

CONFIGURATION OF A VIRTUAL LOCAL AREA NETWORK IN A RING OF DEVICES

BACKGROUND

[0001] In a datacenter, network modules, i.e., modules including servers, power distribution units, or other attachable devices attached to network switches, may be configured in a ring topology to provide improved connectivity and redundancy for virtual local area networks (VLANs). The devices attached to the network switches provide various services that may be configured in different VLANs.

[0002] The larger the datacenter, the more complicated it is to configure VLANs on these devices. For instance, a datacenter may include more than one hundred network modules linked together, and it will be difficult for a network administrator to configure all of the links necessary to communicate with the devices in each VLAN. Moreover, not all devices may be capable of running a complex VLAN pruning protocol.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. 1 is a block diagram of an example system of the present disclosure;

[0004] FIG. 2 illustrates a flowchart of an exemplary method for configuring a virtual local area network around an Ethernet ring;

[0005] FIG. 3 illustrates a flowchart of another exemplary method for configuring a virtual local area network around an Ethernet ring;

[0006] FIGs. 4A-4B illustrate an exemplary format for a virtual local area network message that may be sent in accordance with the methods illustrated in FIGs. 2 and 3;

[0007] FIG. 5 illustrates an exemplary format for a virtual local area network database that may be maintained in accordance with the methods illustrated in FIGs. 2 and 3; and

[0008] FIG. 6 depicts a high-level block diagram of a computer that can be transformed into a machine capable of performing the functions described

herein.

DETAILED DESCRIPTION

[0009] The present disclosure broadly discloses a method and non-transitory computer-readable medium for configuring and managing virtual local area networks (VLANs) in a network (e.g., a network within a datacenter) in which network devices are connected in an Ethernet ring. As discussed above, it is difficult for a network administrator to configure all of the links necessary to communicate with the devices in each VLAN supported by an Ethernet ring.

[0010] Examples of the present disclosure provide a novel method for configuring and managing virtual local area networks (VLANs) in a network (e.g., a network within a datacenter) in which network devices are connected in an Ethernet ring. For instance, examples of the present disclosure designate a first device in the Ethernet ring to be responsible for receiving VLAN requests from the other devices, where the VLAN requests may request addition or deletion of VLANs on the switch ports of other devices in the ring. Responsive to such requests, the first device will update a VLAN database to identify which VLANs need to be programmed on the switch ports, and then send a copy of the VLAN database to all other devices in the ring. When the other devices receive the copy of the VLAN database, they will each compare it to a locally stored copy of the VLAN database to determine whether any changes need to be configured. VLANs can thus be configured dynamically and automatically around a ring using a generic protocol that can be run by all devices on the ring.

[0011] In an example, a VLAN can be read from a field replaceable unit (FRU) or a flat file and configured dynamically. Alternatively, a VLAN can be statically configured, e.g., by a network administrator, for a single device and then configured dynamically around the ring. Examples of the present disclosure configure the trunk ports between two end points as well as program VLANs on the devices on each network module in the Ethernet ring. A message format employed by examples of the present disclosure includes user defined bits that represent different devices on switch ports and accommodate various configurations. The message format also allows for definition of Class

of Service (CoS) queues based on VLAN priority.

[0012] FIG. 1 illustrates an example system 100 of the present disclosure. In one example, the system 100 includes a management network 102 in communication with a customer network 104, e.g., a data network, via a customer network link 103. It should be noted that although one customer network 104 is illustrated in FIG. 1, any number of customer networks may be in communication with the management network 102.

[0013] The management network 102 includes a plurality of network modules 106₁-106_n, hereinafter collectively referred to as “network modules 106,” arranged in a ring topology. Referring to network module 106₂ as an exemplary network module, each network module 106 includes a central processing unit (CPU) 108, a network switch 110, and a set 112 of one or more devices that connect to the network switch 110, such as one or more power distribution units, blade servers, or simply “blades”, or other attachable devices. In the example illustrated in FIG. 1, each network module 106 includes a plurality of blades, e.g., blades 1-y of network module 106₂; the number of blades residing on each network module 106 may differ. One network module, e.g., network module 106₂ in FIG. 1, additionally includes a customer interface manager 122 for managing the customer network link 103. Although examples of the present disclosure make reference to devices attached to network modules, it will be appreciated that the method and non-transitory computer-readable medium disclosed herein may be implemented for any devices attached to a network switch.

[0014] The CPU 108 includes a management port 114 that connects to the network switch 110, so that the CPU 108 can configure the network switch 110 with the appropriate configuration. The CPU 108 also runs all of the management network software. The network switch 110 includes a first link port 116₁ and a second link port 116₂, hereinafter collectively referred to as “link ports 116,” for connecting the network module 106 to other network modules 106. The link ports 116 may also be referred to as “trunk ports,” as they connect the network switches of the network modules 106. The network switch 110 also provides connectivity to the set 112 of one or more devices. The set

112 of one or more devices provide various services that may be configured in different VLANs for the customer network 104. In addition, each network module 106 includes a first ring port 118₁ and a second ring port 118₂, hereinafter collectively referred to as “ring ports 118,” that connects the network module 106 to the Ethernet ring. The ring ports 118 may also be referred to as “trunk ports,” as they ultimately connect the network switches of the network modules 106.

[0015] In the example illustrated in FIG. 1, the system 100 supports a plurality of VLANs 120₁-120_m, hereinafter collectively referred to as “VLANs 120.” All of the network modules 106 in the management network 102 configure a management network VLAN 120₁. The management network VLAN 120₁ is configured on the CPU management port 114 and the ring ports 118 of each network module 106. The management network VLAN 120₁ is a dedicated VLAN that allows all of the network modules 106 in the management network 102 to communicate over a private connection, without any data being received by any other devices connected to the network switches, including the customer network 104. A customer network VLAN 120₂ allows a customer to access devices in the management network 102 for the purposes of configuring VLANs.

[0016] The customer network 104 includes groups of devices in different VLANs and some devices in multiple VLANs. As an example, in FIG. 1, a customer has configured blade 2 on network module 106₁ and blade 3 on network module 106_n to be in the same blade VLAN 120_m, as indicated by the bolded lines around those blades; this blade VLAN 120_m is configured by the customer across the customer VLAN 120₂. For the selected blades to communicate with each other and with the customer network 104, the blade VLAN 120_m must be configured on the link ports 116 around the ring and on the customer network link 103.

[0017] In one example, a configuration and management protocol according to the present disclosure is used to configure a VLAN such as the blade VLAN 120_m around the ring. This protocol runs on the management network 102. In one example, the CPU of each network module 106 runs a VLAN daemon. A first network module 106, or a first VLAN daemon running on a network module

106, is designated as a configuration manager. In one example, the configuration manager is also the ring protection link (RPL) owner for the ring, i.e., the network module responsible for blocking traffic at one end of a ring protection link for the purposes of avoiding loops. The configuration manager is responsible for centralizing the configuration and management of VLANs around the ring. To this end, the configuration manager sends instructions to the other network modules 106, which are implemented locally by the other network modules 106 to configure the VLANs. The configuration manager also maintains a master VLAN database that includes an entry for each VLAN that is currently configured around the ring. The VLAN daemons running on the other network modules learn of the configuration manager when the configuration manager broadcasts a status message to the other network modules. In one example, if the configuration manager experiences an error or is removed from the ring, the new RPL owner for the ring will also become the new configuration manager. Each of the other network modules 106 will store the VLAN database locally, so that any of the other network modules may become the new configuration manager in such circumstances.

[0018] FIG. 2 illustrates a flowchart of an exemplary method 200 for configuring a virtual local area network (VLAN) around an Ethernet ring. In one example, the method 200 may be performed by the CPU of a network module designated as the configuration manager, referred to as the “first device” for the purposes of FIG. 3, or a computer as illustrated in FIG. 6 and discussed below. The method 200 assumes that the configuration manager has already identified itself to the other network modules as the device to which the other network modules should send any messages relating to configuration of the VLAN, e.g., by broadcasting a status message to the other network modules.

[0019] At block 202, the method 200 begins. At block 204, a first device, e.g., the configuration manager, monitors the management VLAN for messages. In one example, the messages that may be received by the first device are of two types. The first type of message is a status message. A status message is a message from a second device, e.g., one of the other network modules 106, reporting the status of an existing VLAN. In one example, status messages are

sent periodically. The second type of message is a request message. A request message is a message from a second device, e.g., one of the other network modules 106, requesting either addition of a new VLAN or deletion of an existing VLAN; thus, a request message requires action to configure, or de-configure, links around the ring. In one example, request messages are sent on-demand, i.e., as configuration changes are required.

[0020] At block 206, the first device receives a first message. In one example, the first message is a unicast message. At block 208, the first device determines whether the first message is a status message. As discussed above, a status message reports the status of an existing VLAN.

[0021] If the first device concludes at block 208 that the first message is a status message, then, at block 210, the first device updates the VLAN database responsive to the status message. In one example, updating the VLAN database includes identifying the VLAN to which the status message pertains, and setting a bit in the database entry for the VLAN to indicate that the VLAN is present. In another example, updating the VLAN database includes identifying the VLAN to which the status message pertains, and deleting the VLAN from the VLAN database.

[0022] Alternatively, if the first device concludes at block 208 that the first message is not a status message, then it is assumed that the first message is a request message. As discussed above, a request message requests either addition of a new VLAN or deletion of an existing VLAN. Accordingly, at block 212, the first device adds or deletes the VLAN in the VLAN database responsive to the request message.

[0023] At block 214, the first device formulates a second message that includes a current copy of the VLAN database. The current copy of the VLAN database may include any recent changes made in accordance with blocks 210 and/or 212.

[0024] At block 216, the first device determines whether a status timer has expired. In one example, the status timer is a timer that is set to expire periodically. Each time the status timer expires, the first device sends a

message to the other devices in the management VLAN that includes a current copy of the VLAN database.

[0025] If the first device concludes in block 216 that the status timer has not expired, then the method 200 returns to block 204, and the first device continues to monitor the management VLAN for messages.

[0026] Alternatively, if the first device concludes in block 216 that the status timer has expired, then, at block 218, the first device sends the second message to the other devices in the management VLAN. In one example, the second message is sent as a multicast message.

[0027] The method 200 then returns to block 204, and the first device continues to monitor the management VLAN for messages.

[0028] FIG. 3 illustrates a flowchart of another exemplary method 300 for configuring a virtual local area network (VLAN) around an Ethernet ring. In one example, the method 300 may be performed by the CPU of a network module not designated as the configuration manager, referred to as the “second device” for the purposes of FIG. 3, or a computer as illustrated in FIG. 6 and discussed below.

[0029] In particular, FIG. 3 specifically illustrates a method for requesting configuration of a VLAN and for performing the configuration. Thus, FIG. 3 omits certain other operations performed by the second device. For instance, when not performing activities relating to VLAN configuration, the second device is always listening for the receipt of status messages from the configuration manager. In addition, the second device may become the configuration manager if the configuration manager is removed from the ring. In this case, the second device will perform the operations described above in FIG. 2.

[0030] At block 302, the method 300 begins. At block 304, a second device, e.g., not the configuration manager, formulates a first message. In one example, the first message is a request message. As discussed above, a request message is a message requesting either addition of a new VLAN or deletion of an existing VLAN; thus, a request message requires action to configure, or de-configure, links around the ring.

[0031] At block 306, the second device sends the first message to the first device, e.g., the configuration manager. In one example, the first message is a unicast message.

[0032] At block 308, the second device receives a second message from the first device that includes a current copy of the VLAN database at the first device. The current copy of the VLAN database may include any recent changes made in accordance with status updates and/or requests to add or delete VLANs, as discussed above. For instance, the current copy of the VLAN database may have been updated to reflect the request included in the first message. In one example, the second message is a multicast message.

[0033] At block 310, the second device updates a local copy of the VLAN database, responsive to the current copy of the VLAN database that was included in the second message. A difference between the local copy of the VLAN database and the current copy of the VLAN database indicates a change that needs to be configured on the switch ports of the second device.

[0034] At block 312, the second device configures its switch ports responsive to the updates made to the VLAN database. The method then ends at block 314.

[0035] FIGs. 4A-4B illustrate an exemplary format for a virtual local area network (VLAN) message 400 that may be sent in accordance with the methods illustrated in FIGs. 2 and 3. In one example, message is a layer-2 packet. The same message format may be used for messages sent by the configuration manager, e.g., multicast messages, and messages sent by the other network modules, e.g., unicast messages; the State field, i.e., at byte 23 of the VLAN message 400, is set accordingly to indicate the sender. In one example, the configuration manager will set the State field to "manager," while a network module other than the configuration manager will set the State field to "remote."

[0036] In addition, byte 24 is set to indicate the requested action. A network module other than the configuration manager will set byte 24 to "add" or "delete," depending on whether it is requesting addition or deletion of a VLAN. The configuration manager will set byte 24 to "status" when it sends a copy of the VLAN database.

[0037] The exemplary VLAN message 400 illustrates three VLANs that are to be added to the defined ports on a network switch: VLAN 4093, VLAN 4094, and VLAN 4095. In practice, the VLAN message 400 may include any number of VLANs. The “VLAN Properties” bits in bytes 35-36, 39-40, and 43-44 represent the switch ports on each of the network modules’ switches. In one example, these properties indicate the following switch ports, which are defined for the hardware connected to the switch ports: “Integrated Lights-Out” or “iLO,” e.g., a particular blade, “Interconnect Module” or “ICM,” “Enclosure Manager CPU” or “EM,” “Link Ports” or “L”, and “Management Port” or “M.” The properties may, however, be defined differently depending on the hardware. The bits may be user defined on the connections to the particular hardware.

[0038] In one example, if a switch port is to be configured, the bit corresponding to the switch port will be set accordingly, e.g., to “1.” In addition, each switch port may be programmed as tagged (“T”) or untagged (“U”). For instance, the U/T bit may be set to “1” to indicate that the VLAN is to be tagged, or set to “0” to indicate that the VLAN is to be untagged.

[0039] In a further example, the VLAN message 400 also includes Class of Service (CoS) definitions to indicate the bandwidth allocated to a particular egress queue. In the exemplary VLAN message 400, CoS is defined in bits [7-5] of the VLAN fields, i.e., bytes 33, 37, and 41. For instance, if bits [7-5] for VLAN 4093 are set to “111,” VLAN 4093 will be mapped to the CoS bandwidth defined in byte 53 of the VLAN message 400. A switch will check the priority bits defined in the VLAN field on ingress, and send packets to the appropriate CoS queue on egress from the switch.

[0040] In a further example, the VLAN message also includes a “Continue” field, e.g., byte 25 in FIG. 4A. A bit in the “Continue” field is set when the copy of the VLAN database must be split among multiple packets. There is a limit to the number of bytes that can be transmitted in a standard Ethernet packet. Thus, if the VLAN database contains entries for a large number of VLANs, a copy of the VLAN database may contain more data than can be sent in a single Ethernet packet. The bit in the “Continue” field is thus set to alert the network modules to the fact that the copy of the VLAN database will arrive in multiple

packets. Each of these multiple packets may be structured in a manner similar to the VLAN message illustrated in FIGs. 4A-4B.

[0041] FIG. 5 illustrates an exemplary format for a virtual local area network (VLAN) database 500 that may be maintained in accordance with the methods illustrated in FIGs. 2 and 3. As illustrated, the entry for each VLAN includes a “present” bit, i.e., byte 5 in FIG. 5. As described above, the network modules 106 will periodically send status messages to the configuration manager to indicate whether the VLANS for which they are configured are present, i.e., active. If the status message indicates that a particular VLAN is present, then the configuration manager will set the “present” bit accordingly, as illustrated in FIG. 5. If a status message is not received for a given VLAN by the time a periodic timeout timer expires, then the configuration manager will delete the VLAN from the database. That is, if a threshold period of time passes without the configuration manager receiving a status message that confirms the presence of the given VLAN, the VLAN is assumed to not be present, and, thus, need not be tracked in the VLAN database. This update to the VLAN database will necessitate the sending of a message to the other network modules including a copy of the updated database.

[0042] As a result, the examples of the present disclosure improve the functioning of a network module or a computer. For example, a network module may achieve more accurate and more efficient configuration of a VLAN than is possible without the improvements provided by the present disclosure. In other words, the technological art of configuring VLANs in Ethernet rings is improved by providing a computer that is modified with the ability to automatically and dynamically configure a VLAN around an Ethernet ring, as disclosed by the present disclosure.

[0043] It should be noted that although not explicitly specified, one or more blocks, functions, or operations of the methods 200 and 300 described above may include a storing, displaying and/or outputting step as required for a particular application. In other words, any data, records, fields, and/or intermediate results discussed in the methods can be stored, displayed, and/or outputted to another device as required for a particular application.

Furthermore, steps, functions, or operations in FIG. 2 and FIG. 3 that recite a determining operation, or involve a decision, do not necessarily require that both branches of the determining operation be practiced. In other words, one of the branches of the determining operation can be deemed as an optional step.

[0044] FIG. 6 depicts a high-level block diagram of a computer that can be transformed into a machine capable of performing the functions described herein. Notably, no computer or machine currently exists that performs the functions as described herein. As a result, the examples of the present disclosure improve the operation and functioning of the general-purpose computer to validate a hard disk drive, as disclosed herein.

[0045] As depicted in FIG. 6, the computer 600 comprises a hardware processor element 602, e.g., a central processing unit (CPU), a microprocessor, or a multi-core processor, a memory 604, e.g., random access memory (RAM) and/or read only memory (ROM), a module 605 for configuring and managing virtual local area networks (VLANs), and various input/output devices 606, e.g., storage devices, including but not limited to, a tape drive, a floppy drive, a hard disk drive or a compact disk drive, a receiver, a transmitter, a speaker, a display, a speech synthesizer, an output port, an input port and a user input device, such as a keyboard, a keypad, a mouse, a microphone, and the like. Although only one processor element is shown, it should be noted that the general-purpose computer may employ a plurality of processor elements. Furthermore, although only one general-purpose computer is shown in the figure, if the method(s) as discussed above is implemented in a distributed or parallel manner for a particular illustrative example, i.e., the steps of the above method(s) or the entire method(s) are implemented across multiple or parallel general-purpose computers, then the general-purpose computer of this figure is intended to represent each of those multiple general-purpose computers. Furthermore, one or more hardware processors can be utilized in supporting a virtualized or shared computing environment. The virtualized computing environment may support one or more virtual machines representing computers, servers, or other computing devices. In such virtualized virtual machines,

hardware components such as hardware processors and computer-readable storage devices may be virtualized or logically represented.

[0046] It should be noted that the present disclosure can be implemented by machine readable instructions and/or in a combination of machine readable instructions and hardware, e.g., using application specific integrated circuits (ASIC), a programmable logic array (PLA), including a field-programmable gate array (FPGA), or a state machine deployed on a hardware device, a general purpose computer or any other hardware equivalents, e.g., computer readable instructions pertaining to the method(s) discussed above can be used to configure a hardware processor to perform the steps, functions and/or operations of the above disclosed methods.

[0047] In one example, instructions and data for the present module or process 605 for configuring and managing VLANs, e.g., machine readable instructions can be loaded into memory 604 and executed by hardware processor element 602 to implement the steps, functions or operations as discussed above in connection with the exemplary methods 200 and 300. For instance, the module 605 may include a plurality of programming code components, including a database updating component 608, a status timer 610, and a timeout timer 612. These programming code components may be included on all of the processing nodes of a computing system, such as all of the network modules 106 of the system 100.

[0048] On the configuration manager, the database updating component 806 may be configured to update the master VLAN database in accordance with request messages received by the configuration manager. On the other network modules 106, the database updating component 806 may be configured to update the local copy of the VLAN database in accordance with messages received from the configuration manager. The database updating component 806 may perform these updates in accordance with the exemplary VLAN message 400 and exemplary VLAN database 500 format discussed above.

[0049] On the configuration manager, the status timer 610 may be configured to schedule updates to the VLAN database. For instance, the status

timer may schedule when the configuration manager sends messages to the other network modules 106 including the most current copy of the VLAN database. On the other network modules, the status timer 610 may be configured to schedule status updates to the configuration manager. For instance, the status timer may schedule when a network module 106 sends a status message to the configuration manager confirming the presence of one or more existing VLANs.

[0050] On the configuration manager, the timeout timer 612 may be configured to schedule purging of the database. For instance, the timeout timer 612 may schedule times at which the configuration manager checks for status messages from the other network modules and deletes from the VLAN database VLANs for which status messages have not been received.

[0051] Furthermore, when a hardware processor executes instructions to perform "operations", this could include the hardware processor performing the operations directly and/or facilitating, directing, or cooperating with another hardware device or component, e.g., a co-processor and the like, to perform the operations.

[0052] The processor executing the machine readable instructions relating to the above described method(s) can be perceived as a programmed processor or a specialized processor. As such, the present module 605 for configuring and managing VLANs, including associated data structures, of the present disclosure can be stored on a tangible or physical (broadly non-transitory) computer-readable storage device or medium, e.g., volatile memory, non-volatile memory, ROM memory, RAM memory, magnetic or optical drive, device or diskette and the like. More specifically, the computer-readable storage device may comprise any physical devices that provide the ability to store information such as data and/or instructions to be accessed by a processor or a computing device such as a computer or an application server.

[0053] It will be appreciated that variants of the above-disclosed and other features and functions, or alternatives thereof, may be combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations, or improvements therein

may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

What is claimed is:

1. A method, comprising:
 - receiving, by a processor of a first device, a first message from a second device requesting configuration of a first virtual local area network on a ring of connected devices, wherein the first device and the second device are connected to the ring by respective network switches;
 - responsive to the first message, formulating, by the processor of the first device, a second message, wherein the second message identifies a plurality of other devices connected to the ring that need to program respective switch ports to support the configuration; and
 - sending, by the processor of the first device, the second message to the plurality of other devices.
2. The method of claim 1, wherein at least one device in the ring of connected devices is connected to a data network.
3. The method of claim 2, wherein the first message is received over a second virtual local area network that is inaccessible to the data network, and the second message is sent over the second virtual local area network.
4. The method of claim 1, wherein the first message is a unicast message.
5. The method of claim 1, wherein the first message includes a field having a byte that is set to specify an action indicated by the configuration.
6. The method of claim 5, wherein the action is an addition of the first virtual local area network.
7. The method of claim 5, wherein the action is a deletion of the first virtual local area network.

8. The method of claim 1, wherein the formulating comprises:
 - updating, by the processor of the first device, a database to reflect the configuration of the first virtual local area network, wherein the database stores information on statuses of all virtual local area networks supported on the ring of connected devices; and
 - including, by the processor of the first device, a copy of the database in the first message.
9. The method of claim 8, further comprising:
 - removing, by the processor of the first device, a second virtual local area network from the database when a threshold period of time has passed without the processor of the first device receiving a message confirming a presence of the second virtual local area network.
10. The method of claim 8, wherein the sending comprises:
 - splitting the second message into multiple packets, when an amount of data contained in the copy of the database exceeds an amount of data that can be transmitted in a single packet; and
 - setting a bit in a field of the second message to indicate that the second message comprises the multiple packets.
11. The method of claim 1, wherein the sending comprises multicasting the second message.
12. The method of claim 1, wherein the second message specifies a Class of Service for the first virtual local area network.
13. The method of claim 1, wherein the second message includes a field that identifies a plurality of switch ports of the plurality of other devices, and a bit is set in the field to indicate which of the plurality of switch ports needs to be programmed to support the configuration.

14. A computer system comprising:
- a processor;
 - a storage coupled to the processor;
 - a user interface device to receive input from a user and present information to the user in human perceptible form; and
 - an instruction set to cooperate with the processor and the storage to:
 - receive a message requesting configuration of a virtual local area network on a ring of connected devices, wherein the devices are connected to the ring by respective network switches;
 - responsive to the first message, formulate a second message, wherein the second message identifies a plurality of the connected devices that need to program respective switch ports to support the configuration; and
 - send the second message to the plurality of the connected devices.
15. A non-transitory machine-readable storage medium encoded with instructions executable by a processor, the machine-readable storage medium comprising:
- instructions to receive a message requesting configuration of a virtual local area network on a ring of connected devices, wherein the devices are connected to the ring by respective network switches;
 - instructions to, responsive to the first message, formulate a second message, wherein the second message identifies a plurality of the connected devices that need to program respective switch ports to support the configuration;
 - instructions to send the second message to the plurality of the connected devices.

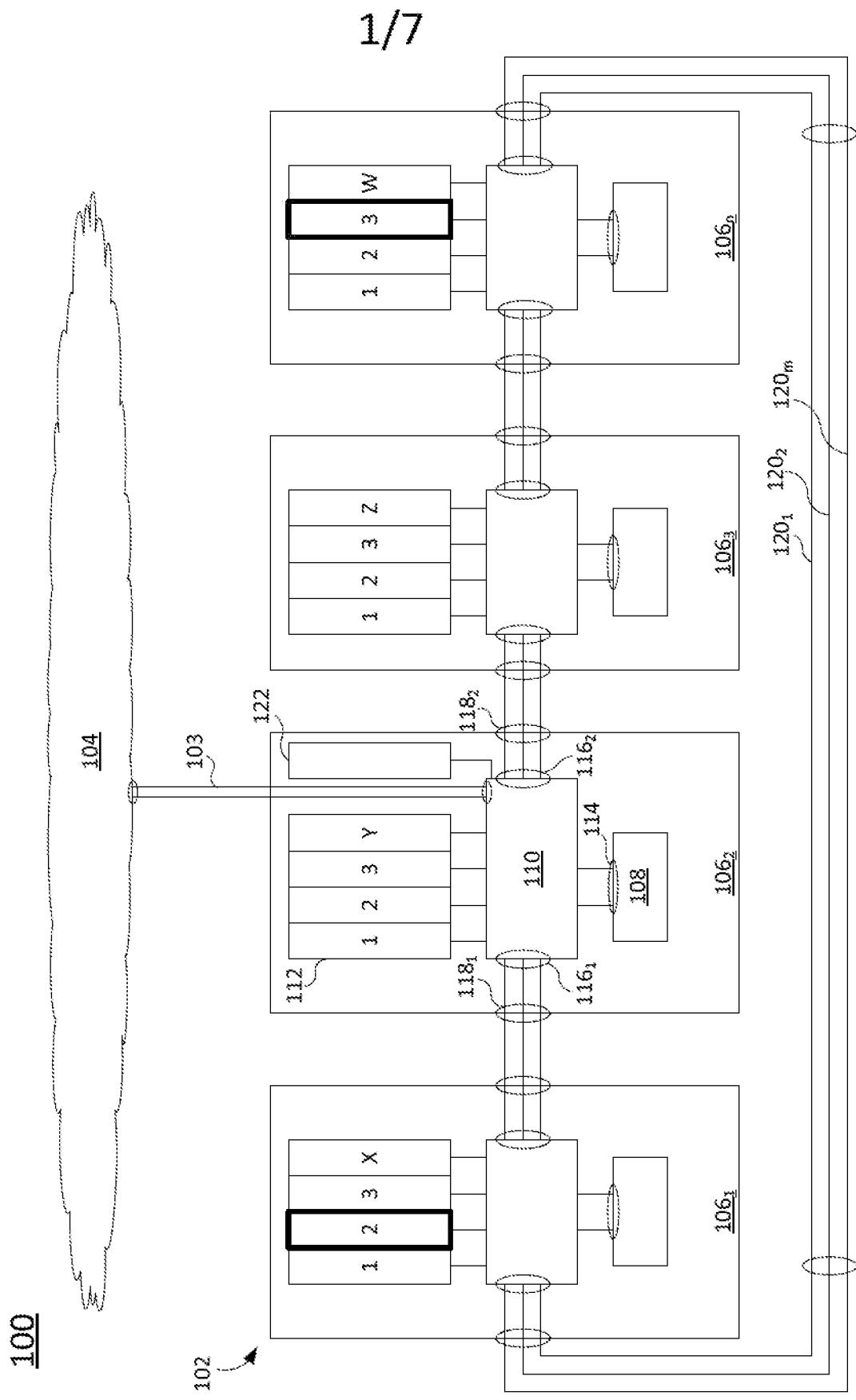


FIG. 1

200

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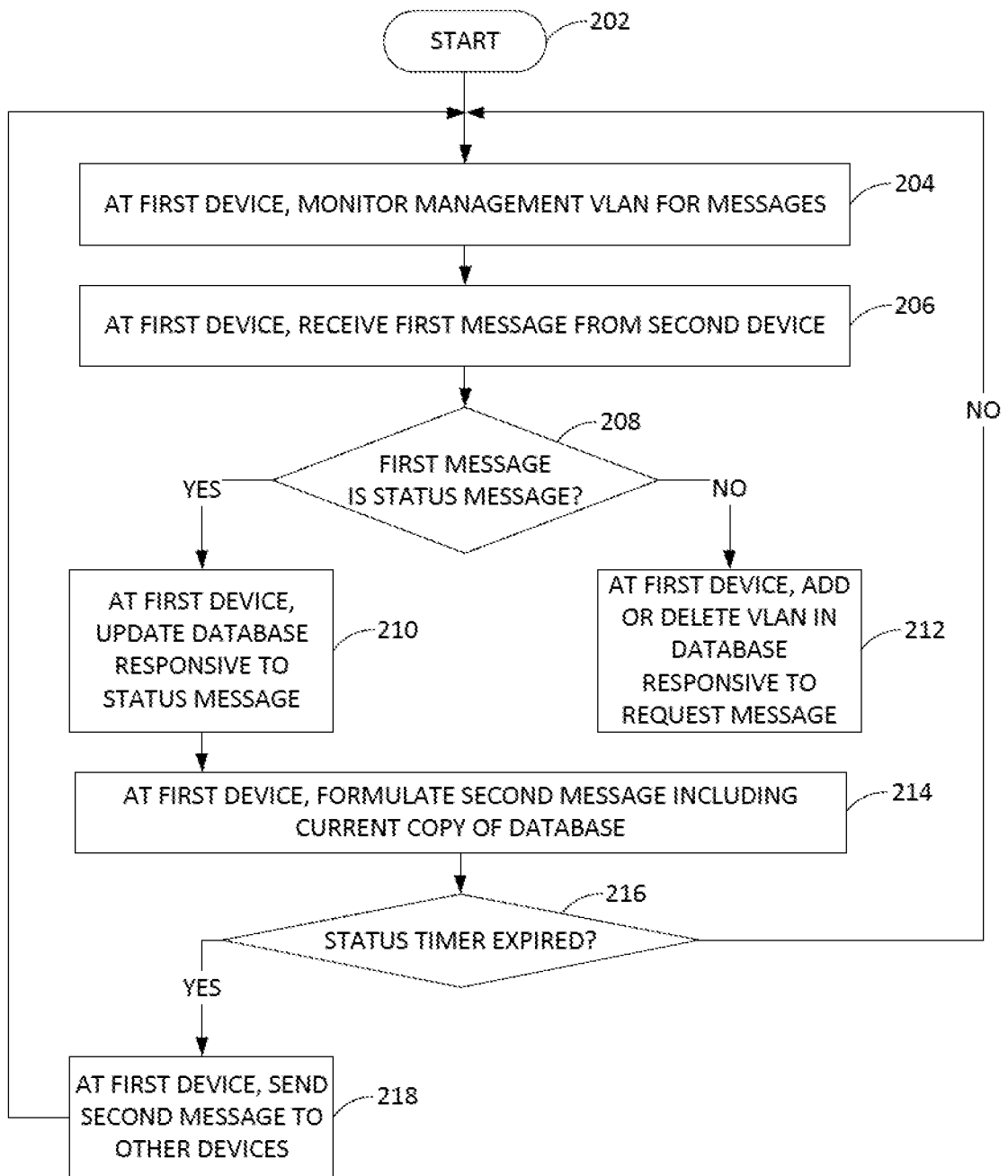


FIG. 2

300

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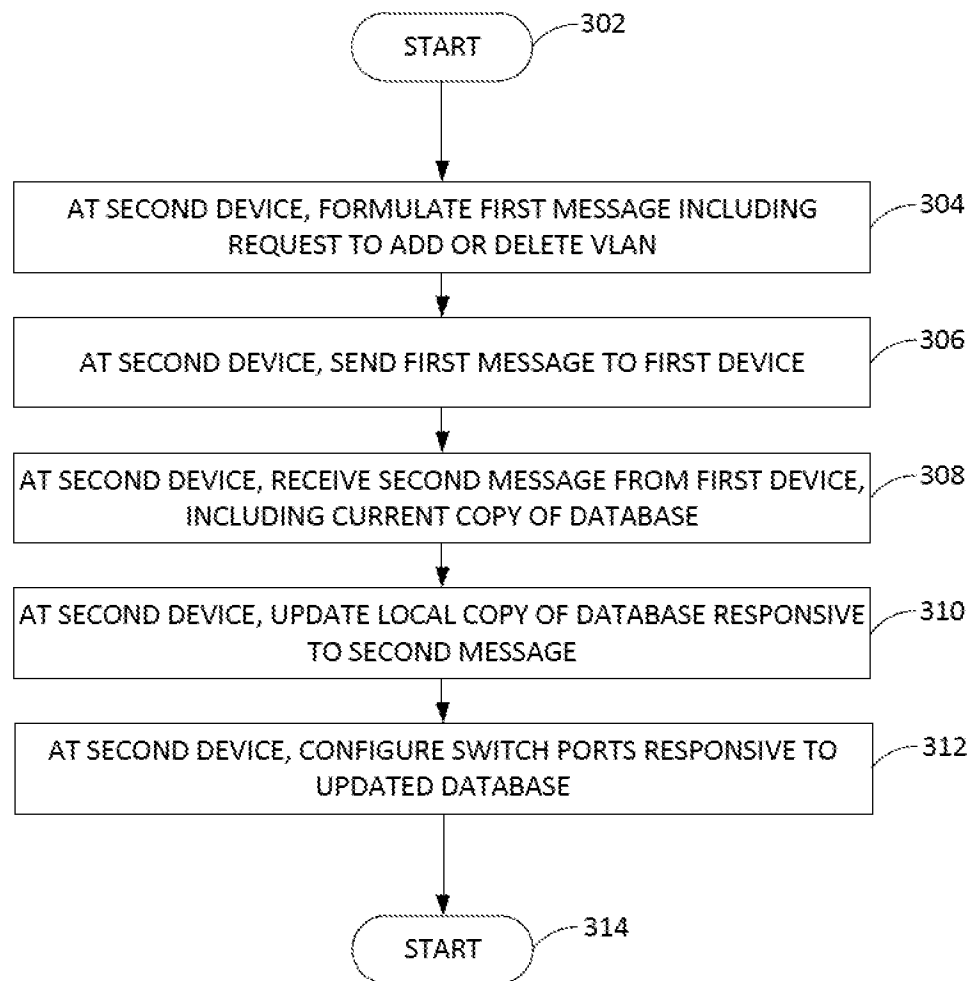


FIG. 3

400

	BYTE 1								BYTE 2								BYTE 3								BYTE 4							
	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
1	DEST MAC BYTE 1								DEST MAC BYTE 2								DEST MAC BYTE 3								DEST MAC BYTE 4							
5	DEST MAC BYTE 5								DEST MAC BYTE 6								SRC MAC BYTE 1								SRC MAC BYTE 2							
9	SRC MAC BYTE 3								SRC MAC BYTE 4								SRC MAC BYTE 5								SRC MAC BYTE 6							
13	VLAN TPID								VLAN TPID								VLAN ID								VLAN ID							
17	ETH TYPE								ETH TYPE								MEL				VERSION				OPCODE							
21	FLAGS								TLV OFFSET								STATE								ADD/DELETE/STATUS							
25	CONTINUE								UNUSED								NODE ID								NODE ID							
29	NODE ID								NODE ID								NODE ID								NODE ID							

FIG. 4A

400

BYTE 1										BYTE 2										BYTE 3										BYTE 4									
VLAN 4093										VLAN 4093										VLAN 4093 PROPERTIES										VLAN 4093 PROPERTIES									
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
COS VLAN										VLAN										L T/U M T/U ILO T/U ICM T/U EM T/U										L T/U M T/U ILO T/U ICM T/U EM T/U									
VLAN 4094										VLAN 4094										VLAN 4094 PROPERTIES										VLAN 4094 PROPERTIES									
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
COS VLAN										VLAN										L T/U M T/U ILO T/U ICM T/U EM T/U										L T/U M T/U ILO T/U ICM T/U EM T/U									
VLAN 4089										VLAN 4089										VLAN 4089 PROPERTIES										VLAN 4089 PROPERTIES									
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
COS VLAN										VLAN										L T/U M T/U ILO T/U ICM T/U EM T/U										L T/U M T/U ILO T/U ICM T/U EM T/U									
TLV OFFSET										COS 000 BANDWIDTH										COS 001 BANDWIDTH										COS 010 BANDWIDTH									
COS 011 BANDWIDTH										COS 100 BANDWIDTH										COS 101 BANDWIDTH										COS 110 BANDWIDTH									
COS 111 BANDWIDTH										RESERVED										END TLV																			

FIG. 4B

500

BYTE 1								BYTE 2								BYTE 3								BYTE 4								BYTE 5							
VLAN 4093								VLAN 4093								VLAN 4093 PROPERTIES								VLAN 4093 PROPERTIES								PRESENT							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
COS VLAN								VLAN								L T/U M T/U								ILO T/U ICM T/U CIM T/U EM T/U															
VLAN 4094								VLAN 4094								VLAN 4094 PROPERTIES								VLAN 4094 PROPERTIES								PRESENT							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
COS VLAN								VLAN								L T/U M T/U								ILO T/U ICM T/U CIM T/U EM T/U															
VLAN 4089								VLAN 4089								VLAN 4089 PROPERTIES								VLAN 4089 PROPERTIES								PRESENT							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
COS VLAN								VLAN																ILO T/U ICM T/U CIM T/U EM T/U															

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FIG. 5

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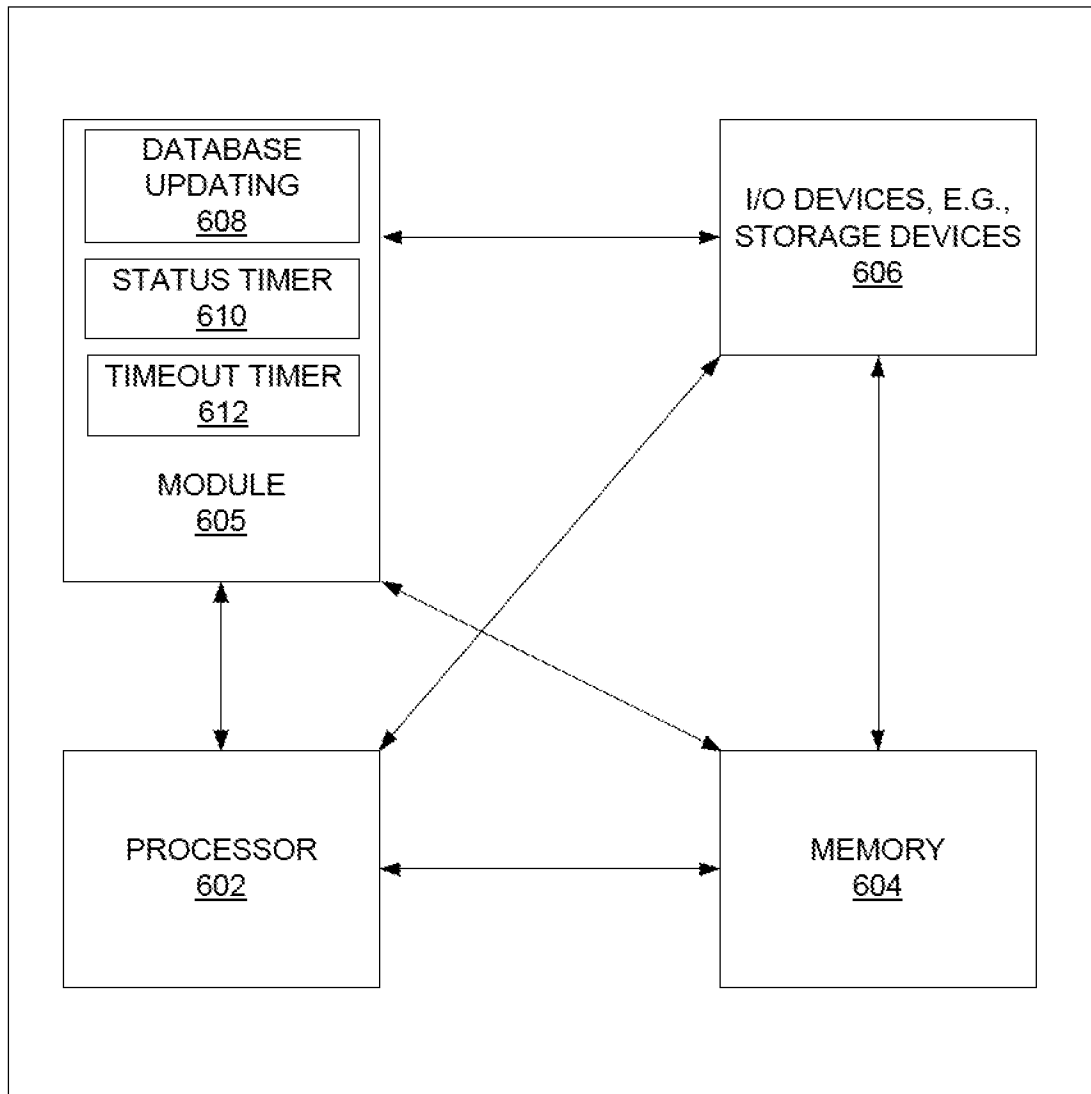
600

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/012767**A. CLASSIFICATION OF SUBJECT MATTER****H04L 12/42(2006.01)i, H04L 12/937(2013.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L 12/42; G06F 15/16; G06F 13/40; H04L 12/437; H04L 12/24; H04L 12/28; G06F 11/00; H04L 12/937

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: network, switch, ring, message, add, delete, VALN, update, database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7877483 B1 (NORMAN W. FINN) 25 January 2011 See column 1, lines 11-25; column 2, lines 43-46; column 3, lines 8-65; column 4, lines 30-36; column 8, line 63 - column 9, line 1; column 10, lines 10-41; column 14, lines 38-52; column 15, lines 3-17; and figure 1.	1-15
A	US 2007-0110078 A1 (SURAN S. DE SILVA et al.) 17 May 2007 See paragraphs [0022], [0032]-[0040], [0067], [0118]; and figure 2.	1-15
A	US 2008-0219149 A1 (KWANG-SEON YOO) 11 September 2008 See paragraphs [0078]-[0092]; and figure 3.	1-15
A	US 06035105 A (KEITH MCCLOGHRIE et al.) 07 March 2000 See column 3, line 40 - column 5, line 34; and figure 2.	1-15
A	KR 10-2011-0010481 A (ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE) 01 February 2011 See paragraphs [0022]-[0023], [0032]-[0038]; and figure 1.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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

"&" document member of the same patent family

Date of the actual completion of the international search

08 October 2015 (08.10.2015)

Date of mailing of the international search report

23 October 2015 (23.10.2015)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/012767

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7877483 B1	25/01/2011	None	
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