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Expansion card adaptation

Abstract

An apparatus, system, and method for emulating a computer expansion card. The apparatus includes an edge connector comprising a plurality of pin fingers, the edge connector conforming with a first connector type and a socket connector configured to receive a computer expansion card conforming with a second connector type. The apparatus further includes a PCB comprising a logic adapter configured to convert a first set of signals associated with the first connector type into a second set of signals associated with the second connector type.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
2022008	12/1934	Price	52/292	E04H 12/2261
10359815	12/2018	Lin	N/A	H01R 12/721
10762025	12/2019	Tsorng	N/A	G06F 13/4081
10820415	12/2019	Stenfort	N/A	G06F 13/385
10956353	12/2020	Bailey	N/A	G06F 13/4068
10976785	12/2020	St. Germain	N/A	H05K 7/1409
11596073	12/2022	Zhang	N/A	G06F 1/187
2015/0277935	12/2014	Desimone	710/313	G06F 13/382
2022/0342463	12/2021	Norton	N/A	G06F 1/187
2024/0107671	12/2023	Heyd	N/A	G06F 1/20
2024/0204433	12/2023	Chen	N/A	H01R 12/716
2024/0288915	12/2023	Grady	N/A	G06F 1/187

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Background/Summary

FIELD

(1) The subject matter disclosed herein relates to computer expansion cards and more particularly relates to emulating a computer expansion card.

BACKGROUND

(2) M.2 solid state storage devices are popular and relatively low-cost. However, M.2 solid state storage devices lack useful features of newer technology drives, such as supporting removal of the device while the system unit is power on, a characteristic referred to as “hot swappable.”

BRIEF SUMMARY

(3) Disclosed are procedures for emulating a computer expansion card. Said procedures may be implemented by apparatus, systems, methods, or computer program products.

(4) According to one aspect, an apparatus that supports techniques for emulating a computer expansion card includes an edge connector comprising a plurality of pin fingers, the edge connector conforming with a first connector type and a socket connector configured to receive a computer expansion card conforming with a second connector type. The apparatus includes a printed circuit board (“PCB”) comprising a logic adapter configured to convert a first set of signals associated with the first connector type into a second set of signals associated with the second connector type.

(5) According to another aspect, a system that supports techniques for emulating a computer

expansion card includes an enclosure dimensioned to conform to a first form factor, a computer expansion card located within the enclosure, and a bridge card coupled to the computer expansion card and located within the enclosure. In various embodiments, the bridge card includes i) an edge connector including a plurality of pin fingers, the edge connector conforming with a first connector type; ii) a socket connector configured to receive the computer expansion card, the socket connector conforming with a second connector type; and iii) a PCB including a logic adapter configured to convert a first set of signals associated with the first connector type into a second set of signals associated with the second connector type.
(6) According to a third aspect, a method for emulating a computer expansion card includes engaging a computer expansion card with a first socket connector conforming with a first connector type and engaging an edge connector with a second socket connector conforming with a second connector type. The first method includes transforming a first set of signals associated with the first connector type into a second set of signals associated with the second connector type.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) A more particular description of the embodiments briefly described above will be rendered by reference to specific embodiments that are illustrated in the appended drawings. Understanding that these drawings depict only some embodiments and are not therefore to be considered to be limiting of scope, the embodiments will be described and explained with additional specificity and detail through the use of the accompanying drawings, in which:
(2) FIG. **1** is a block diagram illustrating one embodiment of a system that supports techniques for emulating a computer expansion card in accordance with aspects of the present disclosure;
(3) FIG. **2** is a block diagram illustrating one embodiment of a bridge card apparatus that supports techniques for emulating a computer expansion card in accordance with aspects of the present disclosure;
(4) FIG. **3** is a block diagram illustrating an E1.S emulation using a bridge card adapter and an M.2 module in accordance with aspects of the present disclosure;
(5) FIG. **4** is a block diagram illustrating one embodiment of a logic adapter that supports techniques for emulating a computer expansion card in accordance with aspects of the present disclosure;
(6) FIG. **5**A is a diagram illustrating one embodiment of a bridge PCB card that supports techniques for emulating a computer expansion card in accordance with aspects of the present disclosure;
(7) FIG. **5**B is a diagram illustrating another embodiment of a bridge PCB card that supports techniques for emulating a computer expansion card in accordance with aspects of the present disclosure;
(8) FIG. **6** is a diagram illustrating one embodiment of a bridge PCB card that supports techniques for emulating a computer expansion card in accordance with aspects of the present disclosure; and
(9) FIG. **7** is a flow chart diagram illustrating one embodiment of a representative method for emulating a computer expansion card in accordance with aspects of the present disclosure.
DETAILED DESCRIPTION
(10) As will be appreciated by one skilled in the art, aspects of the embodiments may be embodied as a system, method, or program product. Accordingly, embodiments may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a “circuit,” “module” or “system.” Furthermore, embodiments may take the form of a program product embodied in one or more computer readable storage

devices storing machine readable code, computer readable code, and/or program code, referred hereafter as code. The storage devices may be tangible, non-transitory, and/or non-transmission. The storage devices may not embody signals. In a certain embodiment, the storage devices only employ signals for accessing code.

(11) Many of the functional units described in this specification have been labeled as modules, in order to more particularly emphasize their implementation independence. For example, a module may be implemented as a hardware circuit comprising custom very large scale integrated ("VLSI") circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as a field programmable gate array ("FPGA"), programmable logic array ("PLA"), programmable logic devices or the like.

(12) Modules may also be implemented in code and/or software for execution by various types of processors. An identified module of code may, for instance, comprise one or more physical or logical blocks of executable code which may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module need not be physically located together but may comprise disparate instructions stored in different locations which, when joined logically together, comprise the module and achieve the stated purpose for the module.

(13) Indeed, a module of code may be a single instruction, or many instructions, and may even be distributed over several different code segments, among different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within modules and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set or may be distributed over different locations including over different computer readable storage devices. Where a module or portions of a module are implemented in software, the software portions are stored on one or more computer readable storage devices.

(14) Any combination of one or more computer readable medium may be utilized. The computer readable medium may be a computer readable storage medium. The computer readable storage medium may be a storage device storing the code. The storage device may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, holographic, micromechanical, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing.

(15) More specific examples (a non-exhaustive list) of the storage device would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random-access memory ("RAM"), a read-only memory ("ROM"), an erasable programmable read-only memory ("EPROM"), an electrically erasable programmable read-only memory ("EEPROM") (also referred to as Flash memory), a static random access memory ("SRAM"), a portable compact disc read-only memory ("CD-ROM"), a digital versatile disk ("DVD"), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium, as used herein, is not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media (e.g., light pulses passing through a fiber-optic cable), or electrical signals transmitted through a wire.

(16) Computer readable program instructions described herein can be downloaded to respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. The network may comprise copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card or network interface in each computing/processing device receives computer readable program instructions from the network

and forwards the computer readable program instructions for storage in a computer readable storage medium within the respective computing/processing device.
(17) Computer readable program instructions for carrying out operations of the present invention may be assembler instructions, instruction-set-architecture ("ISA") instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++ or the like, and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The computer readable program instructions may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network ("LAN"), wireless LAN ("WLAN"), or a wide area network ("WAN"), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider ("ISP")). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, FPGAs, or PLAs may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present invention.
(18) Furthermore, the described features, structures, or characteristics of the embodiments may be combined in any suitable manner. In the following description, numerous specific details are provided, such as examples of programming, software modules, user selections, network transactions, database queries, database structures, hardware modules, hardware circuits, hardware chips, etc., to provide a thorough understanding of embodiments. One skilled in the relevant art will recognize, however, that embodiments may be practiced without one or more of the specific details, or with other methods, components, materials, and so forth. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of an embodiment.
(19) Reference throughout this specification to "one embodiment," "an embodiment," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases "in one embodiment," "in an embodiment," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment, but mean "one or more but not all embodiments" unless expressly specified otherwise. The terms "including," "comprising," "having," and variations thereof mean "including but not limited to," unless expressly specified otherwise. An enumerated listing of items does not imply that any or all of the items are mutually exclusive, unless expressly specified otherwise. The terms "a," "an," and "the" also refer to "one or more" unless expressly specified otherwise.
(20) As used herein, a list with a conjunction of "and/or" includes any single item in the list or a combination of items in the list. For example, a list of A, B and/or C includes only A, only B, only C, a combination of A and B, a combination of B and C, a combination of A and C or a combination of A, B and C. As used herein, a list using the terminology "one or more of" includes any single item in the list or a combination of items in the list. For example, one or more of A, B and C includes only A, only B, only C, a combination of A and B, a combination of B and C, a combination of A and C or a combination of A, B and C. As used herein, a list using the terminology "one of" includes one and only one of any single item in the list. For example, "one of A, B and C" includes only A, only B or only C and excludes combinations of A, B and C. As used herein, "a member selected from the group consisting of A, B, and C," includes one and only one of A, B, or C, and excludes combinations of A, B, and C. As used herein, "a member selected from the group consisting of A, B, and C and combinations thereof" includes only A, only B, only C, a

combination of A and B, a combination of B and C, a combination of A and C or a combination of A, B and C.
(21) Aspects of the embodiments are described below with reference to flowchart illustrations and/or block diagrams of methods, apparatuses, systems, and program products according to embodiments. It will be understood that each block of the schematic flowchart diagrams and/or schematic block diagrams, and combinations of blocks in the schematic flowchart diagrams and/or schematic block diagrams, can be implemented by code or computer readable program instructions.
(22) The code (e.g., computer readable program instructions) may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.
(23) The code (e.g., computer readable program instructions) may also be stored in a computer readable storage medium that can direct a computer, a programmable data processing apparatus, and/or other devices to function in a particular manner, such that the computer readable storage medium having instructions stored therein comprises an article of manufacture including instructions which implement aspects of the function/act specified in the flowchart and/or block diagram block or blocks.
(24) The code (e.g., computer readable program instructions) may also be loaded onto a computer, other programmable data processing apparatus, or other device to cause a series of operational steps to be performed on the computer, other programmable apparatus or other device to produce a computer implemented process, such that the instructions which execute on the computer, other programmable apparatus, or other device implement the functions/acts specified in the flowchart and/or block diagram block or blocks.
(25) The call-flow diagrams, flowchart diagrams and/or block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of apparatuses, systems, methods, and program products according to various embodiments. In this regard, each block in the flowchart diagrams and/or block diagrams may represent a module, segment, or portion of code, which includes one or more executable instructions of the code for implementing the specified logical function(s).
(26) It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the Figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. Other steps and methods may be conceived that are equivalent in function, logic, or effect to one or more blocks, or portions thereof, of the illustrated Figures.
(27) Although various arrow types and line types may be employed in the call-flow, flowchart and/or block diagrams, they are understood not to limit the scope of the corresponding embodiments. Indeed, some arrows or other connectors may be used to indicate only the logical flow of the depicted embodiment. For instance, an arrow may indicate a waiting or monitoring period of unspecified duration between enumerated steps of the depicted embodiment. It will also be noted that each block of the block diagrams and/or flowchart diagrams, and combinations of blocks in the block diagrams and/or flowchart diagrams, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and code.
(28) The description of elements in each figure may refer to elements of proceeding figures. Like numbers refer to like elements in all figures, including alternate embodiments of like elements.
(29) Generally, the present disclosure describes apparatuses, systems, and methods that support techniques for emulating a computer expansion card. In certain embodiments, the methods may be performed using computer code embedded on a computer-readable medium. In certain

embodiments, an apparatus or system may include a computer-readable medium containing computer-readable code which, when executed by a processor, causes the apparatus or system to perform at least a portion of the below described solutions.

(30) When a new generation of computer expansion cards, such as solid state drives, hits the market, the new products generally have new and/or improved features, while the older generation is generally more available (i.e., more plentiful) and less expensive. Regarding solid state storage devices, such as those used in data centers, the M.2 devices are still popular with many low cost modules available even as the new flash form factor E1.S is becoming pervasive.

(31) These common M.2 solid state storage devices are not hot swappable, that is they are not removable while the system unit is powered on. However, it is beneficial for a system administrator or technician to be able to remove a solid state storage device, e.g., in case of device failure or for physical security. Newer technologies, such as E1.S flash drives are designed to be hot swappable, thereby allowing a storage device to be removed and replaced without requiring the system unit to power down first.

(32) To benefit from the abundance of low cost M.2 solid state storage devices (also referred to as a "M.2 modules"), the present disclosure provides solutions for emulating an E1.S device with an M.2 flash drive and a bridge card that emulates the E1.S interface (both electrically and mechanically). Beneficially, the bridge card allows plugging an M.2 module into an E1.S slot connector and making the M.2 module hot swappable.

(33) To allow an M.2 module to emulate an E1.S drive, the proposed solutions provide a PCB and electrical circuits to emulate the E1.S interface both electrically (i.e., by adapting the signaling) and mechanically (i.e., with compatible connectors).

(34) E1.S is a relatively new flash form factor defined under the Enterprise and Datacenter Standard Form Factor ("EDSFF") specifications. The E1.S form factors are becoming pervasive for high capacity and hot swappable non-volatile memory express ("NVME") storage. The form factors included in the EDSFF specification are the E1.S (short) and the E1.L (long). The EDSFF specifications define the physical dimensions, mechanical connectors, and electrical interfaces that an E1.S device is to have, to ensure compatibility among different hardware providers. The E1.S standard is meant to replace previous generation solid state storage device form factors, such as the M.2 standard. While M.2 devices are popular today, it is expected that the industry will shift quickly to the new E1.S form factors.

(35) The EDSFF specifications define five thicknesses for the E1.S form factor, with the thinnest form factor being substantially similar to the width of a standard M.2 drive. The thicket E1.S form factors allow for the addition of heat sinks/heat spreaders to increase the thermal headroom of the device (thereby allowing for increased power and performance). When compared to the M.2 form factor, the E1.S form factors are longer and wider. The inventors have recognized that a M.2 module can fit within the footprint of an E1.S drive.

(36) An E1.S device is designed to be hot swappable; however, M.2 NVME solid state drives ("SSDs") are also not hot-swappable because the M.2 connector was not made for hot swapping. The M.2 form factor and interface are defined by the Peripheral Component Interconnect Special Interest Group ("PCI-SIG"). While M.2 modules have been popular in data centers, M.2 modules have challenges in hotplug/serviceability and overheating. A M.2 edge connector is not compatible with an E1.S socket connector (also referred to as a slot connector), nor is an E1.S edge connector compatible with an M.2 socket connector. Therefore, an M.2 device cannot be plugged into an E1.S slot. Further, the signaling interfaces are different between the E1.S and M.2 specifications.

(37) An apparatus, a system, and a method that support techniques for emulating a computer expansion card are disclosed. According to one aspect of the disclosure, the apparatus may include A) an edge connector comprising a plurality of pin fingers, the edge connector conforming with a first connector type; B) a socket connector configured to receive a computer expansion card conforming with a second connector type; and C) a PCB comprising a logic adapter configured to

convert a first set of signals associated with the first connector type into a second set of signals associated with the second connector type.

(38) In some embodiments, the first connector type comprises an E1.S edge connector, and wherein the second connector type comprises an M.2 socket connector. In some embodiments, the edge connector has a 2C connector size and comprises a notch separating the first set of the plurality of pin fingers from the remainder of the plurality of pin fingers. In other embodiments, the edge connector may have a 1C connector size.

(39) In various embodiments, a subset of the plurality of pin fingers has an extended finger length compared to the remainder of the plurality of pin fingers. In such embodiments, the subset of the plurality of pin fingers corresponding to ground pins.

(40) In some embodiments, the PCB supports a first superset of signals via the edge connector and supports a second superset of signals via the socket connector. In such embodiments, the first superset of signals comprises the first set of signals and a third set of signals, and the second superset of signals comprises the second set of signals and the third set of signals. In various embodiments, the PCB bridges the third set of signals between the edge connector and the socket connector.

(41) In some embodiments, the PCB comprises an amber light-emitting diode ("LED") and a blue LED. In such embodiments, the logic adapter may be configured to A) receive an electrical signal from a particular pin of the edge connector and B) convert the electrical signal into user information presentable to a user via the amber LED and the blue LED. In certain embodiments, the user information comprises failure information and location information.

(42) In some embodiments, the PCB comprises a green LED. In such embodiments, the logic adapter may be configured to A) receive an electrical signal from a particular pin of the edge connector, B) pass the electrical signal to a corresponding pin of the socket connector, and C) convert the electrical signal into state information presentable to a user via the green LED. In certain embodiments, the state information comprises a power state of the computer expansion card and host-initiated input/output ("I/O") activity state of the computer expansion card.

(43) In some embodiments, the logic adapter comprises a serializer I/O expander configured to multiplex a plurality of digital inputs into a plurality of bits. In certain embodiments, the serializer I/O expander comprises a serial general purpose input/output ("SGPIO") interface. In certain embodiments, the plurality of digital inputs comprises a power loss indication signal and a power loss acknowledgement ("ACK") signal.

(44) According to another aspect of the invention, a system may include A) an enclosure dimensioned to conform to a first form factor, B) a computer expansion card located within the enclosure, and C) a bridge card coupled to the computer expansion card and located within the enclosure. In various embodiments, the bridge card includes i) an edge connector including a plurality of pin fingers, the edge connector conforming with a first connector type; ii) a socket connector configured to receive the computer expansion card, the socket connector conforming with a second connector type; and iii) a PCB including a logic adapter configured to convert a first set of signals associated with the first connector type into a second set of signals associated with the second connector type.

(45) In some embodiments, the computer expansion card conforms to a second form factor smaller than the first form factor, where the first form factor comprises an E1.S form factor and the second form factor comprises an M.2 form factor. In some embodiments, the first connector type comprises an E1.S edge connector and the second connector type comprises an M.2 socket connector.

(46) In some embodiments, the edge connector has a 2C connector size and comprises a notch separating the first set of the plurality of pin fingers from the remainder of the plurality of pin fingers. In other embodiments, the edge connector may have a 1C connector size.

(47) In various embodiments, a subset of the plurality of pin fingers has an extended finger length

compared to the remainder of the plurality of pin fingers. In such embodiments, the subset of the plurality of pin fingers corresponding to ground pins.

(48) In some embodiments, the bridge card supports a first superset of signals via the edge connector and supports a second superset of signals via the socket connector. In such embodiments, the first superset of signals comprises the first set of signals and a third set of signals, and the second superset of signals comprises the second set of signals and the third set of signals. In various embodiments, the bridge card bridges the third set of signals between the edge connector and the socket connector.

(49) In some embodiments, the bridge card comprises an amber LED and a blue LED. In such embodiments, the logic adapter may be configured to A) receive an electrical signal from a particular pin of the edge connector and B) convert the electrical signal into user information presentable to a user via the amber LED and the blue LED. In certain embodiments, the user information comprises failure information and location information.

(50) In some embodiments, the bridge card comprises a green LED. In such embodiments, the logic adapter may be configured to A) receive an electrical signal from a particular pin of the edge connector, B) pass the electrical signal to a corresponding pin of the socket connector, and C) convert the electrical signal into state information presentable to a user via the green LED. In certain embodiments, the state information comprises a power state of the computer expansion card and host-initiated I/O activity state of the computer expansion card.

(51) In some embodiments, the logic adapter comprises a serializer I/O expander configured to multiplex a plurality of digital inputs into a plurality of bits. In certain embodiments, the serializer I/O expander comprises a SGPIO interface. In certain embodiments, the plurality of digital inputs comprises a power loss indication signal and a power loss ACK signal.

(52) According to a third aspect of the invention, a method may include engaging a computer expansion card with a first socket connector conforming with a first connector type and engaging an edge connector with a second socket connector conforming with a second connector type. The method includes transforming a first set of signals associated with the first connector type into a second set of signals associated with the second connector type.

(53) In some embodiments, to transform the first set of signals into the second set of signals, the method includes multiplexing a plurality of digital inputs into a plurality of bits via a SGPIO interface. In such embodiments, the plurality of digital inputs includes a power loss indication signal and a power loss ACK signal. In some embodiments, the first connector type comprises an E1.S edge connector, and wherein the second connector type comprises an M.2 socket connector.

(54) In some embodiments, the bridge card device supports a first superset of signals via the edge connector and supports a second superset of signals via the socket connector. In such embodiments, the first superset of signals comprises the first set of signals and a third set of signals, and the second superset of signals comprises the second set of signals and the third set of signals. In various embodiments, the method includes bridging the third set of signals between the edge connector and the socket connector.

(55) In some embodiments, the bridge card device comprises an amber LED and a blue LED. In such embodiments, the method may include A) receiving an electrical signal from a particular pin of the edge connector and B) converting the electrical signal into user information presentable to a user via the amber LED and the blue LED. In certain embodiments, the user information comprises failure information and location information.

(56) In some embodiments, the bridge card comprises a green LED. In such embodiments, the method may include A) receiving an electrical signal from a particular pin of the edge connector, B) passing the electrical signal to a corresponding pin of the socket connector, and C) converting the electrical signal into state information presentable to a user via the green LED. In certain embodiments, the state information comprises a power state of the computer expansion card and host-initiated I/O activity state of the computer expansion card.

(57) FIG. **1** depicts an exemplary system **100** for emulating a specific type of computer expansion card, in accordance with aspects of the present disclosure. The system **100** includes is presented to show one example of an environment where an apparatus and method may be implemented in accordance with the embodiments of the disclosure. As depicted, the system **100** may include a computing device **101** comprising at least one processor **102**, at least one memory device **104**, at least one network adapter **106**, at least one I/O controller **108**, and at least one bridge card apparatus **110**. In some embodiments, the computing device **101** may be an enterprise server and/or a server in a data center.
(58) The processor(s) **102** may be operably connected to the memory device(s) **104**. The memory device(s) **104** may include one or more non-volatile storage devices such as hard drives, solid state drives, CD-ROM drives, DVD-ROM drives, tape drives, or the like. The memory device(s) **104** may also include non-volatile memory such as a read-only memory (e.g., ROM, EPROM, EEPROM, and/or Flash ROM) or volatile memory such as a random access memory (e.g., RAM or operational memory). A computer bus, or plurality of buses, may interconnect the processor(s) **102**, memory device(s) **104**, the network adapter(s) **106**, the I/O controller(s) **108**, the bridge card apparatus(es) **110**, and other devices to enable data and/or instructions to pass therebetween.
(59) To enable communication with external systems or devices, the computing device **101** may include one or more I/O controllers **108**. Such I/O controller(s) **108** may be embodied as wired ports (e.g., Universal Serial Bus ("USB") ports, serial ports, Firewire ports, Small Computer System Interface ("SCSI") ports, parallel ports, etc.) or wireless ports (e.g., BLUETOOTH®, Infrared Data Association® ("IrDA®"), etc.). The I/O controller(s) **108** may enable communication with one or more input devices (e.g., keyboards, mice, touchscreens, cameras, microphones, scanners, storage devices, etc.) and output devices (e.g., displays, monitors, speakers, printers, storage devices, etc.). The I/O controller(s) **108** may also enable communication with other computing devices **101**.
(60) In certain embodiments, the computing device **101** includes a wired or wireless network adapter **106** to connect the computing device **101** to a network **116**, such as a LAN, WAN, or the Internet. Such a network **116** may enable the computing device **101** to connect to one or more servers, workstation, mobile computing devices, or other devices. Via the network **116**, the computing device **101** may be interact with one or more communication client devices, such as a table computer **118***a*, a mobile phone **118***b*, a workstation or personal computer **118***c*, and/or laptop **118***d* (referred to collectively as "client devices" **118**). While not depicted in FIG. **1**, the system **100** may include—or be coupled to—various telecommunications equipment, such as email servers, communications servers, routers, switches, gateways, and other network elements and networking devices.
(61) The system **100** is representative of various systems where the embodiments described herein may be deployed. The computing device **101**, in some embodiments, is in a data center. In other embodiments, the computing device **101** is user-owned. While a single bridge card apparatus **110** (and expansion card **112**) is depicted, one of skill in the art will recognize that multiple bridge card apparatuses **110** (i.e., each coupled to a respective expansion card **112**) may be deployed on the computing devices **101**.
(62) In some embodiments, the computing device **101** may be a rack-mounted server, a workstation, a mainframe computer, a desktop server, a laptop server, and the like or any combination thereof. In such embodiments, the computing device **101** includes one or more processors, memory, data buses, access to non-volatile data storage, I/O connections, and the like. One of skill in the art will recognize other implementations of a computing device **101** comprising at least one bridge card apparatus **110** coupled to an expansion card **112**.
(63) The peer devices **118** are depicted as a tablet computer, a smartphone, a desktop computer, and a laptop computer as examples but may be implemented by a workstation, a terminal, or other computing device capable of connection to the computing device **101** over the network **116**. In

some embodiments, a peer device **118** is used by a system administrator for installation, maintenance, control, etc., of the bridge card apparatus **110** coupled to an expansion card **112**. In other embodiments, the peer devices **118** are user devices for using the bridge card apparatus **110** coupled to an expansion card **112**. For example, a user may use a smartphone as a peer device **118** to interact with the bridge card apparatus **110** coupled to an expansion card **112**.
(64) The network **116** connects the peer devices **118** to the computing device **101** to access the expansion card **112** coupled to the bridge card apparatus **110**. The network **116** includes one or more networks. For example, the network **114** may include a LAN and may include a gateway to the Internet. The network **116** network may include cabling, optical fiber, etc. and may also include a wireless connection and may include a combination of network types. The network **116** may include a LAN, a WAN, a storage area network ("SAN"), an optical fiber network, etc. Various computer networks that are part of the depicted network **116** may be private and/or public, for example, through an Internet Service Provider.
(65) The wireless connection may be a mobile telephone network. The wireless connection may also employ a Wi-Fi network based on any one of the Institute of Electrical and Electronics Engineers ("IEEE") 802.11 standards. Alternatively, the wireless connection may be a BLUETOOTH® connection. In addition, the wireless connection may employ a Radio Frequency Identification ("RFID") communication including RFID standards established by the International Organization for Standardization ("ISO"), the International Electrotechnical Commission ("IEC"), the American Society for Testing and Materials® ("ASTM"®), the DASH7™ Alliance, and EPCGlobal™.
(66) Alternatively, the wireless connection may employ a ZigBee® connection based on the IEEE 802 standards. In one embodiment, the wireless connection employs a Z-Wave® connection as designed by Sigma Designs®. Alternatively, the wireless connection may employ an ANT® and/or ANT+® connection as defined by Dynastream® Innovations Inc. of Cochrane, Canada.
(67) The wireless connection may be an infrared connection including connections conforming at least to the Infrared Physical Layer Specification ("IrPHY") as defined by the IrDA®. Alternatively, the wireless connection may be a cellular telephone network communication. All standards and/or connection types include the latest version and revision of the standard and/or connection type as of the filing date of this application.
(68) In various embodiments, the expansion card **112** comprises a solid state storage device. The bridge card apparatus **110** provides physical connectors, electrical interfaces, and signal adaptation to allow the expansion card **112** to emulate a different type of storage device. The bridge card apparatus **110** and expansion card **112** may be located within a common enclosure **114**. As described herein, the expansion card **112** may conform to the M.2 specifications, while the bridge card apparatus **110** provides a connector and interface compatible with the E1.S specifications. Moreover, the bridge card apparatus **110** provides signal adaptation (also referred to as signal blending) to allow the expansion card **112** (e.g., a M.2 module) to emulate an E1.S drive. While the expansion card **112** and bridge card apparatus **110** are described primarily with reference to the M.2 and E1.S specifications, one of skill in the art will recognize other expansion card (e.g., storage drive) specifications that can be adapted and emulated using the bridge card apparatus **110** coupled to an expansion card **112**.
(69) In various embodiments, the bridge card apparatus **110** includes an edge connector for coupling the bridge card apparatus **110** to the computing device **101**. Here, the edge connector may extend through the enclosure **114** to insert into a slot or socket connector of the computing device **101**. In various embodiments, the edge connector conforms with the E1.S specifications, having the proper physical dimensions, mechanical connectors, and electrical interfaces to couple to an E1.S slot or socket connector. The edge connector is described in greater detail below.
(70) The bridge card apparatus **110** includes a socket connector for receiving the expansion card **112**. In various embodiments, the socket connector conforms with the M.2 specifications, having

the proper physical dimensions, mechanical connectors, and electrical interfaces to couple to an M.2 edge connector of the expansion card **112**. The socket connector is described in greater detail below.

(71) The bridge card apparatus **110** includes a way to bridge signaling between the E1.S host (i.e., the computing device **101**) and the M.2 device (i.e., the expansion card **112**). In one embodiment, the bridge card apparatus **110** includes a logic adapter that adapts signals unique to the E1.S connector into signals recognized by the M.2 device, and adapts signals unique to the M.2 connector into signals recognized by the E1.S host. Moreover, the bridge card apparatus **110** may pass through signals common to the E1.S and M.2 connectors. The bridge card apparatus **110** is described in more detail below in relation to FIGS. **2** through **6**.

(72) FIG. **2** depicts an exemplary apparatus **200** for emulating a specific type of computer expansion card, in accordance with aspects of the present disclosure. The apparatus **200** includes one embodiment of the bridge card apparatus **110** that includes an edge connector **202**, a socket connector **204**, and a PCB **206** including at least a logic adapter **208** and one or more indicators **210**, which are described below.

(73) The apparatus **200** includes an edge connector **202** configured to be inserted into a host device. The edge connector **202** includes a multiple pin fingers (also referred to as signal pins). In certain embodiments, the pin fingers may comprise gold fingers, e.g., conductive pins made of or plated with gold. In some embodiments, the multiple pin fingers include a set of ground pins. To support hot swapping, the set of ground pins may have an extended finger length compared to the remainder of the pin fingers.

(74) In various embodiments, the edge connector **202** is an E1.S edge connector complying with EDSFF specifications for E1.S electrical and mechanical interfaces, e.g., complying with SFF-TA-1006. In one embodiment, the edge connector **202** has a 2C connector size as defined in EDSFF specification. Here, the edge connector **202** may include a notch separating a first set of pin fingers from the remainder of the pin fingers. In another embodiment, the edge connector **202** has a 1C connector size as defined in EDSFF specifications.

(75) The apparatus **200** includes a socket connector **204** configured to couple with an expansion card **112**, such as a solid state storage device complying with the M.2 standards. As such, the socket connector may comprise a slot for receiving the expansion card **112**. In certain embodiments, the socket connector **204** may include various pins providing an electrical interface with the expansion card **112**.

(76) In various embodiments, the socket connector **204** is a M.2 socket complying with PCI-SIG specification for M.2 mechanical and electrical interfaces. In one embodiment, the socket connector **204** is a keyed socket having a Socket 3, Key-M size.

(77) The apparatus **200** includes a logic adapter **208** configured to convert a first set of signals associated with the first connector type into a second set of signals associated with the second connector type. The logic adapter **208** is described in more detail below in relation to FIG. **4**.

(78) As described above, the logic adapter **208** is configured to adapt signals unique to an interface of the edge connector **202** into signals recognizable by the expansion card **112**. For example, the logic adapter **208** may adapt E1.S signals into signals recognizable by an M.2 device. Additionally, the logic adapter **208** is configured to adapt signals unique to an interface of the socket connector **204** into signals recognizable by the host system, such as the computing device **101**. For example, the logic adapter **208** may adapt M.2 signals into signals recognized by an E1.S host.

(79) In further embodiments, the PCB **206** may be configured to pass through various signals common to the edge connector **202** and socket connector **204**. For example, common signaling between an E1.S edge connector and a M.2 socket connector may include Peripheral Component Interconnect Express ("PCIe") transmit and receive signals, clock signals, sideband signaling, and the like.

(80) Accordingly, the PCB **206** may support a superset of signals comprising a first set of signals

unique to the edge connector **202** and not common to the socket connector **204**, a second set of signals unique to the socket connector **204** and not common to the edge connector **202**, and a third set of signals common to the edge connector **202** and socket connector **204**. In such embodiments, the PCB **206** may bridge the third set of signals between the edge connector **202** and the socket connector **204**, while the logic adapter **208** may transform the first set of signals (e.g., E1.S-specific signaling) into the second set of signals (e.g., M.2-specific signaling) and/or transform the second set of signals into the first set of signals. Signal blending is described in greater detail below with reference to FIGS. **4** and **6**.
(81) The apparatus **200** includes one or more indicators **210** configured to signal information to a user. In some embodiments, the one or more indicators **210** includes an amber LED and a blue LED. In one embodiment, the apparatus **200** includes a combined function LED capable of outputting both amber and blue light. In another embodiment, the apparatus **200** includes discrete amber and blue LEDs. In the following descriptions, the notation “amber/blue LED” is used with reference to the amber and blue LEDs, which may be discrete component or a combined function component.
(82) In various embodiments, the logic adapter **208** may receive an electrical signal from a particular pin of the edge connector **202** and then convert the electrical signal into user information presentable to a user via the amber/blue LED. In certain embodiments, the user information comprises failure information and location information.
(83) In some embodiments, the one or more indicators **210** includes a green LED. In various embodiments, the logic adapter **208** is configured to receive an electrical signal from a particular pin of the edge connector **202**, to pass the electrical signal to a corresponding pin of the socket connector **204**, and to convert the electrical signal into state information presentable to a user via the green LED. In certain embodiments, the state information comprises a power state of the expansion card **112** (e.g., M.2 module) and host-initiated I/O activity state of the expansion card **112**.
(84) Note that the blocks **202-210** represent functional blocks of the apparatus **200** and may include any component or set of components that perform the functionality attributed to the component. This may include one or more physical processors which execute processor-readable instructions, the processor-readable instructions (e.g., as software application or other executable), circuitry, computer hardware, storage media, some combination of software, hardware, and/or firmware, interfaces, adapters, or any other components. The description of the functionality provided by the different components **202**, **204**, **206**, **208** and/or **210** described below is for illustrative purposes, and is not intended to be limiting, as any of components **202**, **204**, **206**, **208** and/or **210** may provide more or less functionality than is described. For example, one or more of components **202**, **204**, **206**, **208** and/or **210** may be eliminated, and some or all of its functionality may be provided by other ones of components **202**, **204**, **206**, **208** and/or **210**. As another example, the apparatus **200** may comprise additional components that may perform some or all of the functionality attributed above to one or more of the components **202**, **204**, **206**, **208** and/or **210**.
(85) FIG. **3** depicts an embodiment of an emulation device **300** for emulating a E1.S device, in accordance with aspects of the present disclosure. The emulation device **300** includes a bridge PCB card **302** coupled to an M.2 module **304**. The bridge PCB card **302** includes an edge connector **306** and a slot connector **308**. The bridge PCB card **302** and M.2 module **304** are housed inside an enclosure **310**.
(86) The edge connector **306** may be one embodiment of the edge connector **202**. In various embodiments, the edge connector **306** emulates an E1.S edge connector complying with the EDSFF specification for mechanical and electrical interfaces. As depicted, the edge connector **306** has a subset of longer pins which correspond to the ground pins for the bridge PCB card **302**.
(87) The slot connector **308** is configured to receive the M.2 module **304**. The slot connector **308** may be one embodiment of the socket connector **204**. In various embodiments, the socket

connector **504** is a M.2 connector complying with the PCI-SIG specification for mechanical and electrical interfaces. The socket connector **504** is coupled to the edge connector **502**. In various embodiments, the bridge PCB card bridges and adapts signals between the edge connector **306** and the slot connector **308**, as described herein.

(88) The M.2 module **304** may be one embodiment of the memory expansion card **112**, as described above. In the various embodiments, the M.2 module **304** comprises a NVME controller and NVME storage media. The combination of the bridge PCB card **302** and the M.2 module **304** fit inside the E1.S enclosure space.

(89) Note that FIG. **3** further depicts an E1.S drive **312** comprising an E1.S module **314** having an E1.S edge connected **316**. In various embodiments, the enclosure **310** is capable of housing an E1.S module **322** or a M.2 module **304** coupled to a bridge PCB card **302**.

(90) FIG. **4** illustrates an exemplary apparatus **400** for converting a first set of signals associated with the first connector type into a second set of signals associated with the second connector type, in accordance with aspects of the present disclosure. The apparatus **400** includes one embodiment of the logic adapter **208** that includes a user information adapter **402**, a state information adapter **404**, a serializer expander **406**, and a power adapter **408**, which are described below.

(91) The apparatus **400** includes a user information adapter **402** configured to convert an electrical signal received at an edge connector pin finger into user information presentable to a user. In certain embodiments, the user information comprises failure information and location information. As described above, the user information may be presented to the user via an amber/blue LED.

(92) The apparatus **400** includes a state information adapter **404** configured to convert an electrical signal received at a socket connector pin into state information presentable to a user via the green LED. In certain embodiments, the state information comprises a power state of the expansion card **112** (e.g., M.2 module) and host-initiated I/O activity state of the expansion card **112**.

(93) The apparatus **400** includes a serializer expander **406** configured to multiplex a plurality of digital inputs into a plurality of bits. For example, a first digital input may be a power loss indication signal and a second digital input may be a power loss ACK signal. In various embodiments, the serializer expander **406** may be implemented by a SGPIO expander.

(94) The apparatus **400** includes a power adapter **408** configured to provide signals at different voltages at the edge connector (e.g., edge connector **202**) and socket connector (e.g., socket connector **204**). In such embodiments, the power adapter may be coupled to the user information adapter **402**, the state information adapter **404**, and/or the serializer expander **406**, so as to control signal voltages when adapting signals between the edge connector and socket connector.

(95) Note that the blocks **402-408** represent functional blocks of the apparatus **400** and may include any component or set of components that perform the functionality attributed to the component. This may include one or more physical processors which execute processor-readable instructions, the processor-readable instructions (e.g., as software application or other executable), circuitry, computer hardware, storage media, some combination of software, hardware, and/or firmware, interfaces, adapters, or any other components. The description of the functionality provided by the different components **402**, **404**, **406**, and/or **408** described below is for illustrative purposes, and is not intended to be limiting, as any of components **402**, **404**, **406**, and/or **408** may provide more or less functionality than is described. For example, one or more of components **402**, **404**, **406**, and/or **408** may be eliminated, and some or all of its functionality may be provided by other ones of components **402**, **404**, **406**, and/or **408**. As another example, the apparatus **400** may comprise additional components that may perform some or all of the functionality attributed below to one or more of the components **402**, **404**, **406**, and/or **408**.

(96) FIGS. **5**A-**5**B depict examples of a bridge card, in accordance with aspects of the present disclosure. FIG. **5**A illustrates a first example of a bridge card **500** having an edge connector **502**, a socket connector **504**, a PCB **506**, and a logic adapter **508**. The bridge card **500** may be one embodiment of the bridge card apparatus **110**, the apparatus **200**, and/or the bridge PCB card **302**.

In various embodiments, the bridge card **500** has a physical outline that enables it to fit inside an E1.S enclosure, such as the enclosure **310**.
(97) The edge connector **502** may be one embodiment of the edge connector **202** and/or the edge connector **306**. In various embodiments, the edge connector **502** emulates an E1.S edge connector, e.g., as defined in EDSFF specification. In the depicted embodiment, the edge connector **502** uses the larger 2C version of the EDSFF connector for extra signal pins. As depicted, the edge connector **502** includes two edge fingers, each having a set of signal pins. In each set of signal pins, there is a subset of longer pins which correspond to the ground pins for the edge connector **502**.
(98) The socket connector **504** may be one embodiment of the socket connector **204** and/or the slot connector **308**. In various embodiments, the socket connector **504** is a M.2 connector configured to receive an M.2 module. The socket connector **504** is coupled to the edge connector **502** and to the logic adapter **508**.
(99) The PCB **506** hosts the edge connector **502**, the socket connector **504**, and the logic adapter **508**. The PCB **506** includes signal traces coupling the edge connector **502**, the socket connector, and to the logic adapter **508**. As described herein, the signal blending is performed by the bridge card **500** so that an M.2 module coupled to the bridge card **500** emulates an E1.S module. In some embodiments, the PCB **506** bridges common signaling between the M.2 module and the E1.S host. In some embodiments, the logic adapter **508** creates new E1.S signals towards the E1.S host and/or creates new M.2 signals towards the M.2 module.
(100) FIG. **5**B illustrates a first example of a bridge card **510** having an edge connector **512**, the socket connector **504**, the PCB **506**, and the logic adapter **508**. The bridge card **510** may be one embodiment of the bridge card apparatus **110**, the apparatus **200**, and/or the bridge PCB card **302**. In various embodiments, the bridge card **510** has a physical outline that enables it to fit inside an E1.S enclosure, such as the enclosure **310**.
(101) The edge connector **512** may be one embodiment of the edge connector **202** and/or the edge connector **306**. In various embodiments, the edge connector **502** emulates an E1.S edge connector, e.g., as defined in EDSFF specification. In the depicted embodiment, the edge connector **512** uses the smaller 1C version of the EDSFF connector. As depicted, there is a subset of longer pins which correspond to the ground pins for the edge connector **502**. Because the edge connector **512** has fewer pins as compared to the edge connector **502**, in one embodiment the logic adapter **508** does not convert certain M.2 signals into E1.S signaling.
(102) FIG. **6** depicts an exemplary scenario **600** of signal blending at a bridge card, such as the bridge card **500**, in accordance with aspects of the present disclosure. In the scenario **600**, it is assumed that an edge connector **502** is coupled to an E1.S slot connector of a host system (such as the computing device **101**, an enterprise server, a server in a datacenter, etc.) and the socket connector **504** is coupled to an M.2 module (such as the M.2 module **304**). In one embodiment, the edge connector **502** is a notched connector having a 2C size, and the socket connector **204** is a keyed socket having a Socket 3, Key-M size.
(103) In various embodiments, the logic adapter **508** is configured to transform the first set of signals (e.g., E1.S-specific signaling) into the second set of signals (e.g., M.2-specific signaling) and/or transform the second set of signals into the first set of signals. In certain embodiments, the logic adapter **508** is configured to pass through a set of common signals. The E1.S pinout and signals are defined in EDSFF specification SFF-TA-1009. While not depicted in FIG. **6**, the logic adapter **508** may contain—or be coupled to—a power converter to adapt signal voltages between the edge connector **502** and the socket connector **504**.
(104) The logic adapter **508** includes an LED control logic circuitry **602** connectively coupled to at least one pin of the edge connector **502**. In the depicted embodiment, the LED control logic circuitry **602** is coupled to the A10 pin of the E1.S connector which is used to transmit/receive an LED signal. Additionally, the LED control logic circuitry **602** is connectively coupled to a blue LED **604** and to an amber LED **606**. As mentioned above, in certain embodiments, the blue and

amber LED are discrete components, while in other embodiments these may be a combined function component.

(105) Based on the signal on the A10 pin, the LED control logic circuitry **602** generates a blue LED signal and/or an amber LED signal. The blue LED signal is output to the blue LED **604** and the amber LED signal is output to the amber LED **606**. Note that the A10 signal on the E1.S edge connector is typically routed directly to an E1.S drive. To emulate the E1.S drive, the bridge card **500** includes this LED control logic circuitry **602**.

(106) In some embodiments, the blue LED **604** and the amber LED **606** are used to signal user information, such as failure information and/or location information. In certain embodiments, the LED source control is the backplane, e.g., of the host system. In other embodiments, the LED source control is the emulated E1.S module (e.g., the bridge card **500** coupled to the M.2 module). Note that the functionality of the blue LED **604** and the amber LED signal **606** is host defined and not defined by EDSFF.

(107) The logic adapter **508** includes a wiring addition that connectively couples a pin of the edge connector **502** to a corresponding pin of the socket connector **504**. In the depicted embodiment, the wiring addition couples the B7 pin of the E1.S connector (which is reserved in EDSFF specification for optional device manufacturing purposes) to the 10 pin of the M.2 connector. Additionally, the wiring addition couples these pins to a green LED **608**.

(108) Based on the signal (i.e., LED_1 #signal) on the 10 pin, the green LED **608** is activated or deactivated to state and/or activity information of the solid state storage device (i.e., the M.2 module). In certain embodiments, the green LED **608** is used to signal a power state of the M.2 module and/or a M.2 presence detection state. In some embodiments, the green LED **608** may be used to signal an I/O activity state of the M.2 module. In certain embodiments, the LED activity signal passed to the host system via the B7 pin (which is otherwise unused to conventional E1.S devices).

(109) In some embodiments, blue LED **604**, the amber LED **606**, and/or the green LED **608** may be located on the PCB of the bridge card **500** and are 'light piped' to a front surface of the enclosure box (e.g., the enclosure **114** and/or enclosure **310**) to be viewed by the user from the front of the host system. In one embodiment, the light pipe may be a clear plastic part (e.g., a rigid part). In another embodiment, the light pipe may be a fiber optic cable (e.g., a flexible part). In other embodiments, the blue LED **604**, the amber LED **606**, and/or the green LED **608** may be located on the front surface of the enclosure box, wherein the logic adapter **508** is communicatively coupled to the LEDs **604**, **606**, and/or **608**.

(110) The logic adapter **508** includes a serializer I/O expander—here the SGPIO expander **610**—coupled to an Inter-Integrated Circuit ("I2C") bus for additional sideband control. The serializer I/O expander is used to bridge certain M.2-specific functions where there are no unused signal pins available on the E1.S connector (e.g., the 2C connector). In various embodiments, the SGPIO expander **610** senses and records digital inputs (e.g., from the right side of the expander block). A System Management Bus ("SMBus") controller at the host system reads the SGPIO expander **610** to retrieve digital input bits **612**.

(111) Note that a SGPIO expander is conventionally used for static and/or ad hoc data bit inputs. However, in accordance with aspects of the present disclosure, when the SMBus controller reads the SGPIO expander **610** at a regular rate, this becomes a digital sampling over the serial I2C/SMBus of the digital input bits. In one embodiment, the number of digital input bits can be eight bits. In one example, the Power Loss Indication ("PLN") signal **614** from M.2 pin 8 is sensed and recorded by the SGPIO expander **610**. In another example, the Power Loss ACK ("PLA") signal **616** from M.2 pin 30 is sensed and recorded by the SGPIO expander **610**. In the depicted embodiment, the SGPIO expander **610** is coupled to the E1.S pin A7 and/or pin A8 (which pins are currently used for sideband signaling of SMBus clock ("SMBCLK") and SMBus data ("SMBDATA") signals).

(112) While FIG. **6** depicts the edge connector **502** having a 2C size, in other embodiments the logic adapter **508** may be coupled to a 1C sized edge connector, such as the edge connector **512**. In such embodiments, the SGPIO expander **610** may sense and record additional signal pins to generate additional digital input bits readable by the SMBus controller, as compared to the case of the 2C sized edge connector.
(113) As depicted, the logic adapter **508** may bridge additional signal pins between the M.2 module and the E1.S host. For example, the logic adapter **508** may bridge the E1.S pin B8 with the M.2 pin 44. Here, the logic adapter may adapt a M.2 sideband Alert signal to a SMBus Alert signal on the E1.S pin B8 (which pin is currently reserved for future sideband signaling use). As another example, the logic adapter **508** may bridge the E1.S pin A12 with the M.2 pin 75. Here, the logic adapter may adapt a E1.S sideband Presence signal to a M.2 Install signal on the M.2 pin 75 (which pin is currently used for a host signal ground or GND).
(114) FIG. **7** depicts an exemplary method **700** for collating and selectively presenting communications, in accordance with aspects of the present disclosure. In various embodiments, the method **700** is performed by a bridge card, such as the computing device **101**, the bridge card apparatus **110**, the apparatus **200**, the bridge PCB card **302**, the apparatus **400**, the bridge card **500**, and/or the bridge card **510**, as described above. In some embodiments, all or a portion of the method **700** is performed by a processor, such as a microcontroller, a microprocessor, a Central Processing Unit (“CPU”), a Graphics Processing Unit (“GPU”), an auxiliary processing unit, a FPGA, or the like.
(115) The method **700** begins and engages **702** a computer expansion card with a first socket connector conforming with a first connector type. In some embodiments, the first connector type comprises an E1.S edge connector.
(116) The method **700** includes engaging **704** an edge connector with a second socket connector conforming with a second connector type. In some embodiments, the second connector type comprises an M.2 socket connector.
(117) The method **700** includes transforming **706** a first set of signals associated with the first connector type into a second set of signals associated with the second connector type. In some embodiments, to transform **706** the first set of signals into the second set of signals, the first method includes multiplexing a plurality of digital inputs into a plurality of bits via a SGPIO interface. In certain embodiments, the plurality of digital inputs includes a power loss indication signal and a power loss acknowledgement signal. The method **700** ends.
(118) Embodiments may be practiced in other specific forms. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

Claims

1. An apparatus comprising: an edge connector comprising a plurality of pin fingers, the edge connector conforming with a first connector type; a socket connector configured to receive a computer expansion card conforming with a second connector type; and a printed circuit board (“PCB”) comprising a logic adapter configured to convert a first set of signals associated with the first connector type into a second set of signals associated with the second connector type, wherein the logic adapter comprises a serializer input/output expander configured to multiplex a plurality of digital inputs into a plurality of bits.
2. The apparatus of claim 1, wherein the first connector type comprises an E1.S edge connector, and wherein the second connector type comprises an M.2 socket connector.
3. The apparatus of claim 1, wherein the edge connector has a 2C connector size, and wherein the

edge connector comprises a notch separating a first set of the plurality of pin fingers from a remainder of the plurality of pin fingers.

4. The apparatus of claim 1, wherein a subset of the plurality of pin fingers corresponding to ground pins comprises an extended finger length compared to a remainder of the plurality of pin fingers.

5. The apparatus of claim 1, wherein the PCB supports a first superset of signals via the edge connector and supports a second superset of signals via the socket connector, wherein the first superset of signals comprises the first set of signals and a third set of signals, wherein the second superset of signals comprises the second set of signals and the third set of signals, and wherein the PCB is configured to bridge the third set of signals between the edge connector and the socket connector.

6. The apparatus of claim 1, wherein the PCB comprises an amber light emitting diode ("LED") and a blue LED, and wherein the logic adapter is configured to receive an electrical signal from a particular pin of the edge connector and to convert the electrical signal into user information presentable to a user via the amber LED and the blue LED.

7. The apparatus of claim 1, wherein the PCB comprises a green light emitting diode ("LED"), and wherein the logic adapter is configured to receive an electrical signal from a particular pin of the edge connector, to pass the electrical signal to a corresponding pin of the socket connector, and to convert the electrical signal into user information presentable to a user via the green LED.

8. The apparatus of claim 1, wherein the serializer input/output expander comprises a serial general purpose input/output ("SGPIO") interface.

9. The apparatus of claim 1, wherein the plurality of digital inputs comprises a power loss indication signal and a power loss acknowledgement signal.

10. A system comprising: an enclosure dimensioned to conform to a first form factor; a computer expansion card located within the enclosure; and a bridge card coupled to the computer expansion card and located within the enclosure, the bridge card comprising: an edge connector comprising a plurality of pin fingers, the edge connector conforming with a first connector type; a socket connector configured to receive the computer expansion card, the socket connector conforming with a second connector type; and a printed circuit board ("PCB") comprising a logic adapter configured to convert a first set of signals associated with the first connector type into a second set of signals associated with the second connector type, wherein the logic adapter comprises a serializer input/output expander configured to multiplex a plurality of digital inputs into a plurality of bits.

11. The system of claim 10, wherein the first form factor comprises an E1.S form factor, wherein the first connector type comprises an E1.S edge connector, and wherein the second connector type comprises an M.2 socket connector.

12. The system of claim 10, wherein the edge connector has a 2C connector size, wherein the edge connector comprises a notch separating a first set of the plurality of pin fingers from a remainder of the plurality of pin fingers, and wherein a subset of the plurality of pin fingers corresponding to ground pins comprises an extended finger length compared to the remainder of the plurality of pin fingers.

13. The system of claim 10, wherein the bridge card supports a first superset of signals via the edge connector and supports a second superset of signals via the socket connector, wherein the first superset of signals comprises the first set of signals and a third set of signals, wherein the second superset of signals comprises the second set of signals and the third set of signals, and wherein the PCB is configured to bridge the third set of signals between the edge connector and the socket connector.

14. The system of claim 10, wherein the bridge card comprises an amber light emitting diode ("LED"), a blue LED, and a green LED, wherein the logic adapter is configured to: receive a first electrical signal from a first pin of the edge connector, convert the first electrical signal into user

information presentable to a user via the amber LED and the blue LED, receive a second electrical signal from a second pin of the edge connector, pass the second electrical signal to a corresponding pin of the socket connector, and convert the second electrical signal into state information presentable to the user via the green LED.

15. The system of claim 10, wherein the serializer input/output expander comprises a serial general purpose input/output (“SGPIO”) interface, and wherein the plurality of digital inputs comprises a power loss indication signal and a power loss acknowledgement signal.

16. A method of a bridge card, the method comprising: engaging a computer expansion card with a first socket connector conforming with a first connector type; engaging an edge connector with a second socket connector conforming with a second connector type; and transforming a first set of signals associated with the first connector type into a second set of signals associated with the second connector type, wherein transforming the first set of signals into the second set of signals comprises multiplexing a plurality of digital inputs into a plurality of bits via a serializer input/output expander.

17. The method of claim 16, wherein the serializer input/output expander comprises a serial general purpose input/output (“SGPIO”) interface, wherein the plurality of digital inputs comprises a power loss indication signal and a power loss acknowledgement signal.

18. The method of claim 16, wherein the first connector type comprises an E1.S edge connector, and wherein the second connector type comprises an M.2 socket connector.

19. The method of claim 16, further comprising: supporting a first superset of signals via the first socket connector, wherein the first superset of signals comprises the first set of signals and a third set of signals; supporting a second superset of signals via the second socket connector, wherein the second superset of signals comprises the second set of signals and the third set of signals; and bridging the third set of signals between the first socket connector and the second socket connector.

20. The method of claim 16, wherein the bridge card comprises an amber light emitting diode (“LED”), a blue LED, and a green LED, wherein transforming the first set of signals associated with the first connector type into the second set of signals associated with the second connector type comprises: receiving a first electrical signal from a first pin of the first socket connector; converting the electrical signal into user information presentable to a user via the amber LED and the blue LED; receiving an electrical signal from a second pin of the first socket connector; passing the electrical signal to a corresponding pin of the socket connector, and converting the electrical signal into state information presentable to the user via the green LED.