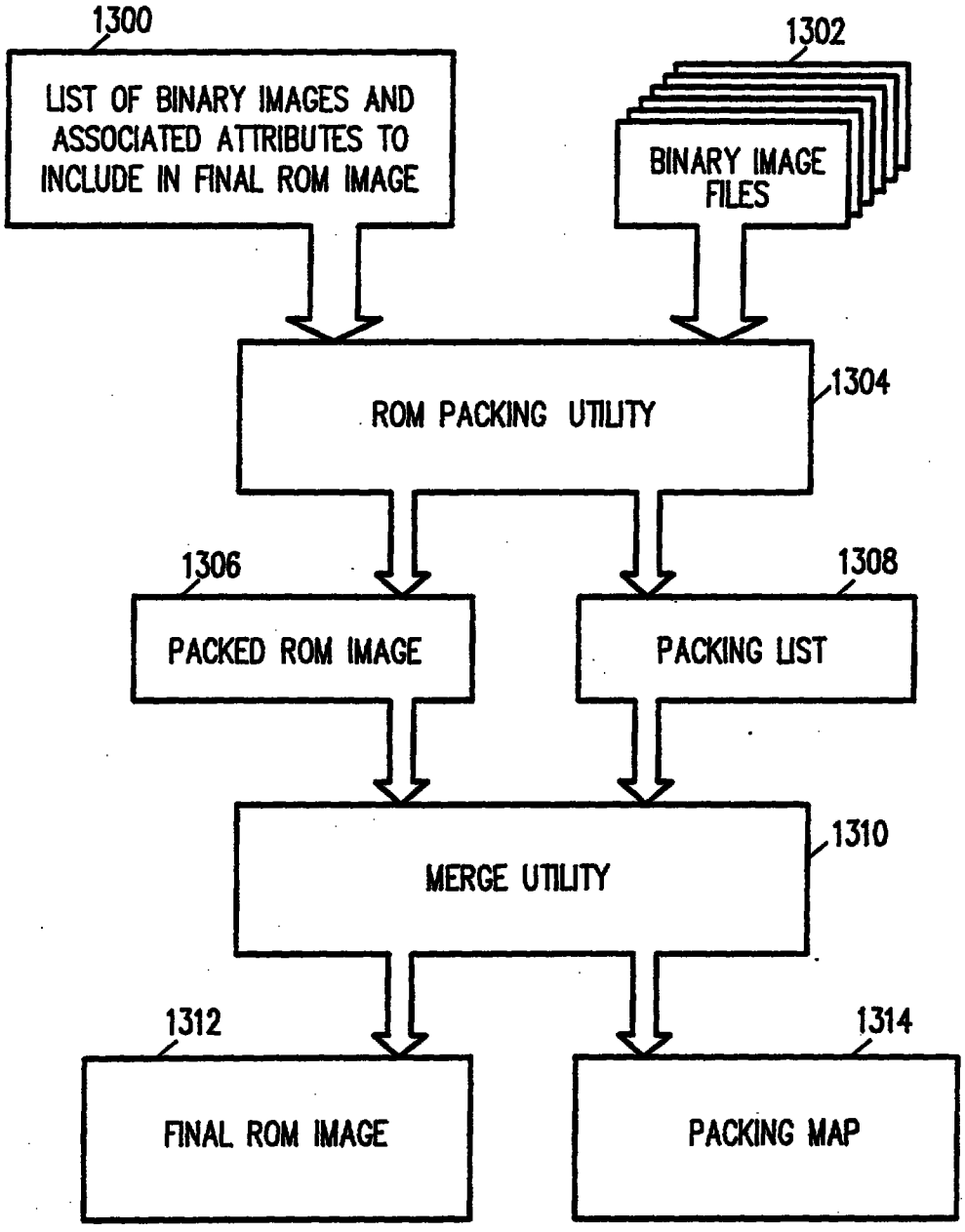

1300
LIST OF BINARY IMAGES AND ASSOCIATED ATTRIBUTES TO INCLUDE IN FINAL ROM IMAGE
1302
BINARY IMAGE FILES
ROM PACKING UTILITY
1304
1306
PACKED ROM IMAGE
1308
PACKING LIST
MERGE UTILITY
1310
1312
FINAL ROM IMAGE
1314
PACKING MAP

FIG. 13

REPLACEMENT SHEET
Date : 25 APR 1998

A METHOD FOR BASIC INPUT-OUTPUT SYSTEM (BIOS) CODE COMPRESSION/DECOMPRESSION DISPATCHER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention is related to personal computers and more particularly to an object-oriented basic input/output system using data compression.

Background Art

In IBM compatible personal computers a set of programs called basic input/output system (BIOS) are encoded in read-only memory (ROM). The BIOS facilitates the transfer of data and instructions between a central processing unit (CPU) and peripheral devices such as disk drives. Computer systems are designed to perform functional tests of the BIOS every time the computer is turned on. When the computer is turned on, BIOS is copied to an area of random access memory (RAM) set aside for it. Since a RAM is much faster acting than a ROM, accessing the BIOS code from RAM results in much faster initialization of the computer.

As more new features are designed into computers, more code has to be stored into the BIOS stored on the ROM. The size of the ROM must be increased to accommodate the additional code, resulting in additional manufacturing costs. It is desirable to decrease product cost by reducing the size of a ROM required to store the BIOS and all of its components. This can be done by decompressing the code as it is stored on the ROM and then decompressing the code at the time it is copied to the RAM.

~~SUMMARY OF THE INVENTION~~

~~Briefly, the present invention provides a method in which memory~~ controller related components, a power on ~~self test~~ (POST) object, and a decompression ~~dispatcher~~ are stored in a read only memory (ROM). The ~~method tests and initializes the memory controller related components;~~

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

SUMMARY OF THE INVENTION

The services to be provided by a basic input/output system (BIOS) of a computer system are implemented via a number of independently executable service components. Additionally, the BIOS is provided with a decompression dispatcher for decompressing and dispatching the service components into random access memory (RAM) of the computer system for execution on an as needed basis, and removing the dispatched service components when they are no longer needed. As a result, the service components may be stored in a non-volatile storage in a compressed state, allowing more services to be implemented without requiring more non-volatile storage.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1996

~~initializes the decompression dispatcher; dispatches the POST object resulting in uncompressed code, and, executes the uncompressed code.~~

More specifically, different basic input/output system (BIOS) functions are split into components, or objects, and selected ones of the components are stored in a compressed state and these compressed components are only decompressed and executed when needed. A decompression dispatcher software takes a request from currently executing BIOS code to decompress another portion of BIOS code that may be needed. The requester can specify whether or not to just decompress the portion of code into memory or to decompress and initialize the decompressed BIOS. The decompression dispatcher can be used to dispatch different portions of BIOS code to different processors in a multi-processor system.

The BIOS stored in a read only memory (ROM) is organized into a set of components, each being dispatched as an independent executable object after being copied to a shadow memory portion of a random access memory (RAM). Three types of components are defined, initialization components, runtime components and functional components. The initialization components are dispatched during a Power On Self Test (POST) cycle such that the initialization components are active during initialization. The initialization components are terminated prior to loading an operating system. The runtime components are maintained in the uncompressed/decompressed state and executable after loading of the operating system. The functional components are decompressed and dispatched on an as needed basis. The components can be actively or passively dispatched. Control over a dispatched object is returned to a requester by the decompression dispatcher upon a condition that the component is to be passively dispatched and the passively dispatched component is recorded in a memory manager. Control over a dispatched object is passed to the decompressed component upon a condition that the component is to be actively dispatched. When dispatching components the decompression dispatcher works from a packing list provided in the ROM image by a BIOS build process. To optimize device usage, the binary images that comprise the different components are packed in the final ROM image.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

The packing list provides a detailed description of the packing as well as other important pieces of information regarding the types of components that have been packed into the ROM.

~~An advantage of this invention is that the decompression dispatcher can~~ be used to embed option ROMs of add-in cards into the BIOS and, by virtue of auto-detection, associate those ROMs with the installed add-in card.

An advantage of this invention is that it provides a way to put more features into existing products and reduce the cost of future products.

A further advantage of this invention is that it provides a solution that is more comprehensive than the prior art by allowing all possible code and text to be compressed.

A further advantage of this invention is that it provides a way of customizing BIOSs without having to change individual binary images.

A further advantage of this invention is that it provides a way of distributing BIOS execution to other area of memory besides the standard 0F0000h, and onto multiple processors.

A further advantage of this invention is that it provides a mechanism for selling low-cost PCI add-in cards without having to ship a ROM on each card, because the ROM can be embedded into the BIOS of the mother ~~board.~~

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention as illustrated in the accompanying drawings.

AMENDED SHEET

REPLACEMENT SHEET
Date : 25 APR 1996

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram of a computer system in which the present invention is embodied;

FIGURE 2 is a flow diagram of a basic input/output system (BIOS) program in accordance with the present invention;

FIGURE 3 is a flow diagram of initializing the decompression dispatcher of FIGURE 2;

FIGURE 4 is a flow diagram of how the decompression dispatcher of FIGURE 2 is revoked.

FIGURE 5 is a flow diagram of how components are dispatched;

FIGURE 6 is a flow chart of the execution of the dispatched component;

FIGURE 7 is a flow diagram of the get component subclass identifier block (506) of FIGURE 5;

FIGURE 8 is a flow diagram of dispatching ~~of~~ components of a class that is protected and having a 4 gig limit~~e~~.

FIGURE 9 is a flow diagram of dispatching ~~of~~ components of a class that is protected and having a 64 K limit~~e~~.

FIGURE 10 is a flow diagram of removing a component from memory;

FIGURE 11 is a flow diagram of a function returning ~~returne~~ the size and address of any dispatched component.

FIGURE 12 is a flow diagram of the procedure for getting a specified component transferred and stored in RAM in an uncompressed and executable state; and

AMENDED SHEET

REPLACEMENT SHEET
25 APR 1998
Date :.....

DESCRIPTION OF THE PREFERRED EMBODIMENT

Refer to FIGURE 1 which is a block diagram of a computer system in which the present invention is embodied. The computer includes a read only memory, or ROM, (10), a dynamic random access memory, or DRAM, (22), a system memory cache (24), a cache/DRAM controller (20), and central processing units (28, 30). A set of programs called basic input/output system (BIOS) are encoded in ROM (10). The BIOS facilitates the transfer of data and instructions between the central processing units (28, 30) and peripheral devices. In the present invention the BIOS is organized into a set of BIOS components (32 through 54), each of which is capable of being dispatched as an independent executable object. Each BIOS component is a self-contained (link independent) binary image that performs a certain task or function. The BIOS components fall into three major types: initialization components, runtime components and functional components.

The ROM (10) is a non-volatile device used to store the BIOS components, some in a compressed state and some in an uncompressed state. The DRAM (22) stores a shadow RAM binary image of selected components stored in the ROM, ~~which have been decompressed and stored~~ For those components stored in the compressed state, they are decompressed before storing in the shadow ROM. In Intel 80386 and 80486 computers, shadow RAM is a portion of upper memory area set aside for programs retrieved from ROM.

Compressed code is the code the resides in the ROM in a compressed state. Decompressed code is code that has been decompressed from its compressed state inside the ROM and now resides in DRAM (22) shadowed memory, in a decompressed ~~an uncompressed~~ state. Uncompressed code is code that resides inside the ROM in an uncompressed state. This is code that was never compressed.

A component that has been decompressed and activated is an object that is manipulated with modular programming techniques.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

Stored in the ROM (10) are the following components: power-on self-test (POST) object (32); advanced power management (APM) object (34); video BIOS option ROM (36); runtime system BIOS object (38); peripheral component interconnect (PCI) BIOS object (40); small computer system interface (SCSI) option ROM (42); configuration utility (44); server management software object (46); miscellaneous optional ROM(48); component packing list (50); decompression dispatcher (52); and power-on self-test (POST) loader module (54). The decompression dispatcher (52) includes a decompressor, a dispatcher and a memory manager.

The ROM (10) is connected to PCI to ISA Bridge Device (14) via Industry Standard Architecture (ISA) Bus (12). The PCI to ISA Bridge Device (14) is connected to the Peripheral Component Interconnect (PCI) Bus (16) which is connected to the host to PCI bridge device (18).

System random access memory, RAM, (22) and system memory cache (24) are connected to the Cache/DRAM Controller (20) via a local memory bus. The CPU 1 (28) and the CPU 2 (30) is connected to the host to PCI bridge device (18) via the Host CPU Bus (26).

FIGURE 13 is a flow diagram of a BIOS build process that automates compressing and packing components into a final ROM binary image. A list of binary images and associated attributes to include in the final ROM image (1300) and a number of binary image files (1302) are provided to a ROM Packing Utility (1304). The ROM Packing Utility (1304) creates a packed ROM image (1306) and a packing list (1308) that are merged by a merge utility (1310) into a final ROM image (1312) and a packing map (1314) that are stored in the ROM (10) shown in FIGURE 1.

Terminology

Compressed Code- Compressed code is the code that resides in the BIOS storage device in a compressed state.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 Apr 2000

Decompressed Code- Decompressed code is code that has been decompressed from its compressed state inside the BIOS storage device and now resides in DRAM or Shadowed Memory in ~~an uncompressed~~ a decompressed state.

Uncompressed Code- Uncompressed code is code that resides inside the BIOS storage device in an uncompressed state, code that never has been compressed.

Storage Device- The non-volatile device used to store the BIOS code (compressed or uncompressed). This may be a FLASH or EEPROM.

Component- A BIOS component is a self-contained (link independent) binary image that performs a certain task or function. A BIOS component could be something as simple as the decompression dispatcher itself or as complex as the entirety of Power On Self Test (POST) software.

Object - an object is ~~a~~ an uncompressed/decompressed component that has been ~~decompressed and~~ activated.

Direct Dependency- A Direct Dependency is a dependency upon another object or component that is satisfied by a far call or absolute jump instruction.

Indirect Dependency- An Indirect Dependency is a dependency upon another object or component that is satisfied by an API such as an interrupt function or the decompression dispatcher.

Packing Utility- The Packing Utility is the utility used by the BIOS build process to automate compressing and packing Components into the final read only memory (ROM) image.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

Packing Script- The Packing Script is the script used by the Packing Utility to describe the packing order of the ROM image. The Packing Script facilitates the automated build process.

Packing List- The Packing List is generated by the Packing Utility and describes all the attributes of the packed ROM image. This list is used by the decompression dispatcher to dispatch components.

Decompression dispatcher - The decompression dispatcher is the component responsible for all ~~decompression and~~ dispatching activities including decompression.

Component Types

The BIOS is organized into a set of components, each being dispatched as an independent executable object. Components fall into three major types: initialization components, runtime components and functional components.

Initialization components are dispatched during what is commonly referred to as the Power On Self Test (POST) cycle. These components are active during initialization and terminated prior to loading the Operating System. Initialization components may contain direct runtime dependencies but these dependencies are limited to objects of the same Component Class. ~~All~~ For the illustrated embodiment, all initialization components ~~must be~~ are segment relocatable. An example of an initialization component is the POST Object.

Runtime components are objects that ~~must~~ are uncompressed or remain decompressed and executable after loading of the Operating System. Typically, runtime components are combined to form the 64K system BIOS image located in the F0000h segment. ~~Runtime~~ For the illustrated embodiment, runtime components ~~may~~ do not contain any direct dependencies to any other component regardless of its type or class, ~~and~~ but may contain indirect dependencies ~~are allowed only~~ to other runtime components. An example of a runtime component is the Runtime System BIOS Object.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

Functional components are dispatched on an as needed basis. ~~A~~ For the illustrated embodiment, a Functional component ~~may~~ does not contain any direct dependencies to any other component regardless of type or class. An example of a Functional component is ~~a~~ the Configuration Utility ~~or a BIOS Setup program~~.

Component Dispatching

Components are dispatched through a utility called the decompression dispatcher. There are two types of dispatching supported by the decompression dispatcher, active and passive.

Components are said to be passively dispatched when the binary image is decompressed into memory and control is returned to the requester by the decompression dispatcher. Passively dispatched components are recorded in the ~~Memory Manager~~ memory manager of the decompression dispatcher. ~~and must be disposed of prior to loading of the boot strap.~~

All runtime components, actively as well as passively dispatched, are disposed of prior to the boot strap.

Components are said to be actively dispatched when the binary image is decompressed into memory and control is given to the decompressed object. Components must support Real mode execution to be actively dispatched. Control is given directly to the actively dispatched component by the decompression dispatcher.

Control may or may not be returned to the requester depending upon the Component being dispatched. The code segment (CS), instruction pointer (IP) and Flags of the requester remain on the stack when control is given to a actively dispatched component. That component may execute a ADD SP, 6 if it chooses to maintain control or execute an IRET instruction to return to the requester.

When dispatching components the decompression dispatcher works from a Packing List provided in the ROM image by the BIOS build process. To optimize device usage, the binary images that comprise the different components are packed into the final ROM image. The Packing List

AMENDED SHEET

REPLACEMENT SHEET
Date : 25 APR 1998

provides a detailed description of the packing as well as other important pieces of information regarding the types of components that have been packed into the ROM.

Class Identification

Each Component is identified by its Class and Sub-Class code. The Class / Sub-Class combination must be unique for each component and there must not be two components of the same Sub-Class within a given Class.

Packing Address

The Packing Address field specifies the offset inside the ROM image where the corresponding Component has been located. The Packing Address is typically provided by the Packing Utility unless specified in the Packing Script.

Unitialized Data components will have a Packing Address of zero (00000000h).

Compressed Size

The Compressed Size field specifies the amount of space (in bytes) consumed by a component when it is in the ROM image.

Unitialized Data components use this field to specify the maximum amount of memory required and be aligned on a 64K boundary.

Decompressed Size

The Decompressed Size field specifies the amount of space (in bytes) consumed by a decompressed component after it has been dispatched. Components that are placed in the ROM uncompressed have identical Compressed and Decompressed sizes.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

Unitialized Data components specify this field to be identical to the Compressed Size field.

Load Address

The Load Address field specifies the 32 bit physical address of where the component is to be dispatched. ~~This field must be~~ For the illustrated embodiment, this field is specified even if the component is intended to be relocatable. Actively dispatched components ~~must~~ specify a Load Address that is below 1Mb and aligned on a paragraph (16 byte) boundary.

Unitialized Data components ~~must~~ specify a load address that is aligned on a 64K boundary. If the Load Address is arbitrary then a value of all FF's (FFFFFFFFh) may be specified. Components referencing Unitialized Data with an arbitrary Load Address ~~must~~ use the Get Unitialized Data Address function to determine the actual Load Address of the Unitialized Data. This function can only be called after the Unitialized Data has been dispatched. Refer to the Memory Management section described below for restrictions on fixed Load Address for Unitialized Data components, for the illustrated embodiment.

Execution Offset

The Execution Offset field specifies a 16 bit offset into the component where execution is to begin. ~~This offset must be~~ For the illustrated embodiment, this offset is specified for all components that satisfy direct dependencies of other components regardless of whether or not they are to be actively dispatched. Components that do not satisfy direct dependencies of other components ~~should~~ specify this field as FFFFh.

Unitialized Data components ~~must~~ specify an Execution Offset of FFFFh.

Relocation Type

The Relocation Type field specifies what type, if any, of component relocation is supported. Types are either: not relocatable; relocatable below 1MB only; relocatable above 1MB only; or relocatable anywhere.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

Dispatch Type

The Dispatch Type field specifies what type of dispatching is supported by the corresponding component. Types are either: passive dispatching; active dispatching; or both active and passive dispatching.

Component Organization

Though the flexibility of Component Type, Class, and Sub-Class allow unique customization of a particular BIOS, ~~there are five components that must be supported in every BIOS.~~ certain components are typically included in every BIOS. These ~~five~~ components are: decompression dispatcher, decompression dispatcher including unitialized data, and memory manager POST Loader, power on self test (POST), and system BIOS runtime executable. These ~~five~~ components are described in the following paragraphs.

Decompression Dispatcher

The decompression dispatcher component contains all the functions that comprise the decompression dispatcher. Access is gained through ~~the interrupt~~ an interface defined in the ~~decompression dispatcher~~ Decompression Dispatcher Functions section described below. This component resides uncompressed in the ROM image.

Decompression Dispatcher Unitialized Data

This component is 128K in length and provides the memory buffers required by the decompression dispatcher.

POST Loader

The POST Loader component handles all hardware generated resets (i.e. power on, front panel, etc.) and software generated resets after being processed by the Shutdown Handler. This component resides uncompressed in the ROM image and may not be dispatched into DRAM.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

The primary responsibility of this module is to configure enough of the system to gain 2Mb of DRAM, activate the decompression dispatcher, and ~~dispatch~~ cause the main Power On Self Test to be decompressed and dispatched.

Power On Self Test

The Power On Self Test component (~~24~~32) is the main POST executable, and is responsible ~~for dispatching all components required~~ for initialization of the system, and causing all necessary components to be dispatched. This component resides in a compressed state in the ROM image, and as described earlier, this component is decompressed and dispatched into DRAM by the decompression dispatcher.

System BIOS Runtime Executable

The System BIOS Runtime Executable component is responsible for all compatible System Services including interrupt and Device Service Routines. This component ~~must also~~ contains the Shutdown Handler responsible for handling all software related resets and dispatching the POST Loader as needed. This component resides in a compressed state in the ROM state, and it is decompressed and dispatched into DRAM by the decompression dispatcher.

Decompression Dispatcher Functions

Dispatch Component ( )

The decompression dispatcher component (~~44~~52) dispatches a Component into memory (~~12~~ 22). Each Component is identified by a unique Class/Sub-Class code combination. Dispatched Components are recorded in an Allocation Table kept by ~~the~~ a Memory Manager. The actual base address of a Component may be retrieved at any time by calling the Get Physical Address( ) function.

~~It is~~ For the illustrated embodiment, it is the responsibility of the caller to ensure that an ~~the~~ Enter Flat Mode() function has been called and 4G Data Segments are active (this implies that Gate A20 is enabled) before calling ~~this~~ the Enter Flat Mode() function. Also, if dispatching is being done into shadowed memory (between C0000h-FFFFFh), ~~then~~ the caller ~~must~~ ensures that the appropriate range has been Read/Write enabled ~~in DRAM~~.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1996

Unitialized Data Components are also dispatched using this function. ~~All~~ For the illustrated embodiment, all possible requests for Unitialized Data ~~must be~~ are satisfied in the Packing List at build time in order for them to be dispatched by this function. ~~Dynamic assigning of~~ Unitialized Data Components ~~is~~ are not supported by the decompression dispatcher.

Input:

AH 00h
AL 00h - Passive Dispatch
01h - Active Dispatch
BX Class Code
CX Sub-Class Code
EDI Relocation Address (00000000h if Relocation not Requested.)
ESI Unitialized Data Size (00000000h if Default)

Output - Success:

CF Clear (0)
AH 00h

Output - Failure:

CF Set (1)
AH Error Code
01h - Invalid Function.
02h - Component Packing List entry not found.
03h - Component does not support relocation
04h - Component cannot relocate above 1Mb
05h - Component does not support Active Dispatching
06h - Cannot Actively Dispatch above 1Mb
07h - Active Dispatch aborted because of invalid segment alignment
08h - Cannot allocate memory for component
09h - Decompression failed, dispatch aborted.

AMENDED SHEET

REPLACEMENT SHEET
Date : 25 APR 1998

Output - Failure:

CF Set (1)

AH 01h - Invalid Function.

02h - Component Allocation Table entry not found.

Get physical Address( )

Return to the caller the base address and size of any dispatched Component identified by the given Class and Sub-Class code. An error is returned to the caller if the given Component does not have an entry in the Allocation Table.

Input:

AH 06h

BX Class Code

CX Sub-Class Code

Output - Success:

CF Clear (0)

AH 00h

EDI 32 bit Base Address of Component

EDX Size of Component in bytes (1K aligned)

Output - Failure:

CF Set (1)

AH 01h - Invalid Function.

02h - Component Allocation Table entry not found.

Memory Management

The memory manager is responsible for managing memory allocation for the BIOS' memory. Memory testing and subsequent update of status ~~to a video moniter~~ are all done in 'Real Big' mode as opposed to constantly switching between Real and Protected Mode. 'Real Big' mode is a mode where the data segment registers of the processor are loaded with Protected Mode type

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

CX Sub-Class Code

Output:
None

Get Memory Block( )
Where am I function.

Input:
BX Class Code
CX Sub-Class Code

Output - Success:
CF Clear (0)
AH 00h
EDI Physical Base Address
EDX Size of Block

Output - Failure:
CF Set (1)
AH 07h - Cannot allocate memory for component

Description of Flow Charts

Refer to FIGURE 2 which is a flow diagram of a basic input/output system (BIOS) program in accordance with the present invention. The program starts (200), and tests and initializes the memory controller ~~related components~~ and its dependencies (202). Next the program initializes ~~the power on self test (POST)~~ its decompression dispatcher (204) shown in more detail in the flow diagram of FIGURE 3. Finally, the program dispatches and executes ~~the~~ its POST component (206) as shown in FIGURES 4 and 5, and stops (208).

Refer to FIGURE 3 which is a flow diagram of initializing the ~~a~~ decompression dispatcher of FIGURE 2. The dispatcher data and executable code is copied (302) from the ROM to the RAM. The dispatcher interrupt vector is

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

described in FIGURE 7. If the subclass is found in the packing list (508) then the count of the subclass index counter is incremented (510). If the subclass is not found in the packing list (508), then the count of the subclass index counter is not incremented and the flow proceeds to get packing information for the component indexed by the count of the component counter (512). The procedure next ~~uncompresses~~ decompresses the component at the index count and places the ~~uncompressed~~ decompressed code in RAM (514). The details of block (514) are shown in more detail in FIGURE 12. At the end of the ~~uncompressing~~ decompressing procedure, a check (516) is made to determine if there are more components in this class to ~~uncompress~~ decompress. If yes, the component index counter is decremented (518). If no, a check (520) is made to determine if this is the last component actively dispatched or if an option ROM is present. If not, the flow ends (524). If yes, then the return address is adjusted to execute the dispatched component (522).

Refer to FIGURE 6 which is a flow chart of the execution of the dispatched component. The list pointer for the packing list entries is fetched (602). The packing list pointer is checked (604) to determine if the end of the packing list is pointed to. If yes, a search failure flag is set (610). If no, a check (606) is made to determine if the pointer is pointing to the desired entry. If no, the list pointer is advanced (608). If yes, the flow proceeds to block (612). If the search of the packing list is successful (612), then the component decompression information is fetched (614). and this part of the procedure ends (616).). If the search of the packing list is not successful (612), an error is displayed (618) and the procedure is halted (620).

Refer to FIGURE 7 which is a flow diagram of the get component subclass identifier block (506) of FIGURE 5. The sub class index is checked (702) to determine if it is valid. If not valid, an error is displayed (722) and the procedure is halted (724). If yes, the packing list pointer is checked (704) to determine if the end of the packing list is pointed to. If yes, a search failure flag is set (710). If no, a check (706) is made to

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1996

determine if the packing list pointer is pointing to an entry from the desired class. If no, the packing list pointer is advanced (708). If yes, a check (712) is made to determine if the packing list pointer is referencing a desired sub component. If no, the packing list pointer is advanced (708). If yes, the component code is fetched from the ROM (714) and this portion of the procedure stops (718).

Refer to FIGURE 8 which is a flow diagram of dispatching of components of a class that is protected and having a 4 gig limit. The procedure loads the GDTR a global descriptor table register GDTR (802) with the a global descriptor table and then enters protected mode (804). The A data segment (DS), an extra segment (ES), a global segment (GS), and a general-purpose file segment (FS), registers of the computer system is are configured with the 4 gig limits and protected mode is exited (808). The registers DS, ES, FS, and GS are loaded with a O base address (810) and the procedure stops (812).

Refer to FIGURE 9 which is a flow diagram of dispatching of components of a class that is protected and having a 64K limits. The procedure loads the GDTR a global descriptor table register GDTR (902) with the a global descriptor table and then enters protected mode (904). The data segment (DS), extra segment (ES), global segment (GS), and general-purpose file segment (FS), registers are configured with 64K limits and protected mode is exited (908). The registers DS, ES, FS, and GS are loaded with a O base address (910) and the procedure stops (912).

Refer to FIGURE 10 which is a flow diagram of removing a component from memory. The procedure loads the pointer to the handle table (1002), and checks to see if it is pointing to the correct entry (1004). If not, it checks to see if it is at the end of the table (1006) and if so sets the not found flag (1010) and flow proceeds to block 1014. If it is not at the end of the table the pointer is incremented to the next entry (1008) and the flow returns to block (1004). If the handle pointer is at the correct entry, the not found flag is cleared (1012) and flow proceeds to block (1014). If the not found flag is set the procedure is exited (1022), otherwise the size

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

and address arc retrieved (1018) and the corresponding entry is cleared from the memory allocation table (1018) and the handle entry is cleared from the handle table (1020).

Refer to FIGURE 11 which is a flow diagram of a function which returns the size and address of any dispatched component. This function loads the pointer to the handle table (1102), and checks to see if it is pointing to the correct entry (1104). If not, it checks to see if it is at the end of the table (1106) and if so sets the not found flag(1110)and flow proceeds to block (1114). If it is not at the end of the table the pointer is incremented to the next entry (1108) and the flow returns to block (1104). If the handle pointer is at the correct entry, the not found flag is cleared(1112)and flow proceeds to block (I114). If the not found flag is set, an error is displayed (1120) and the function is halted (1122), otherwise the size and address are retrieved (I116) and the function is exited (1118).

Refer to FIGURE 12 which is a flow diagram of the procedure for getting a specified component transferred and stored in RAM in an uncompressed and executable state.

A RAM memory block large enough to hold the specified component is found (1202) and allocated. After the memory space is allocated (1204), the size field in the packing list is accessed to get the size information (1206). The compressed and decompressed size information is obtained from the packing list entry (1206). The Compressed Size field specifies the amount of space (in bytes) consumed by a component when it is in the ROM image. Unitialized Data components use this field to specify the maximum amount of memory required and that they be aligned on a 64K boundary. The Decompressed Size field specifies the amount of space (in bytes) consumed by a component after it has been decompressed and dispatched. ~~Components~~ As described earlier, components that are placed in the ROM uncompressed have identical Compressed and Decompressed sizes. Unitialized Data Components specify this field to be identical to the Compressed Size field.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

* C L M S *

CLAIMS:

1. An apparatus comprising:

a) a non-volatile storage having a basic input/output system (BIOS) stored therein, the BIOS being constituted of a plurality of independently executable service components and a decompression dispatcher, the service components being stored in a compressed state, and the decompression dispatcher being used during operation of a computer system within which the apparatus is integrated, to decompress and dispatch the service components for execution, on an as needed basis, to provide basic input/output services to the computer system, and to remove the dispatched service components upon execution when the dispatched service components are no longer needed.

2. The apparatus as set forth in claim 1, wherein the decompression dispatcher includes a first function invocable during operation of the computer system by a first executing one of the service components to cause a first non-executing one of the service components to be decompressed and dispatched for execution.

3. The apparatus as set forth in claim 2 wherein the first executing one of the service components identifies the first non-executing one of the service components to be decompressed and dispatched for execution to the first function of the decompression dispatcher using a first unique component classification code.

AMENDED SHEET

CLMS

REPLACEMENT SHEET
Date 25 APR 1998

4. The apparatus as set forth in claim 2, wherein the first function is equipped to dispatch a non-executing one of the service components in an active or a passive manner, the non-executing one of the service components being given execution control when dispatched in the active manner, and not given control when dispatched in the passive manner.

5. The apparatus as set forth in claim 2, wherein the decompression dispatcher further includes a second function invocable during operation of the computer system by a second executing one of the service components to remove a third executing one of the service components from execution.

6. The apparatus as set forth in claim 1, wherein the decompression dispatcher includes a function invocable during operation of the computer system by an executing one of the service components to obtain information about another service component.

7. The apparatus as set forth in claim 6, wherein the BIOS is further constituted of a component packing list wherein the information about the service components are stored.

8. The apparatus as set forth in claim 7, wherein the information about a service component includes classification information, a compressed size and a decompressed size of the service component.

AMENDED SHEET

* C L M S *

REPLACEMENT SHEET
Date 25 APR 1998

9. The apparatus as set forth in claim 1, wherein the decompression dispatcher includes a function invocable during operation of the computer system by an executing one of the service components to change the computer system from a first manner of memory management to a second manner of memory management.

10. The apparatus as set forth in claim 1, wherein the BIOS is further constituted of a power-on self-test (POST) loader for servicing reset of the computer system, including configuring a predetermined minimum amount of memory of the computer system for the decompression dispatcher, and loading the decompression dispatcher into the configured memory for execution, both the POST loader as well as the decompression dispatcher being stored in the non-volatile storage in an uncompressed state.

11. The apparatus as set forth in claim 10, wherein the service components include a POST object for performing power-on self-test during an initialization period of the computer system.

12. A computer system comprising:

a) random access memory (RAM); and

b) a non-volatile storage having a basic input/output system (BIOS) stored therein, the BIOS being constituted of a plurality of independently executable service components and a decompression dispatcher, the service components being stored in a compressed state, and the decompression dispatcher being loaded into the RAM and used during operation to decompress and dispatch the service components into the RAM for execution, on an as needed basis, to provide basic input/output services to the

AMENDED SHEET

* C L M S *

REPLACEMENT SHEET
Date : 25 APR 1998

computer system, and to remove the dispatched service components from the RAM upon execution, when the dispatched service components are no longer needed.

13. The computer system as set forth in claim 12, wherein the decompression dispatcher includes a first function invocable during operation by a first executing one of the service components in the RAM to cause a first non-executing one of the service components to be decompressed and dispatched into the RAM for execution.

14. The computer system as set forth in claim 13, wherein the first executing one of the service components in the RAM identifies the first non-executing one of the service components to be decompressed and dispatched into the RAM for execution to the first function of the decompression dispatcher using a first unique component classification code.

15. The computer system as set forth in claim 13, wherein the first function is equipped to dispatch a non-executing one of the service components into the RAM for execution in an active or a passive manner, the non-executing one of the service components being given execution control when dispatched in the active manner, and not given control when dispatched in the passive manner.

AMENDED SHEET

* C L M S *

REPLACEMENT SHEET
Date 25 APR 1998

16. The computer system as set forth in claim 13, wherein the decompression dispatcher further includes a second function invocable during operation by a second executing one of the service components in the RAM to remove a third executing one of the service components from execution in the RAM.

17. The computer system as set forth in claim 12, wherein the decompression dispatcher includes a function invocable during operation by an executing one of the service components in the RAM to obtain information about another service component.

18. The computer system as set forth in claim 17, wherein the BIOS is further constituted of a component packing list wherein the information about the service components are stored.

19. The computer system as set forth in claim 18, wherein the information about a service component includes component classification, a compressed size and a decorepressed size of the service component.

20. The computer system as set forth in claim 12, wherein the decompression dispatcher includes a function invocable during operation by an executing one of the service components in the RAM to change the computer system from a first manner of memory management to a second manner of memory management.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1998

21. The computer system as set forth in claim 12, wherein the BIOS is further constituted of a power-on self-test (POST) loader for servicing reset of the computer system, including configuring a predetermined minimum amount of the RAM for the decompression dispatcher, and loading the decompression dispatcher into the configured RAM for execution, both the POST loader as well as the decompression dispatcher being stored in the non-volatile storage in an uncompressed state.

22. The computer system as set forth in claim 21, wherein the service components include a POST component for performing power-on self-test during an initialization period of the computer system.

23. In a computer system, a computer implemented method for providing basic input/output service to the computer system during operation, the computer implemented method comprising the steps of:

a) loading a decompression dispatcher of a basic input/output system (BIOS) from a non-volatile storage of the computer system into random access memory (RAM) of the computer system for execution, the BIOS including the decompression dispatcher and a plurality of independently executable service components being pre-stored in the non-volatile storage, the decompression dispatcher being pre-stored in an uncompressed state, whereas the service components were pre-stored in a compressed state;

b) the decompression dispatcher decompressing and dispatching, on an as needed basis, needed ones of the service components from the non-volatile storage into the RAM for execution; and

c) the decompression dispatcher removing the dispatched service components from the RAM when the dispatched service components are no longer needed.

AMENDED SHEET

* C L M S *

REPLACEMENT SHEET
Date 25 APR 1990

24. The computer implemented method as set forth in claim 23, wherein step (b) includes the steps of:

(b.1) a first executing one of the service components invoking a first function of the decompression dispatcher and identifying a first non-executing one of the service components to the first function; and

(b.2) the first function decompressing and dispatching the first non-executing one of the service components from the non-volatile storage to the RAM for execution.

25. The computer implemented method as set forth in claim 24, wherein in step (b.1) the first executing one of the service components identifies the first non-executing ones of the service components using a unique service component classification code.

26. The computer implemented method as set forth in claim 24, wherein in step (b.2) the first function decompresses and dispatches the first non-executing one of the service components in either an active or a passive manner, the first non-executing one of the service component being given control when dispatched in the active manner, and not given control when dispatched in the passive manner.

27. The computer implemented method as set forth in claim 24, wherein step (b) further includes the steps of:

(b.3) a second executing one of the service components invoking a second function of the decompression dispatcher, and identifying a third executing one of the service components to the second function, and

(b.4) the second function removing the third executing one of the service component from the RAM.

AMENDED SHEET

* C L M S *

REPLACEMENT SHEET
Date: 25 APR 1994

28. The computer implemented method as set forth in claim 23, wherein step (b) includes the steps of:

(b.1) a first executing one of the service components invoking a function of the decompression dispatcher, and identifying another service component to the function, and

(b.2) the function returning information about the other service component to the first executing one of the service components.

29. The computer implemented method as set forth in claim 28, wherein step (b.2) includes the function retrieving the returned information from a packing list of the BIOS, wherein the returned information are stored.

30. The computer implemented method as set forth in claim 29, wherein the retrieval in step (b.2) includes retrieving a classification, a compressed size, and a decompressed size of the other service component.

31. The computer implemented method as set forth in claim 24, wherein step (b) includes the steps of:

(b.1) a first executing one of the service components invoking a function of the decompression dispatcher, and identifying a first manner of memory management to the function, and

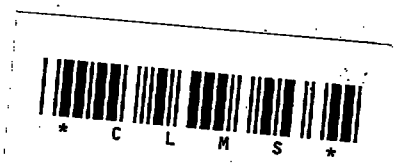
(b.2) the function switching the computer system to the first manner of memory management.

32. The computer implemented method as set forth in claim 23, wherein step (a) including the steps of:

(a.1) executing a power-on self-test (POST) loader module upon reset of the computer system, the POST loader module being pre-stored in a decompressed state in the non-volatile storage; and

AMENDED SHEET

REPLACEMENT SHEET
Date : 25 APR 1999



(a.2) the POST loader module loading the decompression dispatcher from the non-volatile storage into the RAM for execution.

33. The computer implemented method as set forth in claim 31, wherein step (b) includes decompressing and dispatching, by the decompression dispatcher, a POST component for performing power-on self-test during an initialization period of the computer system.

AMENDED SHEET

REPLACEMENT SHEET
Date 25 APR 1996

ABSTRACT

A METHOD FOR BASIC INPUT-OUTPUT SYSTEM (BIOS) CODE COMPRESSION/DECOMPRESSION DISPATCHER

The services to be provided by a basic input/output system (BIOS) (38) of a computer system are implemented via a number of independently executable service components. Additionally, the BIOS is provided with a decompression dispatcher (52) for decompressing and dispatching the service components into random access memory (RAM) (22) of the computer system for execution on an as needed basis, and optionally removing the dispatched service components when they are no longer needed. As a result, the service components may be stored in a non-volatile storage in a compressed state, allowing more services to be implemented without requiring more non-volatile storage.

(Figure 1)

AMENDED SHEET

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(54) Title: A METHOD FOR BASIC INPUT-OUTPUT SYSTEM (BIOS) CODE COMPRESSION/DECOMPRESSION DISPATCHER

(57) Abstract

A basic input/output system (BIOS) (38) stored in a read only memory (ROM) (10) is organized into a set of components, each being dispatched as an independent executable object after being copied to a shadow memory portion of a random acess memory (RAM) (22). Three types of components are defined, initialization components, runtime components and functional components. The initialization components are dispatched during a Power On Self Test (POST) cycle such that the initialization components are active during initialization. The initialization components are terminated prior to loading an operating system. The runtime components are maintained decompressed and executable after loading of the operating system. The functional components are dispatched on an as needed basis. When dispatching components a decompression dispatcher (52) works from a component packing list (50) provided in the ROM image by a BIOS build process.

