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(54) **SYSTEM AND METHOD FOR INDIRECT THROTTLING OF A SYSTEM RESOURCE BY A PROCESSOR**

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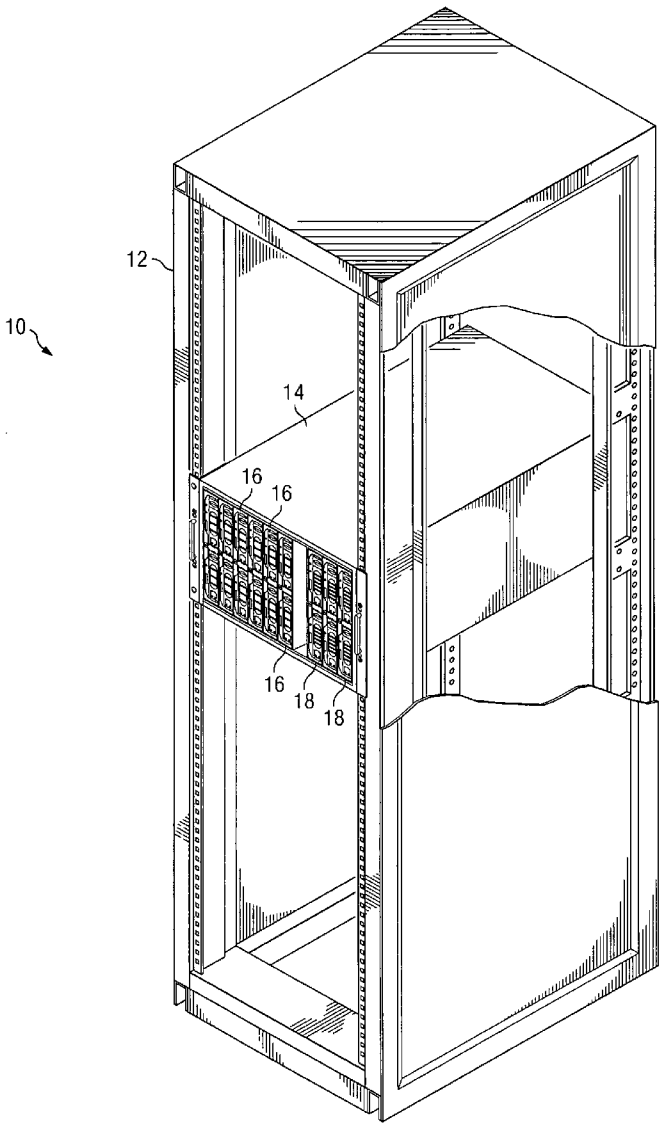
(57) **ABSTRACT**

A system and method for indirect throttling of a system resource by a processor are disclosed. An information handling system includes a chassis that receives modular components, a processor disposed in the chassis and a system resource in communication with the processor. A management module associated with the chassis generates a throttle signal that throttles operation of the processor in response to receiving an alarm such that the processor reduces the throughput of the system resource.



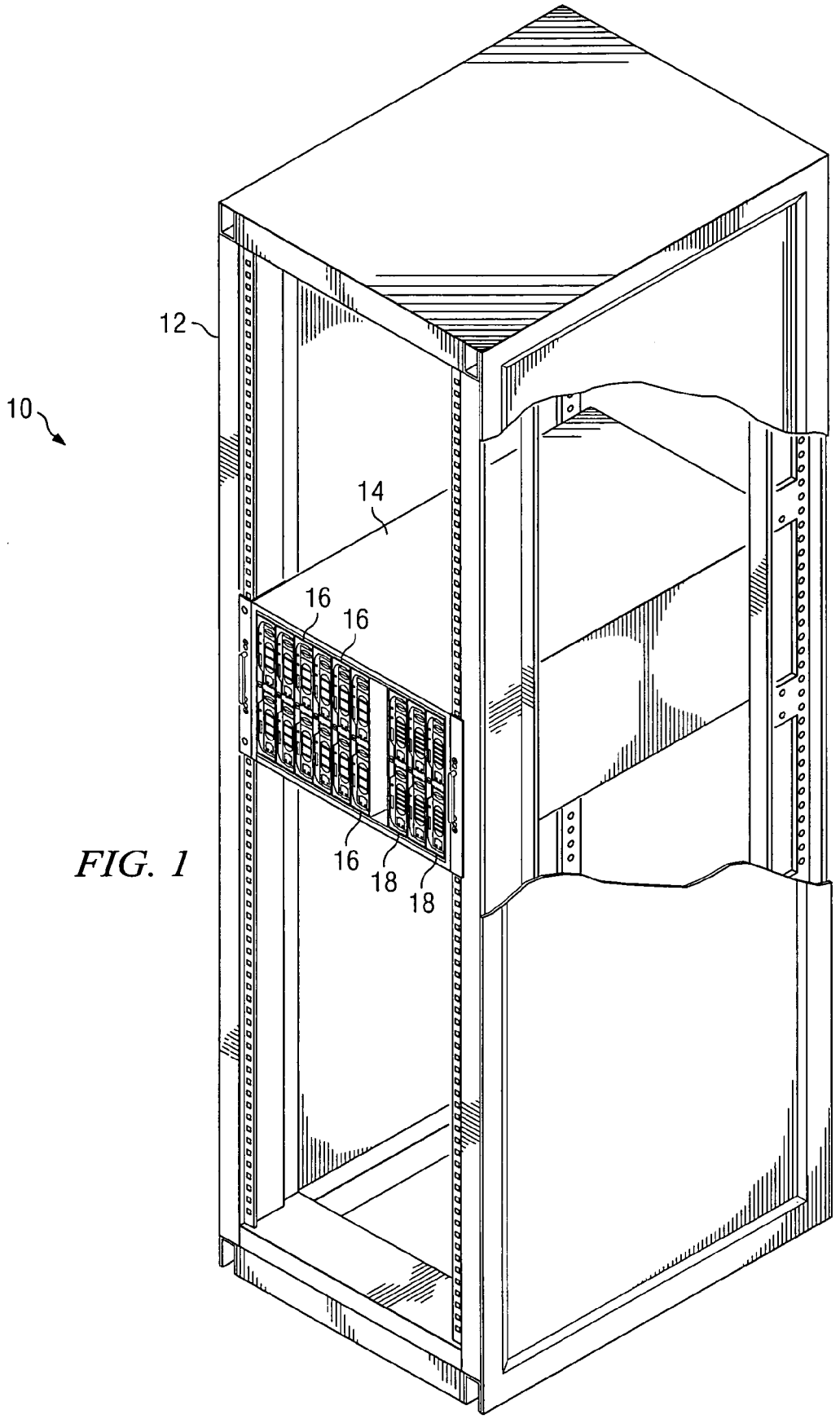
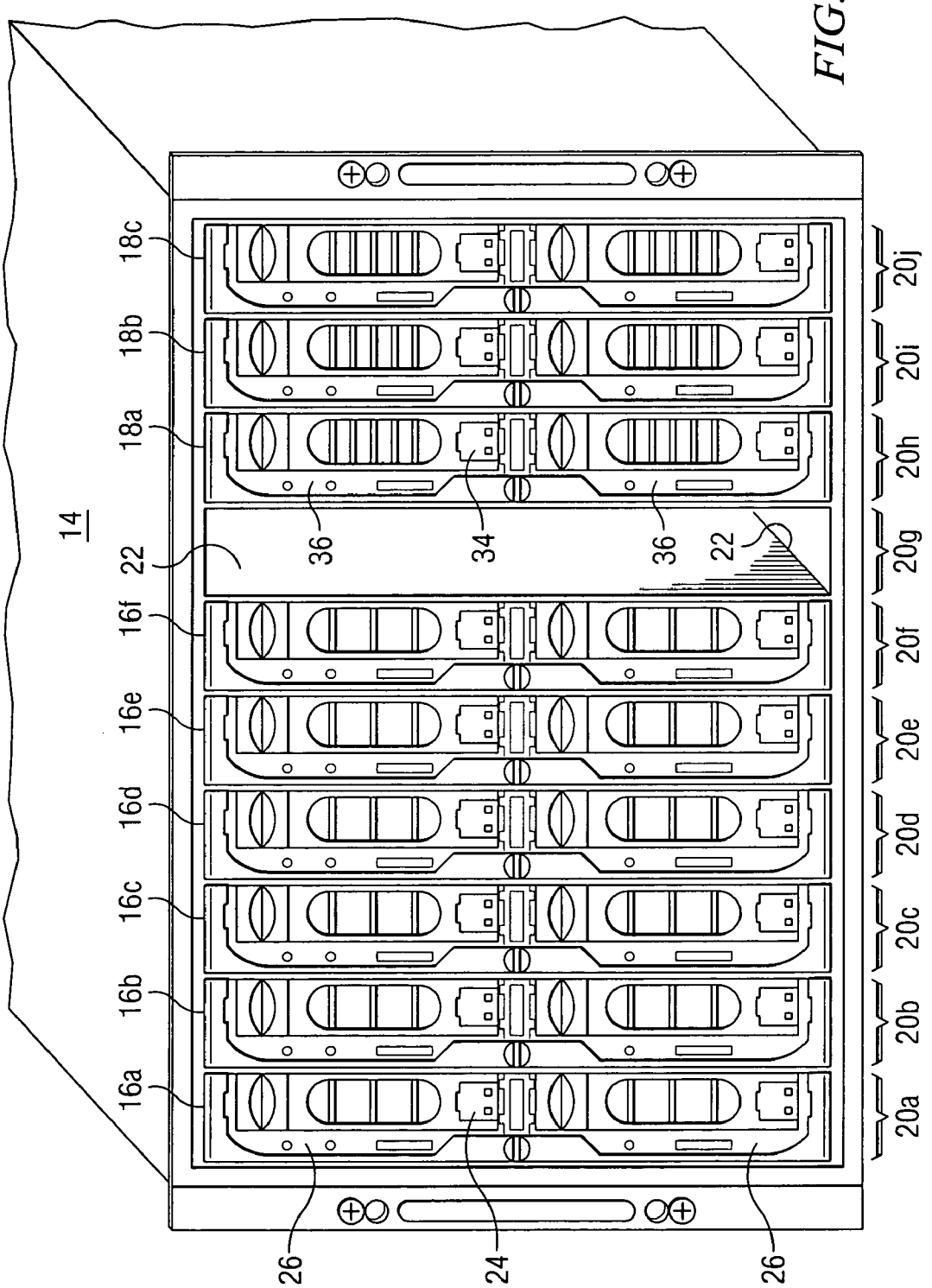


FIG. 1

FIG. 2A


14
18c
18b
18a
22
16f
16e
16d
16c
16b
16a
36
34
36
22
20j
20i
20h
20g
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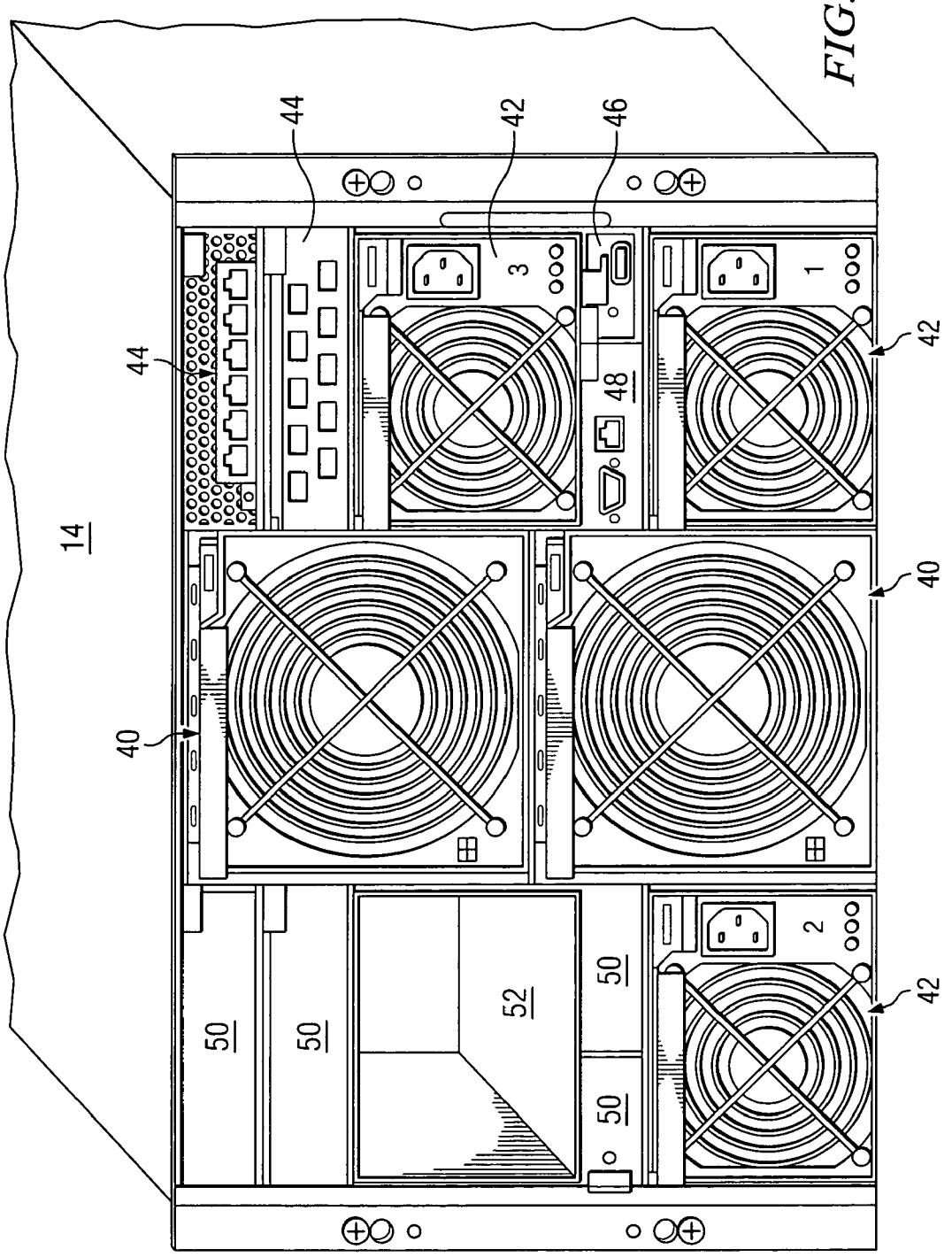
20c
20b
20a
26
24
26

FIG. 2B



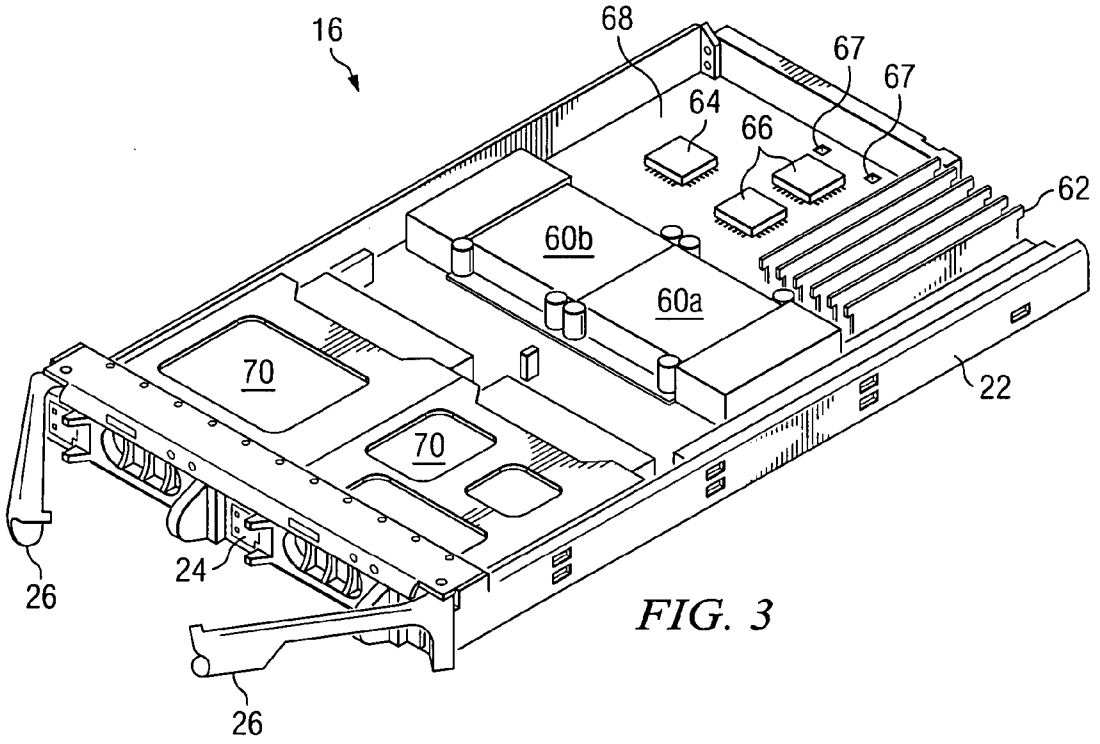


FIG. 3

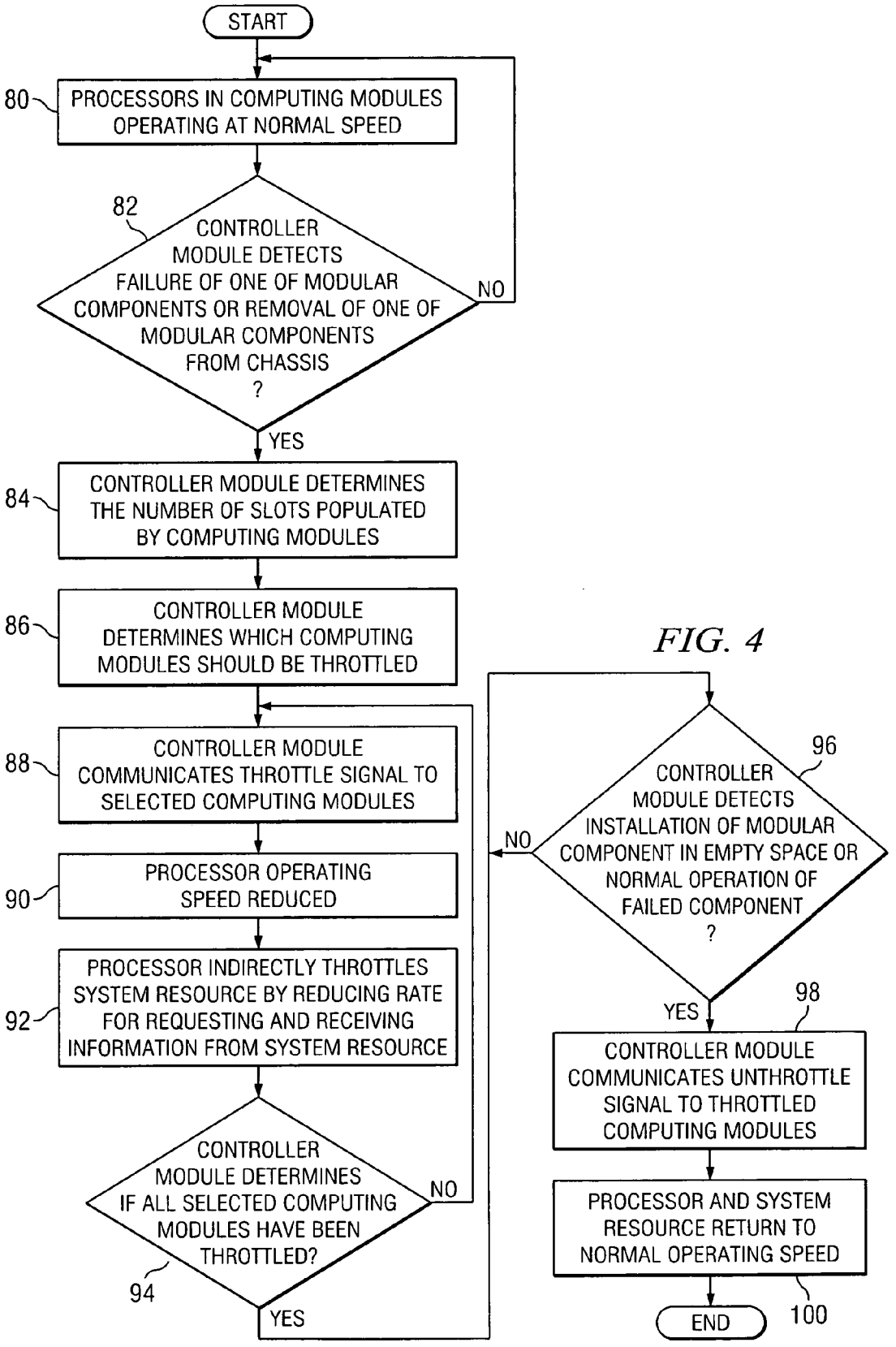

START
80
PROCESSORS IN COMPUTING MODULES OPERATING AT NORMAL SPEED
82
CONTROLLER MODULE DETECTS FAILURE OF ONE OF MODULAR COMPONENTS OR REMOVAL OF ONE OF MODULAR COMPONENTS FROM CHASSIS ?
NO
YES
84
CONTROLLER MODULE DETERMINES THE NUMBER OF SLOTS POPULATED BY COMPUTING MODULES
86
CONTROLLER MODULE DETERMINES WHICH COMPUTING MODULES SHOULD BE THROTTLED
88
CONTROLLER MODULE COMMUNICATES THROTTLE SIGNAL TO SELECTED COMPUTING MODULES
90
PROCESSOR OPERATING SPEED REDUCED
92
PROCESSOR INDIRECTLY THROTTLES SYSTEM RESOURCE BY REDUCING RATE FOR REQUESTING AND RECEIVING INFORMATION FROM SYSTEM RESOURCE
CONTROLLER MODULE DETERMINES IF ALL SELECTED COMPUTING MODULES HAVE BEEN THROTTLED?
94
NO
YES
96
CONTROLLER MODULE DETECTS INSTALLATION OF MODULAR COMPONENT IN EMPTY SPACE OR NORMAL OPERATION OF FAILED COMPONENT ?
NO
YES
98
CONTROLLER MODULE COMMUNICATES UNTHROTTLE SIGNAL TO THROTTLED COMPUTING MODULES
PROCESSOR AND SYSTEM RESOURCE RETURN TO NORMAL OPERATING SPEED
END
100

FIG. 4

SYSTEM AND METHOD FOR INDIRECT THROTTLING OF A SYSTEM RESOURCE BY A PROCESSOR

TECHNICAL FIELD

[0001] The present disclosure relates in general to information handling systems, and more particularly to a system and method for indirect throttling of a system resource by a processor.

BACKGROUND

[0002] As the value and use of information continues to increase, individuals and businesses seek additional ways to process and store information. One option available to users is information handling systems. An information handling system generally processes, compiles, stores, and/or communicates information or data for business, personal, or other purposes thereby allowing users to take advantage of the value of the information. Because technology and information handling needs and requirements vary between different users or applications, information handling systems may also vary regarding what information is handled, how the information is handled, how much information is processed, stored, or communicated, and how quickly and efficiently the information may be processed, stored, or communicated. The variations in information handling systems allow for information handling systems to be general or configured for a specific user or specific use such as financial transaction processing, airline reservations, enterprise data storage, or global communications. In addition, information handling systems may include a variety of hardware and software components that may be configured to process, store, and communicate information and may include one or more computer systems, data storage systems, and networking systems.

[0003] Today, information handling systems, such as servers and storage subsystems, use an increasing amount of power and resources. As computing and power requirements continue to increase, users are looking for ways to pack more computing power into smaller spaces while at the same time saving money, conserving energy, and having flexibility. For example, companies are migrating towards high density server applications or modular computing systems, such as blade servers and brick servers, instead of conventional U-sized servers (a U is a standard unit of measure for designating the height in computer enclosures and rack cabinets where 1U equals approximately 1.75 inches). The modular systems may include modular components such as blade servers, power supplies, cooling fans, disk drives and input/output (I/O) devices that can be easily installed in or removed from the system as individual modules.

[0004] Information handling systems that include multiple servers within a single server rack cabinet generally require additional cooling in order to account for the heat generated by the operation of the blade servers. Therefore, additional cooling fans or cooling fans having greater cooling capacity may be needed in order to prevent the servers from overheating due to the increased heat load of the processors in each of the servers. Because modular components may be easily installed in and removed from a server chassis, a user may not completely fill the chassis with the modular components, which results in the chassis having one or more empty sections. The empty sections adversely affect the cooling of the installed modular servers because air, like water, flows in the path of least resistance. For example, the majority of the cooling air flows in the empty sections and not through the installed modular servers when the cooling fans pull cooling air into the server chassis. Therefore, the installed modular servers do not receive adequate cooling and the operating temperature of one or more of the modular servers increases.

[0005] Each server in the information handling system may include one or more sensors that measure the operating temperature of the various devices in the server. The sensors typically are mounted on the circuit board adjacent to the devices and thus, depend on the air flowing over the devices to determine operating temperatures. However, in situations where the internal temperature of the devices rise above the ambient temperature in the system, such as when the airflow is altered by an empty section in the chassis, the sensor may report a temperature that is lower than the actual operating temperature of the devices. If the operating temperature continues to increase, the system may shut down without any warning to the users because the sensors are reporting lower temperatures. Furthermore, the overheating may result in system down time and less efficient operation.

SUMMARY

[0006] In accordance with the present disclosure, the disadvantages and problems associated with controlling component temperature in an information handling system have been substantially reduced or eliminated. In a particular embodiment, a management module generates a throttle signal in response to receiving an alarm and throttles operation of a processor such that the processor reduces throughput of a system resource in communication with the processor.

[0007] In accordance with one embodiment of the present disclosure, an information handling system includes a chassis that receives modular components, a processor disposed in the chassis and a system resource in communication with the processor. A management module associated with the chassis generates a throttle signal that throttles operation of the processor in response to receiving an alarm such that the processor reduces throughput of the system resource.

[0008] In accordance with another embodiment of the present disclosure, a method for indirect throttling of a system resource by a processor includes receiving a throttle signal at a processor disposed in a chassis if a management module associated with the chassis receives an alarm. The throttle signal throttles operation of the processor such that the processor reduces throughput of a system resource in communication with the processor.

[0009] In accordance with a further embodiment of the present disclosure, a system for indirect throttling of a system resource by a processor includes a modular chassis having a plurality of modular components and a plurality of blade servers installed therein. A management module is associated with the chassis and operably coupled to the blade servers and the modular components. The management module operable generates a throttle signal in response to receiving an alarm from one of the blade servers or one of the modular components. A processor in communication with a system resource and a controller in communication

with the processor are disposed in each of the blade servers. The controller receives the throttle signal from the management module and throttles operation of the processor such that the processor reduces throughput of the system resource.

[0010] Important technical advantages provided by certain embodiments of the present disclosure include an information handling system having the ability to reduce throughput of any system resources communicating with an associated processor. The information handling system may include one or more computing modules, such as blade servers, installed in a chassis. The computing modules typically include one or two processors in communication with system resources such as memory and various peripheral devices. If cooling in the information handling system is altered, the computing components in the computing modules may generate too much heat and cause a system failure. A management module associated with the chassis may generate a throttle signal when an alarm is received based on the altered cooling conditions and communicate the throttle signal to the processor in the computing modules. The throttled processors have a reduced operating speed and therefore, request and receive information from the system resources at a reduced frequency, which reduces the throughput of the system resources.

[0011] Another important technical advantage provided by certain embodiments of the present disclosure includes an information handling system that dissipates less heat during throttled operation. If a management module associated with a chassis in the information handling system determines that the cooling conditions of the system have been altered, the management module throttles one or more of the computing modules installed in the chassis. The throttle signal generated by the management module is communicated to processors in the selected computing modules such that the processors operate at a reduced speed. The processors also reduce the throughput of any system resources in the computing modules by requesting and receiving information from the system resources at a reduced frequency. The reduced operating speed of the processors and the reduced throughput of the system resources decrease the operating temperatures of the processors and the system resources such that the ambient temperature rise through the computing modules also decreases. System failures due to overheating, therefore, will e reduced or even eliminated.

[0012] All, some, or none of these technical advantages may be present in various embodiments of the present disclosure. Other technical advantages will be readily apparent to one skilled in the art from the following figures, descriptions, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] A more complete understanding of the present embodiments and advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features, and wherein:

[0014] **FIG. 1** illustrates a perspective diagram of an example information handling system in accordance with teachings of the present disclosure;

[0015] **FIG. 2A** illustrates a front perspective view of an example modular chassis in accordance with teachings of the present disclosure;

[0016] **FIG. 2B** illustrates a rear perspective view of an example modular chassis in accordance with teachings of the present disclosure;

[0017] **FIG. 3** illustrates a top perspective view of a computing module included in a modular chassis in accordance with teachings of the present disclosure; and

[0018] **FIG. 4** illustrates a flow chart of a method for indirect throttling of a system resource by a processor in accordance with teachings of the present disclosure.

DETAILED DESCRIPTION

[0019] Preferred embodiments and their advantages are best understood by reference to **FIGS. 1 through 4**, wherein like numbers are used to indicate like and corresponding parts.

[0020] A conventional information handling system that includes multiple blade servers may use one or more sensors to monitor operating conditions, such as temperature, of devices mounted on the server circuit boards. In operation, the sensors monitor operating temperature by measuring the temperature of the cooling air that flows over both the devices and the sensors. The temperature readings provided by the sensors may be used by a management module associated with the system to control cooling fans in order to reduce the operating temperature of the processor and other devices mounted on the circuit boards if the measured temperatures rise above a certain level. The sensors, however, typically do not provide an accurate measure of the operating temperatures of the devices because the sensors are not located on the devices and depend on the airflow over the devices to measure the ambient temperature associated with the devices. If one of the modular components in the system is removed, the airflow in the system may change such that the air circulates in the empty space instead of flowing through the installed servers. Since the sensors use airflow to determine operating temperature, the sensors may provide inaccurate results and the devices may overheat, which may cause the system to unexpectedly shut down. Additionally, the response time of the sensor may be much slower than the response time of the component due to fast transient temperatures associated with a component having high heat flux.

[0021] The present disclosure provides a system and method for indirect throttling of system resources mounted on a circuit board by a processor such that the system resources do not overheat. In one embodiment, a management module associated with the chassis detects when one of the modular components has a failure or has been removed from the chassis and communicates a throttle signal to one or more of the installed servers. The throttle signal instructs the processor to reduce its operating speed. When the operating speed of the processor is reduced, the processor requests and receives information from the system resources (e.g., memory and peripheral devices) at a reduced frequency such that the system resources are indirectly throttled by the processor, which reduces the power consumption and operating temperature of the system resources. The ability to indirectly throttle the system resources prevents system failures due to overheating in the information handling system. Additionally, throttling of the system resources reduces throughput in the server, which reduces ambient temperatures in the system.

[0022] For purposes of this disclosure, an information handling system may include any instrumentality or aggregate of instrumentalities operable to compute, classify, process, transmit, receive, retrieve, originate, switch, store, display, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, or other purposes. For example, an information handling system may be a personal computer, a network storage device, a server, or any other suitable device and may vary in size, shape, performance, functionality, and price. The information handling system may include random access memory (RAM), one or more processing resources such as a central processing unit (CPU) or hardware or software control logic, read only memory (ROM), and/or other types of nonvolatile memory. Additional components of the information handling system may include one or more disk drives, one or more network ports for communicating with external devices as well as various input and output (I/O) devices, such as a keyboard, a mouse, and a video display. The information handling system may also include one or more buses operable to transmit communications between the various hardware components.

[0023] **FIG. 1** illustrates a perspective diagram of information handling system **10** including rack structure **12**, modular chassis **14**, computing modules **16**, and blank modules **18**. Information handling system **10** shown in **FIG. 1** represents one configuration for rack structure **12**, modular chassis **14**, computing module **16**, and blank modules **18**. Information handling system **10** may be utilized in a computing center such as those used in any computer hardware intensive environment. In the embodiment shown in **FIG. 1**, rack structure **12** of information handling system **10** is a 42U rack structure and modular chassis **14** is a 7U sized chassis thereby allowing rack structure **12** to receive up to six of 7U modular chassis **14** disposed therein. In other embodiments, rack structure **12** may accept any combination and number of U-sized modular chassis **14** such that the total height of modular chassis **14** do not exceed the maximum height of rack structure **12**. In a further embodiment, modular chassis **14** may be a stand-alone information handling system where rack structure **12** is not needed to house modular chassis **14**.

[0024] **FIG. 2A** illustrates a front perspective view of modular chassis **14** including an example configuration for computing modules **16** and blank modules **18**. In the illustrated embodiment, modular chassis **14** is of a 7U size and includes ten slots **20***a*, **20***b*, **20***c*, **20***d*, **20***e*, **20***f*, **20***g*, **20***h*, **20***i* and **20***j* (generally referred to as slots **20**). Modular chassis **14** is operable to accept in slots **20***a*-**20***j* up to ten computing modules **16**, up to ten blank modules **18**, or up to ten of any combination of computing modules **16** and blank modules **18**. In the illustrated embodiment, computing modules **16***a*-**16***f* are respectively installed in slots **20***a*-**20***f*, slot **20***g* is empty and blank modules **18***a*-**18***c* are respectively installed in slots **20***h*-**20***j*. In another embodiment, modular chassis **14** may be of a different size than 7U and may include more than ten or less than ten slots to accept any combination of computing modules **16** and/or blank modules **18**.

[0025] Computing modules **16** are modular components, such as blade servers and brick servers, that include computing components and may be easily installed or removed within modular chassis **14**. In the embodiment shown in the FIGURES, computing module **16** is a blade server. A blade server is a thin, ultra-dense, modular electronic circuit board that contains one or more processors, associated memory and various peripheral devices. Server blades are complete computing systems due to the inclusion of processors, memory, and storage and network functionality on a single circuit board. Computing module **16** further includes housing **22** which encloses the necessary components of computing modules **16**. Housing **22** further includes a front section **24**, which includes handles **26** that enables a user to install and remove computing modules **16** in and out of slots **20** in modular chassis **14**.

[0026] Blank modules **18** do not include any of the electronic and/or computing components in computing module **16**. In the embodiment shown in the **FIG. 2A**, blank modules **18** only include housing **22** and do not include any internal components such as a processor, memory, or circuit board. Blank modules **18** include front section **34** and may also include handles **36**. Front section **34** and handles **36** may be different from front section **24** and handles **26** of computing module **16** so that a user can easily determine upon viewing whether computing module **16** or blank module **18** is installed in slot **20**. For instance, front section **24** may have a different hole pattern than front section **34** and handles **36** may be a different color than handles **26**. Therefore, a user only seeing front sections **24** and **34** can quickly determine the type of module installed in each of slots **20**. Although blank module **18** has been described as housing **22** including front section **36**, in alternate embodiments blank module **18** may only be a front section and not include the full housing. In order to provide the desired functionality of acting as a substitute for computing module **16**, blank module **18** can be of any type so long as blank module **18** has a large enough body and/or area to allow for proper and adequate air flow through modular chassis **14**.

[0027] As illustrated in **FIG. 2A**, either one of computing module **16** or blank module **18** has been removed from slot **20***g*. Removal of the module in slot **20***g* creates an empty space in modular chassis **14** and changes the airflow through modular chassis **14**. Typically, cooling air generated by one or more cooling fans (as shown below in **FIG. 2B**) flows through modular chassis **14** and over the components in computing modules **16**. When one or more of computing modules **16** and/or blank modules **18** is removed, the cooling air flows through the empty space because the cooling air follows the path of least resistance, here empty slot **20***g*. Installed computing modules **16***a*-**16***f*, therefore, do not receive adequate cooling and may overheat causing one or more of computing modules **16** to unexpectedly shut down.

[0028] As described more fully below, the present disclosure provides a system and method for indirectly throttling a system resource in one or more of computer modules **16** by using the corresponding processors. If one of computing modules **16** or blank modules **18** is removed from modular chassis **14**, a management module associated with modular chassis **14** may detect the empty space when an alarm is received (e.g., slot **20***g* as illustrated in **FIG. 2A**) and throttle the processor in one or more of computing modules **16**. The throttled processors have a reduced operating speed, and thus request and receive information from system resources at a lower rate. The throttled processors, therefore indirectly throttle the system resources and lower the system resources power draw, which lowers the operating temperature of the system resources. In addition, the reduced operating speeds of both the processor and the system resources reduces

ambient temperature in associated computing modules **16** such that system failures due to overheating may be reduced or even eliminated.

[**0029**] **FIG. 2B** illustrates a rear perspective view of modular chassis **14** including an example configuration for various modular components. In the illustrated embodiment, modular chassis **14** houses multiple modular components, including, but not limited to, cooling fans **40**, power supplies **42**, I/O devices **44**, keyboard, video, mouse (KVM) module **46**, management module **48** and blank module **50**. These modular components communicate with any computing module **16** installed in modular chassis **14**. I/O devices **44** may be a Fibre-Channel pass-through, an Ethernet pass-through, an Ethernet switch module or any other suitable devices that provides input and output capability for computing modules **16** installed in modular chassis **14**. KVM module **46** may be used to connect computing modules **16** to a single mouse, keyboard and video monitor in a point-to-point topology. Blank modules **50**, like blank modules **18** illustrated in **FIG. 2A**, do not include any of the electronic and/or computing components in, for example, cooling fans **40**, power supplies **42**, I/O modules **44**, KVM module **46** and management module **48**.

[**0030**] Management module **48** may be a remote access controller that performs power management functions and monitors system operating conditions for modular chassis **14**. For example, management module **48** may be in communication with the other modular components described above and a baseboard management controller (BMC) mounted to the circuit board of each computing module **16**. Each BMC may interface with the processor and any sensors mounted on the circuit board of corresponding computer module **16**. The BMC may receive signals from the sensors on the circuit board and in turn may send signals to management module **48**. The signals received from the sensors may include information related to the operating conditions in computing module **16**. The BMCs in each of computing modules **16** may communicate the received information to management module **48**.

[**0031**] Additionally, management module **48** may be able to independently detect operating conditions associated with the modular components installed in the chassis. For example, management module **48** may be able to detect if one of the modular components (e.g., computing modules **16**, blank modules **18**, cooling fans **40**, power supplies **42**, I/O modules **44**, KVM module **46** and blank modules **50**) have been removed from modular chassis **14** and may be able to monitor fan speeds of the cooling devices (e.g., cooling fans **40** and the fans in power supplies **42**) installed in modular chassis **14**. If management module **48** detects an empty space in modular chassis **14** or determines that the fan speed for at least one of the cooling devices is too low, management module **48** may communicate a signal to one or more of computing modules **16** that throttles the processor in the corresponding computing module.

[**0032**] When computing modules **16** are installed in modular chassis **14**, computing modules **16** interface with a midplane (not expressly shown). The midplane may be a circuit board and may include passive components such as connectors and resistors. Furthermore, the midplane may include connectors on the side facing computing modules **16** as well as the side opposite from computing modules **16** so that computing modules **16** may interface with other modular components, such as cooling fans **40**, power supplies **42**, I/O modules **44**, KVM module **46** and management module **48**.

[**0033**] In **FIG. 2A**, modular chassis **14** includes computing modules **16***a*-**16***f* respectively installed in slots **20***a*-**20***f* and blank modules **18***a*-**18***c* respectively installed in slots **20***h*-**20***j*. Slot **20***g* does not contain computing module **16** or blank module **18** and, therefore, is empty. Additionally, one of power supplies **42** has been removed from modular chassis **14** to create empty space **52** as shown in **FIG. 2B**. When computing module **16** is operating, it generates heat and must be cooled so that it does not overheat. Cooling fans **40**, in addition to the fans in power supplies **42**, provide the cooling air for computer modules **16**. Although the embodiments of **FIGS. 2A and 2B** include space for two cooling fans **40** and four power supplies **42**, in alternate embodiments, modular chassis **14** may include space for more than two or less than two cooling fans and more than four or less than four power supplies. In operation, cooling fans **40** and the fans in power supplies **42** pull in cooling air through front section **24** of computing modules **16** and front section **34** of blank modules **18** so that the cooling air may pass over computing components in computing modules **16** to cool the components and prevent computing modules **16** from overheating. Blank modules **18** act as substitutes for computing modules **16** that are absent from modular chassis **14** and ensure that cooling air properly flows through modular chassis **14**.

[**0034**] However, as illustrated in **FIGS. 2A and 2B**, empty spaces in modular chassis **14** may cause cooling problems because of changes in the pressure boundary conditions that control airflow through modular chassis **14**. The increased open area of empty slot **20***g* and/or empty space **52** causes decreased air flow through the remaining slots **20***a*-**20***f* and **20***h*-**20***j* and, therefore, reduced cooling in those areas. Since air, much like water or electricity, follows the path of least resistance, the majority of the cooling air travels through slot **20***g* and empty space **52**.

[**0035**] Because the majority of the cooling air flows through empty slot **20***g* and empty space **52**, computing module **16***f* installed in slot **20***f* may receive some cooling air but computing modules **16***a*-**16***e* respectively installed in slots **20***a*-**20***e* may receive little or no cooling air. The inadequate cooing air supplied to computing modules **16***a*-**16***f* may cause the operational temperatures of the processor and system resources to increase. The sensors included in computing modules **16** may detect the increasing operating temperature and communicate a signal to management module **48**. The sensors, however, may be unable to adequately track the temperature increase because the sensors measure operating temperature based on airflow over the devices. When one of the modular components is removed from modular chassis **14**, the air flow over the devices may be significantly reduced. Therefore, the operating temperature of computing modules **16** continues to increase because of inadequate cooling.

[**0036**] As the operating temperature of computing modules **16** continue to increase, management module **48** may increase the operational speed of cooling fans **40** in order to generate more cooling air but the additional cooling air may not achieve the desired effect of lowering the operating

temperature of computing modules **16**. When cooling fans **40** reach their maximum operational speeds and the operating temperatures of computing modules **16** remain too high, computing modules **16** may shut down to prevent system failure due to overheating. The shut down happens immediately without any warning to the user of information handling system **10** and results in ungraceful shutdowns, loss of data, and increased down-time.

[**0037**] The overheating of computing modules **16** in modular chassis **14** can be prevented by throttling the processors in one or more of computing modules **16** such that any system resources interfaced with the processors are indirectly throttled. For example, when the processors are throttled the operating speed of the processors decreases. The processors, therefore, communicate commands to and receive information from the system resources at a decreased rate. Since throughput of the system resources is reduced, the operating speed of the system resources is also reduced, which decreases the operating temperature of the system resources. Additionally, the operating temperature of the throttled processors is reduced. Since the processors and the system resources have lower operating speeds and, thus, lower operating temperatures, the ambient temperature in computing modules **16** will also be reduced. By reducing the ambient temperature, the possibility that computing modules **16** will shut down due to a system failure caused by overheating may be reduced and even eliminated.

[**0038**] **FIG. 3** illustrates a top perspective view of computing module **16** including an example configuration for various computing components. In the illustrated embodiment, computing module **16** includes processors **60***a* and **60***b*, memory **62**, baseboard management controller (BMC) **64**, peripheral devices **66** and sensors **67** mounted on circuit board **68**. Computing module **16** may further include modular components, such as hard disk drives (HDDs) **70***a* and **70***b* that respectively interface with processors **60***a* and **60***b* mounted on circuit board **68**. In other embodiments, HDDs **70** may interface with both of processors **60**. HDDs **70** may store the operating system and other programs that are executable by processors **60**.

[**0039**] Processors **60** may be microprocessors, microcontrollers, digital signal processors (DSP) or any other digital or analog circuitry configured to execute processing instructions stored in memory **62**. Memory **62** may be random access memory (RAM), electrically erasable programmable read-only memory (EEPROM), a PCMCIA card, flash memory, or any suitable selection and/or array of volatile or non-volatile memory. BMC **64** may be a microprocessor, microcontroller, DSP or any other digital or analog circuitry configured to perform inventory, monitoring, logging, and recovery control functions independent of processors **60**. Peripheral devices **66** may be a chip set associated with one or both of processors **60**, a video adapter, an audio adapter, a communication device or an other device that interfaces with one or both of processors **60** to add functionality to computing module **16**. Memory **62** and peripheral devices **66** may generally be referred to as system resources, which are accessible by processors **60** when computing module **16** is operational. Although, computing module **16** as illustrated in **FIG. 3** includes memory **62** and peripheral devices **66**, other embodiments of computing module **16** may include any configuration of memory modules and less than two or more than two peripheral devices.

[**0040**] In one embodiment, sensors **67** may be mounted on circuit board **68** to monitor various operating conditions associated with computing module **16**. Sensors **67** are hardware components that measure operating characteristics including, but not limited to, temperature, current, voltage, power supplies, fan speed, memory errors, or any other appropriate operating parameters that affects performance of computing module **16**. For instance, sensors **67** may measure temperature levels for memory **62** and peripheral devices **66** and, therefore, report ambient temperature for computing module **16**. Sensors **67** may be linear, non-linear, discrete, or threshold sensors.

[**0041**] Sensors **67** may be located adjacent system resources, such as memory **62** and/or one or more of peripheral devices **66**, in order to measure various operating conditions associated with memory **62** and/or peripheral devices **66**. For example, sensors **67** may measure operating temperatures associated with memory **62** and peripheral devices **66**. Sensors **67**, however, do not provide an accurate temperature for memory **62** and peripheral devices **66** because sensors **67** are mounted on circuit board **68** adjacent to memory **62** and peripheral devices **66** such that sensors **67** reply on airflow through computing module **16** to measure temperature. When one or more of the modular components is removed from modular chassis **14** and/or one or more of the cooling devices has failed, the path of the cooling air flowing from front to back through modular chassis **14** is altered such that the air flow over both the system resources and the sensors **67** may be reduced. Sensors **67** measure operating temperature of memory **62** and peripheral devices **66** by measuring the temperature of the air flowing through computing module **16**. Since the airflow through computing module **16** may be reduced, sensors **67** may not provide an accurate temperature reading because the same amount of air may not be flowing over memory **62** and/or peripheral devices **66** and sensors **67**.

[**0042**] The present disclosure prevents the operating temperature in computing module **16** from increasing by indirectly throttling system resources (e.g., memory **62** and/or peripheral devices **66**). When management module **48** (as illustrated in **FIG. 2B**) receives an alarm indicating that the temperatures measured by sensors **67** in one or more of computing modules **16** have reached a maximum level, one or more of modular components has been removed from modular chassis **14** and/or one or more of the cooling devices has failed, management module **48** determines the position in modular chassis **14** of the overheated computing module, empty space and/or the failed cooling device. In one embodiment, management module **48** may throttle one or both of processors **60** all installed computing modules **16**. In another embodiment, management module **48** may throttle a subset of installed computing modules **16** based on the number and position of empty spaces and/or failed devices in modular chassis **14**. For example, modular chassis **14** may include empty slot **20***g* created by removing computing module **16** or blank module **18** and empty space **52** created by removing power supply **42** as illustrated in **FIGS. 2A and 2B**. Management module **48** may receive an alarm generated by sensors (not expressly shown) associated with modular chassis **48** indicating the position of empty slot **20***g* and empty space **52** within modular chassis. Based on the determined positions of the empty spaces, management module **48** may, for example, determine to throttle processors **60** in computing modules **16***a*-**16***f*.

[0043] In one embodiment, management module **48** throttles processors **60** by communicating a throttle signal to BMC **64** in each of selected computing modules **16**. BMC **64** then throttles one or both of processors **60** by asserting, for example, an externally driven throttle signal (e.g., FORCEPR# on an Intel processor). When processors **60** are throttled, the operating speed is reduced and processors **60** request and receive information from memory **62** and/or peripheral devices **66** at a reduced rate. Since processors **60** demand less of memory **62** and/or peripheral devices **66** when throttled, utilization of memory **62** and peripheral devices **66** declines and the operating temperature of the devices will decrease. Therefore, processors **60** effectively reduce operating speed of memory **62** and/or peripheral devices **66** such that the devices are indirectly throttled.

[0044] **FIG. 4** illustrates a flow diagram of an example method for indirectly throttling a system resource. Generally, removal of one or more modular components from a chassis and/or the failure of a cooling device can cause installed computing modules to overheat because the amount of cooling air flowing over the computing components in the installed computing modules is reduced. A management module installed in the chassis may detect that one or more modular components have been removed or that one or more cooling devices have failed. The management module determines which of the installed computing modules may overheat due to the altered air flow and communicates a throttle signal to the selected computing modules. The throttle signal is used to throttle one or both of processors in the selected computing modules. The throttled processor has a reduced operating speed and, therefore, requests and receives information from system resources at a reduced rate. The system resources, therefore, are indirectly throttled and also operate at a reduced speed. The reduced operating speed of the processors and the system resources also reduces the ambient temperature in the computing module and may prevent the computing module from shutting down due to overheating.

[0045] At step **80**, all modular components may be installed in modular chassis **14** and all cooling devices may be functioning properly such that processors **60** in computing modules **16** may be operating at a normal speed. Management module **48** may monitor the modular components to determine if one or more of the modular components has been removed from modular chassis **14**, if one or more of cooling fans **40** has failed and/or if sensors **67** in one or more of computing modules **16** have measured temperatures above a maximum level at step **82**. In one embodiment, a sensor, including but not limited to, optical switches such as an infra-red sensor, contact sensors, magnetic switches, or a continuity, may be used to determine if a modular component is installed in modular chassis **14**. For example, if a sensor detects that a modular component has been removed from modular chassis, the sensor may generate an alarm and communicate the alarm to management module **48**. In addition to indicating that a modular component has been removed, the alarm may indicate the position of the empty space in modular chassis **14**. In another embodiment, the sensor may also indicate if a cooling device (e.g., cooling fans **40** and/or the fans in power supplies **42**) has failed. The sensor may generate an alarm indicating the failure and communicate the alarm to management module **48** such that management module **48** may determine the location of the failed cooling device. In a further embodiment, the alarm may be generated by sensors **67** in one or more of computing modules **67** indicating that the measured temperature is above a maximum level. The alarm may be communicated to management module **48** such that management module **48** determines the location of the corresponding computing module.

[0046] If management module **48** does not detect that one of the modular components has been removed or that one of the cooling devices has failed, processors **60** in computing modules **16** continue to operate at normal speed at step **80**. If management module **48** detects that at least one of the modular components has been removed from modular chassis **14** or that at least one of the cooling devices has failed, management module **48** determines the number of slots **20** populated by computing modules **16** at step **84**. For example, as illustrated in **FIG. 2A**, modular chassis may include computing modules **16***a*-**16***f* respectively installed in slots **20***a*-**20***f*. In other embodiments, computing modules **16** may be installed in any number of slots **20** included in modular chassis **14**. Management module **48** also may determine which computing modules **16** should be throttled to prevent overheating at step **86**. In one embodiment, management module **48** may determine which of computing modules **16** should be throttled based on the position of the empty spaces and/or the position of the failed cooling device in modular chassis **14**. For example, as illustrated in **FIGS. 2A and 2B**, modular chassis may include empty slot **20***g* and empty space **52**. In other embodiments, modular chassis **14** may include fewer than two empty spaces or more than two empty spaces. Management module **48** may determine the position of the empty spaces and/or failed devices based on the electrical signals received from the sensors coupled to the slots for receiving each of the modular components. Although the steps have been described as being performed in a specific order, steps **84** and **86** may be performed in a different order or simultaneously.

[0047] At step **88**, management module **48** communicates a throttle signal to each one of selected computing modules **16**. The selection of computing modules **16** may be based on the number of computing modules **16** installed in modular chassis **14** and the position of the empty spaces and/or failed devices in modular chassis **14**. In one embodiment, management module **48** may determine that all of installed computing modules **16***a*-**16***f* should be throttled. In other embodiments, management module **48** may determine that a subset of computing modules **16***a*-**16***f* should be throttled. In one embodiment, the throttle signal may be communicated to BMC **64** included in each one of selected computing modules **16**. Once BMC **64** receives the throttle signal, BMC **64** may assert a throttle signal on one or both of processors **60**. For example, processors **60** may be any type of Intel processor that include a FORCEPR# pin. When BMC **64** receives the throttle signal from management module **48**, BMC **64** may force the FORCEPR# signal to an asserted state such that one or both of processors **60** are throttled. Each processor **60** that receives the throttle signal reduces its operating speed at step **90**. The reduced operating speed may reduce the operating temperature of processors **60** and thus reduce the ambient temperature in selected computing modules **16**.

[0048] At step **92**, system resources, including but not limited to, memory **62** and peripheral devices **66**, may be indirectly throttled by processors **60** because processors **60**

reduce the frequency with which they request and receive information from memory **62** and peripheral devices **66**. Thus, the effective throughput of memory **62** and peripheral devices **66** may be reduced, which also reduces the operating temperature of the devices. Therefore, the possibility that selected computing modules **16** will shut down due to a high operating temperature may be reduced or even eliminated.

[**0049**] At step **94**, management module **48** determines if processors **60** in all of selected computing modules **16** have been throttled. In one embodiment, BMC **64** in computing module **16** may communicate a signal to management module **48** indicating that processors **60** are throttled. If management module **48** does not receive the signal from all of selected computing modules **16**, management module **48** determines which one of computing modules **16** was not throttled and communicates throttle signal to selected computing modules **16** that have not been throttled at step **88**. If management module **48** has received signals from all of selected computing modules **16**, management module **48** determines if the modular components that were removed to create empty slot **20***g* and empty space **52** have been replaced and/or the failed cooling device is operating normally at step **96**. If one of the modular components have not been replaced and/or one cooling device is not operating properly, processors **60**, memory **62** and peripheral devices **66** may continue to operate at a reduced speed and management module **48** may continue to monitor whether the modular components have been replaced and/or the cooling device is operating properly at step **96**.

[**0050**] If management module **48** detects that the modular components have been replaced and/or the cooling devices are operating properly, management module **48** communicates a signal to unthrottle processors **60** in selected computing modules **16** at step **98**. In one embodiment, management module **48** may detect that the modular components have been replaced and/or that the cooling devices are operating properly based on a signal received from the sensors associated with the removed computing modules or the failed devices. For example, the sensors may deassert the signals associated with the removed modular components, which indicates that the modular components have been replaced. In one embodiment, the unthrottle signal may be communicated to BMC **64** for each of selected computing modules **16** and BMC **64** may communicate the signal to processors **60**. For example, BMC **64** may force the FORCEPR# signal for processors **60** to a deasserted state, which instructs processors **60** to exit the throttle state. At step **100**, processors **60**, memory **62** and peripheral devices **66** return to normal operating speed.

[**0051**] Although the disclosed embodiments have been described in detail, it should be understood that various changes, substitutions and alterations can be made to the embodiments without departing from their spirit and scope.

What is claimed is:

1. An information handling system, comprising:

a chassis operable to receive modular components;

a processor disposed in the chassis;

a system resource in communication with the processor; and

a management module associated with the chassis, the management module operable to generate a throttle signal that throttles operation of the processor in response to receiving an alarm;

wherein throttling operation of the processor reduces throughput of the system resource.

2. The system of claim 1, further comprising the reduced throughput of the system resource operable to decrease operating temperature of the system resource.

3. The system of claim 1, further comprising the modular components selected from the group consisting of blade servers, blank modules, cooling fans, power supplies, hard drives, I/O devices, KVM devices and any combination thereof.

4. The system of claim 1, further comprising the system resource selected from the group consisting of a chip set, a memory device, a graphics device, an audio device and a communication device.

5. The system of claim 1, further comprising the management module operable to deassert the throttle signal in response to the alarm being deasserted such that the processor increases the operating speed of the system resource.

6. The system of claim 1, further comprising:

the processor, the system resource and a controller disposed in a blade server, the processor in communication with the controller;

a plurality of the blade servers disposed in the chassis; and

the management module operably coupled to the blade servers, the management module operable to instruct the controller in at least one of the blade servers to communicate the throttle signal to the processor in response to receiving the alarm.

7. The system of claim 1, further comprising the alarm operable to indicate at least one of failure of one of the modular components or removal of one of the modular components from the chassis.

8. The system of claim 7, further comprising a sensor associated with each of the modular components, the sensor operable to detect the failure of one of the modular components or the removal of one of the modular component from the chassis.

9. A method for indirect throttling of a system resource by a processor, comprising:

receiving a throttle signal at a processor disposed in a chassis if a management module associated with the chassis receives an alarm, the throttle signal operable to throttle operation of the processor; and

reducing throughput of a system resource in communication with the processor in response to receiving the throttle signal.

10. The method of claim 9, further comprising the reduced throughput of the system resource operable to decrease operating temperature of the system resource.

11. The method of claim 9, further comprising:

generating the throttle signal by the management module in response to receiving the alarm; and

communicating the throttle signal to the processor by a controller in communication with the management module.

12. The method of claim 11, further comprising generating the alarm by a sensor associated with each of a plurality of modular components installed in the chassis, the alarm operable to indicate at least one of failure of one of the modular components or removal of one of the modular components from the chassis.

13. The method of claim 9, further comprising the modular components selected from the group consisting of blade servers, blank modules, cooling fans, power supplies, hard drives, I/O devices, KVM devices and any combination thereof.

14. The method of claim 9, further comprising the system resource selected from the group consisting of a chip set, a memory device, a graphics device, an audio device and a communication device.

15. The method of claim 9, further comprising:

receiving a deasserted throttle signal at the processor in response to the alarm being deasserted such that the processor is removed from throttling operation; and

increasing the operating speed of the system resource in response to receiving the deasserted throttle signal.

16. A system for indirect throttling of a system resource by a processor, comprising:

a modular chassis including a plurality of modular components and a plurality of blade servers;

a management module associated with the chassis and operably coupled to the blade servers and the modular components, the management module operable to generate a throttle signal in response to receiving an alarm from one of the blade servers or one of the modular components;

a processor disposed in each of the blade servers;

a system resource in communication with each of the processors; and

a controller in communication with each of the processors, the controller operable to receive the throttle signal from the management module and throttle operation of the processor;

wherein throttling operation of the processor reduces throughput of the system resource.

17. The system of claim 16, further comprising the reduced throughput of the system resource operable to decrease operating temperature of the system resource.

18. The system of claim 16, further comprising the modular components selected from the group consisting of blank modules, cooling fans, power supplies, hard drives, I/O devices, KVM devices and any combination thereof.

19. The system of claim 16, further comprising the system resource selected from the group consisting of a chip set, a memory device, a graphics device, an audio device and a communication device.

20. The system of claim 16, further comprising the alarm operable to indicate at least one of failure of one of the modular components, removal of one of the modular components from the chassis or removal of one of the blade servers from the chassis.

21. The system of claim 20, wherein the management module determines the blade servers that should be throttled by determining a position of at least one of the failed modular component, an empty space created by removal of one of the modular components or an empty slot created by removal of one of the blade servers.

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