

- (51) International Patent Classification:
Not classified

(21) International Application Number:
PCT/US2024/032837

(22) International Filing Date:
06 June 2024 (06.06.2024)

(25) Filing Language:
English

(26) Publication Language:
English

(30) Priority Data:
63/507,858 13 June 2023 (13.06.2023) US

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(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO,

(54) Title: INSTRUMENT INTEGRITY AND HEALTH OPERATIONS

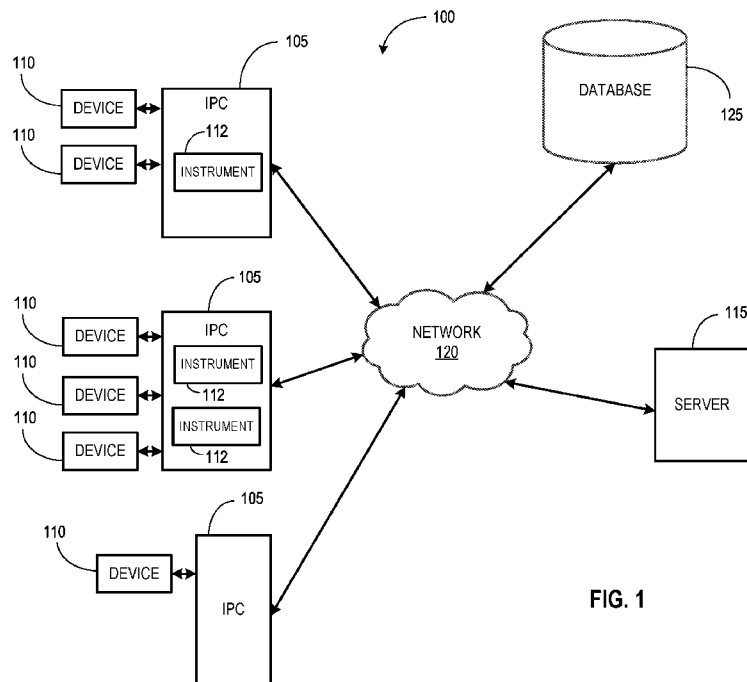


FIG. 1

(57) Abstract: Disclosed herein are scientific instrument support systems, as well as related methods, computing devices, and computer-readable media. For example, in some embodiments, a scientific instrument support apparatus includes first logic to generate a first command frame including a flag having a first value and second logic to transmit the first command frame to a first device. The first value indicates that the first device should ignore an operation indicated by the first command frame. The scientific instrument support apparatus includes third logic to determine whether a confirmation signal indicating a successful operation is received and fourth logic to generate, when the confirmation signal is received, a second command frame including the flag having a second value. The second value indicates that the first device should perform an operation indicated by the second command frame.

RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,
TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS,
ZA, ZM, ZW.

- (84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *of inventorship (Rule 4.17(iv))*

Published:

- *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

INSTRUMENT INTEGRITY AND HEALTH OPERATIONS

Background

[0001] Scientific instruments may include a complex arrangement of movable components, sensors, input and output ports, energy sources, and consumable components. Failures or changes in any part of this arrangement may result in a “downed” instrument, one that is not able to perform its intended function.

Brief Description of the Drawings

[0002] Embodiments will be readily understood by the following detailed description in conjunction with the accompanying drawings. To facilitate this description, like reference numerals designate like structural elements. Embodiments are illustrated by way of example, not by way of limitation, in the figures of the accompanying drawings.

[0003] FIG. 1 is a block diagram of an example scientific instrument support system in which some or all of the scientific instrument support methods disclosed herein may be performed, in accordance with various embodiments.

[0004] FIG. 2 is a block diagram of an example scientific instrument support module for performing support operations, in accordance with various embodiments.

[0005] FIG. 3 is a block diagram of a command frame implemented within the scientific instrument support system of FIG. 1, in accordance with various embodiments.

[0006] FIG. 4 is a flow diagram of an example method of performing support operations, in accordance with various embodiments.

[0007] FIGS. 5A-5B are block diagrams of an example command route for the command frame of FIG. 3, in accordance with various embodiments.

[0008] FIG. 6 is a block diagram of an example graphical user interface that may be used in the performance of some or all of the support methods disclosed herein, in accordance with various embodiments.

[0009] FIG. 7 is a view provided on the graphical user interface of FIG. 6, in accordance with various embodiments.

[0010] FIG. 8 is a block diagram of an example method of providing indications of scientific instrument status, in accordance with various embodiments.

[0011] FIG. 9 is a block diagram of an example computing device that may perform some or all of the scientific instrument support methods disclosed herein, in accordance with various embodiments.

[0012] FIG. 10 is a block diagram of another example scientific instrument support system in which some or all of the scientific instrument support methods disclosed herein may be performed, in accordance with various embodiments.

Detailed Description

[0013] Modern laboratory systems include a significant number of medical and research devices and instruments across large facilities. Additionally, during research and use of the instruments, users in one facility may utilize a device or instrument in another facility connected via a wired or wireless communication network (for example, via

the cloud). While these technological advances have allowed for improved interconnectivity and new means of conducting research, latency and breaks in connection may hinder the efficient operation of laboratory equipment and associated computing and communication device as well the experience of a user interacting with said system.

[0014] Embodiments described herein provide systems, methods, and apparatuses for determining the integrity of a research system. For example, should a desired operation fail or take an undesirably long amount of time to complete, methods described herein provide for determining a status of devices within the system. The status may include determining whether the device is operating, whether devices are reachable, and whether the device responds within an acceptable time limit, among others. In response to detecting a dead or unreachable a device, the location and identification of the device is provided via one or more user interfaces. Alternative devices or pathways may be provided via the user interfaces and an operator interacting with the user interfaces may be able to select an alternative device or path in addition to or as an alternative to automatic remediation methods that may be implemented, including, for example, switching an operation or job to a different device or path, initiating a maintenance or other service request, running further diagnostics on a device or path, or the like. Accordingly, embodiments provided herein narrow the possible sources of errors such that they may be corrected efficiently and accurately.

[0015] Additionally, an operator may wish to see a view of the health of all devices provided in the research system. Embodiments described herein provide a user interface providing a summarized view of devices with the research system. Devices and their statuses may be represented on the user interface by various shapes, icons, colors, patterns, and the like. An operator may interact with the devices using the user interface to view additional details of the device and adjust characteristics of the device.

[0016] Disclosed herein are scientific instrument support systems, as well as related methods, computing devices, and computer-readable media. For example, in some embodiments, a scientific instrument support apparatus includes first logic to generate a first command frame including a flag having a first value and second logic to transmit the first command frame to a first device. The first value indicates that the first device should ignore an operation indicated by the first command frame. The scientific instrument support apparatus includes third logic to determine whether a confirmation signal indicating a successful operation is received and fourth logic to generate, when the confirmation signal is received, a second command frame including the flag having a second value. The second value indicates that the first device should perform an operation indicated by the second command frame. The use of the flag allows a simulated process to be performed to ensure that a device is operational or reachable or otherwise determine an operational state of a device or pathway without performing a complete job or task that may waste processing, communication resources, and prepared sample resources.

[0017] The scientific instrument support embodiments disclosed herein may achieve improved performance relative to conventional approaches. For example, scientific laboratories are drastically increasing in size. Additionally, instruments and devices used for experiments may be located in different laboratories, adding communication

latency to the time of performing an experiment. These changes cause issues for laboratory managers in identifying which devices need service, and may drastically increase the amount of delay during periods of high workload. The embodiments disclosed herein thus provide improvements to scientific instrument technology (e.g., improvements in the computer technology supporting such scientific instruments, among other improvements).

[0018] The embodiments disclosed herein may achieve a means for identifying device errors in a large laboratory environment. Additionally, among other things, various ones of the embodiments disclosed herein may provide improvements to graphical user interface (GUI) technology. For example, GUIs provided herein provide an organized view of the status of all components (e.g., devices and scientific instruments) within a support system.

[0019] Various ones of the embodiments disclosed herein may improve upon conventional approaches to achieve the technical advantages of increased throughput of performing experiments by identifying instrument errors and delaying performance of operations until the system recovers from errors and latency. Such technical advantages are not achievable by routine and conventional approaches, and all users of systems including such embodiments may benefit from these advantages (e.g., by assisting the user in the performance of a technical task, such as identifying downed instruments and failed command routes, by means of a guided human-machine interaction process). The technical features of the embodiments disclosed herein are thus decidedly unconventional in the field of laboratory communication systems, as are the combinations of the features of the embodiments disclosed herein. The computational and user interface features disclosed herein do not only involve the collection and comparison of information, but apply new analytical and technical techniques to change the operation of instrument support systems. The present disclosure thus introduces functionality that neither a conventional computing device, nor a human, could perform.

[0020] Accordingly, the embodiments of the present disclosure may serve any of a number of technical purposes, such as controlling a specific technical system or process; determining from measurements how to control a machine; optimizing load distribution in a computer network; simulating the behavior of a technical item or process; or providing a faster processing of sensor data.

[0021] In the following detailed description, reference is made to the accompanying drawings that form a part hereof wherein like numerals designate like parts throughout, and in which is shown, by way of illustration, embodiments that may be practiced. It is to be understood that other embodiments may be utilized, and structural or logical changes may be made, without departing from the scope of the present disclosure. Therefore, the following detailed description is not to be taken in a limiting sense.

[0022] Various operations may be described as multiple discrete actions or operations in turn, in a manner that is most helpful in understanding the subject matter disclosed herein. However, the order of description should not be construed as to imply that these operations are necessarily order dependent. In particular, these operations may not be performed in the order of presentation. Operations described may be performed in a different order from the

described embodiment. Various additional operations may be performed, and/or described operations may be omitted in additional embodiments.

[0023] For the purposes of the present disclosure, the phrases "A and/or B" and "A or B" mean (A), (B), or (A and B). For the purposes of the present disclosure, the phrases "A, B, and/or C" and "A, B, or C" mean (A), (B), (C), (A and B), (A and C), (B and C), or (A, B, and C). Although some elements may be referred to in the singular (e.g., "a processing device"), any appropriate elements may be represented by multiple instances of that element, and vice versa. For example, a set of operations described as performed by a processing device may be implemented with different ones of the operations performed by different processing devices.

[0024] The description uses the phrases "an embodiment," "various embodiments," and "some embodiments," each of which may refer to one or more of the same or different embodiments. Furthermore, the terms "comprising," "including," "having," and the like, as used with respect to embodiments of the present disclosure, are synonymous. When used to describe a range of dimensions, the phrase "between X and Y" represents a range that includes X and Y. As used herein, an "apparatus" may refer to any individual device, collection of devices, part of a device, or collections of parts of devices. The drawings are not necessarily to scale.

[0025] FIG. 1 is a block diagram of a scientific instrument support system 100 (henceforth referred to simply as support system 100) for performing support operations, in accordance with various embodiments. As illustrated in FIG. 1, the support system 100 includes a plurality of instrument personal computer (IPC)s 105 connected over a communication network 120. One or more devices 110 are connected to each IPC 105. Devices 110 are physical entities that perform some function of sample preparation and/or sample analysis. For example, devices 110 may be physical devices having a serial number, a means of communicating with other external entities, and may include processors, memory, and firmware. Devices 110 may include, for example, sensors, detectors, actuators, spectrometers, spectrograms, oscilloscopes, electrometers, interferometers, and the like. The IPCs 105 may also include one or more instruments 112. Instruments 112 are logical containers that include a collection of devices 110. For example, devices 110 work together to perform operations and produce results. The logical collection of devices 110, (e.g., the instrument 112) prepares or analyzes inputs, such as blood samples. Each IPC 105 is connected to its respective device(s) 110 and may be capable of uni-directional or bi-directional communication with the connected device(s) 110. Each IPC 105 may be connected to the device(s) 110 via wired or wireless communication means and/or protocols. Each IPC 105 may transmit commands to the connected device(s) 110, receive status signals from the device(s) 110, receive measurements from the device(s) 110, and the like, as described below in more detail. The IPCs 105, the devices 110, and the instruments 112 may be more generally referred to as service components.

[0026] The support system 100 includes a database 125 and a server 115 communicatively coupled with the plurality of IPCs 105 (and with each other) through the communication network 120. In other embodiments, the plurality of IPCs 105, the server 115, and the database 125 communicate via one or more dedicated wire connections or other forms of wired or wireless electronic communication. It should be understood that the support

system 100 may include fewer or additional components than those illustrated in FIG. 1. For example, the support system 100 may include fewer or more IPCs 105, multiple servers 115, multiple databases 125, or a combination thereof. In some instances, rather than including an independent database, the storage functionality of the database 125 is provided by the server 115. The components of the support system 100 may also communicate through one or more intermediary devices not illustrated in FIG. 1.

[0027] The server 115 serves as a “control hub” for the plurality of IPCs 105. For example, the server 115 communicates with each of the IPCs 105 by sending commands to the IPCs 105 to perform methods described herein over a wired connection, a wireless connection, or a combination thereof. Additionally, the server 115 receives measurements and statuses of device(s) 110 and instrument(s) 112 from their respective IPCs 105 over a wired connection, wireless connection, or a combination thereof. The database 125 stores data indicating the status of components within the support system 100. For example, the database 125 may store a current status of the device(s) 110 and instrument(s) 112, historical statuses of the device(s) 110 and instrument(s) 112, measurements recorded by the device(s) 110 and instrument(s) 112, and the like.

[0028] FIG. 2 is a block diagram of a scientific instrument support module 200 for performing support operations, in accordance with various embodiments. The scientific instrument support module 200 may be, for example, the server 115. The scientific instrument support module 200 may be implemented by circuitry (e.g., including electrical and/or optical components), such as a programmed computing device. The logic of the scientific instrument support module 200 may be included in a single computing device, or may be distributed across multiple computing devices that are in communication with each other as appropriate. Examples of computing devices that may, singly or in combination, implement the scientific instrument support module 200 are discussed herein with reference to the computing device 900 of FIG. 9, and examples of systems of interconnected computing devices, in which the scientific instrument support module 200 may be implemented across one or more of the computing devices, is discussed herein with reference to the scientific instrument support system 1000 of FIG. 10.

[0029] The scientific instrument support module 200 may include first logic 202, second logic 204, third logic 206, fourth logic 208, and fifth logic 210. As used herein, the term “logic” may include an apparatus that is to perform a set of operations associated with the logic. For example, any of the logic elements included in the support module 200 may be implemented by one or more computing devices programmed with instructions to cause one or more processing devices of the computing devices to perform the associated set of operations. In a particular embodiment, a logic element may include one or more non-transitory computer-readable media having instructions thereon that, when executed by one or more processing devices of one or more computing devices, cause the one or more computing devices to perform the associated set of operations. As used herein, the term “module” may refer to a collection of one or more logic elements that, together, perform a function associated with the module. Different ones of the logic elements in a module may take the same form or may take different forms. For example, some logic in a module may be implemented by a programmed general-purpose processing device, while other logic in a

module may be implemented by an application-specific integrated circuit (ASIC). In another example, different ones of the logic elements in a module may be associated with different sets of instructions executed by one or more processing devices. A module may not include all of the logic elements depicted in the associated drawing; for example, a module may include a subset of the logic elements depicted in the associated drawing when that module is to perform a subset of the operations discussed herein with reference to that module.

[0030] The first logic 202 may include an apparatus for generating a first command frame including a flag having a first value. FIG. 3 illustrates a command frame 300 according to one example. The command frame 300 includes a command identification block 305, a device address block 310, a command data block 315, and an integrity flag block 320. The command identification block 305 includes an identification code corresponding to a type of the frame being provided, such as a type of operation to be performed. The device address block 310 includes an address (for example, a node-address) indicating a device 110 or an instrument 112 for which the command frame 300 is intended. In some embodiments, the device address block 310 may include the address of multiple devices 110, instruments 112, or a combination thereof. The command frame 300 illustrated in FIG. 3 is an example, and other command frames generated by the first logic 202 may include additional fields, a subset of the illustrated fields, or a combination thereof. Components of the command frame 300 may also be arranged in various sequences and using various encoding techniques.

[0031] In some instances, the operation indicated by the command identification block 305 requires the use of multiple devices 110 and/or instruments 112. In such an instance, the device address block 310 may include a sequence of addresses indicating all devices 110 and/or instruments 112 that are needed to perform the operation. Each device 110 and/or instrument 112 may perform their respective part of the operation and send transmit the command frame 300 to the next sequential device 110 and/or instrument 112, as described below in more detail. In another instance, each device 110 and/or instrument 112 maintains a table including the identification codes and an associated next device 110 and/or instrument 112. When the device 110 and/or instrument 112 receives the command frame 300, the device 110 and/or instrument 112 refers to the table to identify a next device 110 and/or instrument 112 that receives the command frame 300 and continue the operation.

[0032] In another embodiment, rather than the device 110 and/or instrument 112 transmitting the command frame 300 to a next device 110 and/or instrument 112, the device 110 and/or instrument 112 transmits a confirmation signal to the server 115. In response to receiving the confirmation signal, the server 115 then generates a new command frame 300 including the address of the next device 110 and/or instrument 112 to continue the operation. In some embodiments, the server 115 generates a command frame 300 for all devices 110 and/or instruments 112 used for performing the operation. The server 115 may transmit one or more of these command frames 300 sequentially to the devices 110 and/or instruments 112, in parallel, or a combination thereof.

[0033] The command data block 315 includes data for performing the operation indicated by the command identification block 305. For example, the command data block 315 may include operational data and settings that

the device 110 and/or the instrument 112 use to perform the indicated operation. In some instances, as the operation is performed, devices 110 and/or instruments 112 may append data associated with their portion of the operation to the command data block 315. The integrity flag block 320 includes a flag value that is set by the first logic 202. The flag value indicates whether the operation indicated by the command identification block 305 should be performed by the recipient, as described below in more detail. In some implementations, the flag value is a binary value. However, in other implementations, non-binary values may be utilized. The first logic 202 may set the integrity flag block 320 to a value indicating that a device should not perform (e.g., ignore) the operation indicated by the command identification block 305. In some embodiments, the integrity flag block 320 is set to a value indicating that a device should perform a “dummy” operation. For example, rather than performing the operation indicated by the command identification block 305, the device 110 and/or instrument 112 generates a dummy response to provide an indication that the operation could be performed. The dummy response may be of a similar size and format as a signal generated by the device 110 and/or instrument 112 during actual performance of the operation, which provides a more accurate response to health check or status inquiry (e.g., as compared to a basic ping function) .

[0034] The second logic 204 may include an apparatus for transmitting the first command frame to a first device. For example, the second logic 204 includes an apparatus for transmitting the command frame 300 to the device 110 and/or instrument 112 indicated by the device address block 310. The third logic 206 may include an apparatus for determining whether a confirmation signal indicating a successful operation is received. For example, when the operation indicated by the command identification block 305 is completed, the last device in the operation may transmit a confirmation signal to the support module 200. However, if the operation is not successful, the support module 200 does not receive a confirmation signal, or receives a failure signal indicating the failure of the operation. In some instances, the confirmation signal includes data associated with the performed operation.

[0035] The fourth logic 208 may include an apparatus for providing an indication of a system error. For example, when the confirmation signal is not received, the fourth logic 208 includes an apparatus for providing a notification on a graphical user interface (GUI). In some instances, the fourth logic 208 also includes an apparatus for providing an indication of the success of the operation.

[0036] The fifth logic 210 may include an apparatus for generating a second command frame including a flag having a second value. For example, the fifth logic 210 may include an apparatus for generating the command frame 300 where the value of the integrity flag block 320 is set or altered to a different value than the first logic 202. The fifth logic 210 may set the integrity flag block 320 to a value indicating that a device should perform the operation indicated by the command identification block 305.

[0037] FIG. 4 is a flow diagram of a method 400 of performing support operations, in accordance with various embodiments. Although the operations of the method 400 may be illustrated with reference to particular embodiments disclosed herein (e.g., the scientific instrument support module 200 discussed herein with reference to FIG. 2, the GUI 600 discussed herein with reference to FIG. 6, the computing devices 900 discussed herein with

reference to FIG. 9, and/or the scientific instrument support system 1000 discussed herein with reference to FIG. 10), the method 400 may be used in any suitable setting to perform any suitable support operations. Operations are illustrated once each and in a particular order in FIG. 4, but the operations may be reordered and/or repeated as desired and appropriate (e.g., different operations performed may be performed in parallel, as suitable).

[0038] At 402, the method 400 includes generating a first command frame including a flag having a first value. For example, the first logic 202 of the support module 200 may perform the operations of 402.

[0039] At 404, the method 400 includes transmitting the first command frame to a first device. For example, the second logic 204 of the support module 200 may perform the operations of 404.

[0040] At 406, the method 400 includes determining whether a confirmation signal indicating a successful operation is received. For example, the third logic 206 of the support module 200 may perform the operations of 406.

[0041] At 408, the method 400 includes indicating, when the confirmation signal is not received ("NO" at 406), a system error. For example, the fourth logic 208 of the support module 200 may perform the operations of 408.

[0042] At 410, the method 400 includes generating, when the confirmation signal is received ("YES" at 406), a second command frame including a flag having a second value. For example, the fifth logic 210 of the support module 200 may perform the operations of 410.

[0043] In some implementations, the method 400 returns to the operations of 402 after performing the operations of 410.

[0044] FIG. 5A provides one example of a server 115 transmitting the command frame 300 along a command route 500 within the support system 100. The command route 500 includes the server 115, an IPC 105, a first device 110A, a second device 110B, and a third device 110C. However, in other embodiments, different command routes may be provided having a different number of device(s) 110, instrument(s) 112, or a combination thereof.

[0045] In the example of FIG. 5A, the server 115 transmits the command frame 300 to the IPC 105. The command frame 300 may, for example, indicate that a first operation to be performed requires functions from the first device 110A, the second device 110B, and the third device 110C. The integrity flag block 320 is set to a first value indicating that the devices 105A-105C should not perform the operation indicated by the command identification block 305. The IPC 105 transmits the command frame 300 to the first device 110A. The first device 110A receives and analyzes the contents of the command frame 300. As the integrity flag block 320 is set to the first value, the first device 110A transmits the command frame 300 to the second device 110B without performing the operation indicated by the command identification block 305. The second device 110B receives and analyzes the contents of the command frame 300. As the integrity flag block 320 is set to the first value, the second device 110B transmits the command frame 300 to the third device 110C without performing the operation indicated by the command identification block 305. The third device 110C receives and analyzes the contents of the command frame 300. As the integrity flag block 320 is set to the first value, the third device 110C does not perform the operation indicated by the command identification block 305. As the third device 110C is the last device included in performing the

operation indicated by the command identification block 305, the third device 110C transmits a confirmation signal to the IPC 105 indicating that the operation was a success. The IPC 105 transmits the confirmation signal to the server 115.

[0046] By setting the integrity flag block 320 to the first value, the server 115 confirms that each device 110 and/or instrument 112 involved in performing an operation is operating properly. Once the server 115 confirms that each device 110 and/or instrument 112 that is needed is operating properly, the server 115 transmits a second version of the command frame 300 with the integrity flag block 320 adjusted to the second value such that the operation is performed.

[0047] However, in some instances, the command frame 300 fails to travel across the command route 500. For example, FIG. 5B provides an example of the support system 100 failing to perform an operation. In the example of FIG. 5B, the server 115 transmits the command frame 300 to the IPC 105. The command frame 300 may, for example, indicate that a first operation to be performed requires functions from the first device 110A, the second device 110B, and the third device 110C. The integrity flag block 320 is set to a first value indicating that the devices 105A-105C should not perform the operation indicated by the command identification block 305. The IPC 105 transmits the command frame 300 to the first device 110A. The first device 110A receives and analyzes the contents of the command frame 300. As the integrity flag block 320 is set to the first value, the first device 110A transmits the command frame 300 to the second device 110B without performing the operation indicated by the command identification block 305. The second device 110B receives and analyzes the contents of the command frame 300. As the integrity flag block 320 is set to the first value, the second device 110B transmits the command frame 300 to the third device 110C without performing the operation indicated by the command identification block 305.

[0048] In FIG. 5B, the third device 110C does not receive the command frame 300. For example, the third device 110C may be disconnected from the second device 110B, may be powered down, or is otherwise inaccessible. Accordingly, a confirmation signal is not generated by the third device 110C, and the server 115 does not receive an indication that the operation was successful. In some embodiments, the second device 110B detects that the transmission of the command frame 300 failed and, in response, generates a failure signal transmitted to the server 115. Once the server 115 determines that the operation was not successful, the server 115 provides an indication (for example, a notification) indicating the failure. In some embodiments, the failure signal includes data indicating which devices 110 and/or instruments 112 were successful and where the failure occurred. While the example of FIG. 5B illustrates the failed transmission between the second device 110B and the third device 110C, this is merely an example, and failures may occur between other devices 110, instruments 112, and IPCs 105 within the command route 500.

[0049] In some embodiments, when the server 115 determines that the operation was not successful, the server 115 continues to monitor the command route 500 (e.g., continues to repeat method 400) until the server 115 receives a confirmation signal. In some instances, the server 115 transmits the command frame 300 at a periodic time interval

(for example, once every 10 seconds, once every minute, etc.). In response to the server 115 receiving a confirmation signal, the server 115 generates a second command frame with the integrity flag block 320 having a second value such that the devices 110 and instruments 112 within the command route 500 perform the operation.

[0050] Accordingly, embodiments described herein determine whether functions, services, devices, instruments, and the like are in proper working condition prior to performance of an operation. In some instances, the support module 200 may determine whether network bandwidth is sufficient for a workflow to progress and finish an operation successfully and within a timely manner. For example, the support module 200 may initiate a bandwidth test to determine whether bandwidth between devices 110 and instruments 112 needed to perform an operation is of an acceptable speed. When the bandwidth is not acceptable, the support module 200 delays performance of the operation and monitors the bandwidth until the bandwidth is acceptable. When the bandwidth is acceptable, the support module 200 performs the operation. This may assist users of the support system 100 in avoiding periods of high traffic.

[0051] As one example, an operator of the support system 100 attempts to download a 1 GB file from an international IPC 105. Initially, the bandwidth is less than acceptable. In response, the support module 200 stops or pauses the download and monitors the bandwidth until the bandwidth is acceptable. In some instances, the support module 200 also provides a notification to the operator indicating that the download is delayed. In some embodiments, the notification also indicates how long the action would take. Once the bandwidth is acceptable, the support module 200 re-initiates the download. In some instances, the bandwidth may become less than acceptable after the download has begun. In such an instance, the support module 200 may stop or pause the download until the bandwidth becomes acceptable.

[0052] As another example, a user wants to ensure a device is available prior to starting an operation. After establishing a command route 500, the user generates the first command frame having the integrity flag block 320 having a first value such that the devices 110 and instruments 112 within the command route 500 do not perform the operation. Should the user receive a confirmation signal, the user knows all needed components for the operation are available. However, if a confirmation signal is not received, a component within the command route 500 may be in use by another user or may otherwise be unavailable.

[0053] In some embodiments, the support module 200 monitors the health of all IPCs 105, devices 110, and/or instruments 112 within the support system 100. For example, the server 115 periodically transmits ping signals to each IPC 105, each device 110, and each instrument 112 requesting a status of the IPC 105, the device 110, and the instrument 112. The server 115 may monitor how long it takes the respective IPC 105, device 110, or instrument 112 to respond to determine the latency of communicating with said component. When the server 115 fails to receive a response, the server 115 detects a failure or error of said respective component. The status of each component may be provided via a GUI, as described below in more detail.

[0054] FIG. 6 depicts an example GUI 600 that may be used in the performance of some or all of the support methods disclosed herein, in accordance with various embodiments. As noted above, the GUI 600 may be provided on a display device (e.g., the display device 910 discussed herein with reference to FIG. 9) of a computing device (e.g., the computing device 900 discussed herein with reference to FIG. 9) of a scientific instrument support system (e.g., the scientific instrument support system 1000 discussed herein with reference to FIG. 10), and a user may interact with the GUI 600 using any suitable input device (e.g., any of the input devices included in the other I/O devices 912 discussed herein with reference to FIG. 9) and input technique (e.g., movement of a cursor, motion capture, facial recognition, gesture detection, voice recognition, actuation of buttons, etc.).

[0055] The GUI 600 may include a data display region 602, a data analysis region 604, a scientific instrument control region 606, and a settings region 608. The particular number and arrangement of regions depicted in FIG. 6 is simply illustrative, and any number and arrangement of regions, including any desired features, may be included in a GUI 600.

[0056] The data display region 602 may display data generated by a scientific instrument (e.g., the scientific instrument 1010 discussed herein with reference to FIG. 10), or may display data related to the status of components within the support system 100. For example, the data display region 602 may display a table or chart providing the status of components within the support system 100, an example of which is shown in FIG. 7.

[0057] FIG. 7 illustrates an example view 700 of the data display region 602. The view 700 includes a status chart 701, a legend 702, and a status window 710. The status chart 701 shows a plurality of blocks (e.g., representative elements), each block representative of an associated IPC 105, a device 110, or an instrument 112. For the sake of clarity, only a few representative blocks are labelled. Particularly, a first block 704, a second block 706, and a third block 708 are labelled within the status chart 701. As indicated by the legend 702, the first block 704 has a status of "OK", or is performing appropriately. The second block 706 has a status of "WARNING", or may be experiencing minor performance issues. The third block 708 has a status of "ERROR", and may not be operating. Other blocks within the status chart 701 may each also have a status of "OK", "WARNING," or "ERROR. Additionally, while sixteen blocks are provided within the status chart 701, in some embodiments, the status chart 701 may have fewer blocks or may have more blocks. In some instances, the status chart 701 may have over 1000 blocks, each block representative of a component of the support system 100.

[0058] In some embodiments, blocks having a status of "WARNING" or "ERROR" may include a selectable indicator 712. When the selectable indicator 712 is selected by a user, a status window 710 is generated and provided in the data display region 602. The status window 710 provides details regarding performance issues or errors associated with the IPC 105, device 110, or instrument 112 represented by the respective block. In the example of FIG. 7, a selectable indicator 712 associated with the third block 708 is selected to generate the status window 710. A wide variety of warnings or errors may be provided by the status window 710. For example, the status window 710 may indicate whether an IPC 105 is connected to the server 115, whether a device 110 and/or

instrument 112 is connected to an IPC 105, whether a device 110 and/or an instrument 112 is being utilized, whether services operated on an IPC 105, device 110, or instrument 112 are performing correctly or are correctly installed (for example, device registry services (DRS), lightweight directory services (LDS), LPC services, DIS, DPM services, ISF services, and the like), CPU, memory, and network bandwidth usage for each service, status of beaconing devices and services, whether a number of 1S events (e.g., how many devices of the same type have the same problem), exceed a threshold, whether or not an application is installed on the respective component, whether driver, firmware, and hardware versions are up to date, a version of the operating system run by the respective component, and the like. In some embodiments, the status window 710 may include a hyperlink that, when selected, allows the operator to email or save the contents of the status window 710.

[0059] While FIG. 7 provides one example view of the data display region 602, other views may be provided. For example, an icon may be provided for each component in the support system 100 indicating a status of the respective component. The representative elements may be other shapes, such as dots, and may be provided in a variety of patterns and colors. In some embodiments, rather than providing a textual status for each component indicated by the legend 702, each component is represented by a percentage or numerical value indicative of the overall health or operation of the respective component. In another example, the data display region 602 displays a list of all components within the support system 100. Selection of a component in the list may result in a status and characteristics of the selected component being provided.

[0060] The data analysis region 604 may display the results of data analysis (e.g., the results of analyzing the data illustrated in the data display region 602 and/or other data). For example, the data analysis region 604 may display recommendations based on the statuses of components within the support system 100. In some embodiments, the data display region 602 and the data analysis region 604 may be combined in the GUI 600 (e.g., to include the status chart 701 and some analysis of the status chart 701, in a common graph or region).

[0061] The scientific instrument control region 606 may include options that allow the user to control a scientific instrument (for example, a device 110, an instrument 112, etc.). For example, the scientific instrument control region 606 may include an interface for adjusting operational settings of the components within the support system 100. The scientific instrument control region 606 may include an interface for adjusting thresholds related to the status of components within the support system 100 (for example, latency thresholds, 1S thresholds, and the like).

[0062] The settings region 608 may include options that allow the user to control the features and functions of the GUI 600 (and/or other GUIs) and/or perform common computing operations with respect to the data display region 602 and data analysis region 604 (e.g., saving data on a storage device, such as the storage device 904 discussed herein with reference to FIG. 9, sending data to another user, labeling data, etc.). For example, the settings region 3008 may include a selectable option to trigger the support module 200 to perform the method 400. In some embodiments, the settings region 608 allows a user to remotely control and/or restart services of the IPCs 105.

[0063] Accordingly, the GUI 600 provides a detailed view of the status of devices 110, instruments 112, and IPCs 105 connected over the network 120. This detailed view has many advantages for operators, such as lab managers, operating within the support system 100. For example, an operator may inquire (e.g., provide an input requesting) which IPCs 105 have been updated to a most-recent version of software. Upon receiving the inquiry, the status chart 701 is updated to indicate which IPCs require updating. For example, the status chart 701 is updated to include an icon provided for the IPCs 105 that require updating based on the inquiry.

[0064] In one example, an operator inquires which IPCs 105 are connected to the network 120. Upon receiving the inquiry, the status chart 701 is updated to indicate which IPCs 105 are connected to the network 120 and which IPCs 105 are disconnected. In another example, an operator inquires which IPCs 105 are having issues or experiencing errors operating services or drivers. For example, the server 115 may maintain a table on the database 125 of all services operated by the IPCs 105. When an IPC 105 experiences an error, the server 115 updates the table to indicate which service or driver failed on the IPC 105. Upon receiving an inquiry from an operator, the status chart 701 is updated to indicate which IPC 105 had an error, and which service or driver resulted in the error. In some instances, the GUI 600 provide information regarding specific events indicating a need for service. For example, the GUI 600 indicates whether service components have experienced unexpected behavior, have rejected certain commands, or have failed a performance test (e.g., a self-test).

[0065] In a further example, an operator requests access to troubleshooting guides for the errors experienced by the IPCs 105. For example, upon receiving an indication of an error, the operator inquires how to fix the error. In some instances, a troubleshooting guide is automatically provided on the status chart 701 or another window of the GUI 600. An operator may perform troubleshooting remotely via the GUI 600. Accordingly, the GUI 600 both notifies an operator of an error and assists the operator in correcting the error.

[0066] In another example, an operator requests a visualization of the utilization of service components in the support system 100. Upon receiving the request, the status chart 701 is updated to include a utilization indicator of each service component represented in the status chart 701. For example, a percentage value may be provided indicating the utilization of each service component, or each block may be color coded to indicate the utilization of the respective service component. In some instances, the GUI 600 may additionally provide operations to order new equipment, schedule the use of service components, schedule maintenance for service components, and observe which service components are reserved based on the utilization of the service components.

[0067] In yet another example, an operator requests to provide a notification indicative of a status of the service components on another device. For example, an operator may request to forward an uncovered error related to an IPC 105 to another user of the support system 100. In some instances, the server 115 maintains a table on the database 125 associating particular errors with a support staff member knowledgeable in correcting the error. When the error is uncovered, the server 115 forwards the error to the appropriate staff member. In some instances, an operator may request to generate a report detailing the status of the service components within the status chart 701.

[0068] FIG. 8 is a flow diagram of a method 800 of performing support operations, in accordance with various embodiments. Although the operations of the method 800 may be illustrated with reference to particular embodiments disclosed herein (e.g., the scientific instrument support module 200 discussed herein with reference to FIG. 2, the GUI 600 discussed herein with reference to FIG. 6, the computing devices 900 discussed herein with reference to FIG. 9, and/or the scientific instrument support system 1000 discussed herein with reference to FIG. 10), the method 800 may be used in any suitable setting to perform any suitable support operations. Operations are illustrated once each and in a particular order in FIG. 8, but the operations may be reordered and/or repeated as desired and appropriate (e.g., different operations performed may be performed in parallel, as suitable).

[0069] At block 802, the method 800 includes determining a status of a plurality of components within a support system. For example, an operator inquires which IPCs 105 connected to the network 120 are having issues or experiencing errors operating services or drivers. The server 115 determines the status of the IPCs 105, such as by sending a ping over the network 120, as previously described.

[0070] At block 804, the method 800 includes generating, on a display device, a first view providing a status chart indicating the status of each of the plurality of components. For example, as described with respect to FIG. 7, an operator requests a visualization of the utilization of service components in the support system 100. Upon receiving the request, the status chart 701 is updated to include a utilization indicator of each service component represented in the status chart 701. The status chart 701 shows a plurality of blocks (e.g., representative elements), each block representative of an associated IPC 105, a device 110, or an instrument 112, as previously described.

[0071] At block 806, the method 800 includes receiving a selection of one of the representative elements. For example, a user of the GUI 600 selects a selectable indicator 712 associated with a representative element.

[0072] At block 808, the method 800 includes generating, on the display device, a status window including a description of the status of the one component associated with the selected representative element. For example, when the selectable indicator 712 is selected by a user, a status window 710 is generated and provided in the data display region 602. The status window 710 provides details regarding performance issues or errors associated with the IPC 105, device 110, or instrument 112 represented by the respective block.

[0073] FIG. 9 is a block diagram of a computing device 900 that may perform some or all of the scientific instrument support methods disclosed herein, in accordance with various embodiments. In some embodiments, the scientific instrument support module 200 (for example, the server 115) may be implemented by a single computing device 900 or by multiple computing devices 900. Further, as discussed below, a computing device 900 (or multiple computing devices 900) that implements the scientific instrument support module 200 may be part of one or more of the scientific instrument 1010, the user local computing device 1020, the service local computing device 1030, or the remote computing device 1040 of FIG. 10.

[0074] The computing device 900 of FIG. 9 is illustrated as having a number of components, but any one or more of these components may be omitted or duplicated, as suitable for the application and setting. In some

embodiments, some or all of the components included in the computing device 900 may be attached to one or more motherboards and enclosed in a housing (e.g., including plastic, metal, and/or other materials). In some embodiments, some these components may be fabricated onto a single system-on-a-chip (SoC) (e.g., an SoC may include one or more processing devices 902 and one or more storage devices 904). Additionally, in various embodiments, the computing device 900 may not include one or more of the components illustrated in FIG. 9, but may include interface circuitry (not shown) for coupling to the one or more components using any suitable interface (e.g., a Universal Serial Bus (USB) interface, a High-Definition Multimedia Interface (HDMI) interface, a Controller Area Network (CAN) interface, a Serial Peripheral Interface (SPI) interface, an Ethernet interface, a wireless interface, or any other appropriate interface). For example, the computing device 900 may not include a display device 910, but may include display device interface circuitry (e.g., a connector and driver circuitry) to which a display device 910 may be coupled.

[0075] The computing device 900 may include a processing device 902 (e.g., one or more processing devices). As used herein, the term "processing device" may refer to any device or portion of a device that processes electronic data from registers and/or memory to transform that electronic data into other electronic data that may be stored in registers and/or memory. The processing device 902 may include one or more digital signal processors (DSPs), application-specific integrated circuits (ASICs), central processing units (CPUs), graphics processing units (GPUs), cryptoprocessors (specialized processors that execute cryptographic algorithms within hardware), server processors, or any other suitable processing devices.

[0076] The computing device 900 may include a storage device 904 (e.g., one or more storage devices). The storage device 904 may include one or more memory devices such as random access memory (RAM) (e.g., static RAM (SRAM) devices, magnetic RAM (MRAM) devices, dynamic RAM (DRAM) devices, resistive RAM (RRAM) devices, or conductive-bridging RAM (CBRAM) devices), hard drive-based memory devices, solid-state memory devices, networked drives, cloud drives, or any combination of memory devices. In some embodiments, the storage device 904 may include memory that shares a die with a processing device 902. In such an embodiment, the memory may be used as cache memory and may include embedded dynamic random access memory (eDRAM) or spin transfer torque magnetic random access memory (STT-MRAM), for example. In some embodiments, the storage device 904 may include non-transitory computer readable media having instructions thereon that, when executed by one or more processing devices (e.g., the processing device 902), cause the computing device 900 to perform any appropriate ones of or portions of the methods disclosed herein.

[0077] The computing device 900 may include an interface device 906 (e.g., one or more interface devices 906). The interface device 906 may include one or more communication chips, connectors, and/or other hardware and software to govern communications between the computing device 900 and other computing devices. For example, the interface device 906 may include circuitry for managing wireless communications for the transfer of data to and from the computing device 900. The term "wireless" and its derivatives may be used to describe circuits, devices,

systems, methods, techniques, communications channels, etc., that may communicate data through the use of modulated electromagnetic radiation through a nonsolid medium. The term does not imply that the associated devices do not contain any wires, although in some embodiments they might not. Circuitry included in the interface device 4006 for managing wireless communications may implement any of a number of wireless standards or protocols, including but not limited to Institute for Electrical and Electronic Engineers (IEEE) standards including Wi-Fi (IEEE 802.11 family), IEEE 802.16 standards (e.g., IEEE 802.16-2005 Amendment), Long-Term Evolution (LTE) project along with any amendments, updates, and/or revisions (e.g., advanced LTE project, ultra mobile broadband (UMB) project (also referred to as "3GPP2"), etc.). In some embodiments, circuitry included in the interface device 4006 for managing wireless communications may operate in accordance with a Global System for Mobile Communication (GSM), General Packet Radio Service (GPRS), Universal Mobile Telecommunications System (UMTS), High Speed Packet Access (HSPA), Evolved HSPA (E-HSPA), or LTE network. In some embodiments, circuitry included in the interface device 4006 for managing wireless communications may operate in accordance with Enhanced Data for GSM Evolution (EDGE), GSM EDGE Radio Access Network (GERAN), Universal Terrestrial Radio Access Network (UTRAN), or Evolved UTRAN (E-UTRAN). In some embodiments, circuitry included in the interface device 4006 for managing wireless communications may operate in accordance with Code Division Multiple Access (CDMA), Time Division Multiple Access (TDMA), Digital Enhanced Cordless Telecommunications (DECT), Evolution-Data Optimized (EV-DO), and derivatives thereof, as well as any other wireless protocols that are designated as 3G, 4G, 5G, and beyond. In some embodiments, the interface device 906 may include one or more antennas (e.g., one or more antenna arrays) to receipt and/or transmission of wireless communications.

[0078] In some embodiments, the interface device 06 may include circuitry for managing wired communications, such as electrical, optical, or any other suitable communication protocols. For example, the interface device 906 may include circuitry to support communications in accordance with Ethernet technologies. In some embodiments, the interface device 906 may support both wireless and wired communication, and/or may support multiple wired communication protocols and/or multiple wireless communication protocols. For example, a first set of circuitry of the interface device 906 may be dedicated to shorter-range wireless communications such as Wi-Fi or Bluetooth, and a second set of circuitry of the interface device 906 may be dedicated to longer-range wireless communications such as global positioning system (GPS), EDGE, GPRS, CDMA, WiMAX, LTE, EV-DO, or others. In some embodiments, a first set of circuitry of the interface device 906 may be dedicated to wireless communications, and a second set of circuitry of the interface device 906 may be dedicated to wired communications.

[0079] The computing device 900 may include battery/power circuitry 908. The battery/power circuitry 908 may include one or more energy storage devices (e.g., batteries or capacitors) and/or circuitry for coupling components of the computing device 900 to an energy source separate from the computing device 900 (e.g., AC line power).

[0080] The computing device 900 may include a display device 910 (e.g., multiple display devices). The display device 910 may include any visual indicators, such as a heads-up display, a computer monitor, a projector, a touchscreen display, a liquid crystal display (LCD), a light-emitting diode display, or a flat panel display.

[0081] The computing device 900 may include other input/output (I/O) devices 912. The other I/O devices 912 may include one or more audio output devices (e.g., speakers, headsets, earbuds, alarms, etc.), one or more audio input devices (e.g., microphones or microphone arrays), location devices (e.g., GPS devices in communication with a satellite-based system to receive a location of the computing device 900, as known in the art), audio codecs, video codecs, printers, sensors (e.g., thermocouples or other temperature sensors, humidity sensors, pressure sensors, vibration sensors, accelerometers, gyroscopes, etc.), image capture devices such as cameras, keyboards, cursor control devices such as a mouse, a stylus, a trackball, or a touchpad, bar code readers, Quick Response (QR) code readers, or radio frequency identification (RFID) readers, for example.

[0082] The computing device 900 may have any suitable form factor for its application and setting, such as a handheld or mobile computing device (e.g., a cell phone, a smart phone, a mobile internet device, a tablet computer, a laptop computer, a netbook computer, an ultrabook computer, a personal digital assistant (PDA), an ultra mobile personal computer, etc.), a desktop computing device, or a server computing device or other networked computing component.

[0083] One or more computing devices implementing any of the scientific instrument support modules or methods disclosed herein may be part of a scientific instrument support system. FIG. 10 is a block diagram of an example scientific instrument support system 1000 in which some or all of the scientific instrument support methods disclosed herein may be performed, in accordance with various embodiments. The scientific instrument support modules and methods disclosed herein (e.g., the scientific instrument support module 200 of FIG. 2, the method 400 of FIG. 4, and the method 800 of FIG. 8) may be implemented by one or more of the scientific instrument 1010, the user local computing device 1020, the service local computing device 1030, or the remote computing device 1040 of the scientific instrument support system 1000. The scientific instrument support system 1000 may be a system that operates within the support system 100 of FIG. 1, or may alternatively be a separate system that implements the support methods described herein. For example, the scientific instrument 1010 may be an example instrument 112, and the operations of the IPC 105 and server 115 may be separated among the user local computing device 1020, the service local computing device 1030, and the remote computing device 1040.

[0084] Any of the scientific instrument 1010, the user local computing device 1020, the service local computing device 1030, or the remote computing device 1040 may include any of the embodiments of the computing device 900 discussed herein with reference to FIG. 9, and any of the scientific instrument 1010, the user local computing device 1020, the service local computing device 1030, or the remote computing device 1040 may take the form of any appropriate ones of the embodiments of the computing device 900 discussed herein with reference to FIG. 9.

[0085] The scientific instrument 1010, the user local computing device 1020, the service local computing device 1030, or the remote computing device 1040 may each include a processing device 1002, a storage device 1004, and an interface device 1006. The processing device 1002 may take any suitable form, including the form of any of the processing devices 902 discussed herein with reference to FIG. 9, and the processing devices 1002 included in different ones of the scientific instrument 1010, the user local computing device 1020, the service local computing device 1030, or the remote computing device 1040 may take the same form or different forms. The storage device 1004 may take any suitable form, including the form of any of the storage devices 1004 discussed herein with reference to FIG. 9, and the storage devices 1004 included in different ones of the scientific instrument 1010, the user local computing device 1020, the service local computing device 1030, or the remote computing device 1040 may take the same form or different forms. The interface device 1006 may take any suitable form, including the form of any of the interface devices 906 discussed herein with reference to FIG. 9, and the interface devices 1006 included in different ones of the scientific instrument 1010, the user local computing device 1020, the service local computing device 1030, or the remote computing device 1040 may take the same form or different forms.

[0086] The scientific instrument 1010, the user local computing device 1020, the service local computing device 1030, and the remote computing device 1040 may be in communication with other elements of the scientific instrument support system 1000 via communication pathways 1008. The communication pathways 1008 may communicatively couple the interface devices 1006 of different ones of the elements of the scientific instrument support system 1000, as shown, and may be wired or wireless communication pathways (e.g., in accordance with any of the communication techniques discussed herein with reference to the interface devices 906 of the computing device 900 of FIG. 9). The particular scientific instrument support system 1000 depicted in FIG. 10 includes communication pathways between each pair of the scientific instrument 1010, the user local computing device 1020, the service local computing device 1030, and the remote computing device 1040, but this “fully connected” implementation is simply illustrative, and in various embodiments, various ones of the communication pathways 1008 may be absent. For example, in some embodiments, a service local computing device 1030 may not have a direct communication pathway 1008 between its interface device 1006 and the interface device 1006 of the scientific instrument 1010, but may instead communicate with the scientific instrument 1010 via the communication pathway 1008 between the service local computing device 1030 and the user local computing device 1020 and the communication pathway 1008 between the user local computing device 1020 and the scientific instrument 1010.

[0087] The user local computing device 1020 may be a computing device (e.g., in accordance with any of the embodiments of the computing device 900 discussed herein) that is local to a user of the scientific instrument 1010. In some embodiments, the user local computing device 1020 may also be local to the scientific instrument 1010, but this need not be the case; for example, a user local computing device 1020 that is in a user’s home or office may be remote from, but in communication with, the scientific instrument 1010 so that the user may use the user local computing device 1020 to control and/or access data from the scientific instrument 1010. In some embodiments, the

user local computing device 1020 may be a laptop, smartphone, or tablet device. In some embodiments the user local computing device 1020 may be a portable computing device. In some embodiments, the user local computing device 5020 may be an IPC 105.

[0088] The service local computing device 1030 may be a computing device (e.g., in accordance with any of the embodiments of the computing device 900 discussed herein) that is local to an entity that services the scientific instrument 1010. For example, the service local computing device 1030 may be local to a manufacturer of the scientific instrument 1010 or to a third-party service company. In some embodiments, the service local computing device 1030 may communicate with the scientific instrument 1010, the user local computing device 1020, and/or the remote computing device 1040 (e.g., via a direct communication pathway 1008 or via multiple “indirect” communication pathways 1008, as discussed above) to receive data regarding the operation of the scientific instrument 1010, the user local computing device 1020, and/or the remote computing device 1040 (e.g., the results of self-tests of the scientific instrument 1010, calibration coefficients used by the scientific instrument 1010, the measurements of sensors associated with the scientific instrument 1010, etc.). In some embodiments, the service local computing device 1030 may communicate with the scientific instrument 1010, the user local computing device 1020, and/or the remote computing device 1040 (e.g., via a direct communication pathway 1008 or via multiple “indirect” communication pathways 1008, as discussed above) to transmit data to the scientific instrument 1010, the user local computing device 1020, and/or the remote computing device 1040 (e.g., to update programmed instructions, such as firmware, in the scientific instrument 1010, to initiate the performance of test or calibration sequences in the scientific instrument 1010, to update programmed instructions, such as software, in the user local computing device 1020 or the remote computing device 1040, etc.). A user of the scientific instrument 1010 may utilize the scientific instrument 1010 or the user local computing device 1020 to communicate with the service local computing device 1030 to report a problem with the scientific instrument 1010 or the user local computing device 1020, to request a visit from a technician to improve the operation of the scientific instrument 1010, to order consumables or replacement parts associated with the scientific instrument 1010, or for other purposes.

[0089] The remote computing device 1040 may be a computing device (e.g., in accordance with any of the embodiments of the computing device 900 discussed herein) that is remote from the scientific instrument 1010 and/or from the user local computing device 1020. In some embodiments, the remote computing device 1040 may be included in a datacenter or other large-scale server environment. In some embodiments, the remote computing device 1040 may include network-attached storage (e.g., as part of the storage device 1004). The remote computing device 1040 may store data generated by the scientific instrument 1010, perform analyses of the data generated by the scientific instrument 1010 (e.g., in accordance with programmed instructions), facilitate communication between the user local computing device 1020 and the scientific instrument 1010, and/or facilitate communication between the service local computing device 1030 and the scientific instrument 1010. The remote computing device may be the

server 115. In some embodiments, operations of the server 115 are split between the remote computing device 1040 and the service local computing device 1030.

[0090] In some embodiments, one or more of the elements of the scientific instrument support system 1000 illustrated in FIG. 10 may not be present. Further, in some embodiments, multiple ones of various ones of the elements of the scientific instrument support system 1000 of FIG. 10 may be present. For example, a scientific instrument support system 1000 may include multiple user local computing devices 1020 (e.g., different user local computing devices 1020 associated with different users or in different locations). In another example, a scientific instrument support system 1000 may include multiple scientific instruments 1010, all in communication with service local computing device 1030 and/or a remote computing device 1040; in such an embodiment, the service local computing device 1030 may monitor these multiple scientific instruments 1010, and the service local computing device 1030 may cause updates or other information may be "broadcast" to multiple scientific instruments 1010 at the same time. Different ones of the scientific instruments 1010 in a scientific instrument support system 1000 may be located close to one another (e.g., in the same room) or farther from one another (e.g., on different floors of a building, in different buildings, in different cities, etc.). In some embodiments, a scientific instrument 1010 may be connected to an Internet-of-Things (IoT) stack that allows for command and control of the scientific instrument 1010 through a web-based application, a virtual or augmented reality application, a mobile application, and/or a desktop application. Any of these applications may be accessed by a user operating the user local computing device 1020 in communication with the scientific instrument 1010 by the intervening remote computing device 1040. In some embodiments, a scientific instrument 1010 may be sold by the manufacturer along with one or more associated user local computing devices 1020 as part of a local scientific instrument computing unit 1012.

[0091] In some embodiments, different ones of the scientific instruments 1010 included in a scientific instrument support system 1000 may be different types of scientific instruments 1010; for example, one scientific instrument 1010 may be a spectrometer, while another scientific instrument 1010 may be an interferometer. In some such embodiments, the remote computing device 1040 and/or the user local computing device 1020 may combine data from different types of scientific instruments 1010 included in a scientific instrument support system 1000.

[0092] The following paragraphs provide various examples of the embodiments disclosed herein.

[0093] Example 1 is a scientific instrument support apparatus, comprising: first logic to generate a first command frame including a flag having a first value, wherein the first value indicates that a first device should ignore an operation indicated by the first command frame; second logic to transmit the first command frame to the first device; third logic to determine whether a confirmation signal indicating a successful operation is received; and fourth logic to generate, when the confirmation signal is received, a second command frame including the flag having a second value, wherein the second value indicates that the first device should perform an operation indicated by the second command frame.

[0094] Example 2 may include the subject matter of Example 1, and may further specify that the first logic, the second logic, the third logic, and the fourth logic are implemented by a common computing device.

[0095] Example 3 may include the subject matter of any of Examples 1 to 2, and may further specify that at least one of the first logic, the second logic, and the third logic are implemented by a computing device remote from a scientific instrument.

[0096] Example 4 may include the subject matter of any of Examples 1 to 3, and may further specify that the scientific instrument support apparatus further includes fifth logic to indicate a system error when the confirmation signal is not received.

[0097] Example 5 may include the subject matter of any of Examples 1 to 4, and may further specify that the first command includes an address associated with the first device.

[0098] Example 6 may include the subject matter of any of Examples 1 to 4, and may further specify that the first command includes a sequence of addresses associated with a plurality of devices to perform the operation, and may further specify that the plurality of devices includes the first device.

[0099] Example 7 may include the subject matter of any of Examples 1 to 6, and may further specify that the second command frame includes instructions for performing the operation indicated by the first command frame.

[0100] Example 8 may include the subject matter of any of Examples 1 to 7, and may further specify that the confirmation signal includes a dummy response indicative of whether the first device is capable of performing the operation.

[0101] Example 9 is a method for scientific instrument support, comprising: generating a first command frame including a flag having a first value, wherein the first value indicates that a first device should ignore an operation indicated by the first command frame; transmitting the first command frame to the first device; determining whether a confirmation signal indicating a successful operation is received; and generating a second command frame including the flag having a second value when the confirmation signal is received, wherein the second value indicates that the first device should perform an operation indicated by the second command frame.

[0102] Example 10 may include the subject matter of Example 9, and may further specify that the first command frame includes an address indicating the first device.

[0103] Example 11 may include the subject matter of any of Examples 9 to 10, and may further specify that the first command frame includes a sequence of addresses indicating a plurality of devices that each perform a respective portion of the operation indicated by the first command frame.

[0104] Example 12 may include the subject matter of Example 11, may further specify that the first device performs a first portion of the operation, and may further specify that the method includes transmitting the first command frame from the first device to a second device configured to perform a second portion of the operation.

[0105] Example 13 may include the subject matter of Example 12, and may further specify that the method includes generating, with the second device, the confirmation signal.

[0106] Example 14 may include the subject matter of any of Examples 12 to 13, and may further specify that the method includes determining an address of the second device based on a table stored in a memory of the first device.

[0107] Example 15 may include the subject matter of any of Examples 9 to 14, may further specify that the second command frame includes instructions for performing the operation indicated by the first command frame, and may further specify that the method includes performing, in response to the flag having the second value, the operation with the first device.

[0108] Example 16 may include the subject matter of any of Examples 9 to 15, and may further specify that the confirmation signal includes a dummy response indicative of whether the first device is capable of performing the operation.

[0109] Example 17 may include the subject matter of any of Examples 9 to 16, may further specify that the first device is included in a plurality of components within a support system, and may further specify that the method includes determining a status of the plurality of components, and generating, on a display device, a first view providing a status chart indicating the status of each of the plurality of components, the status chart including a plurality of representative elements, each representative element representative of one component of the plurality of components.

[0110] Example 18 may include the subject matter of Example 17, and may further specify that the method includes receiving a selection of one of the representative elements, and generating, on the display device, a status window including a description of the status of the one component associated with the selected representative element.

[0111] Example 19 may include the subject matter of any of Examples 17 to 18, and may further specify that the method includes updating a first representative element of the plurality of representative elements associated with the first device based on the confirmation signal.

[0112] Example 20 is one or more non-transitory computer readable media having instructions thereon that, when executed by one or more processing devices of a scientific instrument support apparatus, cause the scientific instrument support apparatus to perform the method of any of Examples 9 to 19.

[0113] Example 21 is a method for scientific instrument support, comprising: determining a status of a plurality of components within a support system; generating, on a display device, a first view providing a status chart indicating the status of each of the plurality of components, the status chart including a plurality of representative elements, each representative element representative of one component of the plurality of components; receiving a selection of one of the representative elements; and generating, on the display device, a status window including a description of the status of the one component associated with the selected representative element.

[0114] Example 22 is a scientific instrument support apparatus comprising: status logic configured to collect status information for each of a plurality of service components within a scientific instrument support system; and monitoring

logic configured to: provide the status information for each of the plurality of service components to a graphical user interface, the graphical user interface including a status chart including a plurality of visual indicators, each of the visual indicators indicating a status of one of the plurality of service components within the scientific instrument support system, wherein each of the plurality of visual indicators includes a respective selectable graphical element, and in response to receiving an input selecting the selectable graphical element associated with one of the plurality of visual indicators, provide a status window including additional status information regarding the one of the plurality of service components.

Claims:

1. A scientific instrument support apparatus, comprising:
first logic to generate a first command frame including a flag having a first value, wherein the first value indicates that a first device should ignore an operation indicated by the first command frame;
second logic to transmit the first command frame to the first device;
third logic to determine whether a confirmation signal indicating a successful operation is received; and
fourth logic to generate, when the confirmation signal is received, a second command frame including the flag having a second value, wherein the second value indicates that the first device should perform an operation indicated by the second command frame.
2. The scientific instrument support apparatus of claim 1, wherein the first logic, the second logic, the third logic, and the fourth logic are implemented by a common computing device.
3. The scientific instrument support apparatus of claim 1, wherein at least one of the first logic, the second logic, and the third logic are implemented by a computing device remote from a scientific instrument.
4. The scientific instrument support apparatus of claim 1, further comprising:
fifth logic to indicate a system error when the confirmation signal is not received.
5. The scientific instrument support apparatus of claim 1, wherein the first command includes an address associated with the first device.
6. The scientific instrument support apparatus of claim 1 wherein the first command includes a sequence of addresses associated with a plurality of devices to perform the operation, wherein the plurality of devices includes the first device.
7. The scientific instrument support apparatus of claim 1, wherein the second command frame includes instructions for performing the operation indicated by the first command frame.
8. The scientific instrument support apparatus of claim 1, wherein the confirmation signal includes a dummy response indicative of whether the first device is capable of performing the operation.
9. A method for scientific instrument support, comprising:

generating a first command frame including a flag having a first value, wherein the first value indicates that a first device should ignore an operation indicated by the first command frame;

transmitting the first command frame to the first device;

determining whether a confirmation signal indicating a successful operation is received; and

generating a second command frame including the flag having a second value when the confirmation signal is received, wherein the second value indicates that the first device should perform an operation indicated by the second command frame.

10. The method of claim 9, wherein the first command frame includes an address indicating the first device.

11. The method of claim 9, wherein the first command frame includes a sequence of addresses indicating a plurality of devices that each perform a respective portion of the operation indicated by the first command frame.

12. The method of claim 11, wherein the first device performs a first portion of the operation, the method further comprising:

transmitting the first command frame from the first device to a second device configured to perform a second portion of the operation.

13. The method of claim 12, further comprising:

generating, with the second device, the confirmation signal.

14. The method of claim 12, further comprising:

determining an address of the second device based on a table stored in a memory of the first device.

15. The method of claim 9, wherein the second command frame includes instructions for performing the operation indicated by the first command frame, the method further comprising:

performing, in response to the flag having the second value, the operation with the first device.

16. The method of claim 9, wherein the confirmation signal includes a dummy response indicative of whether the first device is capable of performing the operation.

17. The method of claim 9, wherein the first device is included in a plurality of components within a support system, and wherein the method further comprises:

determining a status of the plurality of components; and

generating, on a display device, a first view providing a status chart indicating the status of each of the plurality of components, the status chart including a plurality of representative elements, each representative element representative of one component of the plurality of components.

18. The method of claim 17, further comprising:
receiving a selection of one of the representative elements; and
generating, on the display device, a status window including a description of the status of the one component associated with the selected representative element.

19. The method of claim 17, further comprising:
updating a first representative element of the plurality of representative elements associated with the first device based on the confirmation signal.

20. One or more non-transitory computer readable media having instructions thereon that, when executed by one or more processing devices of a scientific instrument support apparatus, cause the scientific instrument support apparatus to perform the method of any of claims 9-19.

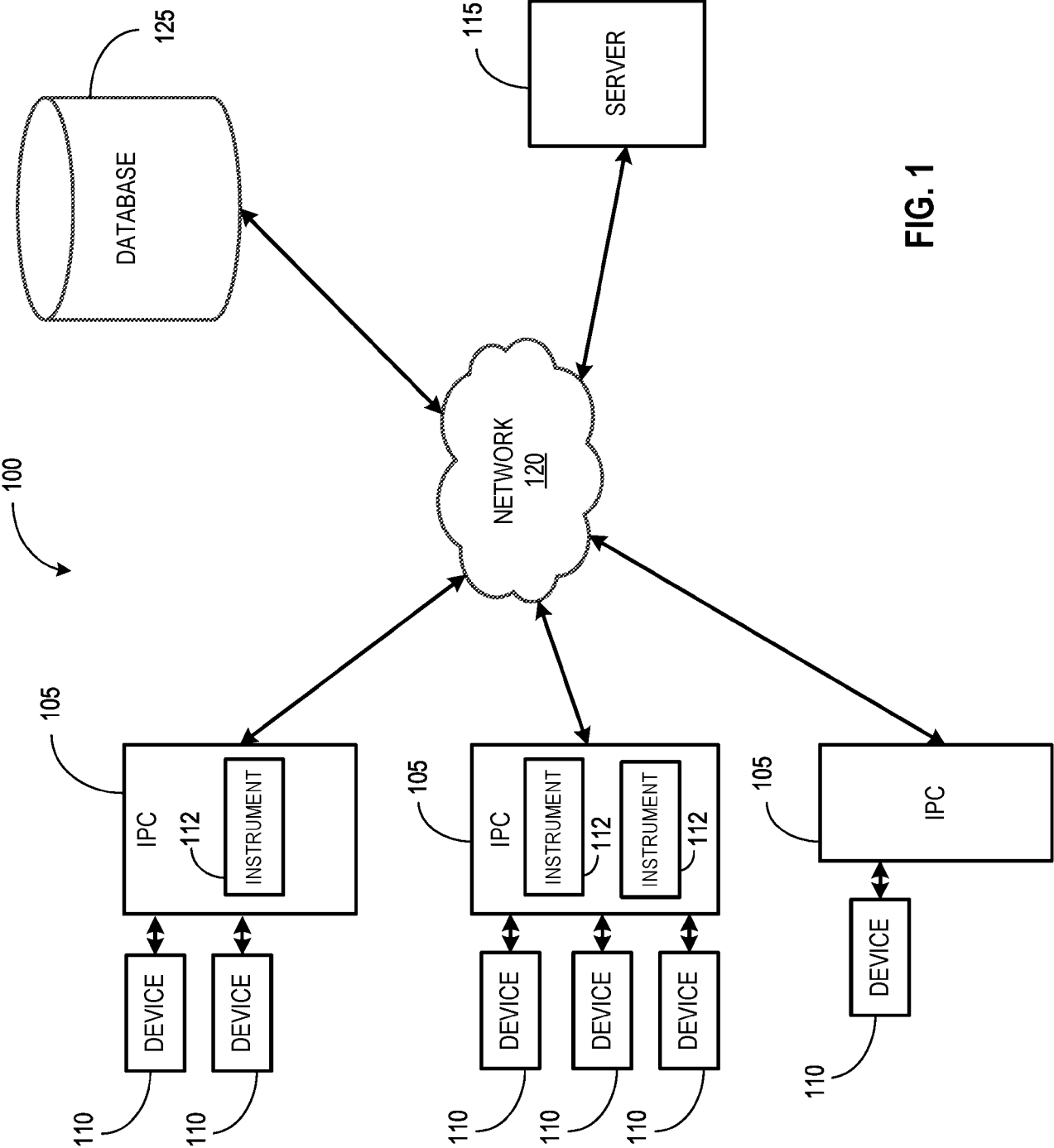


FIG. 1

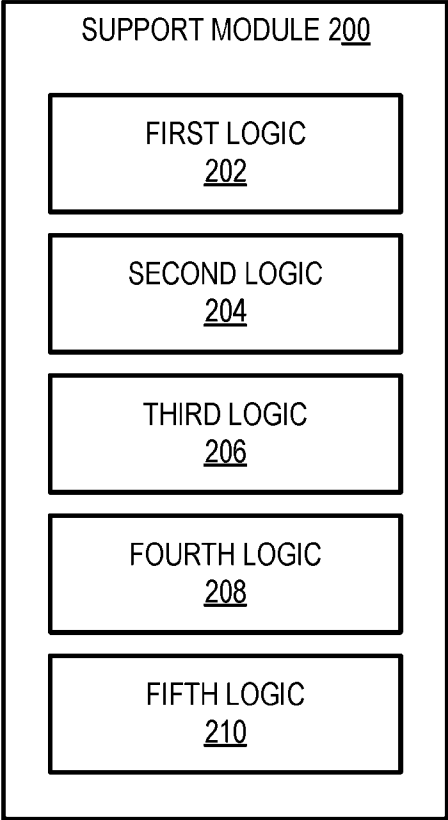


FIG. 2

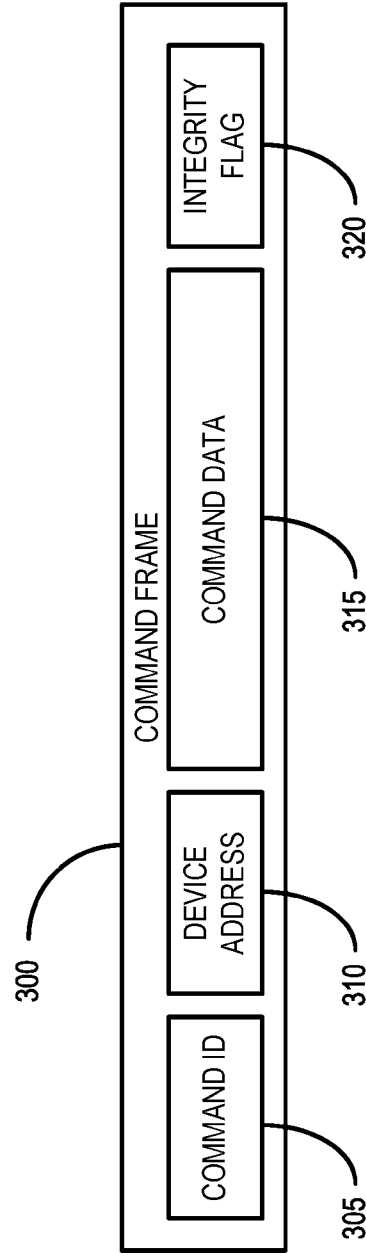


FIG. 3

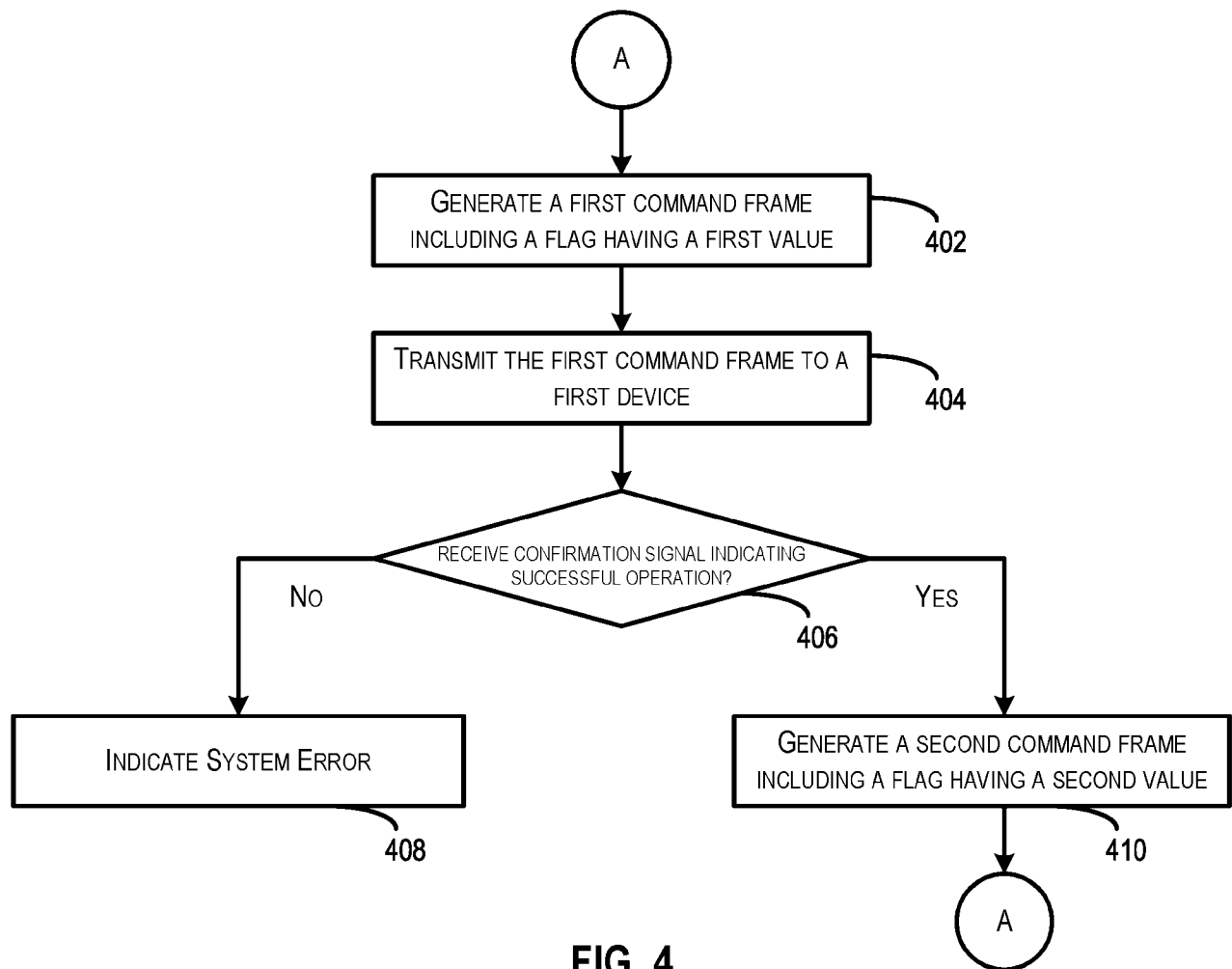


FIG. 4

500

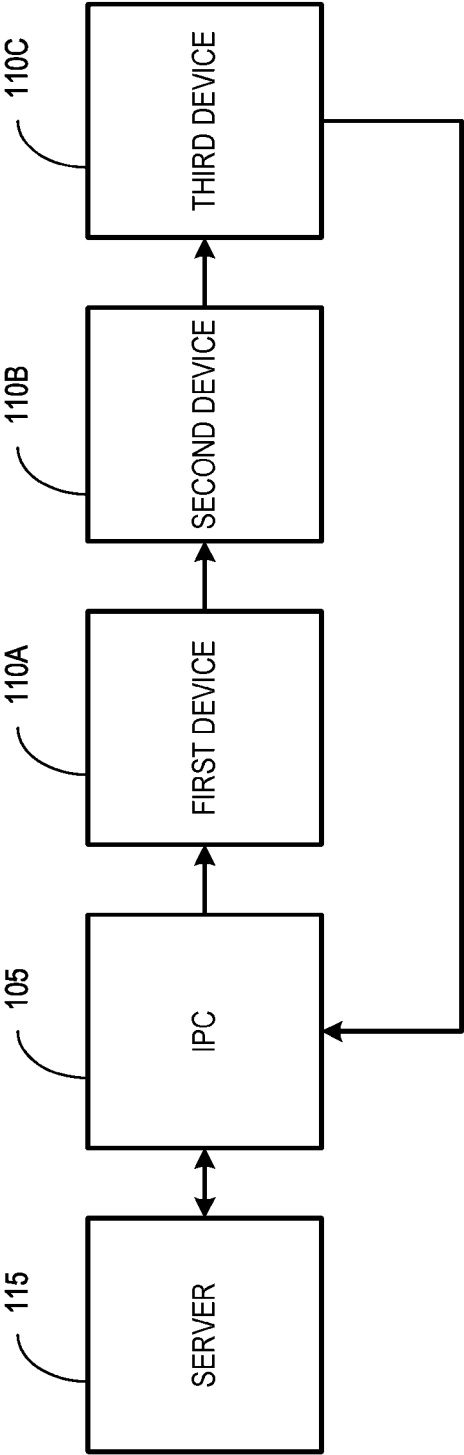


FIG. 5A

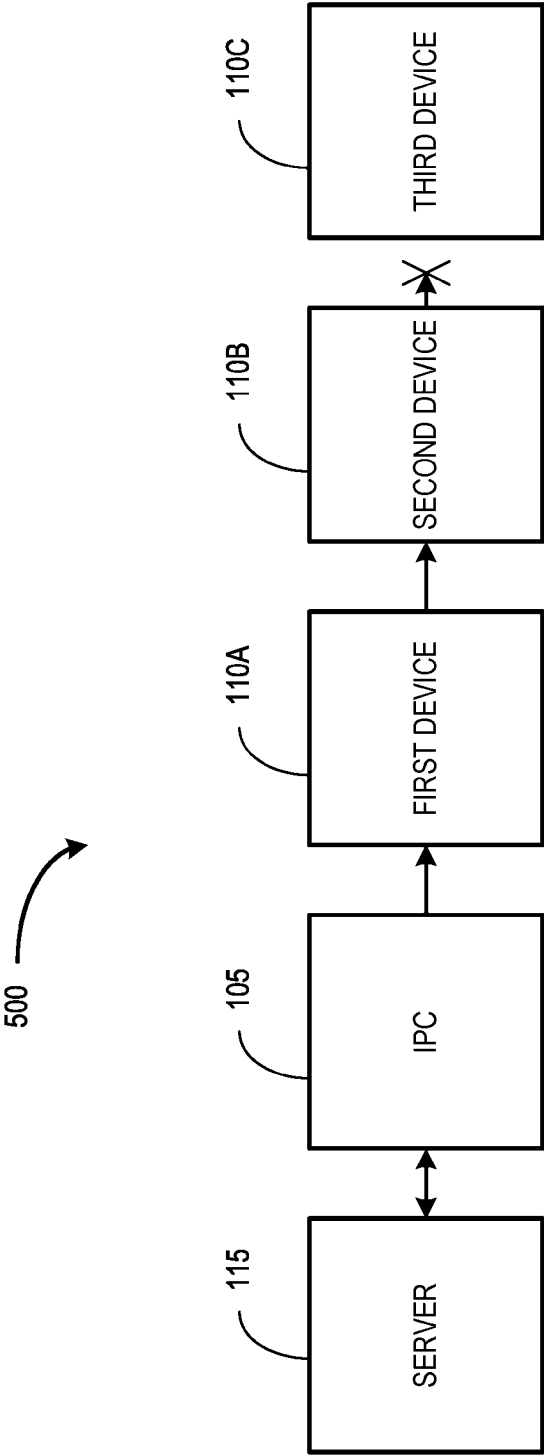


FIG. 5B

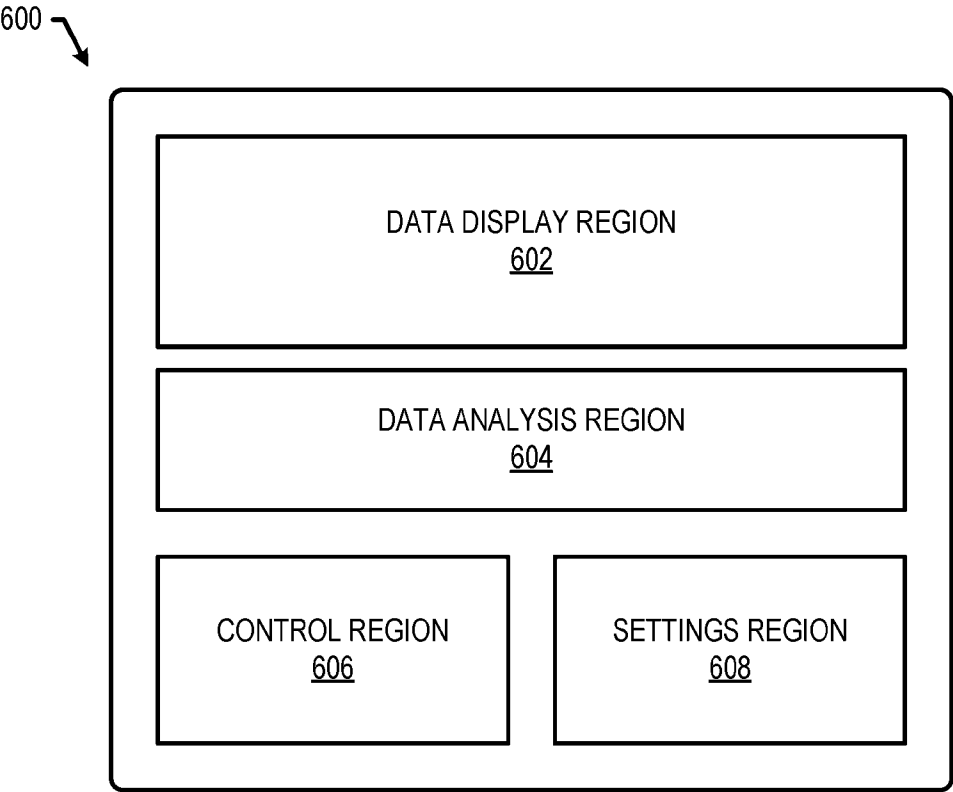


FIG. 6

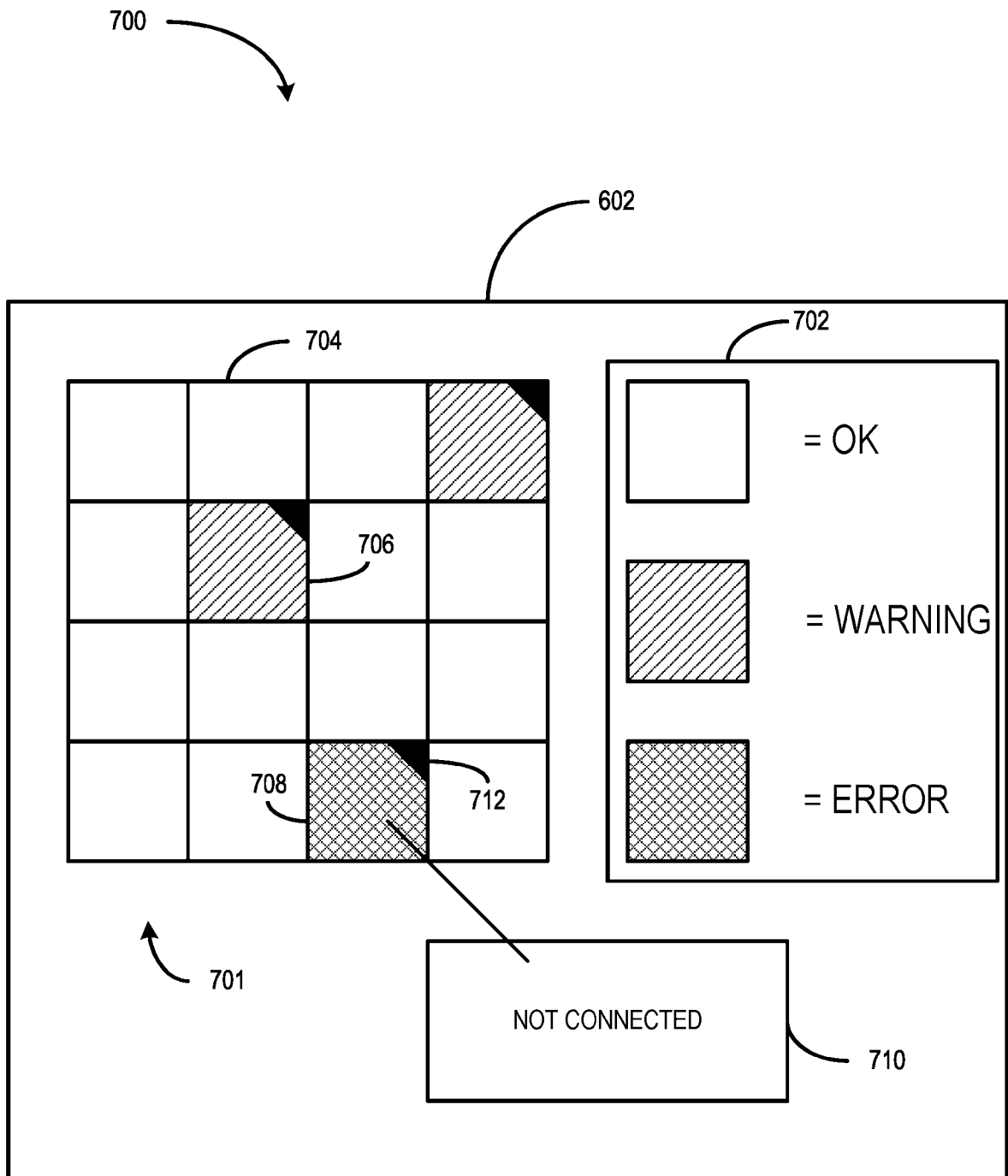
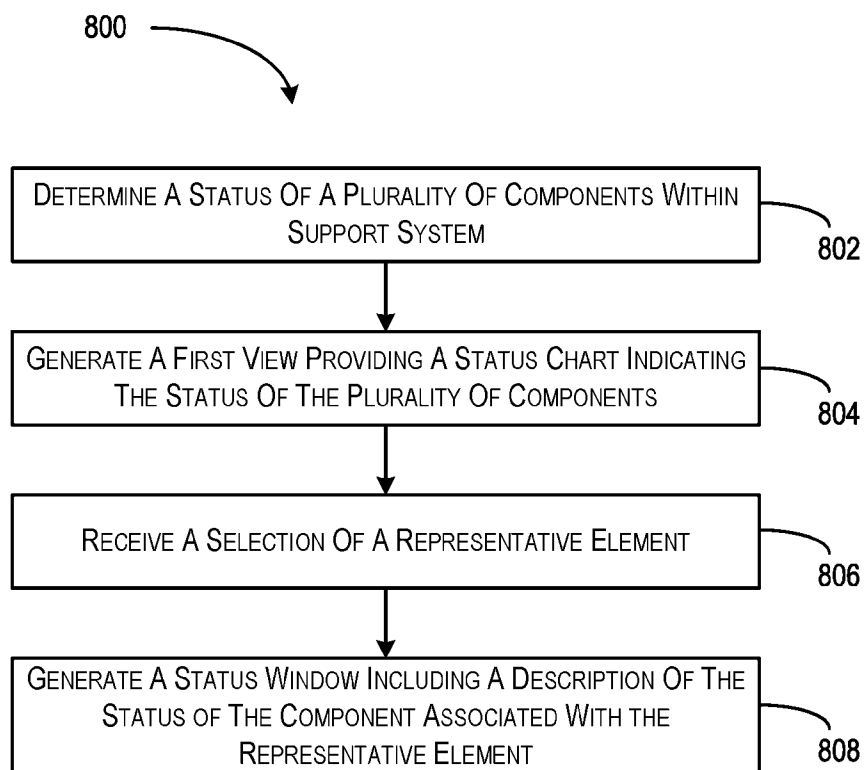


FIG. 7

**FIG. 8**

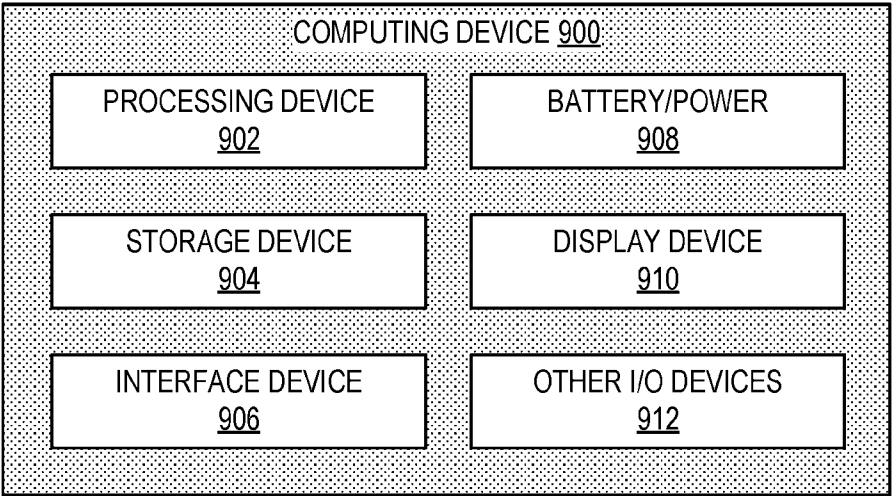


FIG. 9

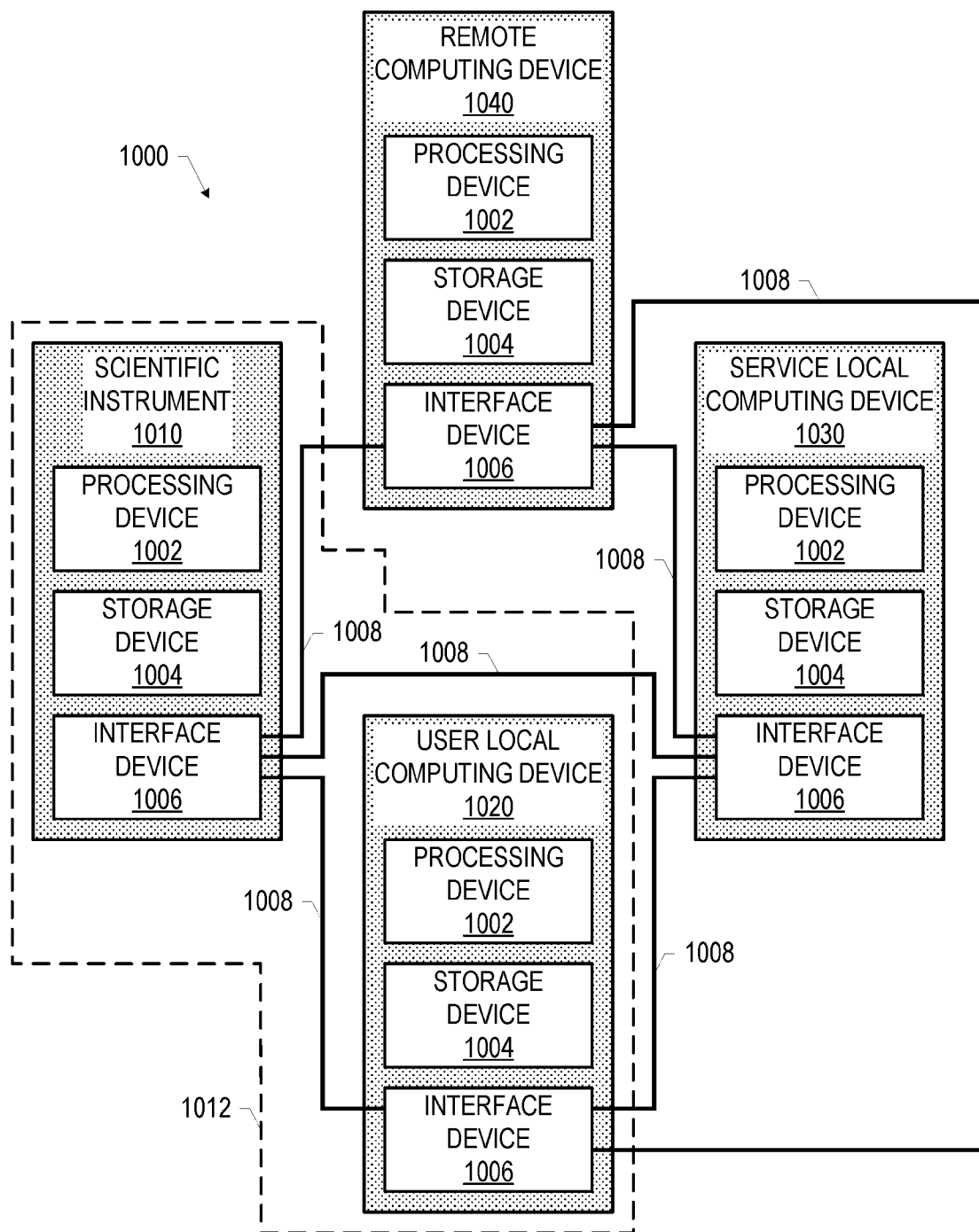


FIG. 10