(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 October 2013 (03.10.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/142991 A1

(51) International Patent Classification:
H04L 12/24 (2006.01)

(21) International Application Number:
PCT/CA2013/050229

(22) International Filing Date:
21 March 2013 (21.03.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
13/431,689 27 March 2012 (27.03.2012) 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, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, 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, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

[Continued on next page]

(54) Title: MANAGING CAPACITY ON DEMAND IN A SERVER CLOUD

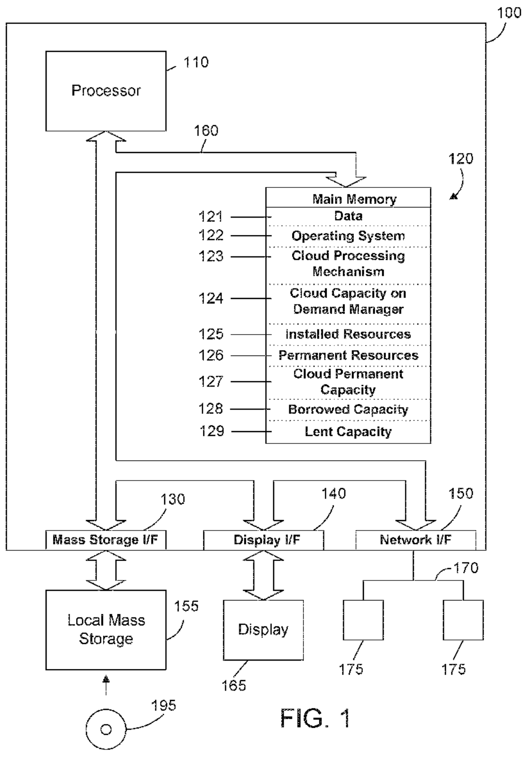


FIG. 1

(57) Abstract: A cloud capacity on demand manager manages capacity on demand for servers in a server cloud. The cloud capacity on demand manager may borrow capacity from one or more servers and lend the capacity borrowed from one server to a different server in the server cloud. When the server cloud is no longer intact, capacity borrowed from servers no longer in the server cloud is disabled, and servers no longer in the server cloud reclaim capacity that was lent to the server cloud.

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

MANAGING CAPACITY ON DEMAND IN A SERVER CLOUD

BACKGROUND

[0001] 1. Technical Field

[0002] This disclosure generally relates to computer systems, and more specifically relates to managing capacity on demand with multiple servers in a server cloud.

[0003] 2. Background Art

[0004] One problem with computer systems today is balancing the cost of the computer hardware with fluctuating demands on computer resources. In most networked computer systems, there are times when the computing demands are relatively low, and other times when the computing demands are very high. If a company purchases a computer system that is capable of meeting peak demand, much of the capacity of the computer system will go unused during non-peak times. In addition, purchasing capacity to meet peak demand is costly. If a company purchases a computer system that is capable of meeting average demand, the cost is lower, but the performance of the computer system suffers during peak times.

[0005] One way to provide a more flexible solution allows a computer user to buy a computer system that has some resources installed, but initially disabled. When the customer determines that more capacity is needed, the customer may enter into an arrangement with the provider of the computer system to enable certain resources for a fixed period of time. This works out particularly well for companies that have seasonal peaks. The companies can purchase a computer system at a reasonable cost that has the capability of providing enhanced computing power during the peak season. The ability to purchase additional capacity when needed is known as Capacity On Demand.

[0006] A simple example will illustrate. Let’s assume that a company that sells goods via catalog sales experiences peak demand in November and December of each year due to holiday shopping. The company could purchase a computer system that has one or more additional processors that are installed but initially disabled. The company may then contract with the provider of the computer system to enable the additional processor(s) for a set period of time. Let's assume that the computer system has two additional processors, and let's assume that the peak buying period runs for the thirty day period from November 15th to December 14th. The customer could purchase sixty processor-days of additional capacity beginning on November 15th. These two additional processors will then be enabled for the thirty day period (providing the sixty processor-days of additional capacity). Once the sixty processor-days have elapsed, the two additional processors are disabled.

[0007] Sever clouds allow different server computer systems to work together. Each server may have additional resources (such as processors, memory, etc.) that are installed but not enabled, but may be enabled as needed on a Capacity On Demand basis. However, even though the servers in a cloud may communicate and cooperate in processing a job, the Capacity On Demand capabilities of each server are separate and distinct from all other servers. Thus, if a server has a compute-intensive job to process and needs additional processor capacity, it does so in a manner based on its own available processor capacity, without regard to the other servers in the server cloud.

BRIEF SUMMARY

[0008] A cloud capacity on demand manager manages capacity on demand for servers in a server cloud. The cloud capacity on demand manager may borrow capacity from one or more servers and lends the capacity borrowed from one server to a different server in the server cloud. When the server cloud is no longer intact, capacity borrowed from servers no longer in the server cloud is disabled, and servers no longer in the server cloud reclaim capacity that was lent to the server cloud.

[0009] The foregoing and other features and advantages will be apparent from the following more particular description, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

[0010] The disclosure will be described in conjunction with the appended drawings, where like designations denote like elements, and:

[0011] FIG. 1 is a block diagram of an apparatus that includes a cloud capacity on demand manager;

[0012] FIG. 2 is a block diagram of an example prior art server cloud system that includes four servers that each have a capacity on demand manager;

[0013] FIG. 3 is a block diagram of a server cloud system that includes a cloud capacity on demand manager;

[0014] FIG. 4 is a block diagram of the server cloud system in FIG. 3 showing capacity shared between servers in the server cloud;

[0015] FIG. 5 is a flow diagram of a method for sharing capacity between servers in a server cloud;

[0016] FIG. 6 is a block diagram of a server cloud system that includes cloud permanent processors;

[0017] FIG. 7 is a block diagram of the server cloud system shown in FIG. 6 showing capacity shared between servers in the server cloud;

[0018] FIG. 8 is a block diagram of a server cloud system that includes the cloud capacity on demand manager in a hardware management console;

[0019] FIG. 9 is a block diagram of one implementation for the cloud capacity on demand manager; and

[0020] FIG. 10 is a block diagram showing a sample cloud resource table that could be a specific implementation for the borrowed capacity and lent capacity shown in FIG. 9.

DETAILED DESCRIPTION

[0021] The claims and disclosure herein provide a cloud capacity on demand manager that manages capacity on demand for servers in a server cloud. The cloud capacity on demand manager may borrow capacity from one or more servers and lend the capacity borrowed from one server to a different server in the server cloud. When the server cloud is no longer intact, capacity borrowed from servers no longer in the server cloud is disabled, and servers no longer in the server cloud reclaim capacity that was lent to the server cloud.

[0022] Referring to FIG. 1, a computer system 100 is one suitable implementation of a server computer system that includes a cloud capacity on demand manager. Server computer system 100 is an IBM eServer System x computer system. However, those skilled in the art will appreciate that the disclosure herein applies equally to any computer system, regardless of whether the computer system is a complicated multi-user computing apparatus, a single user workstation, or an embedded control system. As shown in FIG. 1, computer system 100 comprises one or more processors 110, a main memory 120, a mass storage interface 130, a display interface 140, and a network interface 150. These system components are interconnected through the use of a system bus 160. Mass storage interface 130 is used to connect mass storage devices, such as local mass storage device 155, to computer system 100. One specific type of local mass storage device 155 is a readable and writable CD-RW drive, which may store data to and read data from a CD-RW 195.

[0023] Main memory 120 preferably contains data 121, an operating system 122, a cloud processing mechanism 123, a cloud capacity on demand manager 124, installed resources 125, permanent resources 126, cloud permanent resources 127, borrowed resources 128, and lent resources 129. Data 121 represents any data that serves as input to or output from any program in computer system 100. Operating system 122 is a multitasking operating system. Cloud processing mechanism 123 is software that supports cooperation between server 100 and other servers in a server cloud. Cloud capacity on demand manager 124 manages capacity on demand for servers in a server cloud, and may borrow capacity from one server and lend that capacity to a different server. Installed resources 125 include resources installed in the server 100, whether enabled for use or not. Permanent resources 126 include resources permanently enabled on the server 100. Cloud permanent capacity 127 includes capacity for resources permanently enabled to any server in a server cloud of which server 100 is a member. Borrowed capacity 128 includes capacity for resources borrowed from other servers in a server cloud by server 100. Lent capacity 129 includes capacity for resources lent by server 100 to other servers in a server cloud. By borrowing capacity from other servers in a server cloud, the cloud capacity on demand manager 124 provides greater flexibility and lower cost for operating with additional resources in a server cloud.

[0024] Computer system 100 utilizes well known virtual addressing mechanisms that allow the programs of computer system 100 to behave as if they only have access to a large, contiguous address space instead of access to multiple, smaller storage entities such as main memory 120 and local mass storage device 155. Therefore, while data 121, operating system 122, cloud processing mechanism 123, cloud capacity on demand manager 124, installed resources 125, permanent resources 126, cloud permanent capacity 127, borrowed capacity 128, and lent capacity 129 are shown to reside in main memory 120, those skilled in the art will recognize that these items are not necessarily all completely contained in main memory 120 at the same time. It should also be noted that the term "memory" is used herein generically to refer to the entire virtual memory of computer system 100, and may include the virtual memory of other computer systems coupled to computer system 100.

[0025] Processor 110 may be constructed from one or more microprocessors and/or integrated circuits. Processor 110 executes program instructions stored in main memory 120. Main memory 120 stores programs and data that processor 110 may access. When computer system 100 starts up, processor 110 initially executes the program instructions that make up operating system 122. Processor 110 also executes the cloud capacity on demand manager 124.

[0026] Although computer system 100 is shown to contain only a single processor and a single system bus, those skilled in the art will appreciate that a cloud capacity on demand manager may be practiced using a computer system that has multiple processors and/or multiple buses. In addition, the interfaces that are used preferably each include separate, fully programmed microprocessors that are used to off-load compute-intensive processing from processor 110. However, those skilled in the art will appreciate that these functions may be performed using I/O adapters as well.

[0027] Display interface 140 is used to directly connect one or more displays 165 to computer system 100. These displays 165, which may be non-intelligent (*i.e.*, dumb) terminals or fully programmable workstations, are used to provide system administrators and users the ability to communicate with computer system 100. Note, however, that while display interface 140 is provided to support communication with one or more displays 165, computer system 100 does not necessarily require a display 165, because all needed interaction with users and other processes may occur via network interface 150.

[0028] Network interface 150 is used to connect computer system 100 to other computer systems or workstations 175 via network 170. Network interface 150 broadly represents any suitable way to interconnect electronic devices, regardless of whether the network 170 comprises present-day analog and/or digital techniques or via some networking mechanism of the future. Network interface 150 preferably includes a combination of hardware and software that allow communicating on the network 170. Software in the network interface 150 preferably includes a communication manager that manages communication with other computer systems 175 via network 170 using a suitable network protocol. Many different network protocols can be used to implement a network. These protocols are specialized computer programs that allow computers to communicate across a network. TCP/IP (Transmission Control Protocol/Internet Protocol) is an example of a suitable network protocol that may be used by the communication manager within the network interface 150.

[0029] As will be appreciated by one skilled in the art, aspects of the present invention may be embodied as a system, method or computer program product. Accordingly, aspects of the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a “circuit,” “module” or “system.” Furthermore, aspects of the present invention may take the form of a computer program product embodied in one or more computer readable medium(s) having computer readable program code embodied thereon.

[0030] Any combination of one or more computer readable medium(s) may be utilized. The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

[0031] A computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electro-magnetic, optical, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device.

[0032] Program code embodied on a computer readable medium may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

[0033] Computer program code for carrying out operations for aspects of the present invention may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like and conventional procedural programming languages, such as the "C" programming language, Streams Processing language, or similar programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

[0034] Aspects of the present invention are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0035] These computer program instructions may also be stored in a computer readable medium that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the computer readable medium produce an article of manufacture including instructions which implement the function/act specified in the flowchart and/or block diagram block or blocks.

[0036] The computer program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0037] The methods disclosed herein may be performed as part of providing a web-based service. Such a service could include, for example, offering the method to online users in exchange for payment.

[0038] Referring to FIG. 2, a sample prior art configuration of servers in a server cloud is shown as server cloud system 200. Server cloud system 200 includes four servers 210A-210D all interconnected via some networking mechanism in a server cloud 230. Each server includes installed processors and permanent processors, where the installed processors specifies the number of processors physically installed on the server and the number of permanent processors specifies the number of processors permanently enabled on the server. For the specific example in FIG. 2, each server includes eight installed processors and two permanent processors, as shown at 225A-225D and 226A-226D. In the prior art server cloud system 200, each server includes its own capacity on demand manager 232A-232D that may increase the capacity of each server by known methods for providing capacity on demand. However, the capacity on demand manager for each server is handled independently from capacity on other servers in the server cloud 230. Thus, the function of each capacity on demand server 232A-232D is no different when the server is part of the server cloud 230 than when the server is not part of the server cloud 230.

[0039] FIG. 3 shows a server cloud system 300 similar in some respects to the prior art server cloud system 200. Server cloud system 300 includes four servers 310A-310D interconnected via some networking mechanism in a server cloud 330. Servers 310A-310D could each be a server computer system 100 as shown in FIG. 1. Each server includes eight installed processors 325A-325D and two permanent processors 326A-326D. However, server 310A additionally includes a cloud capacity on demand manager 124 that manages capacity on demand for the servers in the server cloud, and can borrow capacity from one server to be lent to another server when needed. Because each server 310A-310D may both borrow capacity and lend capacity, each server tracks borrowed processors 328A-328D and lent processors 329A-329D. While 328A-328D are shown as “borrowed processors” in FIG. 3, it is actually the capacity for the processors that is borrowed. Similarly, while 329A-329D are shown as “lent processors” in FIG. 3, it is actually the capacity for the processors that is lent. The configuration shown in FIG. 3 assumes each server can handle its own processing load with its two permanent processors.

[0040] Now turning to FIG. 4, we assume for this example that server 310D has need for additional processor capacity due to an increased processing load, and we further assume server 310D needs capacity for three additional processors in addition to the two permanent processors 326D already enabled. In the prior art, a capacity on demand manager on server 310D could enable three more of the installed processors, resulting in a total of five permanent processors on server

310D. However, the cloud capacity on demand manager 124 recognizes that there may be unused capacity in the server cloud that could be temporarily borrowed from one or more servers in the server cloud and lent to server 310D. For the specific example in FIG. 4, we assume that each of servers 310A, 310B and 310C can process their workloads using one of the two permanent processors on each server, which means each has capacity of one processor that could be lent to the server 310D that needs additional capacity. Thus, the cloud capacity on demand manager 124 reduces the number of permanent processors from two to one as shown at 326A-326C in FIG. 4, and increases the number of lent processors from zero to one as shown at 329A-329C in FIG. 4. The cloud capacity on demand manager may then lend the capacity of these lent processors 329A-329C to server 310D, as shown by the dotted lines with arrows providing three borrowed processors 328D in FIG. 4. Note that what is lent and borrowed in FIG. 4 is processor capacity. Thus, the total number of processors enabled in the server cloud system 300 shown in FIG. 3 is two permanent processors 326A-326B on each of the four servers, for a total of eight enabled processors. The total number of processors enabled in the serer cloud system 300 shown in FIG. 3 is still eight, one permanent processor 326A-326C from each of three servers, two permanent processors 326D on server 310D, and three borrowed processors 328D on server 310D. The ability of the cloud capacity on demand manager to borrow capacity from one server and lend that capacity to a different server in the server cloud provides a system that is incredibly flexible and will allow a customer to utilize unused capacity on servers instead of purchasing additional capacity for a particular server. The result is a system that uses total capacity in the server cloud more efficiently and in a more cost-effective manner.

[0041] Referring to FIG. 5, a method 500 begins when a server cloud is established (step 510). When the server cloud is intact (step 520=YES), when a server in the server cloud needs additional capacity (step 530=YES), and when one or more other servers in the server cloud have capacity to lend (step 540=YES), one or more other servers lend capacity (step 550), and the server uses the borrowed capacity (step 560). When no server in the server cloud needs additional capacity (step 530=NO), method 500 loops back to step 520 and continues. Similarly, when no other server has capacity to lend (step 540=NO), method 500 loops back to step 520 and continues. Method 500 may continue until the server cloud is no longer intact (step 520=NO), at which point the borrowed capacity is disabled (step 570), and the lent capacity is reclaimed (step 580). Note that steps 570 and 580 may function in two different manners. In a first implementation, when the server cloud is no longer intact (step 520=NO) due to one server no longer being a member of the server cloud, the borrowed capacity on all servers in the server cloud is disabled in step 570 and the lent capacity on all servers in the server cloud is reclaimed. In a second implementation, when the server cloud is no longer intact (step 520=NO) due to one server (lost server) no longer being a member of the server cloud, the borrowed capacity for the lost server is disabled in step 570 in any server that is still in the server cloud that had borrowed capacity from the lost server, and the lost server reclaims the lent capacity in step 580 when it detects it is no longer a member of the server cloud. The first implementation is an all-or-nothing approach, where the loss of any server in the server cloud causes all borrowed capacity to be disabled and all lent capacity to be reclaimed. The second implementation selectively disables borrowed capacity from the lost server and reclaims lent capacity on the lost server, while allowing the remainder of servers in the server cloud to function with borrowed and lent capacity that is not affected by the loss of the lost server.

[0042] In step 520, the determination of whether the server cloud is intact may be made in any suitable way. For example, in one specific implementation, a token is circulated between the servers in the server cloud to maintain the server cloud. If a server does not send its token within a defined period of time, it is assumed the server is no longer functioning properly, which means the server cloud is no longer intact. In an alternative implementation, the cloud capacity on demand manager may log the members of the server cloud, and may periodically interrogate each server in the server cloud. If each server responds with an appropriate response, the cloud capacity on demand manager knows the server cloud is still intact. If one of the servers does not respond, the cloud capacity on demand manager knows the server that did not respond is not functioning properly, and is therefore no longer in the server cloud. The cloud capacity on demand manager may then take action as discussed above to disable borrowed capacity and reclaim lent capacity. The disclosure and claims herein extend to any suitable method for determining whether a server cloud is intact, whether currently known or developed in the future.

[0043] Because the cloud capacity on demand manager 124 may manage capacity across servers in a server cloud, this gives rise to a new concept shown in FIG. 6. Server cloud system 600 includes four servers 610A-610D with the same installed processors 325A-325D, permanent processors 326A-326D, borrowed processors 328A-328D, and lent processors 329A-329D. Servers 610A-610D could each be a server computer system 100 as shown in FIG. 1. In addition, a new concept referred to herein as "cloud permanent processors" is introduced to represent capacity on a server that is permanently enabled and that may be used by any server in the server cloud. For the specific example in FIG. 6, each server 610A-610D includes two cloud permanent processors 627A-627D. These capacity for these cloud permanent processors could be used by any server in the server cloud 630, including the server on which the cloud permanent processors reside.

[0044] Referring to FIG. 7, we assume the same conditions in FIG. 4 that prompted the borrowing and lending of capacity, namely, server 610D needs three capacity for three more processors. The server 610D may use the two cloud permanent processors 627D, and may borrow the third needed processor from server 610C, as shown by the dotted lines with arrows in FIG. 7. Note the one lent processor 329C on server 610C reduces the number of cloud permanent processors 627C from two to one. By defining this new feature called cloud permanent processors, the cloud capacity on demand manager may have more flexibility regarding which resources are borrowed or lent among servers in the server cloud. For example, the cloud capacity on demand manager 124 could first borrow all cloud permanent processors because they are dedicated to cloud processing before borrowing any permanent processors on a server. In the alternative, the cloud permanent processors could be the only capacity that is allowed to be shared between servers in a server cloud. By having capacity for cloud permanent processors defined separately from permanent processors, the cloud capacity on demand manager 124 has more flexibility in borrowing and lending capacity across a server cloud.

[0045] In FIGS. 3, 4, 6 and 7, the cloud capacity on demand manager 124 is shown to reside on one of the servers in the server cloud. In an alternative implementation, the cloud capacity on demand manager 124 may reside on a separate entity in the server cloud, as shown in FIG. 8. In server cloud system 800, four servers 810A, 610B, 610C and 610D are interconnected in a server cloud 830. Also connected in the server cloud 830 is a hardware management console 820, which contains the cloud capacity on demand manager 124. The hardware management console 820 allows configuring the servers in the server cloud, and provides a user interface for managing resources and capacity in the servers in the server cloud. The hardware management console 820 can also monitor the servers in the server cloud and can detect when the server cloud is no longer intact. The hardware management console 820 thus provides an independent control point outside of the servers rather than having the servers themselves manage their relationships, which makes it much easier when a server leaves the server cloud. For example, in FIG. 7, if server 610A malfunctions and becomes non-responsive, the cloud capacity on demand manager 124 can no longer do its job. By placing the cloud capacity on demand manager 124 in a separate hardware management console 820 as shown in FIG. 8, the cloud capacity on demand manager 124 may continue to function regardless of which server leaves the server cloud.

[0046] Referring to FIG. 9, the cloud capacity on demand manager 124 tracks cloud membership 910, *i.e.*, which servers are members of the server cloud, and tracks borrowed capacity 920 and lent capacity 930. The cloud capacity on demand manager 124 also includes a capacity query mechanism 940 that can query each server in the server cloud to determine whether the server has capacity to lend (see step 540 in FIG. 5). The borrowed capacity 920 and lent capacity 930 may be tracked in any suitable way. For example, the cloud resource table 1010 shown in FIG. 10 represents one suitable way to keep track of borrowed capacity 920 and lent capacity 930. Entry 1020 shows a capacity ID of P3, a resource type of processor, that Server A is the owner of this capacity, and this capacity is not yet lent out. Entry 1030 shows a capacity ID of P14, a resource type of processor, that Server C is the owner of this capacity, and this capacity has been lent to Server D. By keeping track of borrowed capacity and lent capacity, the cloud capacity on demand manager 124 may disable borrowed capacity (step step 570 in FIG. 7) when the server cloud is no longer intact. Note that each server preferably includes a mechanism that can detect when the server is no longer in the server cloud, and in response will reclaim any capacity it previously lent out to other servers in the cloud (see step 580 in FIG. 8).

[0047] While processors are discussed in the examples above, processors represent one suitable example of resources that have capacity that may be borrowed and lent within a server cloud. The disclosure and claims herein expressly extend to any suitable resources in a server and any suitable resources in a server cloud, including without limitation processors, memory, input/output (I/O) slots, network adapters, etc. Note also that what is being borrowed and lent by the cloud capacity on demand manager is capacity for resources, not the resources themselves. Thus, when server 310D has two permanent processors 326D and three borrowed processors 328D, this means that five of the eight installed processors 325D in server 310D may be used. The "borrowed processors" 328D represent capacity for processor borrowed from other servers. Note the sum of permanent processors and borrowed processors on a server cannot exceed the total number of installed processors.

[0048] The disclosure and claims relate to a cloud capacity on demand manager that manages capacity on demand for servers in a server cloud. The cloud capacity on demand manager may borrow capacity from one or more servers and lend the capacity borrowed from one server to a different server in the server cloud. When the server cloud is no longer intact, capacity borrowed from servers no longer in the server cloud is disabled, and servers no longer in the server cloud reclaim capacity that was lent to the server cloud

[0049] One skilled in the art will appreciate that many variations are possible within the scope of the claims. Thus, while the disclosure is particularly shown and described above, it will be understood by those skilled in the art that these and other changes in form and details may be made therein without departing from the spirit and scope of the claims.

CLAIMS

1. An apparatus comprising:

at least one processor;

a memory coupled to the at least one processor; and

a cloud capacity on demand manager residing in the memory and executed by the at least one processor, the cloud capacity on demand manager managing capacity for a plurality of resources for a plurality of servers in a server cloud that includes the apparatus, the cloud capacity on demand manager borrowing capacity for at least one of the plurality of resources from at least one of the plurality of servers in the server cloud and lending the borrowed capacity to a different one of the plurality of servers in the server cloud as long as the server cloud is intact, and when the server cloud is no longer intact, the cloud capacity on demand manager disables borrowed capacity and reclaims lent capacity.

2. The apparatus of claim 1 wherein at least one of the plurality of servers includes cloud permanent capacity that may be shared with any other server in the server cloud, wherein the cloud permanent capacity is capacity permanently enabled on the one of the plurality of servers in the server cloud that may be shared with other servers in the server cloud.

3. The apparatus of claim 1 wherein the plurality of resources comprises processors.

4. The apparatus of claim 1 wherein the plurality of resources comprises memory.

5. The apparatus of claim 1 wherein when the server cloud is no longer intact due to one of the plurality of servers no longer being in the server cloud, the cloud capacity on demand manager disables all borrowed capacity from all of the plurality of servers and reclaims all lent capacity from all of the plurality of servers.

6. The apparatus of claim 1 wherein when the server cloud is no longer intact due to one of the plurality of servers no longer being in the server cloud, the cloud capacity on demand manager

disables borrowed capacity borrowed from the one server, reclaims lent capacity on the one server, and retains other borrowed capacity and lent capacity for a plurality of servers that are still in the server cloud.

7. A computer-implemented method executed by at least one processor for managing capacity for a plurality of resources for a plurality of servers in a server cloud, the method comprising the steps of:

(A) borrowing capacity for at least one of the plurality of resources from at least one of the plurality of servers in the server cloud;

(B) lending the borrowed capacity to a different one of the plurality of servers in the server cloud as long as the server cloud is intact; and

(C) when the server cloud is no longer intact, the cloud capacity on demand manager disables borrowed capacity and reclaims lent capacity.

8. The method of claim 7 further comprising the step of sharing cloud permanent capacity in at least one of the plurality of servers in the server cloud with another server in the server cloud, wherein the cloud permanent capacity is capacity permanently enabled on the one of the plurality of servers in the server cloud that may be shared with other servers in the server cloud.

9. The method of claim 7 wherein the plurality of resources comprises processors.

10. The method of claim 7 wherein the plurality of resources comprises memory.

11. The method of claim 7 wherein step (C) comprises the steps of:

when the server cloud is no longer intact due to one of the plurality of servers no longer being in the server cloud, performing the steps of:

disabling all borrowed capacity from all of the plurality of servers; and

reclaiming all lent capacity from all of the plurality of servers.

12. The method of claim 7 wherein step (C) comprises the steps of:

when the server cloud is no longer intact due to one of the plurality of servers no longer being in the server cloud, performing the steps of:

disabling borrowed capacity borrowed from the one server;

reclaiming lent capacity on the one server; and

retaining other borrowed capacity and lent capacity for a plurality of servers that are still in the server cloud.

13. A computer-implemented method executed by at least one processor for managing capacity for a plurality of resources for a plurality of servers in a server cloud, the method comprising the steps of:

borrowing cloud permanent capacity for at least one of the plurality of resources from at least one of the plurality of servers in the server cloud, wherein the plurality of resources comprises processors and memory, and wherein the cloud permanent capacity is capacity permanently enabled on the one of the plurality of servers in the server cloud that may be shared with other servers in the server cloud;

lending the borrowed capacity to a different one of the plurality of servers in the server cloud as long as the server cloud is intact;

when the server cloud is no longer intact due to one of the plurality of servers no longer being in the server cloud, performing the steps of:

disabling borrowed capacity borrowed from the one server;

reclaiming lent capacity on the one server; and

retaining other borrowed capacity and lent capacity for a plurality of servers that are still in the server cloud.

14. An article of manufacture comprising software stored on a non-transitory computer readable storage medium, the software comprising:

a cloud capacity on demand manager that manages capacity for a plurality of resources for a plurality of servers in a server cloud, the cloud capacity on demand manager borrowing capacity for at least one of the plurality of resources from at least one of the plurality of servers in the server cloud and lending the borrowed capacity to a different one of the plurality of servers in the server cloud as long as the server cloud is intact, and when the server cloud is no longer intact, the cloud capacity on demand manager disables borrowed capacity and reclaims lent capacity.

15. The article of manufacture of claim 14 wherein at least one of the plurality of servers includes cloud permanent capacity that may be shared with any other server in the server cloud, wherein the cloud permanent capacity is capacity permanently enabled on the one of the plurality of servers in the server cloud that may be shared with other servers in the server cloud.

16. The article of manufacture of claim 14 wherein the plurality of resources comprises processors.

17. The article of manufacture of claim 14 wherein the plurality of resources comprises memory.

18. The article of manufacture of claim 14 wherein when the server cloud is no longer intact due to one of the plurality of servers no longer being in the server cloud, the cloud capacity on demand manager disables all borrowed capacity from all of the plurality of servers and reclaims all lent capacity from all of the plurality of servers.

19. The article of manufacture of claim 14 wherein when the server cloud is no longer intact due to one of the plurality of servers no longer being in the server cloud, the cloud capacity on demand manager disables borrowed capacity borrowed from the one server, reclaims lent capacity on the one server, and retains other borrowed capacity and lent capacity for a plurality of servers that are still in the server cloud.

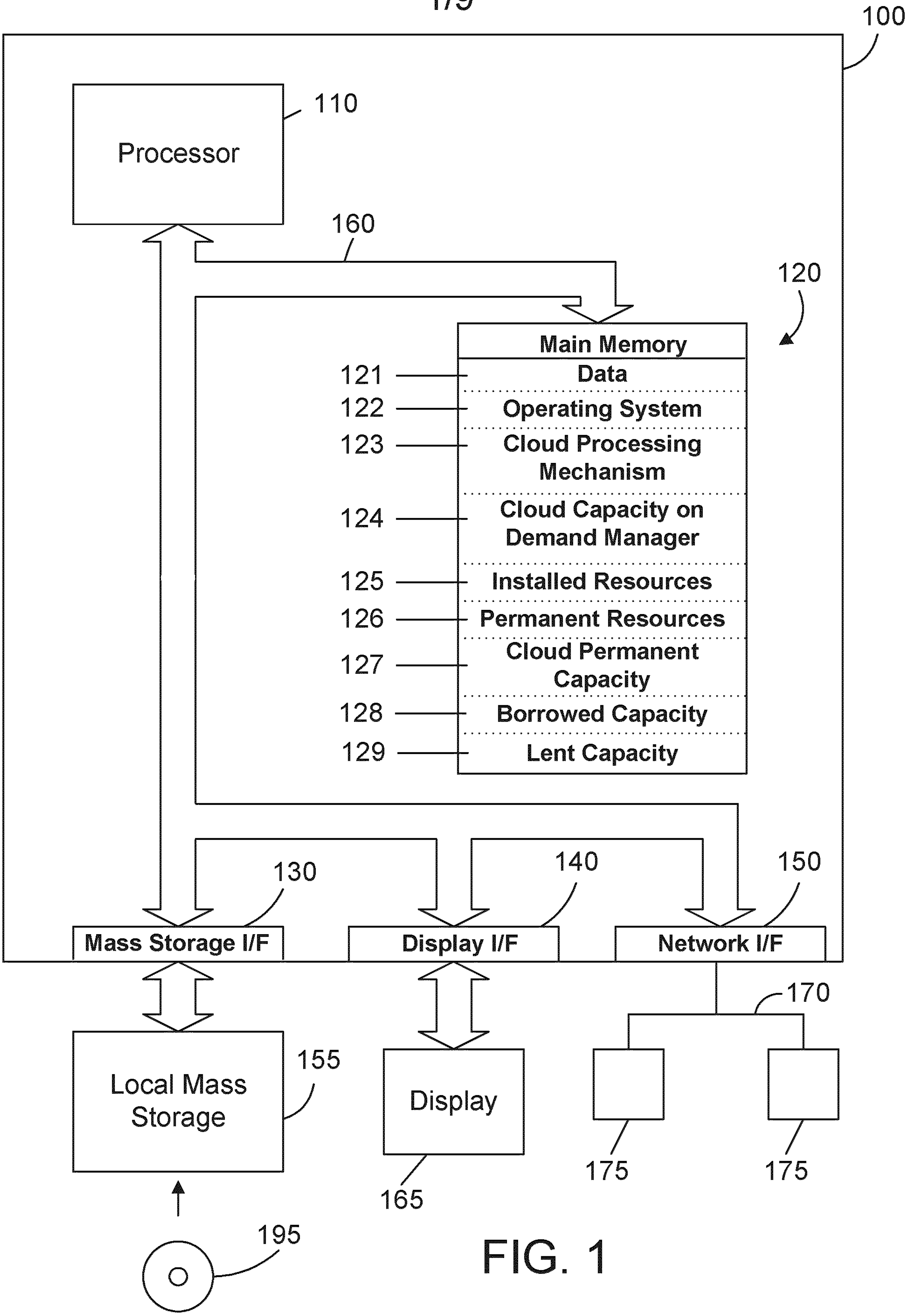

100
Processor
110
160
120
Main Memory
121
Data
122
Operating System
123
Cloud Processing Mechanism
124
Cloud Capacity on Demand Manager
125
Installed Resources
126
Permanent Resources
127
Cloud Permanent Capacity
128
Borrowed Capacity
129
Lent Capacity
130
140
150
Mass Storage I/F
Display I/F
Network I/F
170
Local Mass Storage
155
Display
165
175
175
195

FIG. 1

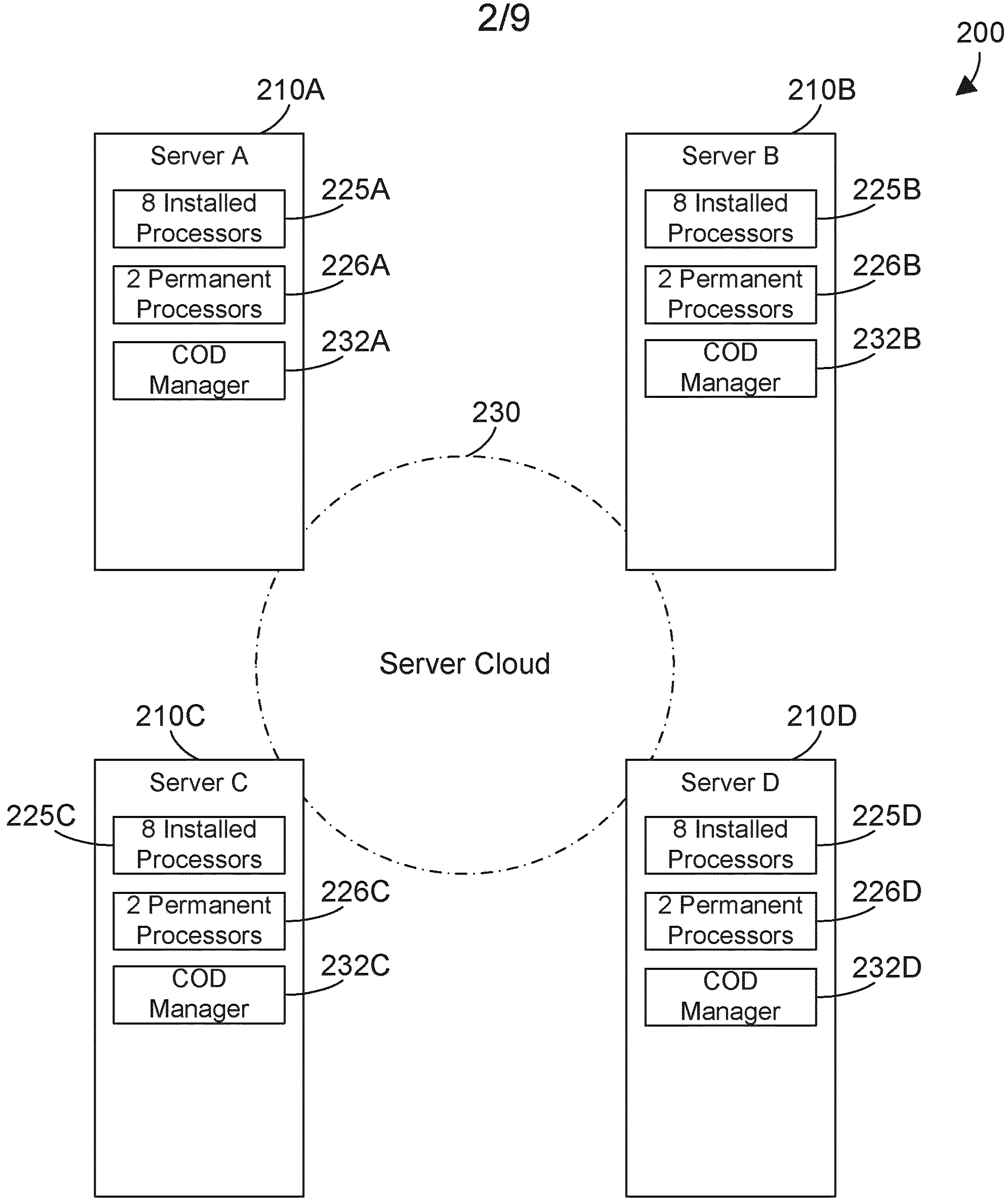


FIG. 2 Prior Art

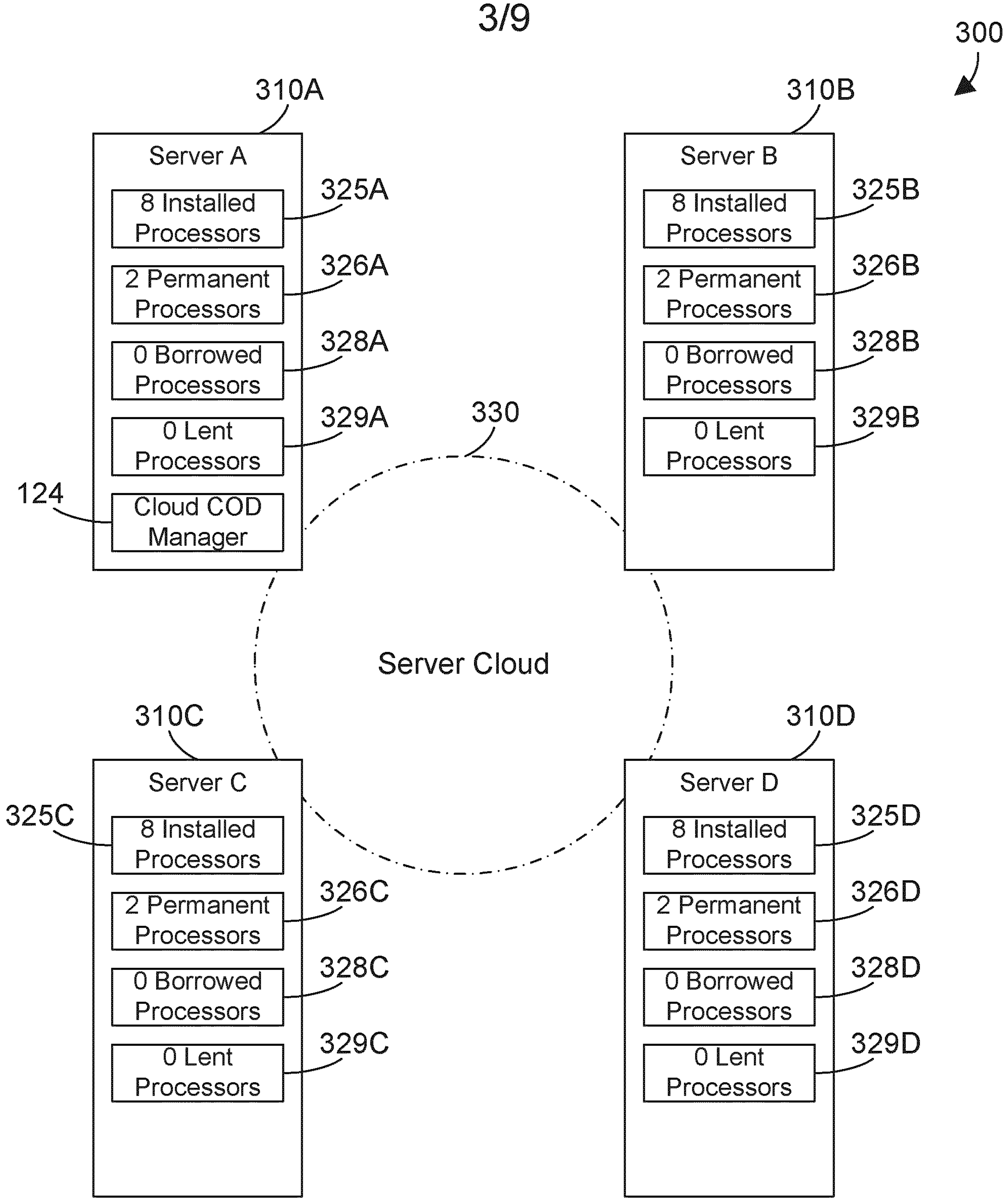

300
310A
Server A
8 Installed Processors
325A
2 Permanent Processors
326A
0 Borrowed Processors
328A
0 Lent Processors
329A
124
Cloud COD Manager
330
310B
Server B
8 Installed Processors
325B
2 Permanent Processors
326B
0 Borrowed Processors
328B
0 Lent Processors
329B
Server Cloud
310C
Server C
325C
8 Installed Processors
2 Permanent Processors
326C
0 Borrowed Processors
328C
0 Lent Processors
329C
310D
Server D
8 Installed Processors
325D
2 Permanent Processors
326D
0 Borrowed Processors
328D
0 Lent Processors
329D

FIG. 3

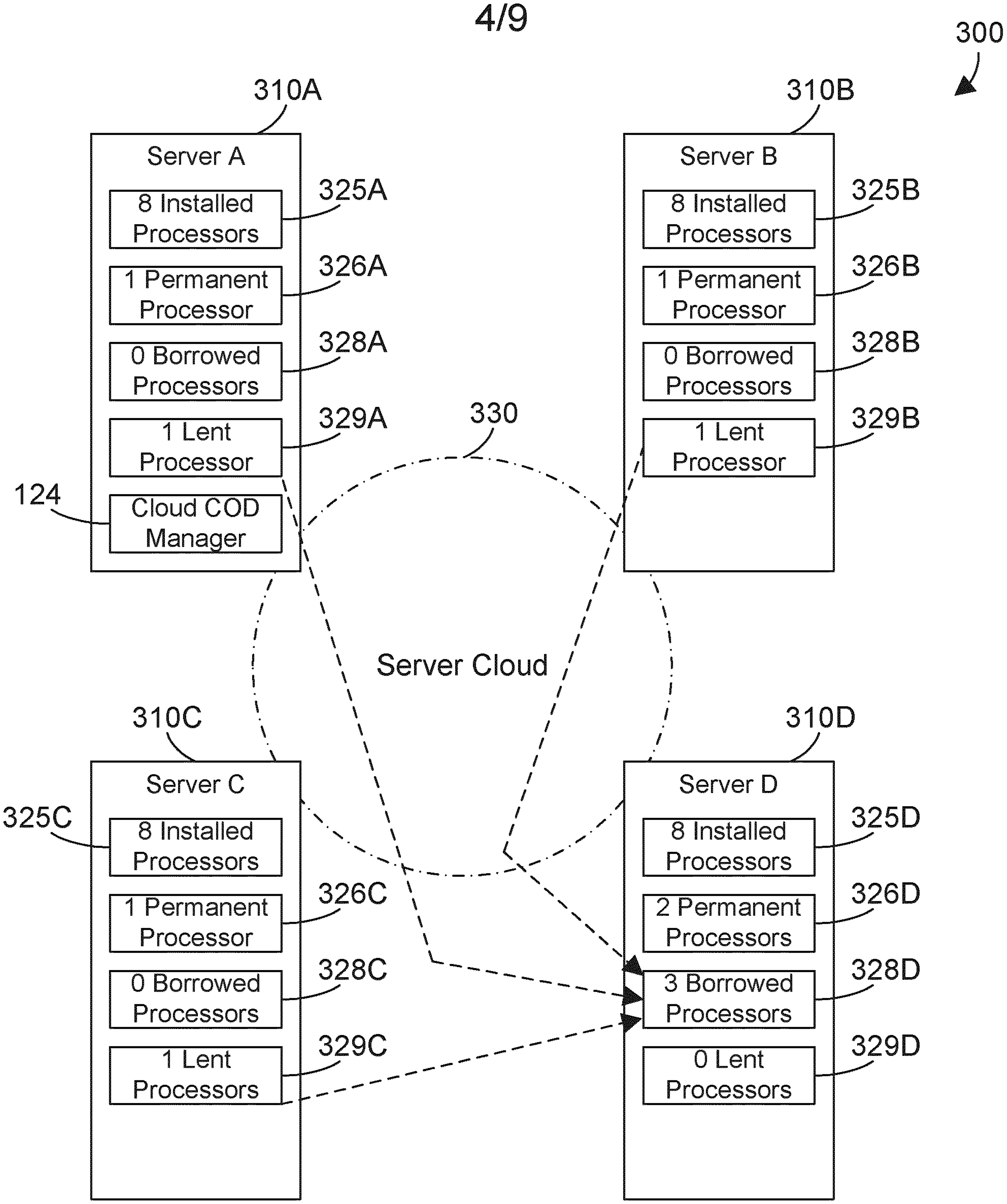

300
310A
Server A
8 Installed Processors
325A
1 Permanent Processor
326A
0 Borrowed Processors
328A
1 Lent Processor
329A
124
Cloud COD Manager
330
310B
Server B
8 Installed Processors
325B
1 Permanent Processor
326B
0 Borrowed Processors
328B
1 Lent Processor
329B
Server Cloud
310C
Server C
325C
8 Installed Processors
1 Permanent Processor
326C
0 Borrowed Processors
328C
1 Lent Processors
329C
310D
Server D
8 Installed Processors
325D
2 Permanent Processors
326D
3 Borrowed Processors
328D
0 Lent Processors
329D

FIG. 4

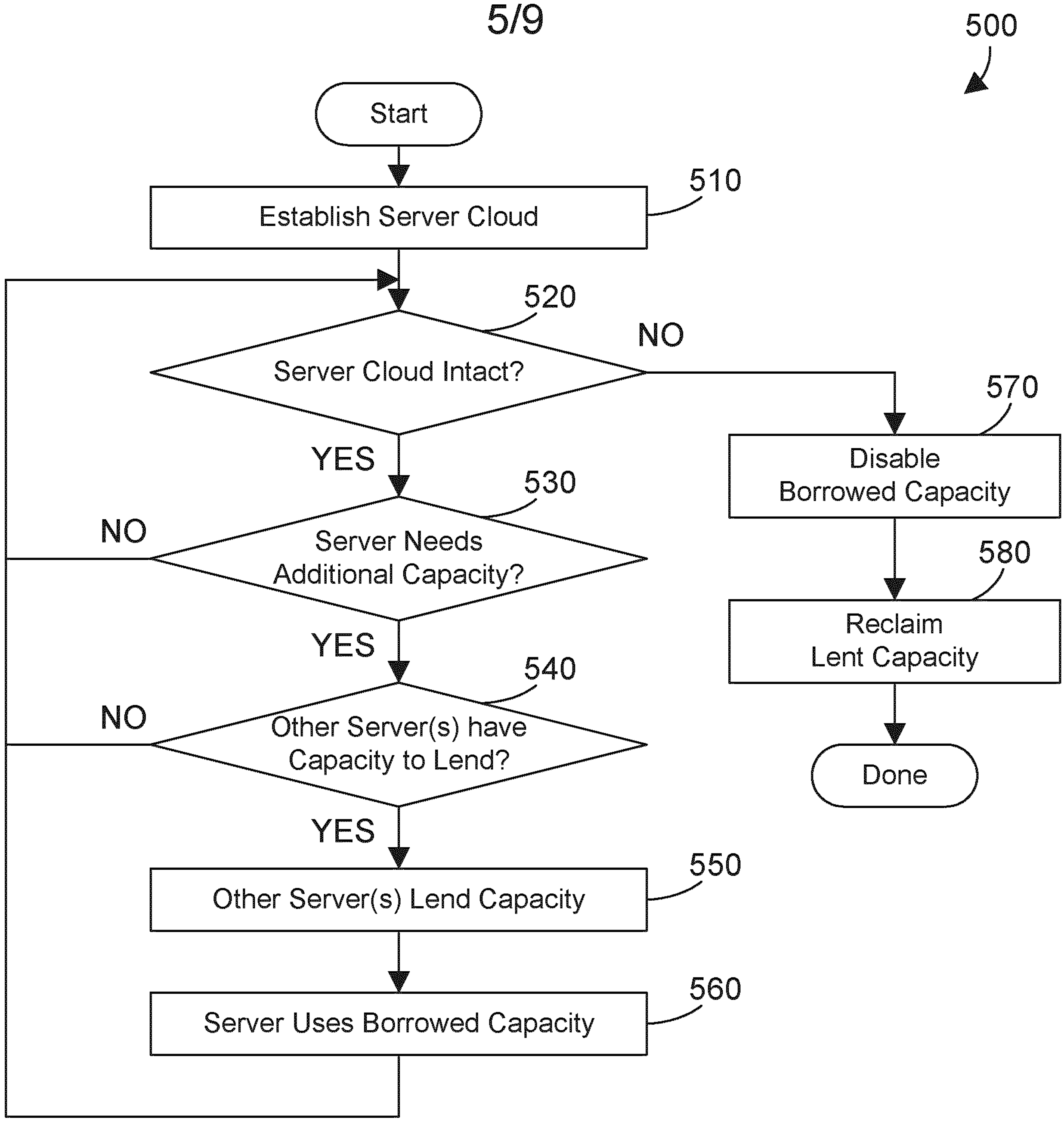

500
Start
Establish Server Cloud
510
520
Server Cloud Intact?
NO
YES
570
Disable Borrowed Capacity
530
Server Needs Additional Capacity?
NO
YES
580
Reclaim Lent Capacity
540
Other Server(s) have Capacity to Lend?
NO
YES
Done
550
Other Server(s) Lend Capacity
560
Server Uses Borrowed Capacity

FIG. 5

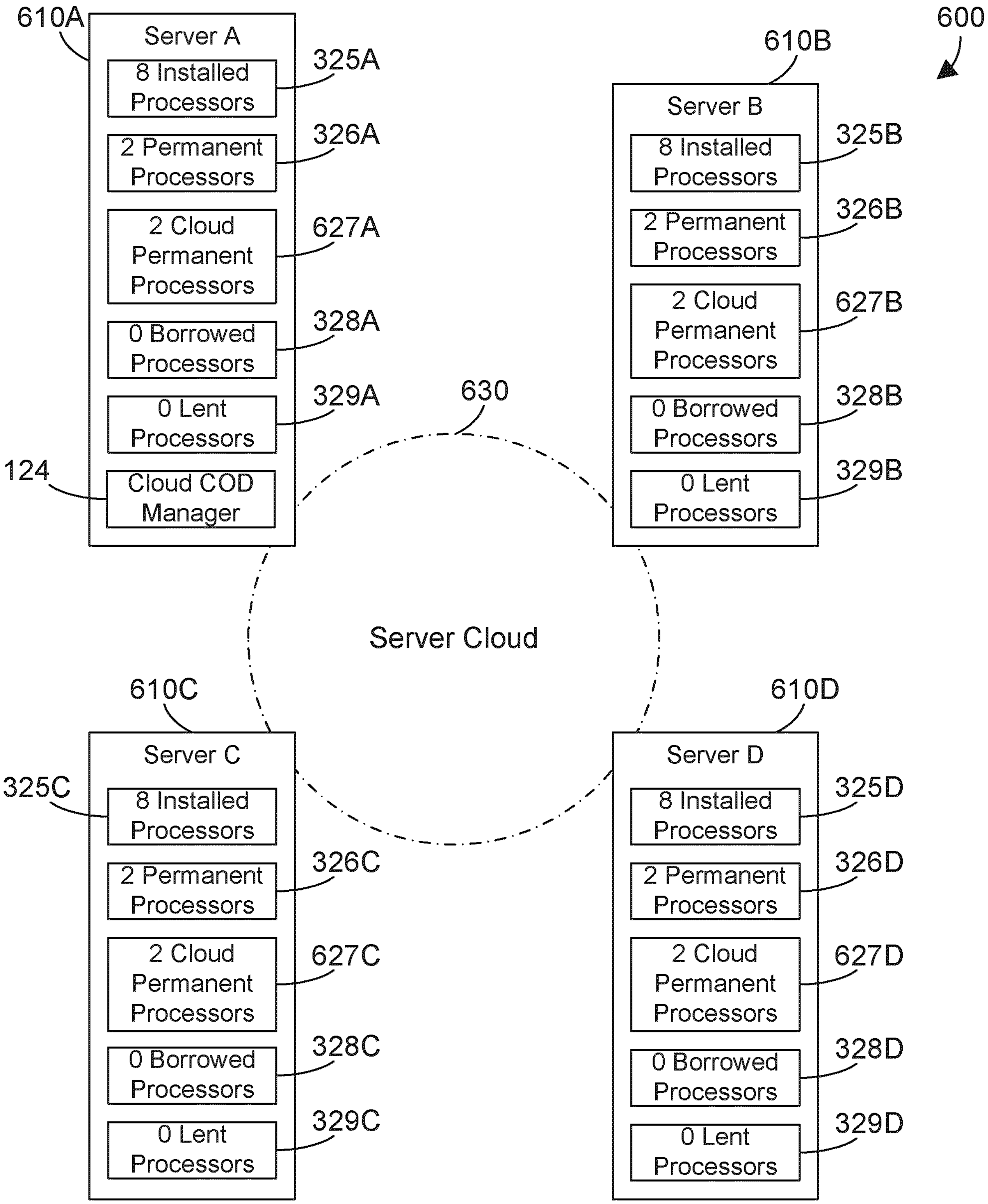

610A
Server A
8 Installed Processors
325A
2 Permanent Processors
326A
2 Cloud Permanent Processors
627A
0 Borrowed Processors
328A
0 Lent Processors
329A
124
Cloud COD Manager
630
610B
600
Server B
8 Installed Processors
325B
2 Permanent Processors
326B
2 Cloud Permanent Processors
627B
0 Borrowed Processors
328B
0 Lent Processors
329B
Server Cloud
610C
Server C
325C
8 Installed Processors
2 Permanent Processors
326C
2 Cloud Permanent Processors
627C
0 Borrowed Processors
328C
0 Lent Processors
329C
610D
Server D
8 Installed Processors
325D
2 Permanent Processors
326D
2 Cloud Permanent Processors
627D
0 Borrowed Processors
328D
0 Lent Processors
329D

FIG. 6

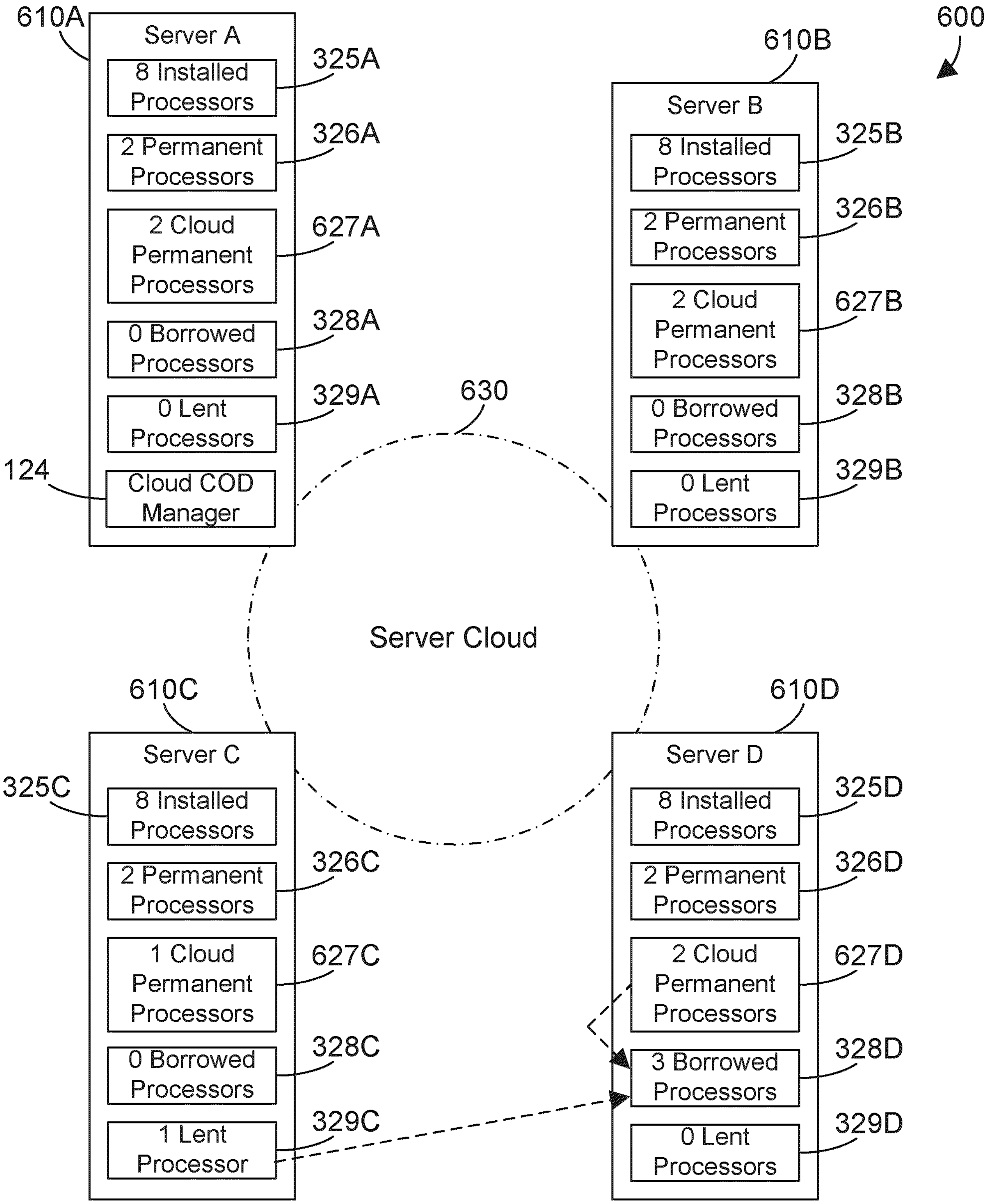

610A
Server A
8 Installed Processors
325A
2 Permanent Processors
326A
2 Cloud Permanent Processors
627A
0 Borrowed Processors
328A
0 Lent Processors
329A
124
Cloud COD Manager
610B
600
Server B
8 Installed Processors
325B
2 Permanent Processors
326B
2 Cloud Permanent Processors
627B
0 Borrowed Processors
328B
0 Lent Processors
329B
630
Server Cloud
610C
Server C
325C
8 Installed Processors
2 Permanent Processors
326C
1 Cloud Permanent Processors
627C
0 Borrowed Processors
328C
1 Lent Processor
329C
610D
Server D
8 Installed Processors
325D
2 Permanent Processors
326D
2 Cloud Permanent Processors
627D
3 Borrowed Processors
328D
0 Lent Processors
329D

FIG. 7

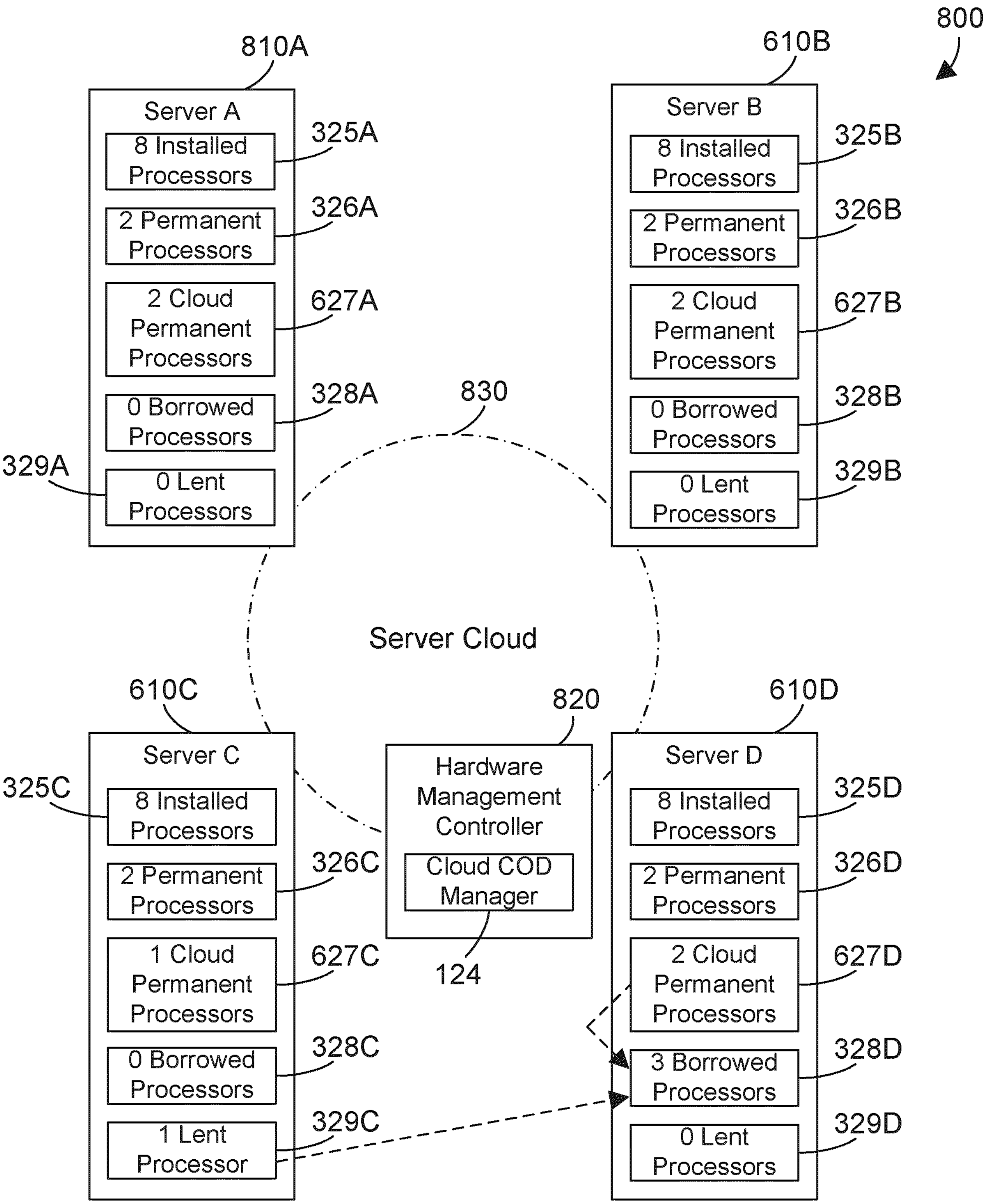

800
810A
Server A
8 Installed Processors
325A
2 Permanent Processors
326A
2 Cloud Permanent Processors
627A
0 Borrowed Processors
328A
0 Lent Processors
329A
830
610B
Server B
8 Installed Processors
325B
2 Permanent Processors
326B
2 Cloud Permanent Processors
627B
0 Borrowed Processors
328B
0 Lent Processors
329B
Server Cloud
610C
Server C
325C
8 Installed Processors
2 Permanent Processors
326C
1 Cloud Permanent Processors
627C
0 Borrowed Processors
328C
1 Lent Processor
329C
820
Hardware Management Controller
Cloud COD Manager
124
610D
Server D
8 Installed Processors
325D
2 Permanent Processors
326D
2 Cloud Permanent Processors
627D
3 Borrowed Processors
328D
0 Lent Processors
329D

FIG. 8

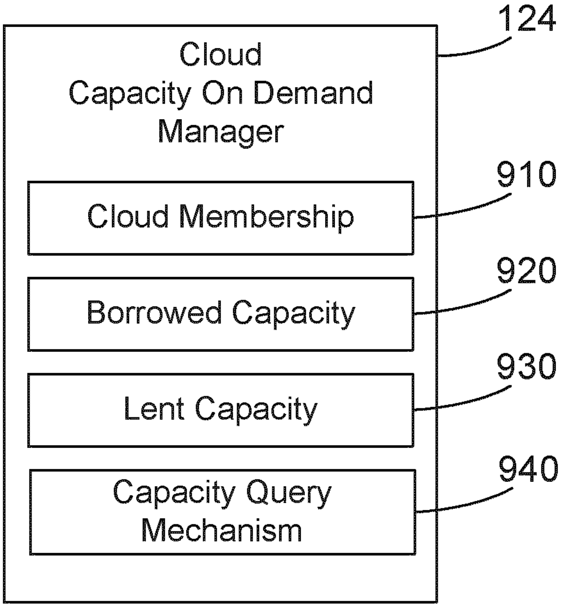
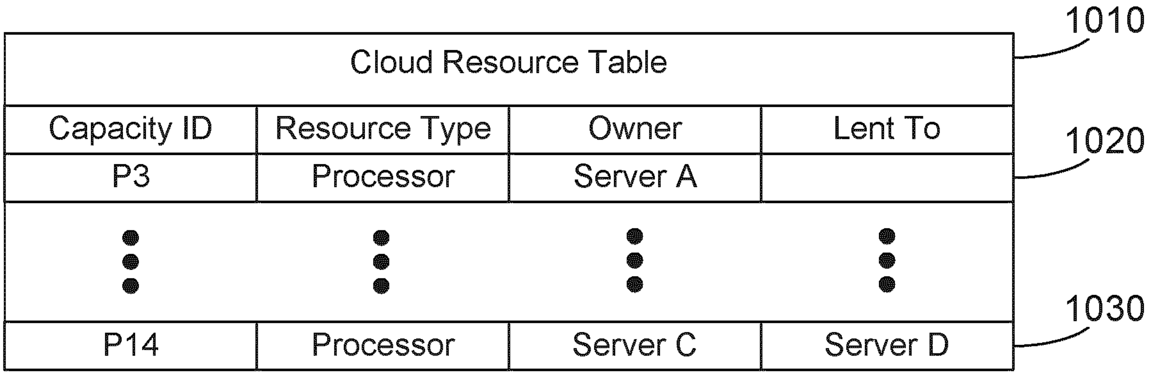


FIG. 9


1010
1020
1030

Cloud Resource Table			
Capacity ID	Resource Type	Owner	Lent To
P3	Processor	Server A	
⋮	⋮	⋮	⋮
P14	Processor	Server C	Server D

FIG. 10

INTERNATIONAL SEARCH REPORT	International application No. PCT/CA2013/050229

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***H04L 12/24*** (2006.01)
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)
IPC: ***H04L 12/24*** (2006.01)

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
TotalPatent, Esp@cenet, Canadian Patent Database, USPTO Database, IEEE Xplore.
Keywords: manage, cloud, capacity, on demand, plurality, multiple, resources, servers, borrow, lend, disable.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US8037187 B2 (Dawson et al.) 11 October 2011 (11-10-2011) -see abstract; -see column 1, lines 50-65; -see column 3, lines 65-67; -see column 4, lines 45-50; -see column 5, lines 1-17; -see column 6, lines 54-57; -see column 9, lines 8-17; -see figures 2, 5.	1-19
A	US2011/0145153 A1 (Dawson et al.) 16 June 2011 (16-06-2011) -see abstract; -see paragraphs [0003], [0005], [0065]; -see figures 4, 6.	1-19

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

*	Special categories of cited documents :	"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
"A"	document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier application or patent but published on or after the international filing date	"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
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 01 June 2013 (01-06-2013)	Date of mailing of the international search report 20 June 2013 (20-06-2013)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Authorized officer Hassan Bayaa (819) 997-7810

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2013/050229

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US2012/0042256 A1 (Jamjoom et al.) 16 February 2012 (16-02-2012) -see abstract; -see paragraphs [0021], [0039], [0057], [0061]-[0062], [0064], [0067], [0070-0072], [0075]; -see figure 8.	1-19
A	US2011/0238460 A1 (Al-Dawsari et al.) 29 September 2011 (29-09-2011) -see abstract; -see paragraphs [0001], [0004]-[0005], [0024], [0027], [0032]-[0035]; -see figures 1, 3A, 6.	1-19

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2013/050229

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US8037187B2	11 October 2011 (11-10-2011)	US2011145413A1	16 June 2011 (16-06-2011)
US2011145153A1	16 June 2011 (16-06-2011)	None	
US2012042256A1	16 February 2012 (16-02-2012)	None	
US2011238460A1	29 September 2011 (29-09-2011)	None	