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(54) **HIGH DENSITY WEB SERVER CHASSIS SYSTEM AND METHOD**

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(58) **Field of Search** 361/686, 788, 361/683, 684, 687, 695; 439/61, 62, 59; 312/223.1, 223.2, 223.3; 174/261

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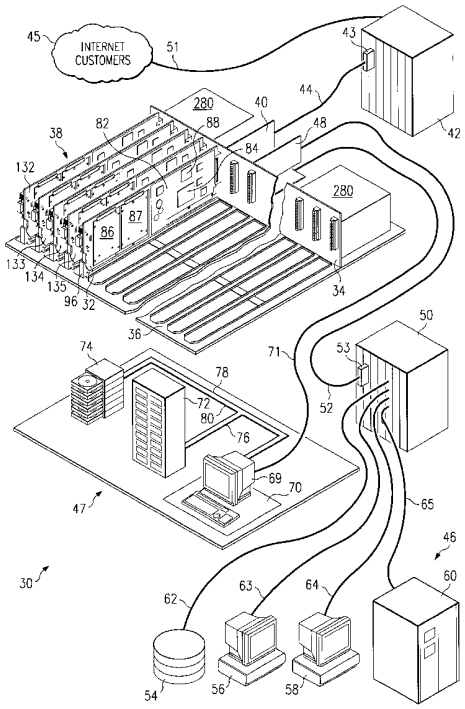
(57) **ABSTRACT**

A web server chassis having a plurality of web server processing cards coupled with a midplane is provided. A first network interface card may also be coupled with the midplane. The midplane may include printed circuitry operable to provide data communications between the plurality of web server processing cards and the first network interface card. A second network interface card may also be coupled with the midplane, the second network interface card operable to couple the plurality of web server processing cards with a private network. In a particular embodiment the first network interface card may be operable to couple the plurality of web server processing cards with a public network. A third network interface card may also be provided. The third network interface card may be operable to couple the plurality of web server processing cards with a management network.

27 Claims, 9 Drawing Sheets



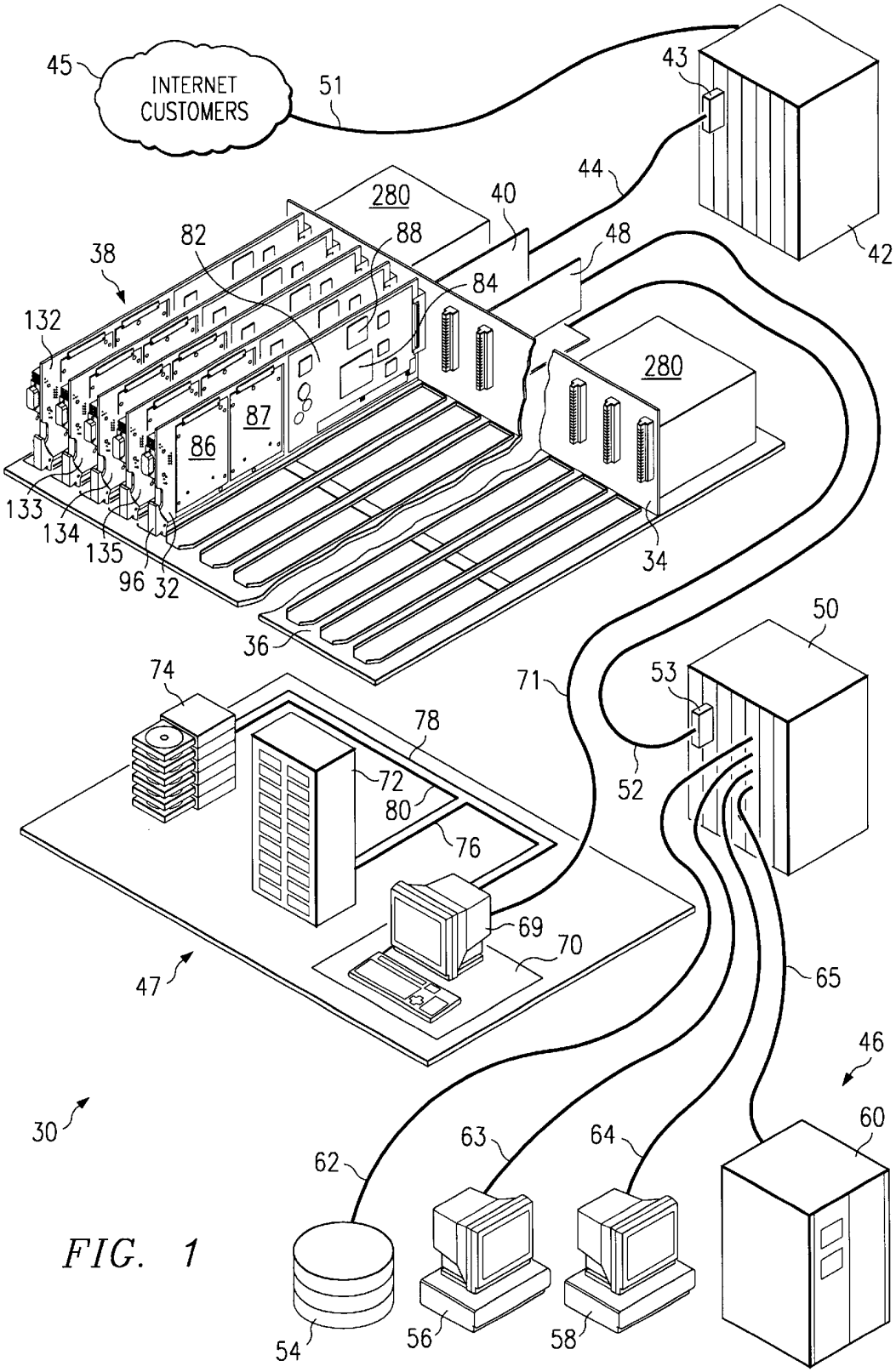

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FIG. 1

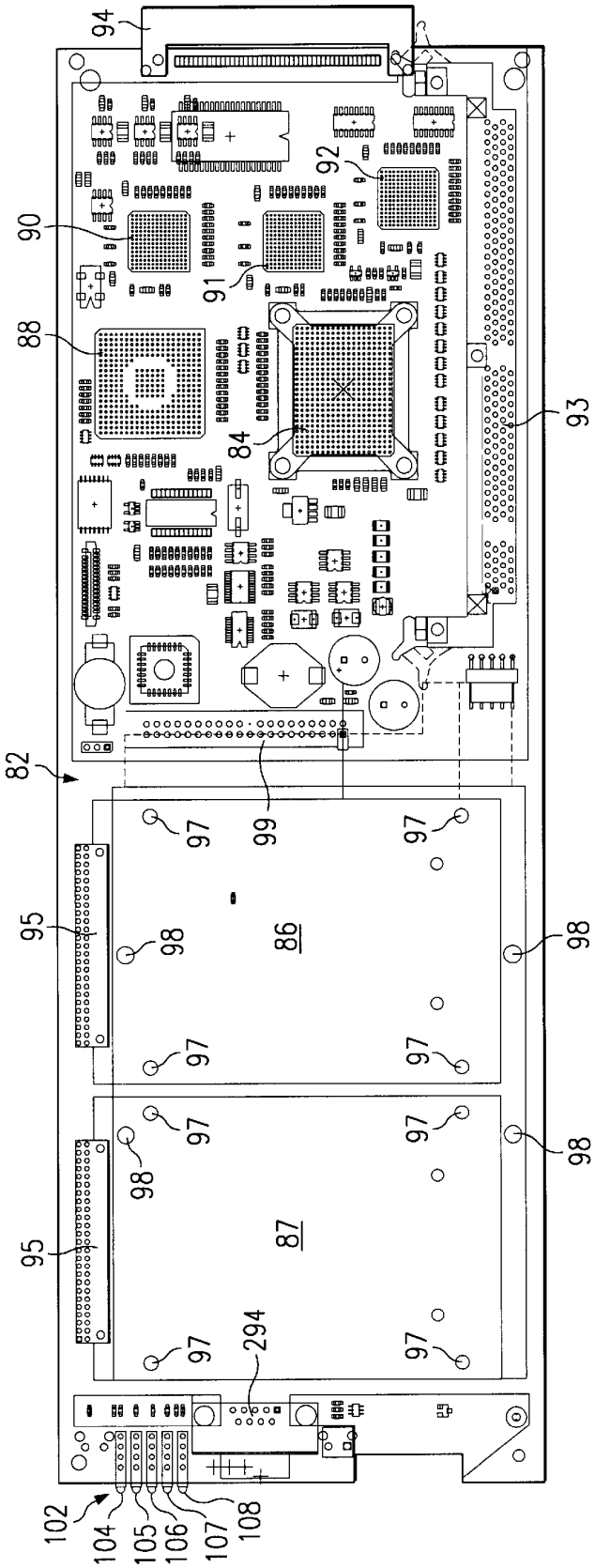
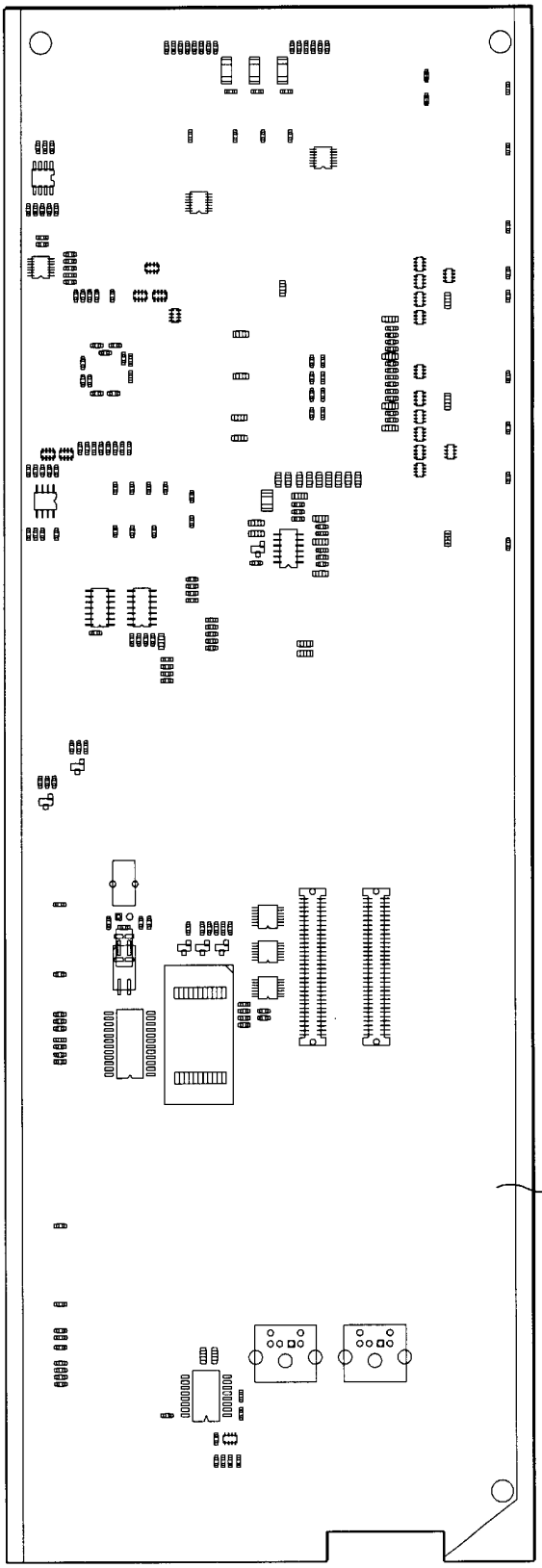


FIG. 2



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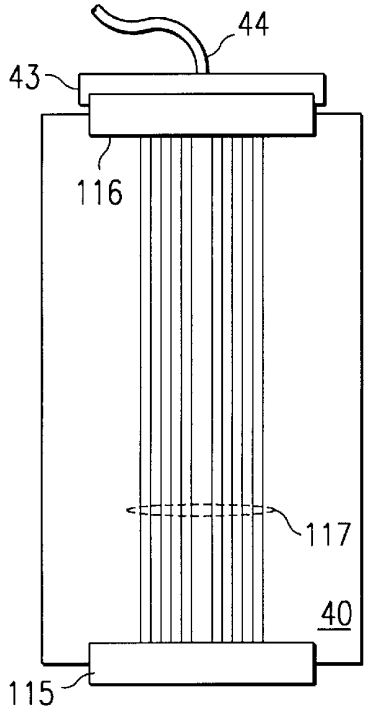


FIG. 4

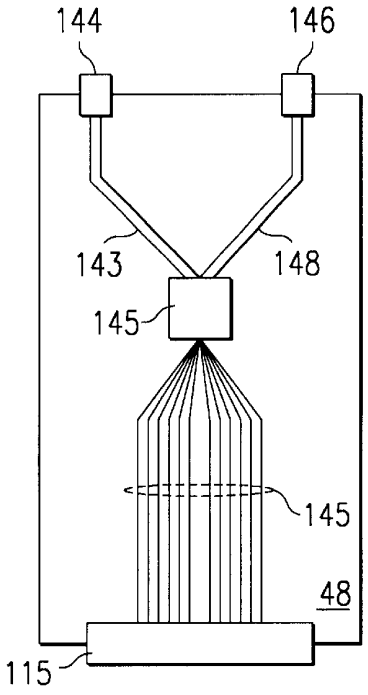
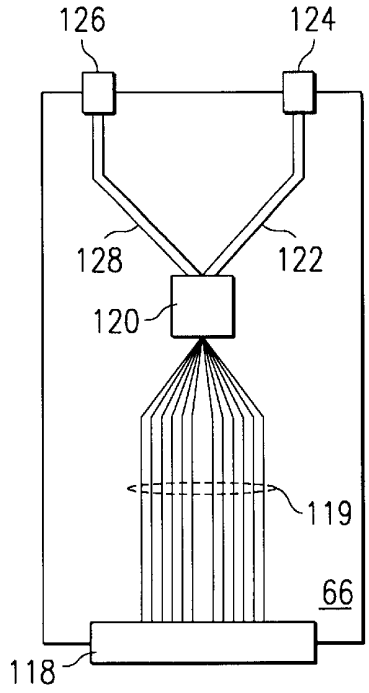


FIG. 5



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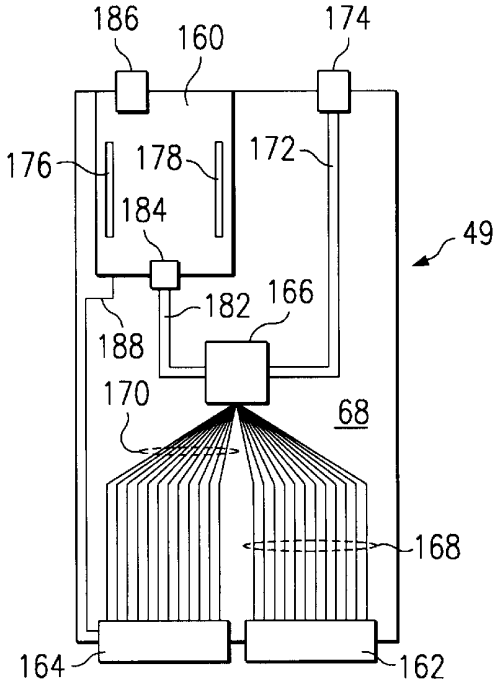

FIG. 7

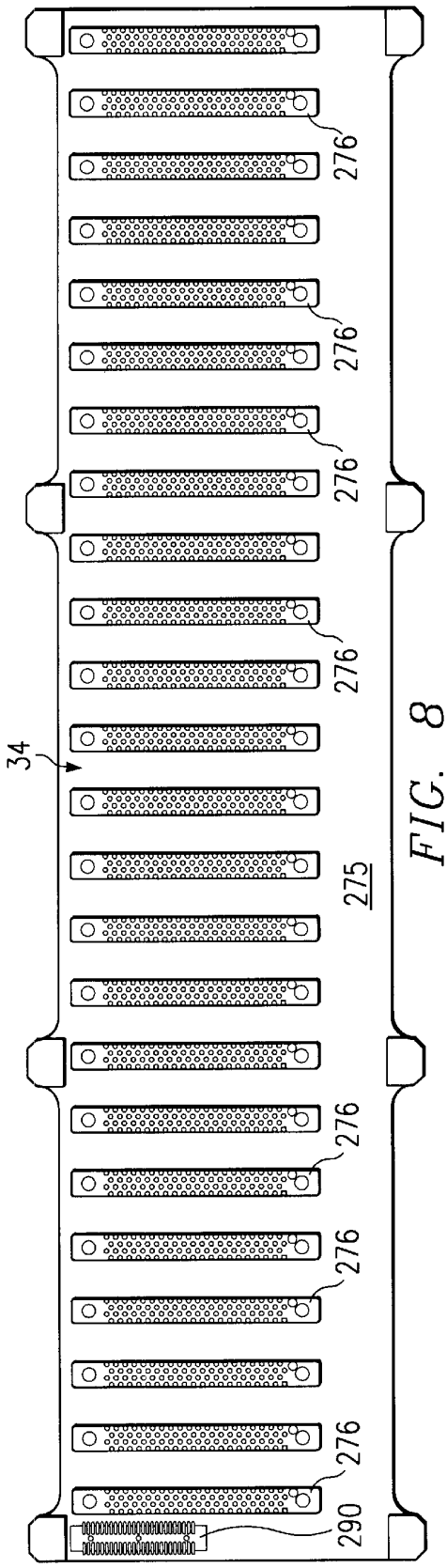
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FIG. 8

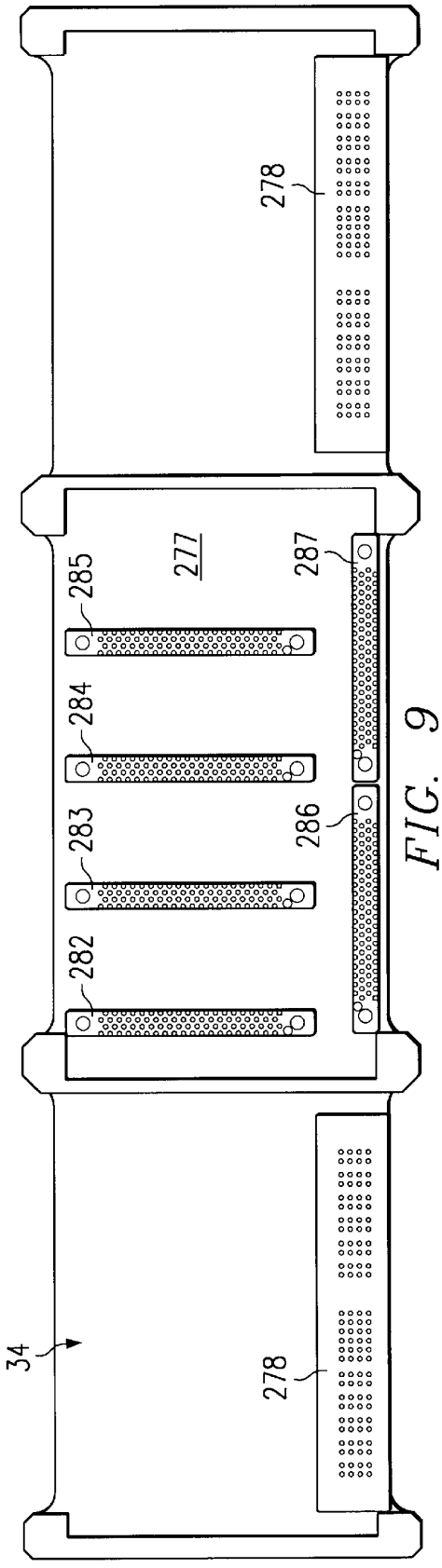
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FIG. 9

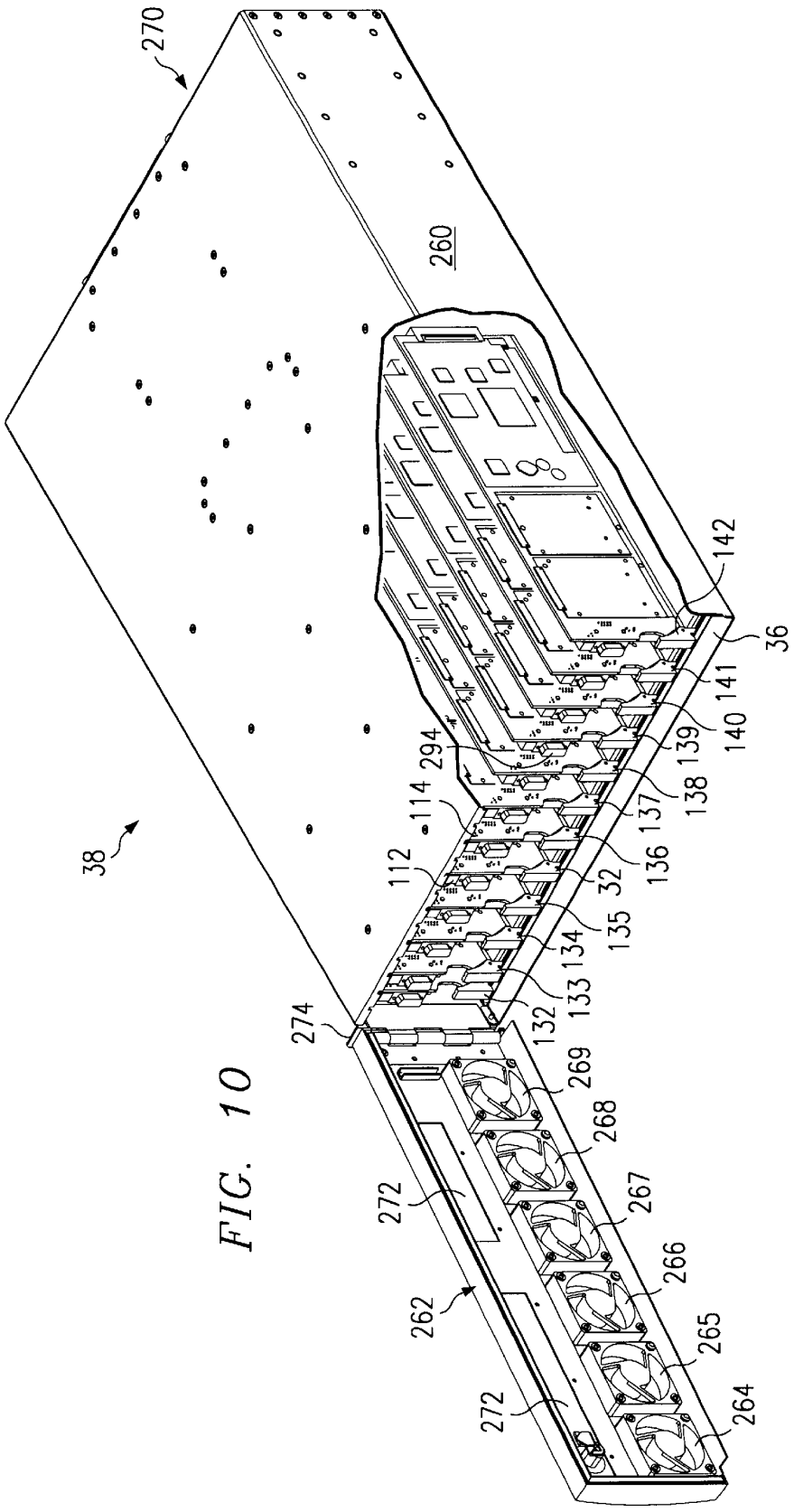
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FIG. 10

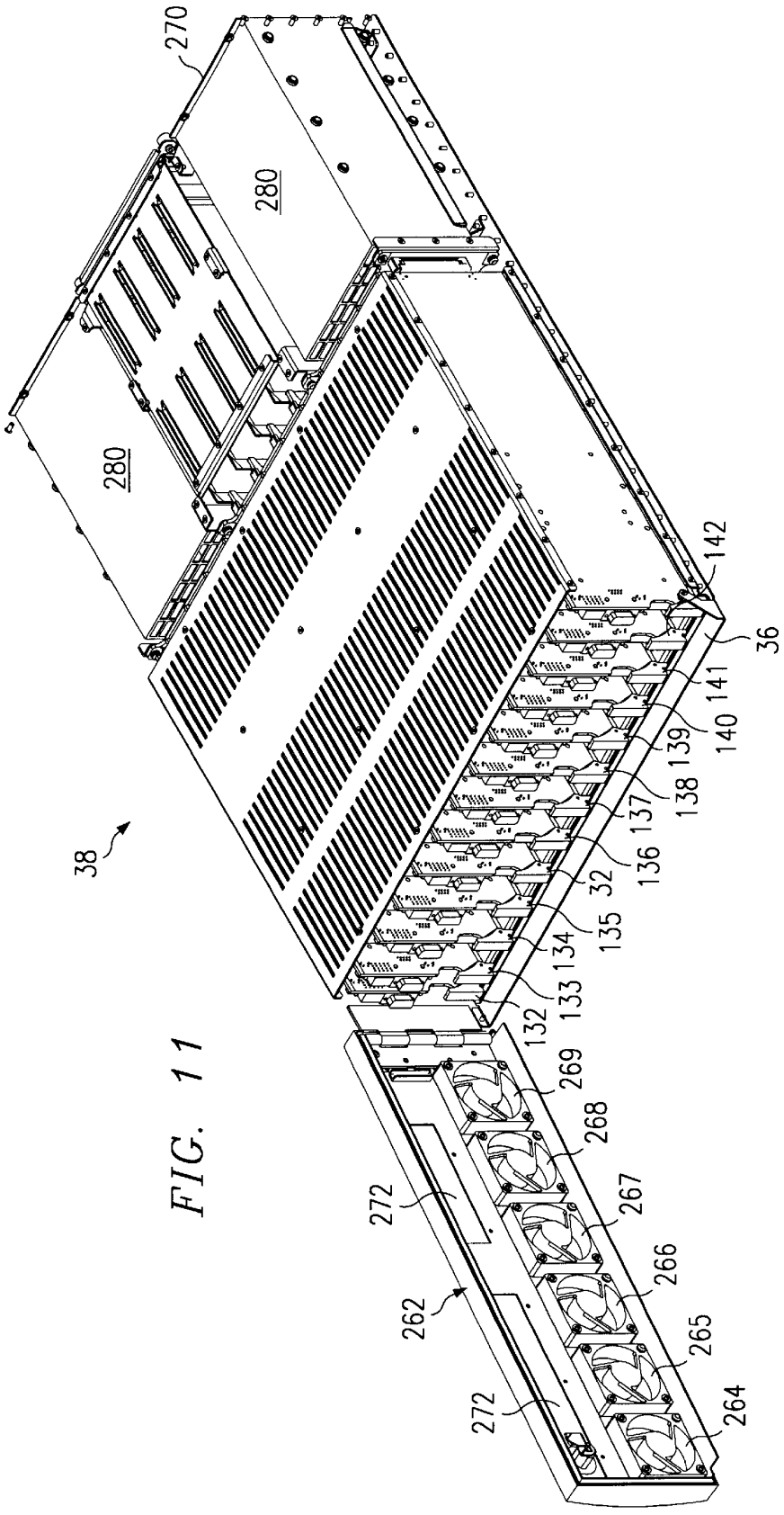
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FIG. 11

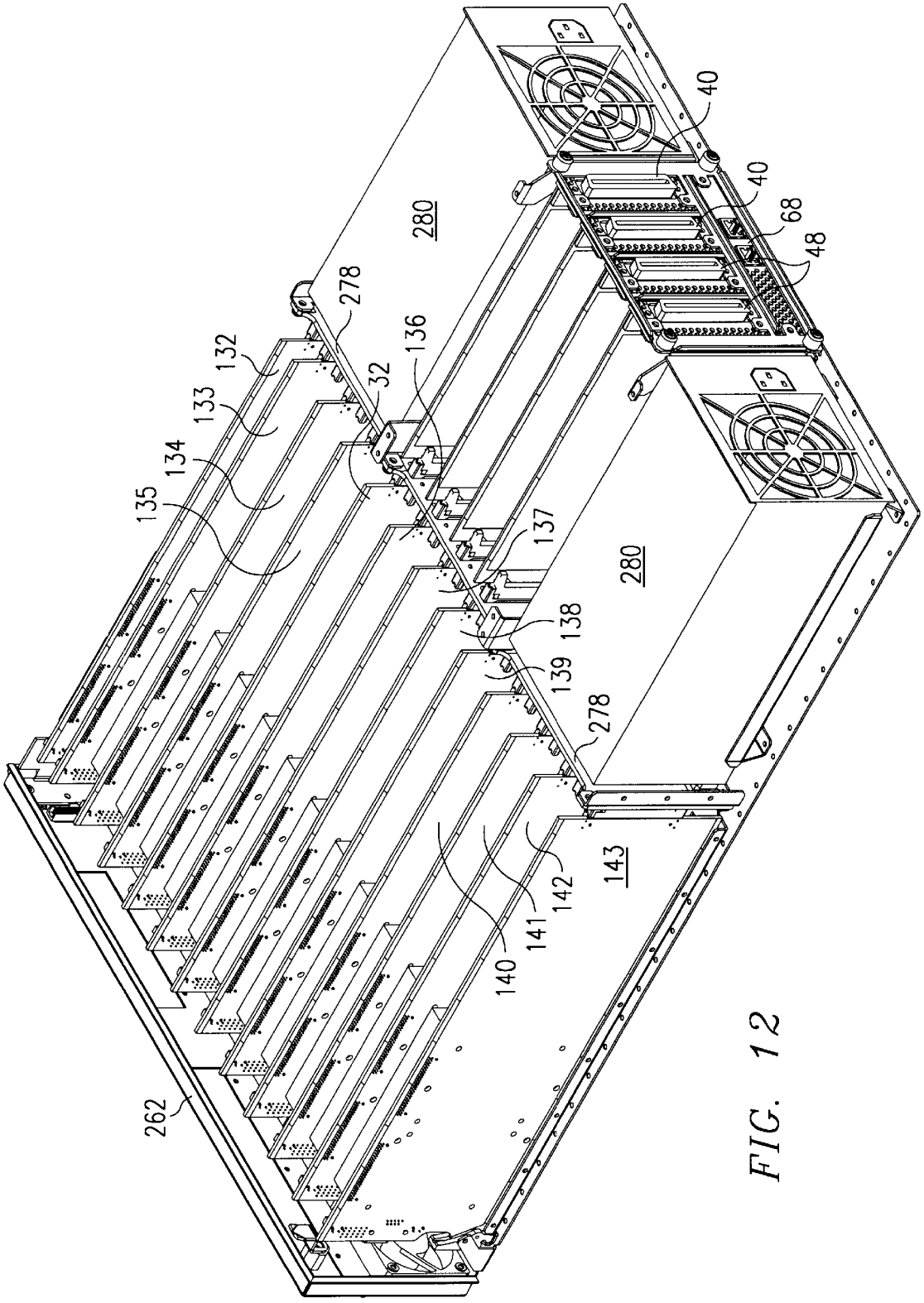
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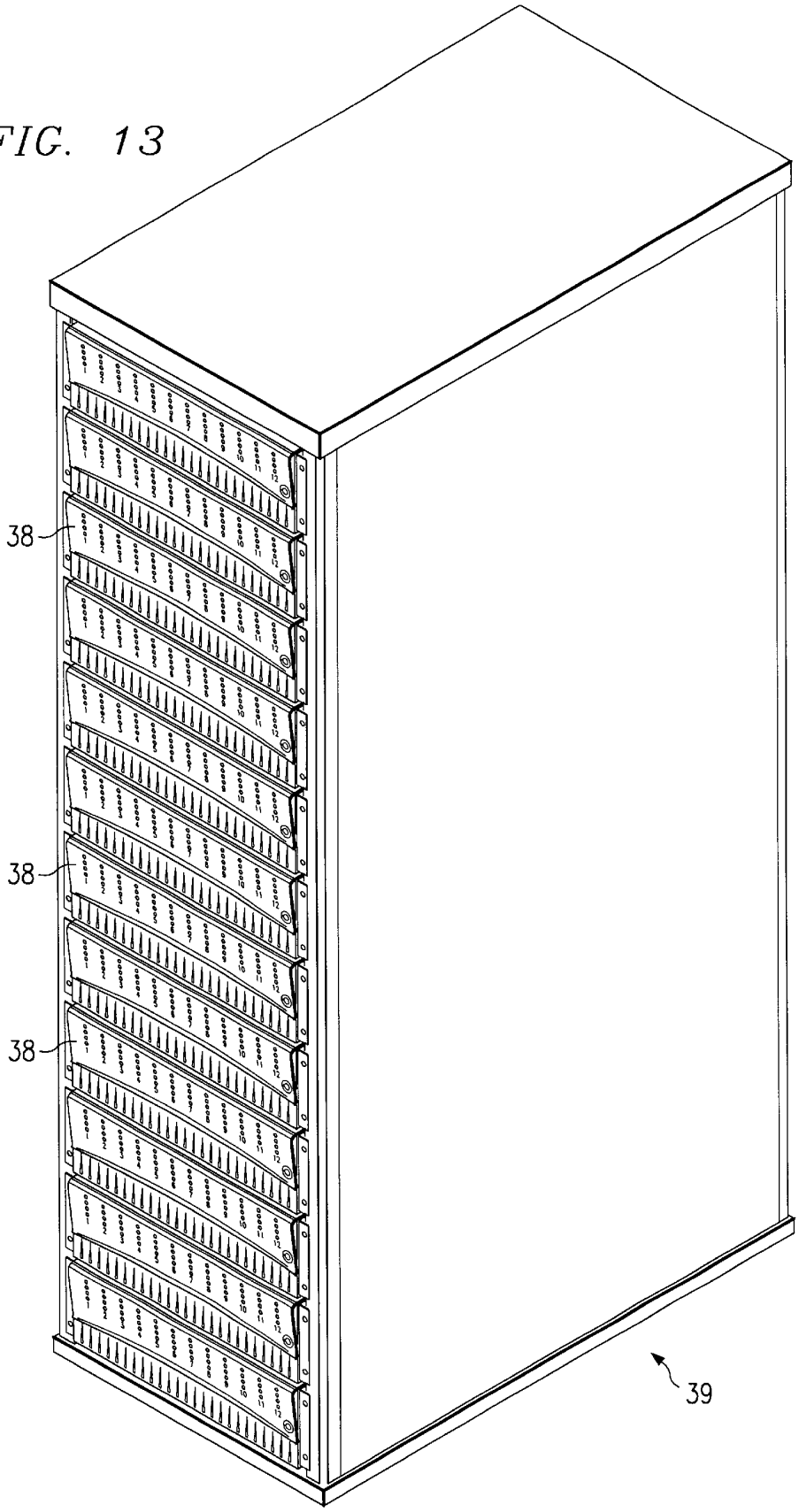
FIG. 12

FIG. 13



HIGH DENSITY WEB SERVER CHASSIS SYSTEM AND METHOD

RELATED APPLICATIONS

The present application is related to co-pending U.S. Patent Applications: Ser. No. 09/620,105, entitled Single Board Web Server System and Method, filed Jul. 20, 2000; Ser. No. 09/620,106, entitled Web Server Network System and Method, filed Jul. 20, 2000; Ser. No. 09/620,0409, entitled Data I/O System and Method, filed Jul. 20, 2000; Ser. No. 09/625,002, entitled Passive Midplane System and Method, filed Jul. 20, 2000; and Ser. No. 09/620,108, entitled Data I/O Management System and Method, filed Jul. 20, 2000.

TECHNICAL FIELD OF THE INVENTION

The present invention relates generally to the field of network servers and, more particularly to a high density web server chassis system and method.

BACKGROUND OF THE INVENTION

A critical component of both private intranets and the publicly accessible internet is what is commonly referred to as a web server. A web server is typically a computer which is capable of receiving requests for information and returning data or performing specialized processing upon the receipt of a network request for such processing. Conventional network architectures envision servers as large scale computing platforms. For example, large commercial entities may include very large systems acting as web servers fielding requests for processing. Alternatively, these entities might employ large parallel server operations where a multitude of individual server computers all service requests for information and processing in parallel.

In today's network architectures, smaller users such as individuals or small businesses that require server systems will typically be forced to share part of the processing capability of one of these large scale systems. In many cases this sharing of resources does not provide adequate processing capability for the individual or small business user. Further, the sharing of a large processing system means that all parties utilizing that server processing capability are vulnerable to the failure of that system. These large processing platforms are also more difficult to customize if one small user needs specific features or components that other small users do not need. Further, as Internet and intranet traffic have grown, it has become apparent that even the largest processing platforms reach a limit to their processing capability especially in light of the increased traffic in large multimedia content and the necessity for real time processing of transactions.

Another difficulty in providing server technology to individual or small business users is associated with the difficulties in maintaining provisioning and administrating the server technology. Conventional server systems are typically very complex to administer. Software development efforts have not focused on providing simple user interfaces because the typical personnel that are tasked with maintaining servers are typically very sophisticated network technicians.

Large scale servers that are shared by multiple small users present difficulties in monitoring and metering traffic for individual users. For example, if a server provider desired to bill a user of a large scale system according to the processing time or the transaction count that occurred relative to that particular user, it is very difficult to arrive at an accurate assessment of that activity when the server hardware is shared by that user and many other users.

In the past, it has been difficult to provide server capability close to the end user. This is in large part because the typical larger server architectures require special environmental conditions and special hardware environments to supply power and large bandwidth communication links. The environment of a telephone company's central office is typically very close to the end user, however, the space power and environmental constraints within these facilities make it completely impractical to co-locate large server platforms within these facilities.

SUMMARY OF THE INVENTION

The present invention provides a high density web server chassis system and method that substantially eliminates or reduces the problems and disadvantages associated with previous methods and systems. In particular, a server chassis operable to consolidate operations of a plurality of web server processing cards over a midplane, to a network interface card, is provided.

In accordance with a particular embodiment of the present invention, a server chassis including a plurality of web server processing cards coupled with a midplane is provided. A first network interface card may also be coupled with the midplane. In accordance with one embodiment of the present invention, the midplane includes printed circuitry operable to provide data communications between the plurality of web server processing cards and the network interface card.

In accordance with another embodiment of the present invention, a second network interface card may be coupled with the midplane. The second network interface card may be operable to couple the plurality of web server processing cards with a private network, and the first network interface card may be operable to couple the plurality of web server processing cards with a public network.

In accordance with yet another embodiment of the present invention, a third network interface card may be provided. The third network interface card may be operable to couple the plurality of web server processing cards with a management network.

In accordance with still another embodiment of the present invention, a first power supply mounting mechanism may be provided. The first power supply mounting mechanism may be operable to couple the midplane with a first power supply. In accordance with this embodiment the printed circuitry is operable to distribute power from the first power supply to the plurality of web server processing cards.

Technical advantages of the present invention include providing a server chassis operable to consolidate data communications between a plurality of web server processing cards, across a midplane, to a network interface card. This provides a single point of data communications, simplifying troubleshooting, operations, administration, management, provisioning and traffic metering and measurement regarding the associated web server processing cards.

Other technical advantages will be readily apparent to one skilled in the art from the following figures, description, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and its advantages, reference is now made to the

following description, taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a schematic drawing illustrating a plurality of web server processing cards coupled with a public network, a private network, and a management network, in accordance with one embodiment of the present invention;

FIG. **2** is a plan view taken from above with portions broken away, illustrating a web server processing card;

FIG. **3** is a plan view taken from below, with portions broken away, illustrating the web server processing card of FIG. **2**;

FIG. **4** is a plan view taken from above, illustrating a network interface card in accordance with one embodiment of the present invention;

FIG. **5** is a plan view taken from above with portions broken away, illustrating an alternative embodiment network interface; and

FIG. **6** is a plan view taken from above, illustrating another alternative embodiment network interface card;

FIG. **7** is a plan view taken from above, illustrating yet another alternative embodiment network interface card;

FIG. **8** is an elevation view illustrating a front portion of a passive midplane in accordance with one embodiment of the present invention;

FIG. **9** is an elevation view, illustrating a rear portion of the passive midplane of FIG. **8**;

FIG. **10** is an isometric view, with portions broken away, illustrating a server chassis, in accordance with one embodiment of the present invention;

FIG. **11** is an isometric view, with portions broken away, illustrating additional components of the web server chassis of FIG. **10**;

FIG. **12** is an isometric view, with portions broken away, illustrating additional components of the web server chassis of FIG. **10**; and

FIG. **13** is an isometric view, illustrating a web server rack, in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIG. **1**, a high density, multiple server network of the present invention is illustrated and generally designated by the reference number **30**. Network **30** includes a plurality of web server processing cards **32** and **132–135** coupled with a public network **45**, a private network **46** and a management network **47**. Each web server processing card **32** and **132–135** are configured and function similarly. Therefore, web server processing card **32** will be described in detail, for illustrative purposes. However, all web server processing cards described within this specification may include all components and functionality described with regard to web server processing card **32**.

Web server processing card **32** provides the functionality of a single board computer which may be employed as a rack mounted web server. Networks **45**, **46** and **47** may be configured, maintained and operated independently of one another, and cooperate to provide distributed functionality of network **30**.

Each web server processing card **32** is coupled with a passive midplane **34** which is coupled with a base **36** of a server chassis **38**. Additional components regarding web server chassis **38** are illustrated and described with respect to FIG. **10**. A network interface card **40** couples passive midplane **34**, and therefore web server processing cards **32** with a public network switch **42**, via communication links **44**. Throughout this specification, the term "switch" may be used to indicate any switch, router, bridge, hub or other data/communication transfer point. Public switch **42** distributes data between web server processing cards **32** and public network **45**. In a particular embodiment, public network **45** may include the Internet. Public network **45** may include a variety of networks including, without limitation, local area networks (LANs), wide area networks (WANs), and/or Metropolitan Area Networks (MANs).

A second network interface card **48** is coupled with passive midplane **34** and distributes data to a private network switch **50** via communication link **52**. A plurality of private network applications including a storage server **54**, application server **56**, database server **58**, and legacy systems **60** are coupled with private network switch **50** through communication links **62**, **63**, **64** and **65**, respectively.

A management network interface **49**, which is illustrated in more detail in FIG. **7**, distributes data between passive midplane **34** and remote management system **70** of management network **47**, through communication link **71**. One or more online/nearline memory storage devices, including non-volatile storage device **72** and secondary non-volatile storage device **74** communicate with management console **70** using communication links **76** and **78**, respectively. Memory storage devices **72** and **74** communicate with one another through communication link **80**.

Public Network

In the illustrated embodiment public network switch **42** includes a Cisco Catalyst 5500, an industry standard Ethernet switch. Alternatively, a Black Diamond public switch, as manufactured by Extreme Networks may be provided as public switch **42**.

A high density connector **43** may be coupled with public switch **42** to facilitate communication between public switch **42** and communications link **44**. In one embodiment, high density connector **43** may include an RJ-21 high density telco (telephone company) type connector for consolidating at least twelve 10/100/1000 megabits per second Ethernet connections through a single cable. The use of high density telco style connectors, like high density connector **43** allows the consolidation of twelve, twenty-four or forty-eight Ethernet connections, at a twelve to one ratio, through a single cable.

Communication link **44** is operable to provide gigabit Ethernet over fiber. In another embodiment, communication link **44** may include gigabit Ethernet over copper. The coupling between public switch **42** and network interface card **40** may be accomplished using a single communication link **44**. However, in another embodiment a second communication link **44** may be provided to accomplish a redundant configuration. This allows a back-up communication link between public switch **42** and network interface card **40**, in case of failure of the primary communication link. Accordingly, redundant fiber connections to public switch **42** or other high density data center switches capable of aggregating hundreds of gigabit connections in a single switch **42**, are provided.

Public switch **42** is coupled with public network **45** over communications link **51**. In a particular embodiment, communication link **51** may include a high bandwidth transport, for example and without limitation T3 or OC48, in order to serve a plurality of servers on an internet service provider (ISP) or application service provider (ASP) network.

Private Network

Similar to public network switch **42**, private network switch **50** may also include either a Catalyst 5500, as

manufactured by Cisco, or a Black Diamond, as manufactured by Extreme Networks. A high density connector **53** may be provided to facilitate communication between private network switch **50** and communications link **52**, and ultimately, network interface card **48**. In a particular embodiment, high density connector **53** may include an RJ-21 high density telco type connector for consolidating at least twelve 10/100/1000 megabits per second Ethernet connections through a single cable. As previously described, the use of high density telco style connectors, like high density connector **53** allows the consolidation of twelve, twenty-four or forty-eight Ethernet connections at a twelve to one ratio, through a single cable.

High density connectors, for example **43** and **53**, facilitate the consolidation of 10/100/1000 megabits per second Ethernet cabling for large numbers of web server processing cards. Accordingly, private switch network switch **50** is cable of aggregating forty-eight or more 10/100/1000 megabits per second Ethernet ports in a single network interface card, and seven hundred sixty-eight ports (web server processing cards) in a single private network switch.

Private network switch **50** is coupled with a plurality of "back office" network applications including storage server **54**, applications server **56**, database server **58** and legacy systems **60**. Storage server **54** provides mass storage to support web server processing cards of various users. This is a private connection because server **54** is not linked directly to public network **45**. Throughout this specification, "back office" will be used to indicate operations, management and support tasks used to support the operation of web server processing cards, which are accomplished at remote locations from server chassis **38**. Communication links **62–65** provide private 10/100/1000 megabits per second Ethernet supporting various high volume business transaction processing systems (HVBTPS). Storage server **54** provides network attached storage (NAS). Application server **56** may be rented, or provided by an application service provider (ASP). Database server **58** provides transaction processing, and legacy systems **60** may include various database servers, etc . . .

Private network **46** is considered "private," because there is no physical connection between private network **46** and public network **45**. Accordingly, security is provided to data and communications of private network **46** because private network **46** is protected from a security breach initiated from public network **45**.

Private network **46** may be configured to provide a plurality of "back-end" network applications. For example, private network **46** may provide end users with secure internet voicemail, internet fax, a "personal" web server, electronic mail accounts, MP-3 servers and/or digital photo collection servers.

In another embodiment, private network **46** may be configured to provide groupware and other associated applications. For example, private network **46** may include the necessary hardware and software to provide users of network **30** with "chat rooms" and other on-line meeting applications. Wireless Application Protocols (WAPS) applications may also be provided. In fact, the WAP applications may be synchronized to groupware associated with the web server processing cards.

Management Network

Remote management system **70** of management network **47** includes the ability to monitor, manage, back-up, restore, activate and operate many of the components of high density server network **30**. For example, an operator of a remote management system **70** can control all of the functions and operations of web server processing cards **32**. In fact, remote management system **70** includes control software and other applications which accomplish these functions and operations automatically, without operator intervention. Many of the software and other applications which may reside upon remote management system **70** will be described later, in more detail.

In a particular embodiment, remote management system **70** performs metering, including without limitation packet level metering, and bandwidth monitoring of web server processing cards **32**. Other characteristics and measurements which remote management system **70** collects, evaluates and stores include operating data and other information regarding web server processing cards **32**.

Remote management system **70** identifies each web server processing card **32** according to at least two identifiers. For example, during start-up of each web server processing card **32**, remote management system **70** is informed of a hardware address associated with each web server processing card **32**. The hardware address is analogous to the IP address assigned by the server to each client, in a client/server network system. The hardware address of each web server processing card **32** may be referred to as the "logical" address of a particular web server processing card.

Also during the startup of web server processing cards **32**, remote management system **70** is informed of a chassis/slot address identifier unique to each web server processing card **32**. The chassis/slot address may also be referred to as the physical identifier, or physical address of a particular web server processing card. The physical address allows remote management system **70** to identify a particular web server processing card **32** in a manner which is more readily identifiable to an operator of remote management system **70** or other user of server network **30**.

Remote management system **70**, non-volatile storage device **72** and secondary non-volatile storage device **74** also provide in-line/near-line storage support for web server processing cards **32**. Storage devices **72** and **74** may include high capacity redundant array of inexpensive disks (RAID)/optical/tape subsystem controlled by hierarchical storage management software which enables automatic back-up and restoration of user data from all servers via remote management system **70**.

Remote management system **70** has the ability to provide a single point of management for thousands of servers. The servers under the control of remote management system **70** may include thousands of web server processing cards **32**. These servers may be configured to provide individual server capacity. In another embodiment, the servers may be "clustered." In other words a plurality of web server processing cards **32** may be joined logically in order to provide a sealed level of service to a user.

Accordingly, remote management system **70** provides management functionality over a private, back end network, which may include thousands of web servers. In a particular embodiment, software associated with remote management system **70** may be installed upon a high capacity Linux server or workstation with enough storage capacity to provide back-up functionality to all servers on any particular network.

Management software, applications and functionality associated with remote management system **70** typically reside on a server. However, remote management system **70** may be accessed remotely by various electronic devices including laptops, desktops and handheld personal digital assistants ("PDAs"). Devices used to access remote management system **70** may also include a secure web browser or other security applications.

A web browser based, graphical user interface **69** associated with remote management system **70** provides the operator of management network **47** with a user-friendly, easy to read overview of operational functions in graphical formats, suitable for "at a glance" monitoring and diagnosis.

As will be described later in more detail, remote management system **70** includes various software, applications and functionality which simplify and improve the operation of associated web servers, including without limitation web server processing cards **32**. For example, remote management system **70** provides "automated preemptive failover" functionality. Automated preemptive failover includes an automated system which monitors and predicts component failures, issues notification to the network operator or administrator and initiates fail-over to a "warm spare" before catastrophic failures occur, without much, if any user intervention.

Remote management system **70**, along with storage devices **72** and **74** provide automated back-up of client data for automated restoration of a web server processing card, or a spare web server processing card to its original state, in the event of a failure.

In a particular embodiment, a software agent residing upon remote management system **70** may be used to collect, store, and analyze measurements and data regarding hardware, software and bandwidth usage measurements for billing purposes. These measurements and data may be exported to a variety of applications including data mining and decision support systems.

Remote management system **70** provides the functionality of a browser-based user administrative graphical user interface. This includes an intuitive user interface for controlling basic functionality of servers on a single server level. Accordingly, a network operator or administrator may add, delete, configure or modify virtual servers and/or web server processing cards **32**. Similarly, remote management system **70** may be used to add, delete, configure and modify users who are granted access to web server processing cards **32** of public network **45**. Remote management system **70** also provides operations, administration, management and provisioning (OAM&P) functionality to the network administrator. Traffic metering and measurement (TM&M) and performance measurements are also collected, stored, analyzed and maintained by remote management system **70**.

Similar to private network **46**, management network **47** is considered a "private" network. Since there is no physical connection between management network **47** and public network **45**, management network **47** is protected from a security breach initiated from public network **45**.

Web Server Processing Cards

Referring now to FIGS. **1–3**, web server processing card **32** will be described in more detail. Web server processing card **32** is a single board computer upon which all of the requisite components and devices are mounted to enable processing card **32** to function and operate as a server hosting a wide array of Internet-based applications. Each web server processing card **32** within a particular chassis **38**, share a common passive midplane **34** through which all power and connectivity passes. Server chassis **38** is intended for rack mount in server rack **39** (See FIG. **13**), and includes passive midplane **34** and all the associated web server processing cards **32**.

In one embodiment, web server processing card **32** includes a powerful computer connected to the Internet and operable to store audio, video, data graphics and/or text files in order to display to a user of public network **46** via protocols including, without limitation, hypertext transfer protocol (http). Each web server processing card **32** includes a printed circuit board **82**, coupled with a central processing unit (CPU) **84**, a disk drive **86**, a dynamic memory integrated circuit **88**, and network interface integrated circuitry **90–92**.

Central processing unit **84** performs the logic, computational and decision making functions of processing card **32**. Many types of central processing units with various specifications may be used within the teachings of the present invention. In the illustrated embodiment, CPU **84** includes a Crusoe 667 MHz CPU, as manufactured by Transmeta. In fact, many central processing units with comparable processing power to a 500 MHz, Pentium III, as manufactured by Intel, may be used within the teachings of the present invention. For example, the Crusoe TM 3200 with speeds in the range of 300–400 MHz, or TM 5400 with speeds in the range of 500–700 MHz, may also be used.

The clock speed of central processing unit **84** will depend in part upon the operating system resident upon web server processing card **32**. In the illustrated embodiment, web server processing card **32** includes a version of the Linux operating system. The clock speed of central processing unit **84** may diminish by as much as twenty percent if a version of the Windows operating system is substituted for the Linux operating system.

CPU **84** of the present invention may include the ability to adapt its processing speed to the processing load placed upon it. In other words, CPU **84** may vary its speed as appropriate to handle any given processing load, whereas many other processors simply include ON or OFF capabilities. The CPU of the present invention preferably includes a maximum continuous power consumption of no more than 4.5 watts, and a maximum operating temperature of below 150 degrees Fahrenheit.

In the illustrated embodiment, the maximum operating temperature of CPU **84** is approximately 120° Fahrenheit. Due to its variable speed feature CPU **84** of the present invention will typically consume significantly less than 4.5 watts of power. CPU **84** of the illustrated embodiment is compatible with the Intel instruction set such that CPU **84** supports standard X86 operating system.

Disk drive **86** includes electronics, motors, and other devices operable to store (write) and retrieve (read) data on a disk. In the illustrated embodiment, disk drive **86** includes a two and one-half inch IBM 9.5 mm notebook hard drive. A second two and one-half inch disk drive **87** may be installed upon a given web server processing card **32**. The use of disk drive **87** is optional, and increases the capacity and functionality of web server processing card **32**.

A plurality of hardware connectors **97** are provided upon printed circuit board **82**, to allow for the installation of up to two, two and one-half inch disk drives. For example, communications ports **95** are affixed to printed circuit board **82**, to allow for the installation of disk drives **86** and/or **87**. Each disk drive **86** and **87** is also affixed to printed circuit board **82**, using connectors **97**.

The use of web server processing card **32** having two, two and one-half inch disk drives allows for the installation of three hundred and thirty-six servers within an industry standard rack having 42 U of usable interior space (standard industry rack). For purposes of this specification, a standard industry rack has the approximate dimensions nineteen inches wide by six feet high by thirty to thirty-four inches deep.

Furthermore, at least two, 6 to 25 gigabyte—two and one-half inch hard drives may be provided with web server processing card **32**, in accordance with the teachings of the

present invention. Alternatively, a 10 to 75 gigabyte, three and one-half inch hard drive may be installed upon web server processing card **32**, in lieu of two and one-half inch drives **86** and **87**. Many other hard drives are suitable for use within the teachings of the present invention. In fact, many hard drives having a maximum operating temperature of 125 degrees Fahrenheit and a maximum continuous power output of 2.5 watts may be substituted for disk drive **86** of the present invention. Accordingly, a plurality of configurations for web server processing cards **32** are envisioned within the teachings of the present invention.

In another embodiment, each web server processing card **32** is equipped with a single, three and one-half inch disk drive, which offers greater spindle speed and product life. Alternatively, two and one-half inch disk drives provide greater density and lower power requirements. In a particular embodiment, the three and one-half inch disk drive may include an IBM DeskStar or the two and one-half inch disk drives may include an IBM TravelStar hard drive. A total of one hundred and sixty-eight web server processing cards having a three and one-half inch disk drive may be mounted in a standard industry rack. In a particular embodiment, for efficiency purposes, each web server processing card may be based upon the same motherboard design, regardless of the number and size of the associated disk drives provided with the web server processing card.

Web server processing card **32** also includes a dynamic memory integrated circuit, or memory **88**. Memory **88** includes a dual in-line memory module ("DIMM"), to provide the appropriate speed and bandwidth for network communication. In a particular embodiment, memory **88** includes a one hundred and sixty-eight pin connector. The storage capacity of memory **88** may be approximately 64 MB RAM, or greater.

Three interface integrated circuit chip sets **90**, **91** and **92** are coupled with printed circuit board **82**. Chip set **90** may be referred to as public network interface integrated circuit since it corresponds with the operation of the public network. Similarly, chip set **91** may be referred to as the private network interface integrated circuit and chip set **92** may be referred to as the management network interface integrated circuit since they correspond to the private network and management network operations, respectively. Collectively, chip sets **90**, **91** and **92** provide three 10/100/1000 megabits per second Ethernet network interfaces. Additional chip sets may be included with web server processing card **32** in order to support more than three independent networks.

Chip sets **90**, **91**, and **92** include "auto sensing" capability from ten megabytes and higher, such that they may operate anywhere within the range of 10/100 Ethernet to gigabit Ethernet. Accordingly, each web server processing card **32** may come equipped with three, 10/100 BaseT network interfaces, one to support public network **45**, one to support private network **46**, and one to support management network **47**. Each chip set **90**, **91** and **92** also includes "boot from LAN" capability. Wake on LAN refers to the ability of a chipset which is not experiencing network traffic to remain idle until a request and/or traffic is received from the associated network. This feature significantly reduces the power consumption associated with chipsets **90**, **91** and **92**, and ultimately web server processing card **32**.

A high density, 80 pin SCA connector **94** is used to couple web server processing card **32** with a corresponding high density, 80 pin SCA connector **276** associated with passive midplane **276** (see FIG. **8**). Connector **94** includes a "blind mate" feature which provides self-alignment properties for simplified installation and removal of processing card **32** from passive midplane **34**. Connectors **94** and **276** also include built-in serial connectors for managing network traffic. In other words, connector **94** and **276** are appropriately sized and configured to accommodate a serial connection independent of the above referenced Ethernet connections and any other required power/communications ports.

The installation and removal of web server processing card **32** from passive midplane **34** may be accomplished using ejector levers **96**. Levers **96** facilitate zero force insertion of connector **94** within connector **276**. The proper mechanical connection between connectors **94** and **276** may be verified by an operator of network **30**, using the relative location and orientation of ejector levers **96**.

Status and operation module **102** provides a user interface for determining the status and configuring web server processing cards **32**. A plurality of LED indicator lights **104–108** are included with status and operation module **102**. LED **104** indicates pass/fail, LED **105** indicates hard disk activity and LEDs **106–108** each indicate activity regarding an associated LAN. Server reset button **112** is also coupled with status and operation module **102**, and may be used to accomplish a "hard" local reset of the associated processing card **32**. A password reset button **114** is provided upon status and operation module **102** and may be used to locally reset the administrative password. In other words, password reset button **114** may be used to erase the existing administrative password such that an operator of network **30** may redefine the administrative password.

A dual in-line memory module (DIMM) connector **93** is also provided upon web server processing card **32**. In the illustrated embodiment, DIMM connector **93** includes a multiple pin connector. The size and configuration of DIMM connector **93** may be significantly altered, within the teaching of the present invention. DIMM connector **93** facilitates the installation of a dual in-line memory module(s) DIMM (s). Accordingly, web server processing card **32** can accommodate significantly more bandwidth than traditional systems which incorporate a single in-line memory module (SIMM).

Web server processing card **32** also includes a custom Basic Input/Output System ("BIOS") which contains the appropriate instructions for sending information from a program to the appropriate hardware device within network **30**. The BIOS of the illustrated embodiment is capable of supporting at least three independent networks, i.e., public network **45**, private network **46**, and management network **47**. The BIOS is also configured to support the "wake on LAN" capability described above. Many of the other components of web server processing card **32** are similar in structure and function to a typical motherboard, although support for video, keyboard and a mouse may be removed. Each web server processing card **32** may include two megabytes of flash read-only-memory (ROM) for BIOS storage.

Each web server processing card **32** includes the appropriate hardware and software to facilitate plug-n-play capability for web server processing cards **32**. All of the components necessary for the operation of a web server processing card **32** are mounted upon a single printed circuit board. Accordingly, an unsophisticated user or operator of network **30** may install, remove and/or replace a web server processing card in a single step.

In a particular embodiment, each web server processing card **32** may include a battery backed-up real time clock.

In the illustrated embodiment, each web server processing card **32** is configured to operate at "low power." In this context, low power refers to a web server processing having a performance standard exceeding 0.5 BIPS/WATTS.

As described above, web server processing card **32** may include a three and one-half inch disk drive, in lieu of disk drives **86** and **87**. Accordingly, printed circuit board **82** includes the appropriate hardware to accommodate the three and one-half inch drive. For example, a plurality of connectors **98** are provided to accommodate a three and one-half inch disk drive. Also, a communications port **99** is provided to facilitate the incorporation of the three and one-half inch disk drive. These "future" connectors are optional, as web server processing card **32** may be provided without appropriate connectors to accommodate the three and one-half inch disk drive.

Printed circuit board **82** includes printed circuitry operable to detect the location and presence of any disk drive(s) installed upon printed circuit board **82**. For example, web server processing card **32** includes three communications ports **95**(x**2**) and **99**. When one or more disk drives are installed in communications ports **95** and/or **99**, printed circuit board **82** automatically detects the presence and exact port location of the disk drives. This allows web server processing card **32** to route data/communications traffic according to the specific configuration of disk drive(s) present.

As previously described, each web server processing card may have either a three and one-half inch disk drive installed, a two and one-half disk drive, or two, two and one-half inch disk drives installed. Standard three and one-half inch disk drives use primarily 12 volt power and standard two and one-half inch disk drives use 5 volt power. Accordingly, 5 and 12 volt loading by each web server processing card may be very different depending on the type and/or size of disk drives installed. In previous web servers, the variation in loading between the 5 and 12 volt supplies would have required the use of different power supplies depending on the type of disk drives installed, or the use of much larger power supplies to compensate for the wide variation in 5 and 12 volt loading. In addition, mixing web servers with two and one-half inch disk drives with web servers with three and one-half inch disk drives, in a single system, was difficult.

Web server processing cards **32** eliminate these problems by balancing to some degree the loading on the 5 and 12 volt supplies as follows:

- The input power to a CPU DC to DC converter, installed upon web server processing card **32**, is 12 volts when a two and one-half inch disk drive is installed.
- The input power to the CPU DC to DC converter is 5 volts when a three and one-half inch disk drive is installed.
- The input power for the CPU DC to DC converter is controlled by a disk drive power cable and is automatically configured when the appropriate cable is installed. Accordingly, web server processing card **32** includes the ability to detect which type/size of disk drive is installed, and change the voltage provided to the DC to DC converter, based upon the disk drive(s) present.
- This technique ensures that the power source for the CPU DC to DC converter will be properly configured because the assembly process of disk drive installation causes the DC to DC converter power source to be configured properly and no additional configuration steps are required.

Network Interface Cards

Public network interface card **40** is illustrated in more detail in FIG. **4**. Each network interface card **40** may support up to twelve independent web server processing cards **32**. In one embodiment, network interface card **40** may include twelve independent Ethernet communication paths **117** between a front connector **115** and rear connector **116**. In this embodiment, network interface card **40** provides modular connectivity, such that an operator of network **30** may access rear connector **116** at a convenient location upon server chassis **38**. Accordingly, a standard RJ-21 connector coupled with communication link **44** may be connected with rear connector **116** in order to distribute data between network interface cards **40**, corresponding web server processing cards **32**, and public network switch **42**. In the illustrated embodiment of FIG. **4**, communication link **44** may include twelve groups of two twisted pair category **5** cable, for a total of twenty-four different Ethernet connections, or forty-eight wires total. The connection between public network switch **42** and network interface card **40** may be accomplished with high density Ethernet connectors. In another embodiment, integrated 10/100/1000 switches may be incorporated using octopus cables which "fan-out" from a high density connector to multiple RJ-45 connectors.

Rear connector **116** is appropriately sized to handle network traffic for up to twelve web server processing cards **32**. Since each Ethernet communication link includes two twisted pairs, rear connector **116** is configured to receive up to forty-eight individual wires.

In another embodiment, a switched network interface card **48** may be used in lieu of network interface card **40** to establish the connection between a respective web server processing card **32** and public network switch **42**. Switched network interface card **48** is illustrated in more detail in FIG. **5**. Similar to network interface card **40**, switch network interface card **48** includes an eighty pin SCA connector **115**, which couples network interface card **48** with passive mid-plane **34**. Each Ethernet communication path **145** associated with switched network interface card **48** terminates at a switch chip **145**. Switch chip **145** monitors and distributes traffic from a respective web server processing card **32** to a corresponding RJ-45 Ethernet connector **144** through an Ethernet communication link **143**. In a particular embodiment, switch chip **145** may include an optional twelve or twenty-four port 10/100 Base T switch with fiber gigabit uplinks. In another embodiment, switch chip **145** may include an optional twelve or twenty-four port 10/100 Base T switch with copper gigabit uplinks.

A redundant configuration may also be included having a second RJ-45 connector **146** and Ethernet communication link **148**. This provides the network operator with the ability to include redundant communication links **44** in separate physical locations, for emergency operation in the event of a failure of one of the communications systems.

As illustrated in FIG. **1**, private network interface card **48** may be used to establish connectivity between corresponding web server processing cards **32** and private network switch **50**. In another embodiment, interface card **48** may be configured similarly to public network interface card **40**. Accordingly, either the straight pass-through configuration of network interface card **40** or the switched pass-through configuration of network interface card **48** may be used for private network interface card **48** and/or public network interface card **40**.

The configuration and operation of an alternative embodiment network interface card **66** is illustrated in more detail in FIG. **6**. Network interface card **66** includes an eighty pin SCA connector **118** in order to couple management network interface card **66** with passive mid-plane **34**. Ethernet communication links **119** distribute data between a respective web-server processing card **32** and a hub chip **120**. A communication link **122** provides a communication path

between hub chip **120** and an RJ-45 connector **124**. Accordingly, communication link **71** (FIG. **1**) may be coupled with RJ-45 connector **124** in order to distribute data between management network interface card **68** and management console **70**.

A second RJ-45 connector **126** may be coupled with hub chip **120** through a communication link **128**. RJ-45 connector **126** provides the network operator with the ability to "daisy-chain" management network interface cards from a plurality of web server chassis **38**. Accordingly, RJ-45 connector **126** is useful when multiple web server chassis are employed in a single network, and daisy-chain ability is desired. In another embodiment, RJ-45 connector **126** may be used to provide a redundant communication path between management console **70** and interface card **68**.

Hub chip **120** consolidates management network traffic from corresponding web server processing cards **32**, for distribution throughout the network. In a particular embodiment, hub chip **120** may include an integrated network hub, for example a sixteen port repeater chip integrated upon interface card **66** for aggregating all management communications through a single 10/100/1000 megabits per second Ethernet connection. Hub chip **120** may be referred to as a repeater because it broadcasts, or repeats every message it receives to all ports of the management network. In another embodiment, hub chip **120** may be replaced with a switch chip which would provide the ability to address and distribute messages according to a packet header, to the appropriate port within the management network.

In a particular embodiment, a hub chip may be employed, in lieu of a switch chip, at the network interface card due to its reduced cost, and simplified operation. In one embodiment, RJ-45 connectors **124**, **126**, **144** and **146** may include gigabit RJ-45 connectors. In another embodiment connectors **124**, **126**, **144** and **146** may be replaced with fiber optic or copper gigabit interface connectors ("GBIC").

Referring now to FIG. **7**, management network interface **49** is illustrated in more detail. Management network interface **49** includes a single board computer **160**, coupled with management network interface card **68**. Single board computer **160** may also be referred to as a "daughter card" to management network interface card **68**. Single board computer **160** includes similar hardware and components to web server processing card **32**, except single board computer **160** does not include a disk drive. Conversely, web server processing card **32** includes disk drive **86**.

Management network interface card **68** includes a pair of high density connectors **162** and **164**. Each high density connector **162** and **164** includes at least twelve Ethernet connectors, a serial port, and a power interface. In a particular embodiment, the serial port associated with each high density connector **162** and **164** includes an I2C bus.

The power interface associated with each high density connector **162** and **164** is configured to provide 3.3, or 5.0 volt power source to management network interface **49**. Accordingly, power may be distributed to various components of management network interface **49**, including single board computer **160**, and a hub chip **166**.

The twelve Ethernet connectors, associated with each high density connector **162** and **164**, enable each high density connector **162** and **164** to interface with twelve web server processing cards. Accordingly, in the illustrated embodiment, each management network interface can collect, interpret and manage communications and data transfer with twenty-four web server processing cards.

Twelve Ethernet connectors **168** are used to couple high density connector **162** with hub chip **166**. Similarly, twelve Ethernet connectors **170** are used to couple high density connector **164** with hub chip **166**. Hub chip **166** consolidates management network traffic from up to twenty-four web server processing cards, for distribution to single board computer **160** and/or throughout network **30**. In another embodiment, a switch chip may be used in lieu of hub chip **166** in order to provide management network interface **49** with the ability to selectively switch and distribute network management information rather than simply broadcasting all messages received to every node coupled with management network interface **49**.

A communications link **172** distributes data between hub chip **166** and an Ethernet connector **174**. Accordingly, Ethernet connector **174** may be coupled with remote management system **70**, of management network **47**. In a particular embodiment, management network interface **49** may be provided without single board computer **160**. In this embodiment, communication between web server processing cards **32** and remote management system **70** may be conducted according to the preceding description.

In another embodiment, single board computer **160** may be provided with management network interface **49**, or management network interface **49** may be upgraded in the future to include single board computer **160**. Accordingly, connectors **176** and **178** are typically provided upon management network interface card **48**, to facilitate the installation of single board computer **160**.

A communication link **182** couples hub chip **166** with an Ethernet connector **184** associated with single board computer **160**. Accordingly, when properly installed, single board computer **160** receives all broadcast signals which are received by hub chip **166**. Single board computer **160** collects, stores, calculates, analyzes and communicates this information to remote management system **70** and/or other components of high density server network **30**. Communication between single board computer **160** and remote management system **70** occurs via Ethernet connector **186**.

When single board computer **160** and its associated Ethernet connector **186** are present upon management network interface **49**, Ethernet connector **174** is no longer required to communicate with remote management system **70**. However, in the event of a failure of single board computer **160** and/or its associated components, including without limitation Ethernet connector **186**, Ethernet connector **174** provides an alternative path of communication between management network interface **49** and remote management console **170**. In an alternative embodiment, Ethernet connector **174** may be omitted from management network interface **49**.

Connectors **174** and **186** provide the network operator with the ability to "daisy-chain" management network interface **49** with a plurality of additional components of network **30**, for example, additional management network interfaces associated with other server chassis **38**. Accordingly, connectors **174** and **186** are useful when multiple web server chassis are employed in a single network, and daisy-chain ability is desired. In another embodiment, connectors **174** and **186** may be used to provide a redundant communication path between management console **70** and interface **49**.

In the illustrated embodiment, another communications link **188** is provided in order to couple single board computer **160** and high density connector **164**. Communication link **188** may include an I2C bus coupled with the serial port associated with high density connector **164**. Another I2C bus may also be provided between single board computer **160** and the serial port associated with high density connector **162**. As will be described later in more detail, the direct

serial connection between single board computer **160** and high density connector **164** allows single board computer **160** to execute a hardware reset, software reset, or password reset upon any particular web server processing card with which high density connector **164** is coupled.

Management network interface **40** includes the ability to perform a hardware reset of any particular web server processing card. Management network interface **40** also includes the ability to perform software resets of various components of network **30**. In a particular embodiment, single board computer **160** collects telemetry data regarding the use, performance and operation of many components of each web server processing card **32**, which will be described later in more detail. Such data may be stored within single board computer **160** and/or forwarded to remote management system **70**, for further processing.

Passive Midplane

Referring now to FIGS. **8** and **9**, passive midplane **34** is illustrated in more detail. On its front face **275**, passive midplane **34** includes a plurality of web server processing card connectors **276** which facilitate the installation of up to twenty-four web server processing cards **32**. Rear face **277** of passive midplane **34** includes a pair of power supply mounting mechanisms **278** which accommodate power supplies **280**, which will be described later in more detail. Rear face **277** of passive midplane **34** also includes a plurality of network interface card connectors **282–287**. In the illustrated embodiment, connectors **286** and **287** accommodate a single network interface **49**.

Passive midplane **34** is considered "passive" because it includes no active components which can fail. Instead, passive midplane **34** includes the necessary wiring to connect each respective web server **32** with its corresponding network interface card. Passive midplane **34** includes a printed circuit board with the appropriate printed circuitry to distribute data and power necessary for the operation of network **30**. For example, passive midplane **34** distributes power to components of web server processing cards **32** and network interface cards **40**, **48** and **68**. Additionally, passive midplane **34** distributes data and/or communications signals between web server processing cards **32** and network interface cards **40**, **48** and **68**.

Passive midplane **34** provides a high-density, hot pluggable connector for as many as twenty-four web server processing cards. It consolidates power, three separate Ethernet networks and serial connections all through a single connector. Passive midplane **34** "auto-senses" web server processing cards and available slots, to allow automatic configuration of networks via remote management system **70**.

Passive midplane **34** also includes a ribbon cable connector **290**. Connector **290** is operable to distribute power and control signals from passive midplane **34** to articulating door **262** of chassis **38**. This accommodates the operation of the LEDs and built in fans associated with articulating door **262**.

Server Chassis

Referring now to FIGS. **10–12**, server chassis **38** is illustrated in more detail. Server chassis **38** includes a box build **260** having a base **36** forming a lower portion thereof. Box build **260**, of the illustrated embodiment, is fabricated from plated steel. An articulating door **262** is coupled to box build **260**. Articulating door **262** and box build **260**, in combination, provide the ability to protect web server processing cards **32** and **132–142** from ambient environment.

Articulating door **262** includes a plurality of box fans **264–269**, mounted therein. Box fans **264–269** draw air from the ambient environment through articulating door **262**, and exhaust through a back plate **270** associated with box build **262**. In the illustrated embodiment, box fans **264–269** include a bank of six, three-inch fans. It will be recognized by those or ordinary skill in the art that the number, size, and configuration of fans associated with server chassis **38** may be significantly altered within the teachings of the present invention. In a particular embodiment, each box fan **264–269** will include a tachometer output having an interface coupled with passive midplane **34** such that interruption of service of any particular fan may be promptly detected.

Articulating door **262** includes a printed circuit board **272** which allows for the viewing of LED indicator lights associated with web server processing cards **32** and **132–142**, by persons standing in front of articulating door **262**. Recessed windows **272** include slightly "smoked" translucent material, such that the associated LED indicator lights shall be reasonably visible through the door.

The interior of articulating door **262**, which faces web server processing cards **32** and **132–142** when articulating door is in the closed position, is fabricated from a metallic material. In a particular embodiment, an RF gasket may be installed between articulating door **262** and box build **260**, at their interface. An injection molded plastic bezel is attached to articulating door **262** in order to achieve a leading-edge industrial design. A pair of mounting ears **274** are installed at the edges of box build **262**, to provide easy installation of server chassis **38** within server rack **39**.

In the illustrated embodiment, server chassis **38** measures 17.3 inches wide (without mounting ears) by 25.5 inches deep by 5.25 inches high. The environmental operating temperature is within the approximate range of 0 to 40 degrees Celsius (32 to 104 degrees Fahrenheit) Server chassis **38** may be operated at altitudes exceeding 10,000 feet above sea level.

Server chassis **38**, and the associated web server processing card connector of midplane **34** contain web server processing card connectors **276** (see FIG. **8**) which accommodate up to **24** web server processing cards. In the illustrated embodiment, web server processing card guides are installed at 0.7 inch center to center dimensions. Up to 12 web server processing cards **32**, including optional three and one-half inch disk drives may be installed upon passive midplane **34** using every other web server processing card guide **276**.

Server chassis **38** includes two power supply mounting mechanisms **278**, which facilitate the installation of two load-balance, hot-swappable power supplies **280**. Power supplies **280** are installed upon backplate **270** with mechanical fasteners, for example, thumbscrews. No other mounting hardware is required to attach/detach power supplies **280** to/from server chassis **38**. Each power supply **280** connects to passive midplane **34** using only power supply connecting mechanisms **278**.

Each power supply **280** includes enough power to operate a fully populated passive midplane **34**, in the event that one of the two power supplies **280** fails. Accordingly, server chassis **38** may be offered and operated using a single power supply **280**, with an optional upgrade to a second power supply.

Each power supply **280** shall be designed to be compliant with the MPS SSI power supply specification. This is a publicly released specification developed by the Server System Infrastructure organization (SSI). In a particular embodiment, power supplies **280** may include power supplies as manufactured Delta Corporation (model #DPS-450CB-1B).

Power supplies **280** are load balanced and hot swappable. Passive midplane **34** includes integrated printed circuitry

which distributes power and signals to components of web server processing cards **32**, **132–142**, and components of the associated network interface cards **40**, **48** and **68**. Since each power supply **280** is sized appropriately to operate an entire chassis **38**, a single power supply **280** may be removed from its associated power supply mounting mechanism **276** and replaced with a new power supply, without powering OFF server chassis **38**, or affecting the operation of network **30**.

Power supplies **280** are considered load balanced because they include "auto sensing" capabilities. Each power supply **280** has the ability to sense the load required of it. The printed circuitry associated with midplane **34** evenly distributes the necessary power consumption load between power supplies **280**. Therefore, power supplies **280** will automatically supply one half of the necessary power (voltage) to midplane **34** when each power supply **280** is properly connected and fully operational. If service from one power supply **280** is diminished, or becomes unavailable, the other power supply **280** will sense this and supply the power necessary for passive midplane **34** to operate at full capacity. In another embodiment, power supplies **280** and midplane **34** may be provided with the printed circuitry necessary to allow power supplies **280** to communicate with one another regarding their load sharing responsibilities, and report trouble and/or diminished capacity to one another.

Power supplies **280** also include interfaces which allow management network interface card **48** and remote management system **70** to monitor voltage and temperature of each power supply **280**. Accordingly, remote management system **70** includes the ability to monitor each power supply **280**, and determine "trouble" situations which require intervention of the network operator or administrator. Furthermore, management network interface card **48** and remote management console **70** may use the data collected from the interface with power supplies **280** to predict an impending failure of one or more power supplies **280**. Remote management console **70** may then take corrective action including without limitation, distributing the power load to another power supply **280**, notifying the network administrator with a trouble alarm, and/or distributing network traffic away from the affected web server chassis **38**, to another server chassis. The latter may be accomplished by mirroring the operation of the affected server chassis using back-up data stored upon another server chassis, or private network **46**.

Detailed power supply specifications regarding power supplies **280**, of the illustrated embodiment, are indicated below, for illustrative purposed only, and not by way of limitation:

Features
- Meet SSI MPS Standard
- Power factor correction >95%
- Automatic fan speed control
- Auto recovery after an AC power failure
- Harmonic current meet IEC1000-3-2
- Low output ripple and noise
- FanC signal meets ATX standard
- Redundancy with active current sharing
- Remote on/off control
- Over voltage, over current, over temperature, and short-circuit protection

Environmental
- Operating temperature: 0 C. to 50 C.
- Storage temperature: −40 C. to 70 C.
- MTBF: >100,000 hours

Cooling: Self-contained fan with speed control based on ambient temperature

Electrical Specifications

Input
- Input range: 90–264 VAC
- Frequency: 47–63 Hz
- Input current: 7.6 A low line input at full load
- Efficiency: >60% @ full load, nominal line
- EMI/RFI FCC Part 15J Class B; VDE 243 Level B, CISPR 22 Class B

Output
- Maximum power: 450 watts
- Holdup time: >20 ms @ full load, nominal line @ full load, nominal line
- Rise time: <200 ms
- Overvoltage protection: +3.3V, +5V, +12V, +5Vsb
- Leakage current: <0.75 mA

As previously discussed, a plurality of RJ-21 style connectors may be mounted on backplate **270** of server chassis **38**. Additionally, up to two RJ-45 style connectors may also be mounted on backplate **270**. These connectors are intended to facilitate daisy chaining of server chassis **38** within server rack **39**.

Passive midplane **34**, of server chassis **38** includes all of the power and connectivity requirements to accommodate web server processing cards **32** and **132–142**. Furthermore, passive midplane **34** can accommodate an additional twelve web server processing cards.

Server chassis **38** is referred to as "hot swappable" because each web server processing card **32** and **232–243** may be replaced from within chassis **38** while chassis **38** is powered on. Chassis **38** may include as many as twelve web server processing cards having a three and one-half inch disk drive, or as many as twenty-four web server processing cards having two, two and one-half inch disk drives. In still another embodiment, web server processing card **32** may be provided without an associated disk drive.

Web server processing cards **32** each include a serial port **294** which facilitates local debugging via a laptop computer or other portable electronic device.

A parallel command bus associated with each web server processing card extends through the midplane and allows an operator of the network to perform a hardware reset (boot from LAN, boot from hard disk) of a targeted web server processing card and/or force a password reset. Serial port **294** also facilitates local debugging of web server processing cards **32** associated with web server chassis **38**. For example, when private network **46** and/or management network **47** are unable to establish proper communication with web server processing cards **32** within a given server chassis **38**, a local PC may be coupled with server chassis **38** in order to establish communications via serial port **294**. In a particular embodiment, another serial port may be coupled directly (serially) to network management cards **40**, **48** and/or **68**, through passive midplane **34**. Accordingly, hardware and software resets and other debugging techniques may be employed to communicate with web server processing cards **32** and network interface cards **40**, **48** and **68**, until network communications are restored.

Each power supply **280** includes an associated built in fan to facilitate airflow through, and cooling of, each power supply **280**. Each fan includes variable speed capability. The fan speed can be adjusted from a constant speed, to a variable speed, temperature control setting. In a particular embodiment, the fans associated with power supplies **280** are used to provide airflow, and therefore cooling to web server processing cards **32**, as described below.

Articulating door **262** of chassis **38** includes a chassis intrusion sensor associated with an LED board. When articu-

lating door **262** is opened, a circuit is closed which forces the fan to a full speed setting. Each power supply **280** includes an associated interface which allows this configuration. This is done to compensate for the loss of airflow from fans **264–269** due to articulating door **262** being opened. In this manner, additional airflow through power supplies **280** at least partially compensates for the loss of airflow through fans **264–269**, and additional airflow is drawn across each web server processing card **32**. When articulating door **262** is closed, the fans associated with power supplies **280**, return to their previous setting.

In a particular embodiment, each server chassis **38** consumes a total of 3 U (1 U=1.75 inches) of space. Accordingly, as many as fourteen server chassis **38** may be installed in an industry standard 42 U rack. Each chassis **38** comes equipped with the ability to support redundant, load-balanced power supplies and RJ-21 style connectors which allow the consolidation of the requisite Ethernet cables to a significantly smaller number of cables than those required through the use of conventional RJ-45 connectors.

The teachings of the present invention may be used to provide more than three hundred and thirty-six servers in a standard six foot equipment rack (See FIG. **13**). The design and configuration of web server processing cards **32** accommodate an extremely low total cost of ownership (TCO). For example, twelve or twenty-four web server processing cards **32** which are ultra-compact, low-power power single board computers which share a common passive midplane, power and cable management system.

Server rack **39** is configured to provide a user friendly operating environment. For example, server rack **39** may be co-located at the physical location of an internet service provided (ISP) or an applications service provider (ASP). Moreover, due to the ease of use and operation, unsophisticated employees of the ISP/ASP can easily operate and maintain all of the components associated with web server rack **39**.

Web server processing cards **32** of the present invention provide a fully scalable and inexpensive alternative to much larger, commercial web servers. There is practically no limit to the amount of web server processing cards any given ISP/ASP may add to their operations, as demand requires. Further, scalability is achieved at minimal increments. Network operators may add a single web server processing card, or an entire server rack including as many as three hundred and thirty six individual web server processing cards, as necessary. Accordingly, multiple web server processing cards operating in parallel can be deployed to achieve equal or better performance than larger commercial servers, without the significant financial investment associated with other commercial servers.

Network Management

As previously described, management network interface card **68** and remote management system **70** include the ability to monitor and manage components of network **30**. Various measurements and characteristics regarding the functionality and operation of network **30** are collected, stored, analyzed and maintained using single board computer **166** of network management card **68**, and remote management system **70**.

In a particular embodiment, CPU **84** includes an interface which collects and stores information regarding the operation of CPU **84**. This information includes "snapshot" and historical measurements including, without limitation the CPU voltage, CPU temperature, CPU wattage, and CPU utilization. Snapshot measurements include those measurements which represent the value at a given point in time. Historical information includes measurements which have been collected over time. For example, information regarding the temperature of the CPU may include the temperature at the time of the communication, or coordinates regarding the temperature of the CPU over predetermined intervals of time.

The embedded circuitry of web server processing card **32** transfers this information through passive midplane **34** to management network interface card **68**. This information is captured and stored within single board computer **160**. Single board computer **160** includes the hardware and software components required to collect, store and analyze this information. Single board computer **160** may also include the ability to react to information collected. For example, single board computer **160** may be pre-programmed to power off a CPU that exceeds a given temperature. Furthermore, single board computer **160** may instruct another component of network **30** to "back-up", or replicate to another component of network **30**, all data, state information and functionality associated with a web server processing card having a CPU operating at an excessive temperature, and/or suffering from some other problematic malady. In fact, single board computer **160** may cause the "back-up" information associated with such a web server processing card to be uploaded to a spare web server processing card which can eventually take over all operations of the affected web server processing card. The identification and autonomous correction of such trouble and potential failures may be referred to as "predictive failover".

In this manner, single board computer **160** may autonomously detect a CPU which is about to fail and seamlessly transfer the operation of the CPU and its associated web server processing card to the spare web server processing card. All of these steps are possible without any user intervention. Also, all of these steps are possible without any service interruption, "downtime" or adverse affect upon the overall operations of network **30**. A network operator may then be notified of the trouble situation, such that the affected web server processing card can be replaced with another spare.

In another embodiment, single board computer may. transfer the information it collects to remote management system **70**. Accordingly, at predetermined intervals, remote management system **70** downloads this information from single board computer **160** for further processing. Remote management console **70** may then use this information in a similar manner as single board computer **160**, in order to automatically identify a potential system failure, and react accordingly, without user intervention.

In a similar manner, information regarding operating disk drives may be collected by single board computer **160** and/or remote management system **70**. For example, single board computer **160** may collect measurements from an interface associated with disk drive **86**. Information available to single board computer **160** regarding disk drive **86** may include, without limitation, disk drive voltage, disk drive temperature, disk drive spindle speed, and/or disk drive utilization. Disk drive utilization may be made available according to bytes used and/or bytes available. In a particular embodiment, this information may be supplied in percentages, for example, 65% used, 35% available. Single board computer **160** may also collect information regarding disk drive's **86** soft error bit rate, a measure of the soft errors over a specific period of time.

The operating system associated with CPU **84** also includes information which may be transferred to single board computer **160** and/or remote management system **70**.

For example, the operating system of web server processing card **32** collects information regarding disk drive utilization (bytes used, bytes available), CPU utilization (used/available), and network traffic (megabits/second). Accordingly, web server processing card **32** may transfer this information to single board computer **160** and/or remote management system **70** for use as described above.

Dynamic memory integrated circuit **88** also includes information which may be collected and analyzed by single board computer **160** and/or remote management system **70**. In a particular embodiment, dynamic memory integrated circuit **88** may include an interface which transfers this information through web server processing card **32** and passive midplane **34**, to single board computer **160** and/or remote management system **70**. In another embodiment, this information may be obtained through the operating system. Information regarding dynamic memory integrated circuit **88** includes, without limitation the amount of memory used (bytes), the amount of memory available, the percentage of memory used, and/or the percentage of memory available.

Various other measurements and characteristics regarding the operation of components of network **30** may be monitored, collected, stored, calculated and analyzed in a similar manner. For example, each power supply **280** may include an interface which includes this information and makes it available to single board computer **160** and/or remote management system **70**. Information regarding power supplies **280** includes, without limitation, the voltage, temperature and/or fan speed associated with power supplies **280**.

A temperature sensor may also be installed on or near web server processing cards **32**, server chassis **38**, power supplies **280** and/or server rack **39**. In the illustrated embodiment, each web server processing card includes an associated temperature sensor. Accordingly, the ambient temperature on or near components of web server processing cards **32** may be used to predict trouble or failure of a given web server processing card **32**, or component thereof. In a particular embodiment, the temperature sensor may be located on the web server processing card side of passive midplane **34**.

In a particular embodiment, single board computer **160**, and/or remote management system **70** may monitor the operation of one or more box fans **264**. Information regarding the box fans may include, without limitation, fan speed, voltage and/or temperature.

Additional measurements and information regarding the operation of various components of network **30** include the age of the component, the service life, history of trouble or failures and historical data regarding the life expectancy and previous trouble or failure associated with identical or similar components. All of these measurements and information may be collected, calculated or generated by components of network **30**, and/or input into management system **70** and/or single board computer **160** by the network operator/administrator.

As previously discussed, management network interface **49** may be provided without single board computer **160**. In this embodiment, all of the information discussed above regarding components of network **30** may be sent directly to remote management system **70**. When network interface **49** is provided without single board computer **160**, remote management system **70** may be configured to "sample" or collect measurements and information regarding components of network **30** at less frequent intervals, than those where a single board computer **160** is provided. This will help decrease network traffic. Accordingly, any data processing, collection of information, analysis and reaction to such information discussed with regard to either management network interface **49** or remote management system **70** may be processed, collected, stored, calculated or analyzed by one, or the other, or both.

Information collected regarding measurements and characteristics of components of network **30** may be used in a variety of ways. In a particular embodiment, this type of information may be collected and stored in a database associated with network **30**, for example non-volatile storage device **72** or storage server **54**. This information may be used in order for the network administrator to evaluate the performance of the system and/or predict service and maintenance needs prior to failure of a given component.

In another embodiment, remote management system **70** may use this information to establish a baseline for system performance and guidelines, or parameters that determine acceptable ranges of operation for all components of network **30**. In this manner, remote management system **70** can use historical data regarding previous component failures to detect potential trouble or failures in the future. In one embodiment, remote management system **70** may monitor the performance of a particular component relative to identical or similar components within network **30**, in order to detect and/or predict trouble or potential failures. In a particular embodiment, remote management system **70** may employ various techniques in order to detect or predict potential failures. For example, remote management system **70** may use logistic regression and/or neural networks to detect or predict potential failures.

Once remote management system **70** determines that one or more components of network **30** are susceptible to failure due to the information collected by remote management system **70**, various actions may be taken. For example, remote management system **70** may be configured to sound an alarm or provide another form of communication to the network administrator regarding the potential failure. The identification of a component operating outside of standard, or baseline performance characteristics, which indicate potential trouble or failure, may be referred to as a "threshold trigger".

Alternatively, remote management system **70** may increase the security, or surveillance of a component that exhibits characteristics outside of the normal range. For example, remote management console may be configured to sample the CPU voltage of every CPU associated with a given server chassis, at one hour intervals. If remote management system **70** detects a CPU with a voltage outside of a predefined range, remote management system **70** may then increase the frequency of voltage measurement regarding that particular CPU. In fact, remote management console **70** may begin to monitor all components of the web server processing card which includes the affected CPU at more frequent intervals, to ensure that the performance of the web server processing card has not deteriorated due to the performance of the CPU.

Furthermore, remote management system **70** may be configured to respond to potential trouble situations in order to prevent a system failure. The active autonomous response or corrective measure to a threshold trigger by remote management system **70** and/or single board computer **160**, may be referred to as a "failover event". For example, if remote management system **70** detects a temperature reading outside a predefined "normal" range for a given web server processing card, remote management system **70** may cause another component to "back-up" all data residing on the web server processing card in order to prevent the loss of such data.

If remote management system **70** determines that the affected web server processing card is likely to fail, remote management system **70** may cause a "spare" web server processing card to begin operations and transfer all of the data, state information and functionality of the affected web server processing card to the spare. Accordingly, once a potential failure is predicted, a seamless transfer of data, state information and operations from one web server processing card to another may be accomplished, without affecting the operation of network **30**, and without user intervention.

Due to the configuration and operation of network **30**, network operators, for example telephone companies, ISPs and/or ASPs may provide varying levels of disaster recovery to customers utilizing server chassis **38**. In one embodiment, the operator will simply receive notification of a failure of a component, and repair or replace the affected component. In another embodiment, a threshold trigger may be received, indicating trouble and/or potential failure of a component, and the operator may take the corrective action necessary to continue operation of server chassis **38**. In another embodiment, the operator may provide a user with predictive failover functionality, such that network **30** may detect and correct potential problems before the operation of server chassis **38** is affected. In yet another embodiment, the operator may provide a customer with a mirror web server processing card such that two web server processing cards are performing the exact same functionality, in case of the failure of one or the other. Similarly, a user may be provided with an entire "mirror" chassis to back up all of the web server cards in a particular server chassis, simultaneously.

In one embodiment, server chassis **38** may be used as a "cache farm". In other words, caching software may be provided on one or more web server processing cards which may be used as independent, or clustered caching devices.

Network **30** and all associated components are configured with minimized points of failure. Since each web server processing card includes the ability to independently detect system status information, the failure of a single web server processing card will not affect network operations.

Although the present invention has been described with several embodiments, various changes and modifications may be suggested to one of ordinary skill in the art. It is intended that the present invention encompass such changes and modifications as fall within the scope of the appended claims.

What is claimed is:

1. A server chassis, comprising:

a plurality of web server processing cards coupled with a midplane;

a first network interface card coupled with the midplane;

wherein the midplane includes printed circuitry operable to provide data communications between the plurality of web server processing cards and the first network interface card;

a second network interface card coupled with the midplane, and operable to couple the plurality of web server processing cards with a private network;

the first network interface card operable to couple the plurality of web server processing cards with a public network;

a third network interface card; and

wherein the third network interface card is operable to couple the plurality of web server processing cards with a management network.

2. The server chassis of claim **1**, wherein the second network interface card is operable to couple the plurality of web server processing cards with a management network.

3. The server chassis of claim **1**, further comprising:

a first power supply mounting mechanism operable to couple the midplane with a first power supply; and

wherein the printed circuitry is operable to distribute power from the first power supply to the plurality of web server processing cards.

4. The server chassis of claim **1**, further comprising:

a first power supply mounting mechanism operable to couple the midplane with a first power supply; and

wherein the printed circuitry is operable to distribute power from the first power supply to the first and second network interface cards.

5. The server chassis of claim **3**, further comprising:

a second power supply mounting mechanism operable to couple the midplane with a second power supply; and

wherein the printed circuitry is operable to distribute power from the second power supply to the plurality of web server processing cards.

6. The server chassis of claim **5**, wherein the printed circuitry is configured to balance the power load from the plurality of web server processing cards between the first and second power supply mounting mechanisms.

7. The server chassis of claim **5**, wherein the printed circuitry is configured to allow the removal of the first power supply from the first power supply mounting mechanism during the operation of at least one of the plurality of web server processing cards, without affecting the operation of the at least one of the plurality of web server processing cards.

8. The server chassis of claim **1**, further comprising:

an enclosure operable to at least partially enclose the web server processing cards; and

at least one of fan coupled with the enclosure and operable to provide ambient air flow adjacent the web server processing cards.

9. The server chassis of claim **8**, wherein the enclosure comprises a box build operable to at least partially enclose the web server processing cards, and an articulating door coupled with the box build, the at least one fan coupled with the articulating door.

10. The server chassis of claim **9**, further comprising:

a power supply coupled with the midplane, the power supply including an integral fan;

the articulating door having an open position and a closed position; and

wherein the articulating door includes a sensor which controls the speed of the integral fan, when the door is in the open position.

11. The server chassis of claim **8**, further comprising:

a ribbon connector coupled with the passive midplane and the at least one fan; and

wherein the ribbon connector is operable to distribute power from the passive midplane to the at least one fan.

12. The server chassis of claim **8**, wherein the fan includes a tachometer coupled with the midplane.

13. The server chassis of claim **1**, wherein at least two of the plurality of web server processing cards are clustered.

14. The server chassis of claim **1**, further comprising:

a serial port coupled the midplane; and

the serial port affixed to the enclosure and operable to provide local connectivity to the passive midplane.

15. The server chassis of claim **1**, further comprising a high density connector coupled with the first network interface card.

16. The server chassis of claim 15, wherein the high density connector includes an RJ-21 connector.

17. The server chassis of claim 15, wherein the high density connector is operable to receive data communications from fiber optic cables providing gigabit ethernet (GE).

18. The server chassis of claim 15, wherein the high density connector is operable to receive data communications from copper wire providing gigabit ethernet (GE).

19. The server chassis of claim 1, further comprising:

a connector coupled with the second network interface card; and

the second connector operable to receive data communications from fiber optic cables providing gigabit ethernet (GE).

20. The server chassis of claim 1, further comprising:

a connector coupled with the second network interface card; and

the connector operable to receive data communications from copper wires providing gigabit ethernet (GE).

21. The server chassis of claim 1, further comprising:

a connector coupled with the third network interface card; and

the connector operable to receive data communications from fiber optic cables providing gigabit ethernet (GE).

22. The server chassis of claim 1, further comprising:

a connector coupled with the third network interface card; and

the connector operable to receive data communications from copper wires providing gigabit ethernet (GE).

23. A method for providing data communications between a plurality of web server processing cards and a network interface card, comprising:

coupling a plurality of web server processing cards with a midplane;

coupling a first network interface card with a midplane; and

providing printed circuitry associated with the midplane, wherein the printed circuitry is operable to provide data communications between the plurality of web server processing cards and the network interface card.

24. The method of claim 23, further comprising:

coupling a second network interface card with a midplane, the second network interface card operable to couple the plurality of web server processing cards with a private network, and

wherein the first network interface card is operable to couple the plurality of web server processing cards with a public network.

25. The method of claim 23, further comprising:

coupling a first power supply mounting mechanism with the midplane, the first power supply mounting mechanism operable to couple a first power supply with the midplane; and

wherein the printed circuitry is operable to distribute power from the first power supply to the plurality of web server processing cards.

26. The method of claim 25, further comprising:

coupling a second power supply mounting mechanism with the midplane, the second power supply mounting mechanism operable to couple the midplane with the second power supply; and

wherein the printed circuitry is operable to distribute power from the second power supply to the plurality of web server processing cards.

27. The method of claim 24, further comprising coupling a third network interface card with the midplane, the third network interface card operable to couple the plurality of web server processing cards with the management network.

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