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[Continued on next page]

- (54) **Title:** INSTALLATION OF MODULAR UNITS IN A COMPUTING DEVICE

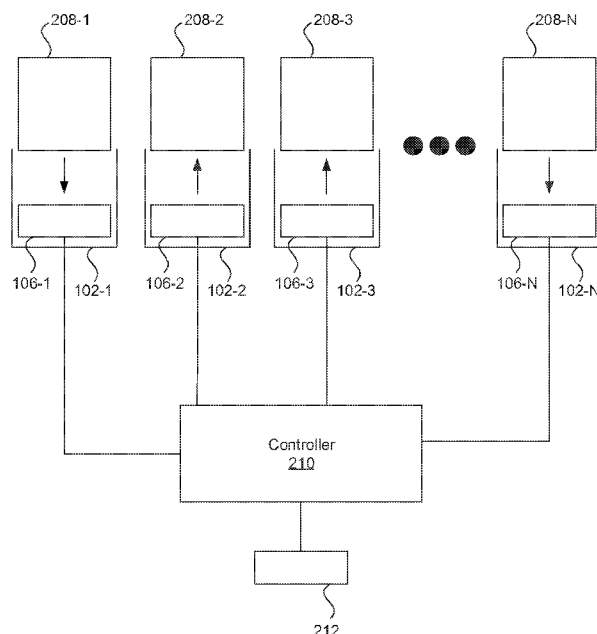


Fig. 2

(57) **Abstract:** In one example in accordance with the present disclosure a system for guiding installation of a modular unit is described. The system includes a computing device having a plurality of slots to receive modular units. An installation device is disposed within each slot. The installation device guides a modular unit into the slot when the slot is to be populated. The installation device also repels a modular unit from the slot when the slot is to remain empty.

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INSTALLATION OF MODULAR UNITS IN A COMPUTING DEVICE

BACKGROUND

[0001] Many organizations, and individuals, rely on servers to carry out various functions. Servers are powerful data processing and data storage devices. For example, data centers include multiple storage racks, each storage rack being able to house multiple servers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] The accompanying drawings illustrate various examples of the principles described herein and are a part of the specification. The illustrated examples are given merely for illustration, and do not limit the scope of the claims.

[0003] Fig. 1 is a top view of a system for guiding installation of a modular unit, according to one example of the principles described herein.

[0004] Fig. 2 is a diagram of slots of the system for guiding installation of a modular unit, according to one example of the principles described herein.

[0005] Fig. 3 is a flow diagram of a method for guiding the installation of a modular unit, according to one example of the principles described herein.

[0006] Figs. 4A and 4B are diagrams illustrating the attraction and repulsion of a modular unit by the system, according to one example of the principles described herein.

[0007] Fig. 5 is a flow diagram of a method for guiding the installation of a modular unit, according to another example of the principles described herein.

[0008] Fig. 6 is a diagram of a controller for guiding installation of a modular unit, according to another example of the principles described herein.

[0009] Throughout the drawings, identical reference numbers designate similar, but not necessarily identical, elements.

DETAILED DESCRIPTION

[0010] Servers have become almost ubiquitous in society. They are used by individuals, small entities, and large entities to manage the storage and processing of large amounts of data. The processing capabilities of servers have also grown, at times at an exponential rate. Servers can receive modular units to process data, store data, or facilitate the functioning of the server. For example, as servers operate, the components, such as central processing units and other components, tend to heat up. With the increased processing capability of servers, the rate of thermal output is increased even more. Accordingly, servers can be populated with fan units that force air through the server to cool the individual components, thus ensuring proper performance of such devices. A single server may have multiple slots within which fan units are installed. In other words, the fan units may be modular in that fan units can be installed based on the characteristics of the servers. Different servers, and different operating configurations of a server lend to different numbers and configuration of fan units. For example, if a server includes one processor, a certain number of slots may be filled with fan units. If a server includes two processors, a greater number of slots may be filled with fan units. Moreover a fan system of a server may be redundant. In a redundant system, a set of secondary, or redundant set of fans, is turned on in the event a primary fan, or series of primary fans, fail.

[0011] While such fan arrays, and modular arrays in general, are helpful in expanding the operating parameters of a server, some characteristics of their use limit their efficacy, and in some cases could lead to damaged server components. For example, referring to a fan unit, a server may come with fan installation rules. Such rules designate a quantity of fan units to install and what

slots said fan units should be inserted into based on the characteristics and configuration of the server. For even a single server, different configurations could lead to different fan population rules. Such rules can be confusing to an end user who is attempting to determine a proper fan installation. While documentation, on screen prompts, and warning messages are employed to guide a user, there is still room for error. Such error may lead to improper placement of fans; with too few fans resulting in improper cooling and potential damage to the server components. Too many fans can lead to excess power consumption.

[0012] Accordingly, the present specification describes the use of installation devices such as electromagnets within a slot to guide the installation of modular units in into slot that is supposed to be populated, and to repel modular units from slots that are supposed to remain empty. The installation device may also include electropermanent magnets (EPMs) to lock an installed modular unit into the slot. More specifically, a controller receives configuration information regarding which slots are to receive modular units and which are not. The configuration information can be based on such information as the number of processors in a server and whether the server implements a redundant or non-redundant modular configuration. Other information may be used as well. For example, the size of the server and the amount of slots available may also dictate which, and how many slots, are to be populated. The controller then generates magnetic fields in each slot to either attract or repel modular units from a particular slot.

[0013] More specifically, the present specification describes a system for guiding installation of a modular unit. The system includes a computing device having a plurality of slots to receive modular units. The system also includes an installation device disposed within each slot. An installation device guides a modular unit into the slot when the slot is to be populated and repels a modular unit from the slot when the slot is to remain empty.

[0014] The present specification also describes a method for guiding installation of a modular unit. According to the method, configuration information for a plurality of slots is received. The plurality of slots are to receive

modular units. An installation device within a slot is then activated to attract a modular unit into the slot when the configuration information indicates the slot is to be populated. An installation device within a slot that is to remain empty is also activated to repel a modular unit from that slot.

[0015] The present specification also describes a non-transitory machine-readable storage medium encoded with instructions for guiding installation of a modular unit. The instructions are executable by a processor to cause the processor to receive configuration information for a plurality of slots within a computing device. The plurality of slots receive modular units and the configuration information indicates a first set of slots that are to be populated by modular units and a second set of slots that are to remain empty. The instructions also are executable by a processor to cause the processor to activate a first set of slots to guide installation of modular units into the first set of slots and to activate the second set of slots to repel installation of modular units from the second set of slots.

[0016] Using installation devices to guide and repel modular units from corresponding slots 1) allows for increased ease of installation of modular units; 2) ensures compliance with configuration information for the server into which the modular units are installed; 3) in the case of fan units, ensures proper cooling of the server; and 4) avoids excess power consumption by improperly installed modular units. However, it is contemplated that the devices disclosed herein may provide useful in addressing other matters and deficiencies in a number of technical areas. Therefore the systems and methods disclosed herein should not be construed as addressing any of the particular matters.

[0017] As used in the present specification and in the appended claims, the term “a number of” or similar language is meant to be understood broadly as any positive number including 1 to infinity; zero not being a number, but the absence of a number.

[0018] In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present systems and methods. It will be apparent, however, to one skilled in the art that the present apparatus, systems, and methods may be practiced without

these specific details. Reference in the specification to “an example” or similar language indicates that a particular feature, structure, or characteristic described in connection with that example is included as described, but may not be included in other examples.

[0019] Turning now to the figures, Fig. 1 is a top view of a system (100) for guiding installation of a modular unit, according to one example of the principles described herein. The system (100) includes a computing device (104). The computing device (104) refers to any device that carries out computational functions. For example, the computing device (104) could be a server in a data center. The computing device (104) includes any number of components for storing data and carrying out operations. More specifically, the computing device (104) may include processors, data storage devices, and other processing elements. In Fig. 1 the spaces for these components is indicated by the various boxes.

[0020] The computing device (104) also includes a plurality of slots (102) to receive modular units. While Fig. 1 depicts 10 slots (102-1, 102-2, 102-3, 102-4, 102-5, 102-6, 102-7, 102-8, 102-9, 102-10) in a particular orientation and location within the computing device (104), the computing device (104) may include any number of slots (102) in any orientation and in any position. Throughout the specification, the presence of an indicator “-*” indicates a specific instance of a component while the lack of the indicator refers to the component in general. For example, a first slot is identified as 102-1 and a general slot is identified as 102.

[0021] Throughout the specification, an example is provided wherein a modular unit is a fan unit, however, other modular units may be implemented as well. Examples of such modular units include modular memory units, modular processing units, etc. Each of the slots (102) can receive, but does not necessarily receive, a modular unit. Which of the slots (102) are to receive a modular unit and which are to remain empty is dictated by configuration information for the computing device (104). The configuration information may be based on various factors. For example, the configuration information may be based on the model of the computing device (104). However, in some cases a

given model of a computing device (104) may have different configurations, i.e., different components, different spacing within the computing device (104), different number of components within the computing device (104), etc.

[0022] Accordingly, the configuration information may indicate which slots (102) are to be populated based on more information than just a model number. Such information includes the number of processors and whether or not a redundant or non-redundant modular system is to be implemented. For example, in the case of the modular unit being a fan unit, a redundant fan system is one where a set of secondary fan units are included in the computing device (104) to cool the components in the event that a primary fan unit is deactivated, or malfunctions. A non-redundant fan system is one where no such secondary fan units are present.

[0023] Another example of a property of a computing device (104) that affects how many slots (102) are filled with modular units is the number of processors. For example, a computing device (104) with more processors implements more fan units to more easily dissipate the greater amounts of heat generated by the multiple processors. A specific numeric example is given as follows. A computing device (104) with one processor in a non-redundant configuration may have a first, second, third, and fourth slot (102-1, 102-2, 102-3, 102-4) that are to be populated with fan units while a fifth, sixth, seventh, eighth, ninth, and tenth slot (102-5, 102-6, 102-7, 102-8, 102-9, 102-10) are to remain empty. By comparison, this same one-processor computing device (104), when having a redundant fan system, may have a first through ninth slot (102-1, 102-2, 102-3, 102-4, 102-5, 102-6, 102-7, 102-8, 102-9) to receive fan units and the tenth slot to remain empty (102-10).

[0024] As yet another example, in a two-processor non-redundant configuration, the first through fifth slots (102-1, 102-2, 102-3, 102-4, 102-5) may be set to receive fan units while the sixth through tenth slots (102-6, 102-7, 102-8, 102-9, 102-10) are to remain empty. This same two-processor computing device (104), with a redundant configuration, may have all slots (102-1, 102-2, 102-3, 102-4, 102-5, 102-6, 102-7, 102-8, 102-9, 102-10) to receive fan units.

[0025] Within each slot (102) is an installation device (106). An installation device (106) is a component that facilitates the installation of a modular unit within each slot (102). Specifically, an installation device (106) can guide a modular unit into a slot (102) that is to be populated and can repel a modular unit from a slot (102) that is to remain empty. The installation devices (106) can do this by generating magnetic fields of different polarities. For example, the installation devices (106) may include magnetic devices that generate a magnetic field having a particular polarity to attract a fan unit to a slot (102) and that generate a different magnetic field, for example having an opposite polarity, to repel a fan unit from a slot (102). Accordingly, the installation devices (106) may include electromagnetic devices to guide or repel the installation of a modular unit. Electromagnets, like regular magnets will repel one another when equal polarity portions are facing one another, and opposite polarity portions will attract. Unlike a regular magnet, an electromagnet can have its polarity changed. Unlike an EPM, an electromagnet is dormant when there is no electric charge present. The polarity of an electromagnet is set depending upon the direction of current through the electromagnet.

[0026] The installation devices (106) may also include a component to lock, or retain, a modular unit in a slot (102). Such a component may also be an electromagnetic device, and more specifically an electropermanent magnetic (EPM) devices. An EPM is a type of magnet that includes an electromagnet and a permanent magnet. The electromagnet generates a magnetic field which changes the magnetization of the permanent magnet. Even after the electromagnet has been deactivated, the permanent magnet of the EPM retains the last magnetic polarity. An EPM is therefore a magnet with variable magnetization, and that maintains the magnetic field after activating force has dissipated.

[0027] The magnetic field of the electromagnet and the EPM can be changed by an electrical pulse. For example, a voltage pulse of one polarity can set the magnetic polarity of the EPM to one value, i.e., to lock a modular unit and a voltage pulse of another value or another polarity can set the magnetic polarity of the EPM to a second value, i.e., to unlock a modular unit.

[0028] An EPM can have many forms. In one example, the EPM includes two magnetic materials capped by a magnetically soft material. A pulse of one polarity magnetizes the two interior materials together increasing the external magnetic flux. A pulse of the opposite polarity reverses the polarity of one of the materials, thus diverting the magnetic flux internal to the device and reducing the external magnetic field. While specific reference is made to one type of EPM, any form of EPM could be implemented in accordance with the principles described herein.

[0029] To summarize, the installation devices (106) in one configuration generate a magnetic field that attracts a modular unit such as a fan unit and in another configuration generate an external magnetic field that repels a modular unit such as a fan unit. As a user attempts to install a modular unit into a slot (102) that is intended to receive a modular unit, the magnetic field of the corresponding installation device (106) is such that the modular unit is drawn into the slot via the magnetic attraction, thus simplifying installation. By comparison, as a user attempts to install a modular unit into a slot (102) that is intended to remain empty, the magnetic field of the corresponding installation device (106) is such that the modular unit is repelled from the slot via the magnetic repulsion. Doing so ensures that modular units are properly installed in accordance with the configuration and type of computing device (104). The installation device (106) also locks an installed modular unit into place. The installation devices (106) also reduce the likelihood of improper installation and the resulting undesirable consequences due to user error. While Fig. 1 depicts a top view of the computing device (104) such that the modular units are installed from the top, the slots (102) may be organized to facilitate installation of modular units in any direction.

[0030] Fig. 2 is a diagram of slots (102) of the system (Fig. 1, 100) for guiding installation of a modular unit (208), according to one example of the principles described herein. As described above, the system (Fig. 1, 100) includes any number of slots (102) and corresponding installation devices (106). Accordingly, in some examples the system (Fig. 1, 100) also includes a plurality of modular units (208) that correspond with the plurality of slots (102). As

described above, in one example, the modular units (208) are fan units that cool the internal components of the computing device (Fig. 1, 104) thus ensuring their longevity and proper functioning.

[0031] As described above, the installation devices (106) may include electromagnets that can switch their magnetic field to either attract or repel modular units (208) in accordance with configuration information for the specific configuration of a computing device (Fig. 1, 104). An electropermanent magnet (EPM) within the slot can then lock modular units (208) into place. Accordingly, the system (Fig. 1, 100) includes a controller (210) that receives the configuration information and controls the different electromagnets and EPMs accordingly. For example, the population rules, i.e., the information indicating which of the slots (102) are to be populated may be included in a field-programmable gate array code. The controller (210) then sends control signals to each of the electromagnets to either generate an attracting magnetic field or a repelling magnetic field and the EPMs to retain an attracting magnetic field.

[0032] In one example, an EPM locks to a metal plate of a modular unit (208) when a high voltage pulse is sent to the EPM, and the EPM unlocks from the metal plate of a modular unit (208) when a low voltage pulse is sent to the EPM. The controller (210), which can include a field-programmable gate array (FPGA), sends these signals to the EPMs. The population rules by which the control signals are defined, are written into an FPGA's internal code. In a hardware-sense, the FPGA may have access to many of the server system's settings and rules for modular unit (208) configuration are written into the FPGA, which rules the controller (210), follows to send lock/unlock signals to each EPM.

[0033] More specifically, an FPGA of the controller (210) may be a chip with many input and output pins. Signals are routed to the input pins, which are consequently passed to output pins. The FPGA is programmable to determine how input signals to input pins are read and what to output based on the rules programmed into the FPGA. In this example, the controller (210) controls attract/repel signals sent to the electromagnets, and lock/unlock signals sent to the EPMs.

[0034] A specific example is given as follows. In this example, the configuration information may indicate that a first slot (102-1) and an n-th slot (102-N) are to be populated and that a second slot (102-2) and a third slot (102-3) are to remain empty. Accordingly, the controller (210) may generate a control signal which instructs the first installation device (106-1) and n-th installation device (106-N) to generate a magnetic field that attracts a first modular unit (208-1) and an n-th modular unit (208-N) into the corresponding slots (102-1, 102-N). The controller (210) also generates a control signal which instructs EPMs of the first installation device (106-1) and the n-th installation device (106-N) to generate magnetic fields that lock the first modular unit (208-1) and the n-th modular unit (208-N) into the corresponding slots (102-1, 102-N).

[0035] Still further, the controller (210) may generate a control signal which instructs the second installation device (106-2) and third installation device (106-3) to generate a magnetic field that repels a second modular unit (208-2) and a third modular unit (208-3) from the corresponding slots (102-2, 102-3). In other words, the generated magnetic fields will either assist in positioning a modular unit (208) inside a particular slot (102) by attracting the modular unit (208) or will exert a force that opposes insertion of the modular unit (208) into the slot (102).

[0036] As described above such a system (Fig. 1, 100) ensures the correct installation of modular units (208) into a computing device (Fig. 1, 104) such as a server. To further ensure proper installation, the system (Fig. 1, 100) may also include an indicator (212) to verify that the modular units (208) have been installed correctly. For example, a light-emitting diode may correspond to each slot (102) such that proper installation of a fan unit (208) in that slot (102) is detected, for example, by emitting light of a certain color. In another example, a light-emitting diode on the computing device (Fig. 1, 104) may indicate that the configuration of all slots (102) i.e., the orientation and number of populated/empty slots (102), is in accord with the configuration information. In other words, the indication of correct/incorrect modular unit (208) installation may be device-specific or slot-specific. The installation devices (106) described herein may ensure proper unit placement as well as preventing excess power

consumption. For example, as a data center may include multiple computing devices (Fig. 1, 104) each potentially with different modular unit population rules, without the system (Fig. 1, 100) described herein, a user may need to be familiar with multiple document instructions, or more difficult still, may need to memorize multiple modular unit (208) population rules. A task which can be daunting. Accordingly, the system (Fig. 1, 100) described herein facilitates easy and correct installation of modular units (208) in any number of computing devices (Fig. 1, 104), thus alleviating the complex operation of determining population rules and compliance therewith.

[0037] Fig. 3 is a flow diagram of a method (300) for guiding the installation of a modular unit (Fig. 2, 208), according to one example of the principles described herein. According to the method (300), configuration information is received (block 301). The configuration information is for a plurality of slots (Fig. 1, 102) that are to receive modular units (Fig. 2, 208) such as fan units. Specifically, the configuration information indicates a first set of slots (Fig. 1, 102) that are to be populated with modular units (Fig. 2, 208) and also indicates a second set of slots (Fig. 1, 102) that are to remain empty. Which, and how many, slots (Fig. 1, 102) are included in the first set is dependent upon a number of factors. For example, the configuration information may indicate a number of processors within the computing device (Fig. 1, 104) and whether the modular units (Fig. 2, 208) should be installed according to a redundant configuration or as a non-redundant configuration. This configuration information is available in a system BIOS and available to the controller (Fig. 2, 210).

[0038] Based on the configuration information, an installation device (Fig. 1, 106) within a slot (Fig. 1, 102) that is to be populated with a modular unit (Fig. 2, 208) attracts (block 302) a corresponding modular unit (Fig. 2, 208) into the corresponding slot (Fig. 1, 102). Following the specific example provided in Fig. 2, in this operation, the controller (Fig. 2, 210) would instruct the electromagnets of the first installation device (Fig. 1, 106-1) and the n-th installation device (Fig. 1, 106-N) to generate magnetic fields that attract the corresponding modular units (Fig. 2, 208-1, 208-N) into the slots (Fig. 1, 102-1, 102-N).

[0039] Similarly based on the configuration information, an installation device (Fig. 1, 106) within a slot (Fig. 1, 102) that is to remain empty repels (block 303) any modular unit (Fig. 2, 208) that a user may attempt to insert into the corresponding slot (Fig. 1, 102). Following the specific example provided in Fig. 2, in this operation, the controller (Fig. 2, 210) would instruct the electromagnets of the second installation device (Fig. 1, 106-2) and the third installation device (Fig. 1, 106-3) to generate magnetic fields that repel the corresponding modular units (Fig. 2, 208-2, 208-3) from entry into the slots (Fig. 1, 102-2, 102-3). The control signals sent that activate installation devices (Fig. 1, 106) to attract or repel modular units (Fig. 2, 208) may be current pulses of different values or polarities. For example, a first current pulse of a first polarity may cause an electromagnet to generate a magnetic field with the north and south pole oriented in a particular fashion, which orientation is the same as a magnetic device placed on the modular unit (Fig. 2, 208) so as to attract the modular unit (Fig. 2, 208) into the slot (Fig. 1, 102). By comparison, a second current pulse of a second polarity may cause the electromagnet to generate a magnetic field with the north and south pole flipped from the first orientation. This flipped orientation is therefore opposite of the magnetic device on the modular unit (Fig. 2, 208) so as to exert a repulsive force to a modular unit (Fig. 2, 208) that a user attempts to insert into the slot (Fig. 1, 102).

[0040] In this fashion, a user is prevented from inserting modular units (Fig. 2, 208) into slots (Fig. 1, 102) that are intended to remain empty as defined by configuration information for the computing device (Fig. 1, 104) by physically preventing installation via a repulsive magnetic force. Similarly, easy installation of a modular unit (Fig. 2, 208) into a particular slot (Fig. 1, 102) is effectuated by magnetically attracting a modular unit (Fig. 2, 208) into a slot (Fig. 1, 102) to be populated during use. Thus the likelihood that user error could result in over-consumption of power or under-cooling of the computing device (Fig. 1, 104) is reduced.

[0041] Figs. 4A and 4B are diagrams illustrating the attraction and repulsion of a modular unit (208-1, 208-2) by the system (Fig. 1, 100), according to one example of the principles described herein. Specifically, Fig. 4A depicts

a first modular unit (208-1) being attracted by a first electromagnet (415-1) and locked into place by a first EPM (414-1) and a second modular unit (208-2) being repelled by a second electromagnet (415-2). In this example, the second EPM (414-2) is not used as there is no locking operation performed when a modular unit (208-2) is repelled. Fig. 4B indicates the respective magnetic fields generated in each case.

[0042] In some examples, each modular unit (208) includes a magnetic device to assist in installation and locking of that modular unit (208) into a slot (Fig. 1, 102). Specifically, a magnetic device of a modular unit (208) includes a magnet (417-1, 417-2) having a fixed polarity that mates with the respective electromagnetic devices (415-1, 415-2) within a slot (Fig. 1, 102). While the electromagnets (415) change their magnetization, the magnets (417) on the surfaces of the modular units (208) may be fixed-polarity magnets (417). While Fig. 4B depicts a particular polarization of the magnets (417-1, 417-2) any polarization may be exhibited in the magnets (417) of the modular units (208).

[0043] As described above, a controller (Fig. 2, 210) sends a control signal (418) to establish a certain magnetic field on the installation devices (Fig. 1, 106). For example, the controller (Fig. 2, 210) may send a first control signal (418-1) to the first electromagnet (415-1) setting the polarity of a surface of the electromagnet (415-1) that mates with the first magnet (417-1) to a polarity opposite the first magnet (417-1). Accordingly, the first magnet (417-1) is magnetically attracted to the first electromagnet (415-1) as indicated by the arrow (420-1).

[0044] In repelling a modular unit (208-2), the controller (Fig. 2, 210) may send a second control signal (418-2) to the second electromagnet (415-2) setting the polarity of a surface of the second electromagnet (415-2) that mates with the second magnet (417-2) to a same polarity as the second magnet (417-2) mating surface. Accordingly, the second magnet (417-2) is magnetically repulsed from the second electromagnet (415-2) as indicated by the arrow (420-2).

[0045] In the case where an installation device (Fig. 1, 106) is to retain an installed modular unit (208), an electropermanent magnet (414) within the

corresponding slot (Fig. 1, 102) may generate a magnetic field to retain the modular unit (208). For example, as described above an electropermanent magnet (EPM) (414) may be a magnetic device that includes an electromagnetic portion to switch a polarity of a permanent portion of the EPM. Accordingly, even after the activation energy has been turned off, the EPM retains a magnetic field designated by that activation energy.

[0046] Returning to Figs 4A and 4B, as the first module (208-1) is to be retained within a slot (Fig. 1, 102), the first EPM (414-1) may be set to the polarity defined in Fig. 4B. This may be done by passing a control signal to set the first EPM (414-1) to a polarity corresponding to the first electromagnet (415-1). To ensure retention, the modules (208) include plates (416-1, 416-2) that interact with the EPMs (414) to retain the modules (208) in place. Put another way, a magnetic field generated between the first EPM (414-1) and the first metal plate (416-1) may be attractive.

[0047] By comparison, in Figs 4A and 4B, the second module (208-2) is to be repelled from a slot (Fig. 1, 102). Accordingly, as there is no locking operation, the second EPM (414-2) may be set to the polarity defined in Fig. 4B. This may be done by passing a control signal to set the second EPM (414-2) to a polarity corresponding to the second electromagnet (415-2).

[0048] Fig. 5 is a flow diagram of a method (500) for guiding the installation of a modular unit (Fig. 2, 208), according to another example of the principles described herein. According to the method (500), configuration information for a plurality of slots (Fig. 1, 102) is received (block 501). This may be performed as described above in connection with Fig. 3.

[0049] An attractive magnetic field is generated (block 502) between some electromagnets (Fig. 4, 415) and some magnets (Fig. 4, 417) on some modular units (Fig. 2, 208) to attract the modular units (Fig. 2, 208). Specifically, a control signal (Fig. 4, 418) of a certain polarity is used to activate an electromagnet (Fig. 4, 415) to a desired polarity. If a slot (Fig. 1, 102) is to be populated with a modular unit (Fig. 2, 208), the control signal (Fig. 4, 418) may switch the polarity of the electromagnet (Fig. 4, 415) such that a mating surface of the electromagnet (Fig. 4, 415) has an opposite polarity of a mating

surface of the magnet (Fig. 4, 417) on the modular unit (Fig. 2, 208) such that the two are attracted to one another.

[0050] Similarly, a repulsive magnetic field is generated (block 503) between other electromagnets (Fig. 4, 415) and other magnets (Fig. 4, 417) on other modular units (Fig. 2, 208) to repel those other modular units (Fig. 2, 208). Specifically, a control signal (Fig. 4, 418) of a certain polarity is used to activate an electromagnet (Fig. 4, 415) to a desired polarity. If a slot (Fig. 1, 102) is to remain empty, the control signal (Fig. 4, 418) may switch the polarity of the electromagnet (Fig. 4, 415) such that a mating surface of the electromagnet (Fig. 4, 415) has the same polarity as a mating surface of the magnet (Fig. 4, 417) on the modular unit (Fig. 2, 208) such that the two are repelled from one another.

[0051] Modular units (Fig. 2, 208) that are properly installed in slots (Fig. 1, 102) that are to be populated are then locked (504) into those slots (Fig. 1, 102). Specifically, as described above, EPMs (Fig. 4, 414) found within slots (Fig. 1, 102) that are to be populated are set to a particular polarity such that a corresponding metal plate (Fig. 4, 416) of a corresponding modular unit (Fig. 2, 208) is attracted to the EPM (Fig. 4, 414). As it is an electropermanent magnet (Fig. 4, 414), the magnetic field, and therefore the modular unit (Fig. 2, 208) is maintained even after a control signal is removed.

[0052] It is then determined (block 505) if the installation of the modular units (Fig. 2, 208) is in accordance with the configuration information. In this example, the controller (Fig. 2, 210) may include a lookup table or other data indicating what the modular unit (Fig. 2, 208) configuration should be, and compares actual data indicating an installed modular unit (Fig. 2, 208) configuration with the lookup table or other data to ensure they are the same. If they are not the same (block 505, determination NO), the controller (Fig. 2, 210) can take appropriate action such as adjusting the external magnetic fields of the corresponding electromagnets (Fig. 4, 415) or outputting a message or indicator suggesting user action be taken. For example an output message such as an on-screen prompt on a display device coupled to the computing device (Fig. 1, 104), or an output indicator such as a powered light-emitting diode may indicate

to the user that the modular units (Fig. 2, 208) have not been installed as anticipated by the configuration information. In some examples, a single indicator, for example a single LED may illuminate when all modular units (Fig. 2, 208) have been installed properly. By comparison, in some examples an indication may be made per slot (Fig. 1, 102), thus indicating which slot (Fig. 1, 102), if any, has been improperly populated with a modular unit (Fig. 2, 208), or still lacks a modular unit (Fig. 2, 208) to be installed in that slot (Fig. 1, 102).

[0053] If it is determined that the modular unit (Fig. 2, 208) installation matches the configuration information (block 505, determination YES), an output message, or other indicator such as an LED of a particular color indicates proper installation of the modular units (Fig. 2, 208). The method (500) described herein allows for easy installation of modular units (Fig. 2, 208) as suggested by configuration information thus ensuring adequate cooling, desired power consumption, all while requiring less effort by the user as the modular units (Fig. 2, 208) can either physically be prevented from being installed via the repulsive or can be physically guided during installation via the attractive magnetic force.

[0054] Fig. 6 is a diagram of a controller (210) for guiding installation of a modular unit (Fig. 2, 208), according to another example of the principles described herein. The controller (210) includes a processor (622) and a machine-readable storage medium (624). Although the following descriptions refer to a single processor (622) and a single machine-readable storage medium (624), the descriptions may also apply to a controller (210) with multiple processors and multiple machine-readable storage mediums. In such examples, the instructions may be distributed (e.g., stored) across multiple machine-readable storage mediums and the instructions may be distributed (e.g., executed by) across multiple processors.

[0055] The processor (622) may include at least one processor and other resources used to process programmed instructions. For example, the processor (622) may be a number of central processing units (CPUs), microprocessors, and/or other hardware devices suitable for retrieval and execution of instructions stored in machine-readable storage medium (624). In the controller (210) depicted in Fig. 6, the processor (622) may fetch, decode, and

execute instructions (626, 628, 630) to guide installation of a modular unit (Fig. 2, 208). As an alternative or in addition to retrieving and executing instructions, the processor (622) may include a number of electronic circuits comprising a number of electronic components for performing the functionality of a number of the instructions in the machine-readable storage medium (624). With respect to the executable instruction representations (e.g., boxes) described and shown herein, it should be understood that part or all of the executable instructions and/or electronic circuits included within one box may, in alternate examples, be included in a different box shown in the figures or in a different box not shown.

[0056] The machine-readable storage medium (624) represent generally any memory capable of storing data such as programmed instructions or data structures used by the controller (210). The machine-readable storage medium (624) includes a machine readable storage medium that contains machine readable program code to cause tasks to be executed by the processor (622). The machine-readable storage medium (624) may be tangible and/or non-transitory storage medium. The machine-readable storage medium (624) may be any appropriate storage medium that is not a transmission storage medium. For example, the machine-readable storage medium (624) may be any electronic, magnetic, optical, or other physical storage device that stores executable instructions. Thus, machine-readable storage medium (624) may be, for example, Random Access Memory (RAM), an Electrically-Erasable Programmable Read-Only Memory (EEPROM), a storage drive, an optical disc, and the like. The machine-readable storage medium (624) may be disposed within the controller (210), as shown in Fig. 6. In this situation, the executable instructions may be “installed” on the controller (210). Alternatively, the machine-readable storage medium (624) may be a portable, external or remote storage medium, for example, that allows the controller (210) to download the instructions from the portable/external/remote storage medium. In this situation, the executable instructions may be part of an “installation package”. As described herein, the machine-readable storage medium (624) may be encoded with executable instructions for dual-power reception.

[0057] Referring to Fig. 6, configuration information instructions (626), when executed by a processor (622), may cause the controller (210) to receive configuration information and process the information such that associated electromagnets (Fig. 4, 415) and EPMs (Fig. 4, 414) may be turned on or turned off. Attraction field generation instructions (628), when executed by a processor (622), may cause the controller (210) to activate a first set of installation devices (Fig. 1, 106) to generate an attraction magnetic field to guide installation of modular units (Fig. 2, 208) into the corresponding slots (Fig. 1, 102). Repulsion field generation instructions (630), when executed by a processor (622), may cause the controller (210) to activate a second set of installation devices (Fig. 1, 106) to repel installation of modular units (Fig. 2, 208) into the corresponding slots (Fig. 1, 102).

[0058] In some examples, the processor (622) and machine-readable storage medium (624) are located within the same physical component, such as a server, or a network component. The machine-readable storage medium (624) may be part of the physical component's main memory, caches, registers, non-volatile memory, or elsewhere in the physical component's memory hierarchy. Alternatively, the machine-readable storage medium (624) may be in communication with the processor (622) over a network. Thus, the controller (210) may be implemented on a user device, on a server, on a collection of servers, or combinations thereof.

[0059] The controller (210) of Fig. 6 may be part of a general purpose computer. However, in alternative examples, the controller (210) is part of an application specific integrated circuit

[0060] Aspects of the present system and method are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to examples of the principles described herein. Each block of the flowchart illustrations and block diagrams, and combinations of blocks in the flowchart illustrations and block diagrams, may be implemented by computer usable program code. The computer usable program code 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 machine-readable program code, when executed via, for example, the processor (622) of the computing system or other programmable data processing apparatus, implement the functions or acts specified in the flowchart and/or block diagram block or blocks. In one example, the computer usable program code may be embodied within a computer readable storage medium; the computer readable storage medium being part of the computer program product. In one example, the computer readable storage medium is a non-transitory computer readable medium.

[0061] Using installation devices to guide and repel modular units (Fig. 2, 208) such as fan units from corresponding slots (Fig. 1, 102) 1) allows for increased ease of installation of modular units (Fig. 2, 208); 2) ensures compliance with configuration information for the server into which the modular units (Fig. 2, 208) are installed; 3) ensure proper cooling of the server; 4) avoid excess power consumption by improperly installed modular units (Fig. 2, 208). However, it is contemplated that the devices disclosed herein may provide useful in addressing other matters and deficiencies in a number of technical areas. Therefore the systems and methods disclosed herein should not be construed as addressing any of the particular matters.

[0062] The preceding description has been presented to illustrate and describe examples of the principles described. This description is not intended to be exhaustive or to limit these principles to any precise form disclosed. Many modifications and variations are possible in light of the above teaching.

CLAIMS

WHAT IS CLAIMED IS:

1. A system for guiding installation of a modular unit comprising:
a computing device having a plurality of slots to receive modular units;
and
an installation device disposed within each slot to:
guide a modular unit into the slot when the slot is to be populated; and
repel a modular unit from the slot when the slot is to remain empty.
2. The system of claim 1, wherein the modular unit is a fan unit to cool components within the computing device.
3. The system of claim 1, wherein the installation device is a magnetic device that:
generates a first magnetic field to attract a modular unit when the slot is to be populated; and
generates a second magnetic field to repel a modular unit when the slot is to remain empty.
4. The system of claim 3, wherein the magnetic device comprises an electromagnetic device.
5. The system of claim 4, wherein the system further comprises a plurality of modular units to be disposed within the plurality of slots, a modular unit comprising a magnet to interact with the electromagnetic device in the slot.

6. The system of claim 1, wherein the installation device comprises an electropermanent magnetic device to lock an installed modular unit into a corresponding slot.
7. The system of claim 1, further comprising an indicator to indicate that multiple modular units have been installed in accordance with configuration information for the plurality of slots.
8. A method for guiding installation of a modular unit comprising:
 - receiving configuration information for a plurality of slots within a computing device, the plurality of slots to receive modular units;
 - attracting, with an installation device within a slot to be populated, a modular unit into the slot when the configuration information indicates the slot is to be populated; and
 - repelling, with an installation device within a slot to remain empty, a modular unit from the slot when the configuration information indicates the slot is to remain empty.
9. The method of claim 8, wherein the configuration information identifies at least one of:
 - a number of processors within the computing device; and
 - whether the modular units should be installed as a redundant configuration or a non-redundant configuration.
10. The method of claim 8, wherein:
 - attracting modular units into slots comprises generating a magnetic field with an electromagnetic device that attracts the modular units into the slots to be populated; and
 - repelling modular units into slots comprises generating a magnetic field with an electromagnetic device that repels the modular units from slots to remain empty.

11. The method of claim 8, further comprising generating an output indicating that a plurality of modular units have been installed in accordance with the received configuration information.

12. The method of claim 11, further comprising locking modular units into slots that are to be populated by generating a magnetic field with an electropermanent magnetic device.

13. A non-transitory machine-readable storage medium encoded with instructions for guiding installation of a modular unit, the instructions executable by a processor to cause the processor to:

receive configuration information for a plurality of slots within a computing device, wherein:

a slot receives a modular unit; and

the configuration information indicates a first set of slots that are to be populated by modular units and a second set of slots that are to remain empty;

activate the first set of slots to guide installation of modular units into the first set of slots; and

activate the second set of slots to repel installation of modular units into the second set of slots.

14. The storage medium of claim 13, further comprising instructions executable by a processor to cause the processor to indicate that a plurality of modular units have been installed correctly.

15. The storage medium of claim 14, wherein the indication is per modular unit.

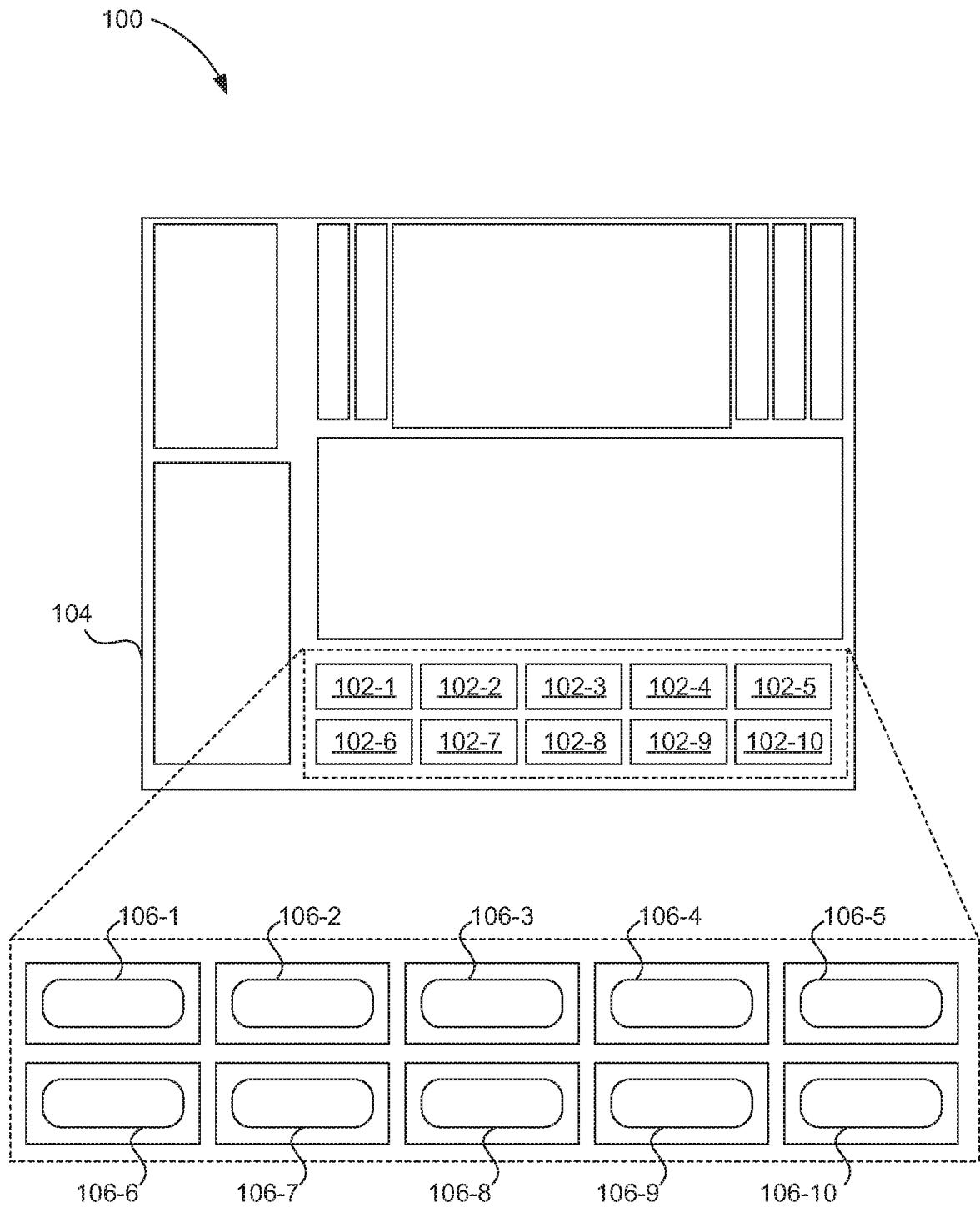
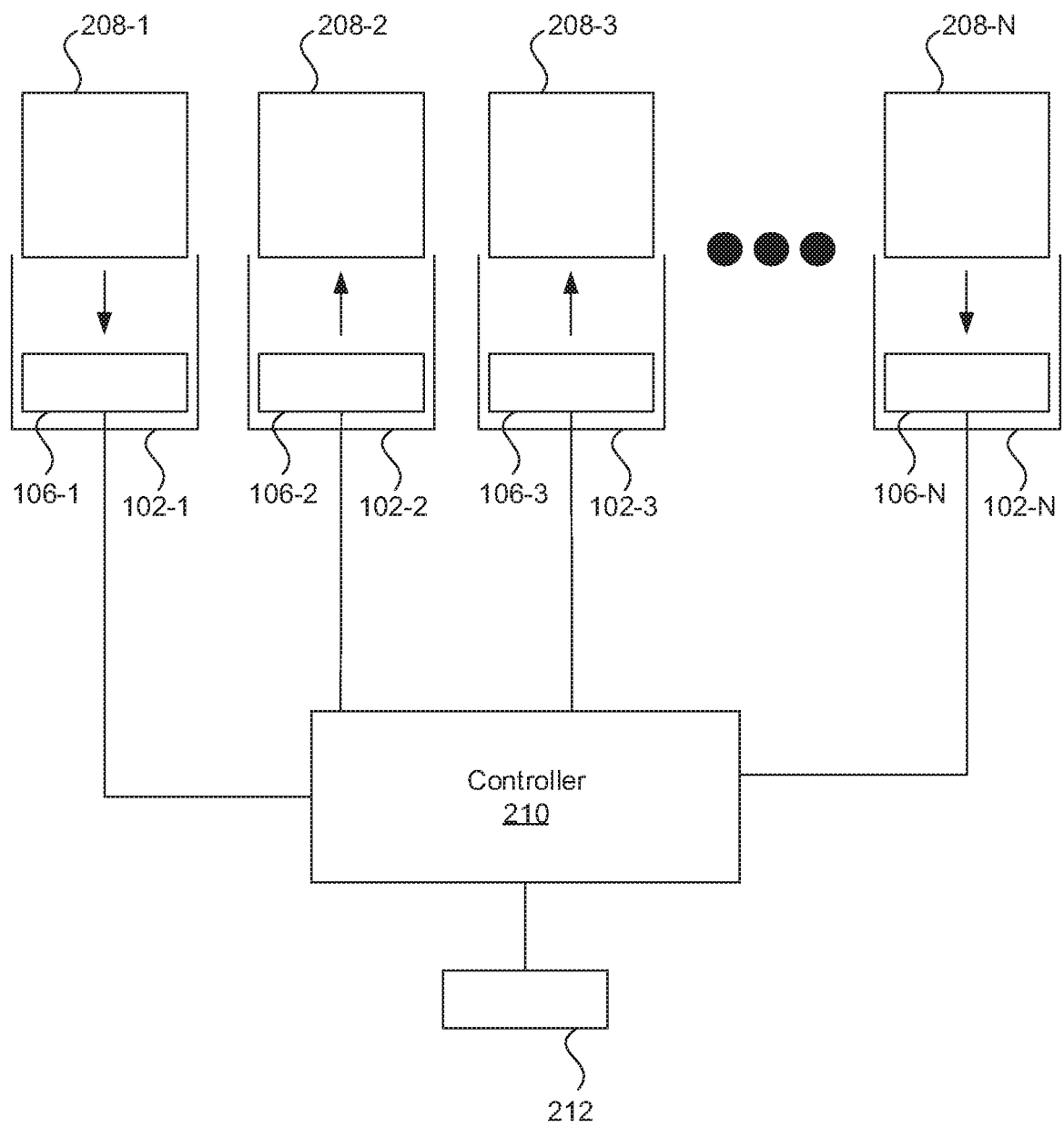
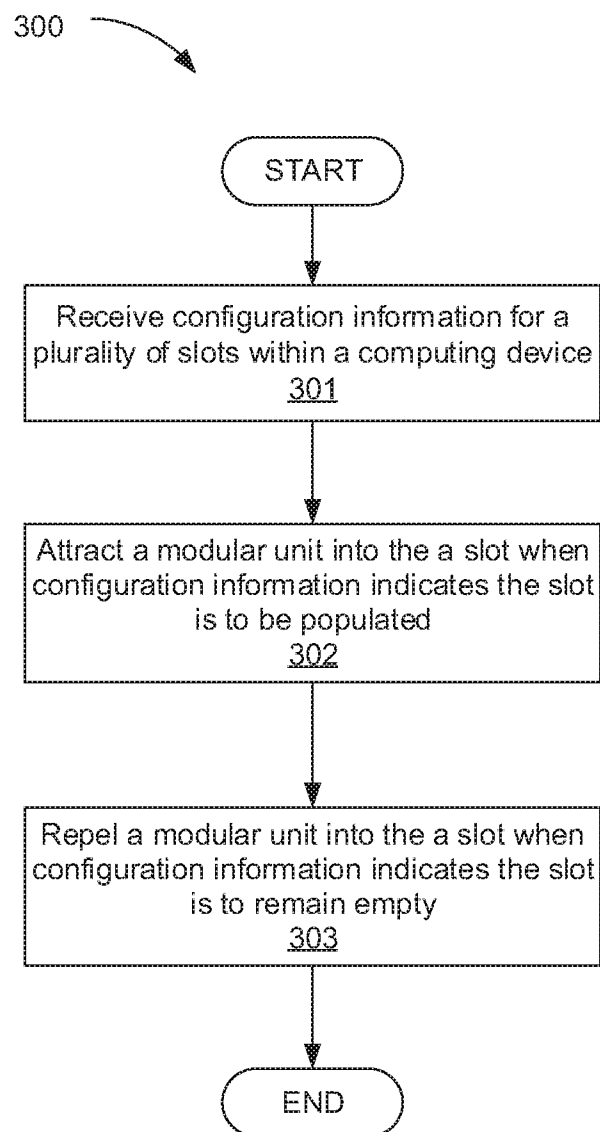


Fig. 1

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**Fig. 2**

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**Fig. 3**

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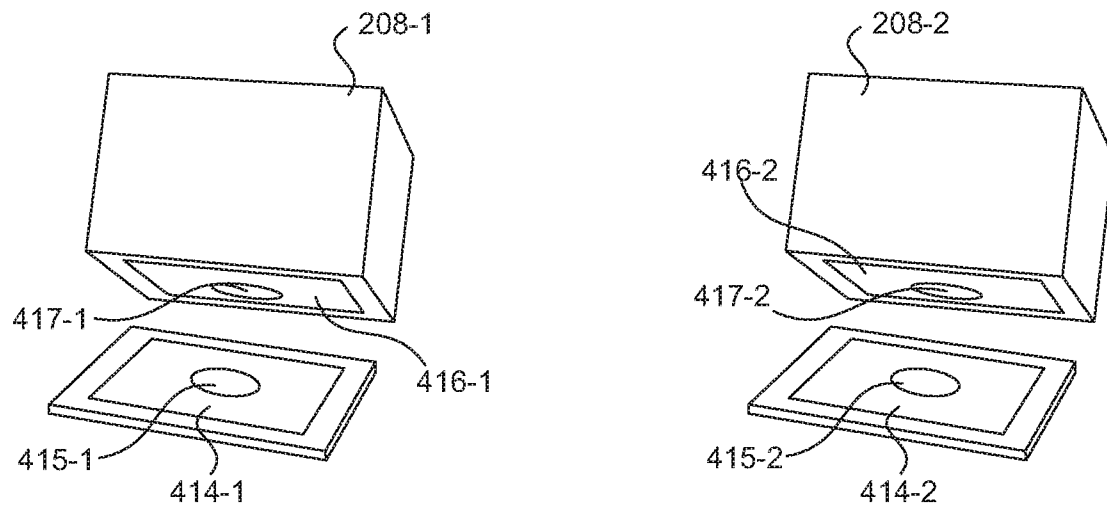


Fig. 4A

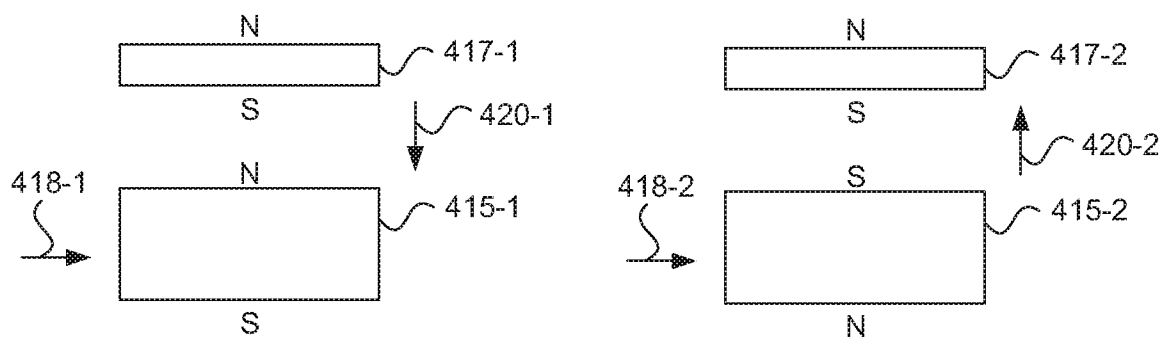
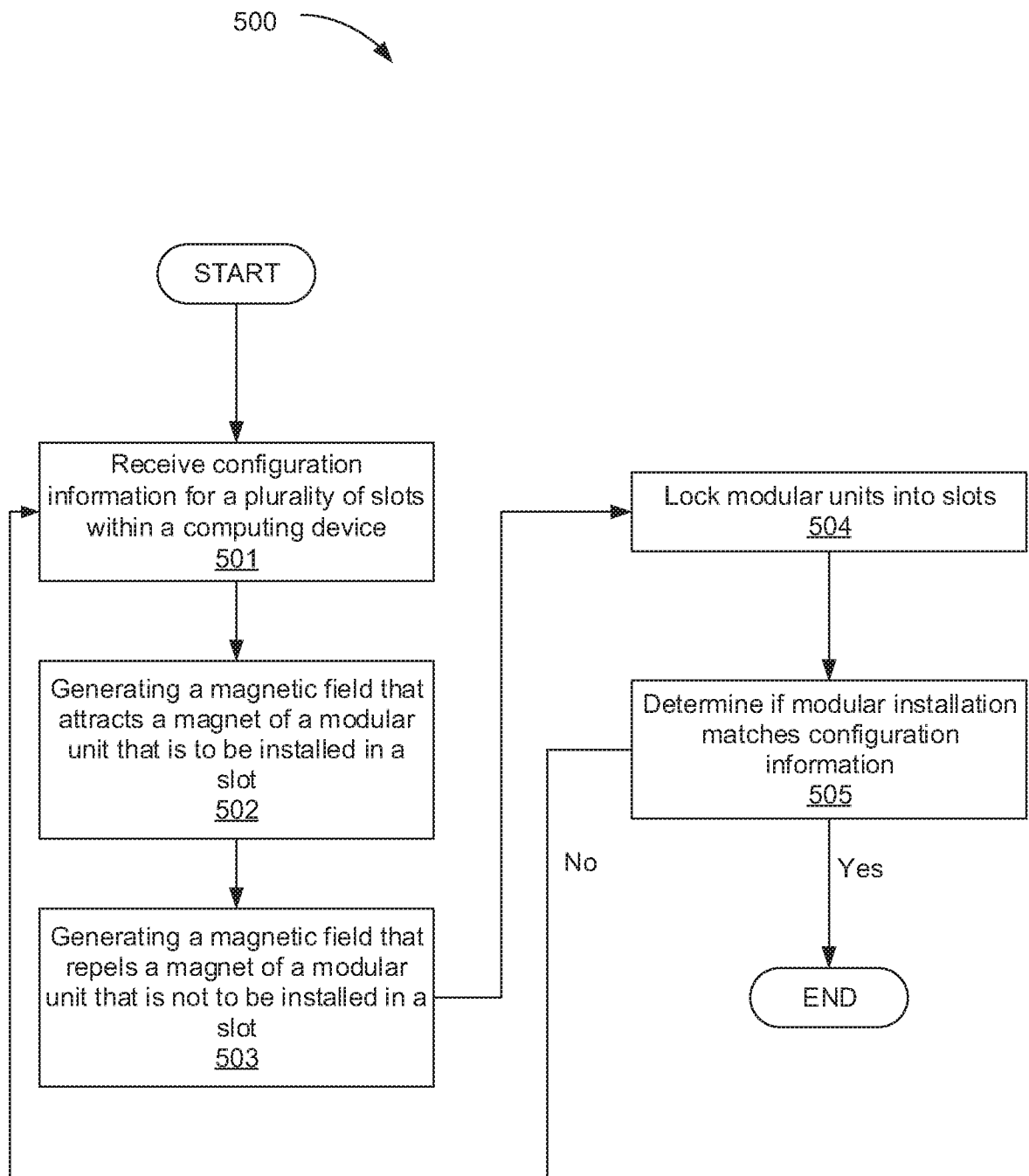


Fig. 4B

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**Fig. 5**

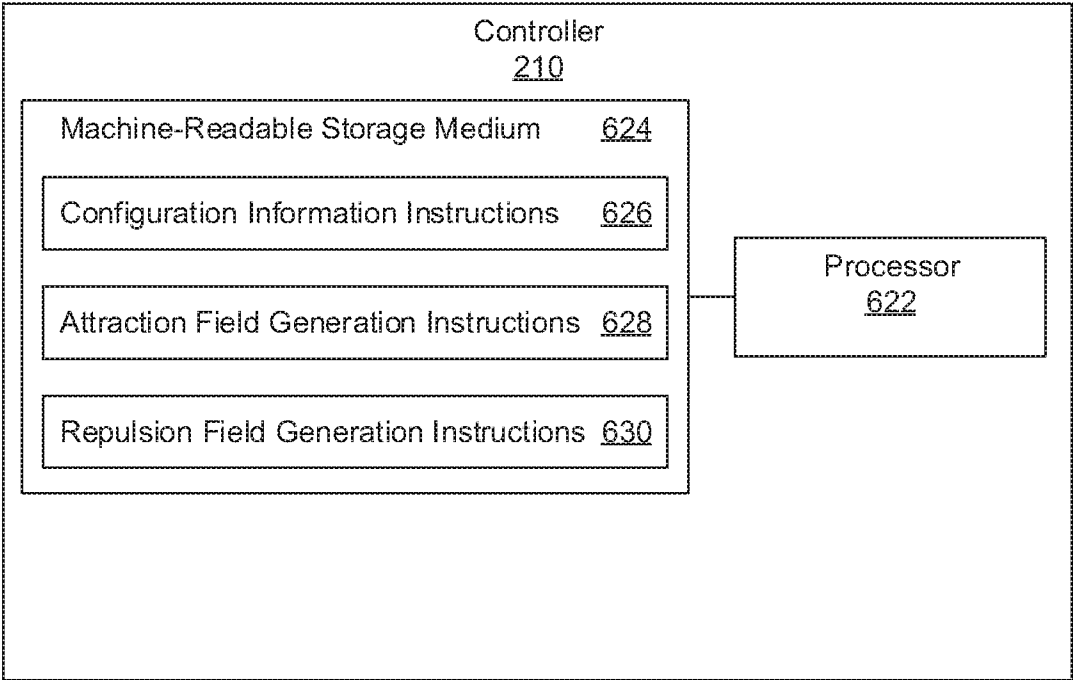


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/012830**A. CLASSIFICATION OF SUBJECT MATTER****H05K 7/14(2006.01)i, H01R 11/30(2006.01)i, H05K 7/20(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H05K 7/14; G11B 33/02; H01R 13/66; H05K 7/20; H05K 7/16; G06F 3/00; G11B 25/04; G06F 1/20; H01R 13/64; H01R 11/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: server, installation device, modular unit, electromagnetic device, fan unit

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2011-0157815 A1 (TSE MIN LIN) 30 June 2011 See paragraphs [0005], [0027]-[0031], [0037]-[0039] and figures 1, 3.	1-15
Y	US 2004-0165358 A1 (LAURENT A. REGIMBAL et al.) 26 August 2004 See abstract, claims 1, 5 and figures 2A, 3A.	1-15
A	US 2008-0222310 A1 (CHRISTOPHER KENT KARSTENS) 11 September 2008 See paragraphs [0024]-[0028] and figures 2-4.	1-15
A	JP 11-039841 A (SONY CORP.) 12 February 1999 See paragraphs [0008]-[0013] and figures 1-3.	1-15
A	US 2015-0072540 A1 (FUJITSU LIMITED) 12 March 2015 See paragraphs [0044]-[0050] and figures 5A-7B.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

10 October 2016 (10.10.2016)

Date of mailing of the international search report

10 October 2016 (10.10.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

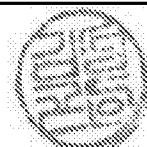
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/012830

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