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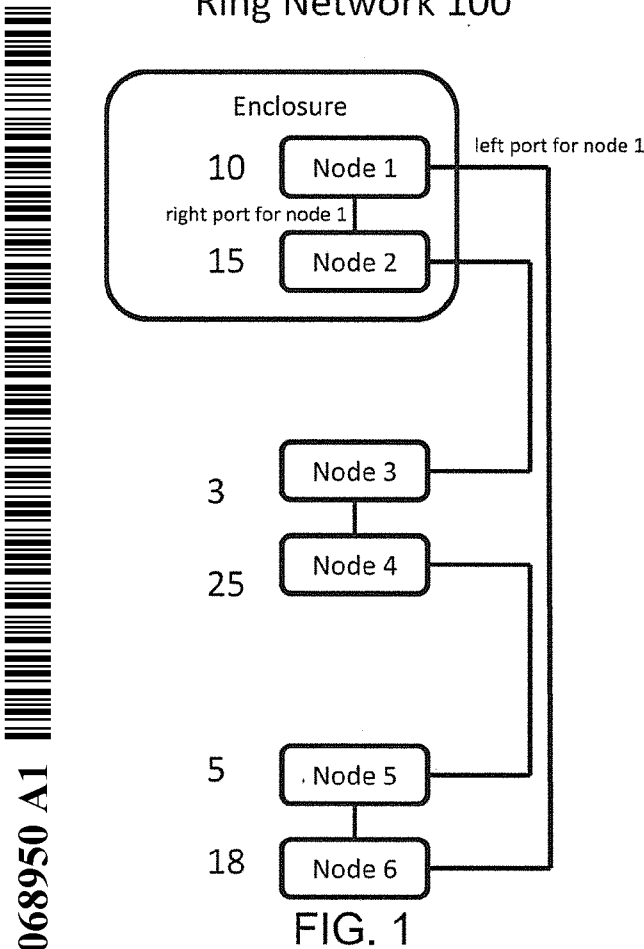
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(54) Title: OWNER NODE FOR RING NETWORK

(57) Abstract: In an example, a network node is in a ring network. The node can determine whether to select an owner node. Also, the owner node may be selected after a signal fail message.



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## OWNER NODE FOR RING NETWORK

### BACKGROUND

**[0001]** When creating a network, a network administrator typically selects a particular topology and protocol for the network. One popular example of protocol commonly used for layer-2 networks is the spanning tree protocol or the rapid spanning tree protocol, which are standardized protocols. These protocols arrange nodes in the network in a tree topology, as their names suggest. These protocols may disable links to prevent loops and provide backup links in the spanning tree in case of node failure.

**[0002]** Another type of topology that may be implemented is a ring topology, which connects nodes in a ring. To prevent loops, a link may be disabled in the ring so packets are not continually forwarded in the ring, which can bring down the network. A protocol that may be used in the ring topology, which prevents loops, is Ethernet Ring Protection Switching (ERPS), which is standardized by the ITU Telecommunication Standardization Sector (ITU-T) under G.8032. Under the G.8032 standard, a node in the ring is selected as an owner, and traffic is blocked on a link for the owner node to prevent a loop.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0003]** Features of the present disclosure are illustrated by way of example and not limited in the following figure(s), in which like numerals indicate like elements, in which:

**[0004]** Figure 1 shows a ring network, according to an example of the present disclosure;

**[0005]** Figure 2 shows a table illustrating information in messages sent in consecutive epochs, according to an example of the present disclosure;

**[0006]** Figure 3 shows a ring network, according to another example of the present disclosure;

**[0007]** Figure 4 shows a table illustrating information in messages sent in consecutive epochs, according to another example of the present disclosure;

**[0008]** Figure 5 shows a node, according to an example of the present disclosure;

**[0009]** Figure 6 shows bytes in a header field of a message, according to an example of the present disclosure;

**[0010]** Figures 7A-B show flow charts, according to examples of the present disclosure;

**[0011]** Figures 8-10 show additional examples of owner node selection; and

**[0012]** Figure 11 shows a flow chart, according to another example of the present disclosure.

## DETAILED DESCRIPTION

**[0013]** For simplicity and illustrative purposes, the present disclosure is described by referring mainly to an example thereof. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. It will be readily apparent however, that the present disclosure may be practiced without limitation to these specific details. In other instances, some methods and structures have not been described in detail so as not to unnecessarily obscure the present disclosure. In the present disclosure, the term “includes” means includes but not limited thereto, the term “including” means including but not limited thereto. The term “based on” means based at least in part on. In addition, the terms “a” and “an” are intended to denote at least one of a particular element.

**[0014]** According to examples of the present disclosure, systems and methods provide selection of an owner node in a ring topology. A ring topology of a network includes multiple nodes connected to each other in a ring such that each node is connected to two other nodes. For example, each node is connected to only 2 other nodes to create the ring. The ring topology provides a redundant path between each node. Each node connects to two network links, referred to as a left and a right link, so that the nodes are connected in a ring. There are two paths through the ring for communicating between any two nodes which are in a clockwise or a counter clockwise direction.

**[0015]** A node in the network is any computer or device that can communicate in the network, such as via a network link, with another node. The links may be wired or wireless. An example of a node is a switch. The switch may be a layer-2 switch and may be an Ethernet switch by way of example. Other types of switches may be used and any device or computer that can connect to two other nodes on the network, such as via two ports, may be a node. Layer-2 refers

to the Data Link Layer of the Open Systems Interconnection Basic Reference Model (the "OSI Model").

**[0016]** An owner node is selected to avoid loops in the ring topology. A loop can cause a packet to be repeatedly forwarded around the loop towards a destination. This can cause the network to overload and can cause failure in a short amount of time. The network with the ring topology, also referred to herein as the ring network, includes an owner node and the owner node is tasked with executing a procedure to prevent loops. In an example, the owner node blocks traffic on one of its ports that is connected to another node in the ring network via a link. For example, the ring network executes the G.8032 standard, which is promulgated by the ITU-T for loop prevention, and the owner node is responsible to block traffic at one end of a ring protection link (RPL) in the ring network according to the G.8032 standard. To prevent loops, traffic is allowed to flow on all but one of the ring links, and this link is called the RPL in the G.8032 standard. The owner node is connected to one end of the RPL and another node in the ring network is connected to the other end of the RPL, and the owner node is responsible for blocking traffic flow on the RPL, such as by blocking traffic on the RPL. G.8032 is one example of a standard that may be used in the ring network. Other standards or protocols may be used in the ring topology for packet forwarding, loop prevention, etc.

**[0017]** According to an example of the present disclosure, an owner node is selected for a network. The owner node may be selected before a protocol, such as G.8032, is executed. The owner node may be selected regardless of whether the network is in a ring topology or in a linear topology, such as when at least one node is not connected to two other nodes in the network. However, if the network is not in a ring topology, the network may enter a failed state if it executes a ring network protocol, such as G.8032, because application of the protocol may initially identify that a node is not connected to two other nodes to form the ring.

Regardless, an owner node may be selected prior to entering the failed state. A failed state for a ring network is entered for example if a node in the ring network cannot directly communicate with two other nodes in the ring network. Directly communicate may include communicating with two other nodes in the ring network without going through any intervening nodes in the ring network, such as two nodes connected to ports of the node. If there is a single failed state, traffic may still flow between all the nodes in the linear network but a ring cannot be formed.

**[0018]** Also, according to another example, an owner node may be selected after a failed state is entered in a ring network, such as described with respect to figures 8-11. This may include selecting a new owner node if the owner node fails.

**[0019]** Figure 1 illustrates a ring network 100 according to an example. The network includes nodes 1-6. More or less nodes may be included in the ring network. Multiple nodes may be provided in a single enclosure. For example, nodes 1 and 2 are shown as provided in the same enclosure. Each node may have a node identifier (ID) that identifies the node. The node ID may be unique in the ring network. The node ID may be used for packet forwarding. The node ID may be an address. In an example, the addresses may be media access control (MAC) addresses for layer-2 switching. The numbers shown to the left of the nodes represent their node IDs, but may be longer, such as 16-bit, 64-bit, or another length. Each node is connected to two other nodes via two ports, referred to as a left port and a right port. For example, node 1 is connected to node 6 via its left port and is connected to node 2 via its right port.

**[0020]** According to an example, during an owner node selection process, the nodes send owner selection messages, each message including a highest priority node ID, an indication of whether the node is an end link or not, and an indication that the message is for owner selection. In an example, a type-length-value (TLV) field is used to provide this information which is further described below. Optional information may be encoded in a TLV field according to a protocol.

The messages may be sent and received at consecutive epochs, such as every 10 milliseconds (ms) but another duration may be used.

**[0021]** Figure 2 shows a table illustrating the node IDs in the messages sent by each of the nodes 1-6 for three consecutive epochs T1-T3. The messages are sent for owner selection and none of the messages indicate the sending node is an end link node since the nodes are connected in a ring topology shown in figure 1 and there are no end links. At each epoch, each node stores a highest priority node ID, which may be the node ID from a received message or a currently stored, highest priority, node ID. Also, each node sends an owner selection message that includes the highest priority node ID, which may be a received node ID or its own node ID. In this example, highest priority means lowest node ID, but it could be defined another way, such as highest node ID. For example, at T1, for node 1, the highest priority node ID is 10, which at T1 is its node ID, but the highest priority node ID known to the node may change over time if the node receives a message with a lower node ID, such as shown at T3. At T1, node 1 receives a message from node 6 on its left port including node ID 18 (e.g., current highest priority node ID from node 6) and receives a message from node 2 on its right port including node ID 15 (e.g., current highest priority node ID from node 2). This is illustrated by “R-18L, 15R” for T1 and node 1 in the table. “R-” refers to received messages and “18L” and “15R” respective means that a node ID of 18 was received on the left port and a node of 15 was received on the right port. “S-”, shown in the table, refers to sent messages and “HP-” refers to the currently stored highest priority node. Since 10 is the lowest node ID when compared to 15 and 18, 10 remains stored as the highest priority node ID. Also, at T1, node 1 sends messages for ownership selection out its left and right port that includes its current highest priority node, which is 10, during the epoch. This process continues and a node’s current highest priority node ID may change if it receives a message with a lower node ID. For example, during T2, node 1 receives on its right port a message with a node ID



of 3 and it stores 3 as its new highest priority node ID. Therefore, by the beginning of T3, the highest priority node ID is shown as HP-3 for node 1 at T3, and a message is sent during T3 with a node ID of 3. This process continues until a node receives messages for the same epoch and the messages have the same highest priority node ID. This is illustrated at T3 for node 6 which receives messages on its right and left ports, both including a node ID of 3. For example, at T1, node 6 receives a message with node ID of 10 from node 1 on its right port and a message with node ID of 5 on its left port and stores the highest priority node ID as 5. At T2 it sends a message with node ID of 5 on its right port to node 1. It does not need to send a message to node 5 on its left port because it just received a message from node 5 with the node ID of 5 on its left port. During T3, node 5 receives messages on both its ports with the same node ID as the highest priority nodes. So now node 6 determines it is the owner node. Once this happens, node 6 sends messages declaring that it's the owner, i.e., the owner is assigned, so all other nodes are notified as such. Then, the ring protocol may be executed and loop prevention tasks may be executed by the owner node, such as blocking traffic on an RPL.

**[0022]** Figures 3 and 4 illustrate assigning an owner when there are end link nodes. For example, as shown in figure 3, assume nodes 1 and 6 are not connected via a link, so both are end link nodes. Thus, there is no ring and the network is in a linear topology rather than a ring topology. Nodes 1 and 6 shown in figure 3 can determine they are end nodes (or end links) for example if either their left or right port is not connected to another node. Similar to discussed above with respect to figures 1 and 2, ownership selection messages are sent, except that the messages sent from nodes 1 and 6 identify that they are end links (i.e., end link state = true), and the indication of end links is propagated in ownership selection messages, which eventually reach nodes in the center of the network, such as nodes 3 and 4 shown in figure 3. For example, a bit or byte is set in an ownership selection message sent from each of the nodes 1 and 6 to indicate that it is an end

link (e.g., set state to end link), and nodes 2 and 5 include the end link state, which was determined from ownership selection messages received from nodes 2 and 5, in their ownership messages sent out their ports, thus propagating an indication through the nodes that there are end link nodes. The table shown in figure 4 illustrates this. For example, at T1, nodes 1 and 6 send messages with the state set for end link to “true”, which is indicated by the “EL”, and nodes 2 and 5 receive the ownership selection messages with the EL. At T2, nodes 2 and 5 keep the end link state and propagate it out their ports. At T3, nodes 3 and 4 both receive ownership selection messages with the end link state set to “true” on both their right and left ports. When a node receives, on both its right and left ports, ownership selection messages with the end link state set to “true”, during the same epoch, the node determines that the network has end links, i.e., no ring, and that the highest priority node ID should be selected as the node owner. For example, at T3, nodes 3 and 4 receive ownership selection messages on both their ports with the end link states set to “true”. Nodes 3 and 4 determine the highest priority nodes, which is shown in figure 4 as HP-3 (i.e., node ID 3). Nodes 3 and 4 send messages to the node with node ID 3 that it is to become the owner node. The messages may indicate “owner assigned” so that node 3 can determine when it receives the messages that it is to become the owner node.

**[0023]** As shown in figure 3, the network is not a ring. Once a ring protocol is executed, failed conditions may be identified and indicated because nodes 1 and 6 are not connected. However, the owner node has already been selected such as described above.

**[0024]** Figures 1-4 show examples of nodes in the ring network that can receive an owner selection message to select an owner node for the network and determine whether the network is in a ring topology from information in the received owner selection message. For example, if the owner selection message identifies an end link state is “true” then the node determines that the network is not

in a ring topology; otherwise the node determines the network is in a ring topology. In response to determining the network is in the ring topology, a first test or second test may be executed, as further described below, to determine whether an owner node for the network is selectable based on information in the received owner selection message (e.g., node ID in the received message) and the highest priority node information stored in the data storage (e.g., the currently stored highest priority node of the node receiving the message).

**[0025]** Figures 5 illustrates an example of a node in the networks shown in figures 1 and 3. In an example, the node is a network switch. As shown in figure 5, the node 500 includes a hardware controller 304, an input/output interface 502, a data storage 506 and modules 510 and 511. The controller 304 may include a microprocessor operable to execute machine readable instructions to perform programmed functions and/or hardware dedicated to perform one or more particular functions, such as an application specific integrated circuit (ASIC), field-programmable gate array (FPGA), or other customized integrated circuit.

**[0026]** The data storage 506 may include volatile and/or non-volatile data storage, such as random access memory, memristors, flash memory, and the like. Machine readable instructions, tables, packet forwarding rules, and any information used by the node 500 may be stored on the data storage 506. Other known electronic components may be added or substituted in the network infrastructure device 300.

**[0027]** The input/output interface 502 may include hardware and/or software to enable the controller 504 to communicate with nodes through ports 516 and 517. The input/output interface 502 may include a network interface card. The ports 516 and 517 may be Ethernet ports. The node 500 may have more than two ports, for example, to connect to other computer systems, which may include servers.

**[0028]** The module 510 may be for network traffic management, such as packet forwarding based on a routing table and packet forwarding rules. The

module 510 may execute a ring network protocol. The module 511 may be an owner node module that implements the methods and functions described herein. For example, the module 511 is to receive an owner selection message to select an owner node for the network; determine whether the network is in a ring topology from information in the received owner selection message; and in response to determining the network is in the ring topology, execute a first test to determine whether to select an owner node for the network based on information in the received owner selection message and the highest priority node information stored in the data storage. In an example, the module 511 is to receive a signal fail message indicating a failed condition and that the ring network is no longer connected in a ring topology; and determine whether the node is to become an owner node for the ring network based on the signal fail message. The modules 510 and 511 may be implemented by the controller 304. The modules 510 and 511 may include hardware customized to perform the functions of the modules and/or may include machine readable instructions stored on a non-transitory computer readable medium (e.g., data storage 506) such as volatile or non-volatile memory or other type of data storage, and executed by the processor 304. In an example, the node may be connected to an external processor that can execute one or more of the functions of the modules 510 and 511. For example, the node may include a layer-2 switch that sends packets related to owner node selection to an external processor to perform the methods described herein.

**[0029]** As discussed above, information is conveyed in the messages to select the owner and to identify the owner node after it is selected. Figure 6 illustrates an example of bytes that may be provided in a field of a packet to carry the information. For example, the field is a TLV field where optional information may be encoded. The bytes identify information used for selecting the owner node. For example, byte 1 identifies whether the packet is for an owner selection message or an owner assignment message or an owner identification message

during a signal fail condition. For example, the exchanged owner selection messages, which are discussed above with respect to figures 1-4, set byte 1 to indicate that the messages are for owner selection. After the owner is identified, byte 1 is set to indicate that the owner is assigned and the packet includes the node ID of the selected owner node. The owner identification message is discussed with respect to figure 10. Byte 2 may indicate the end link state, such as whether the messages are from an end link or not. Messages described with respect to figures 3 and 4 set the end link state to “true” when propagating from the end links towards nodes 3 and 4 shown in figure 3. Multiple bytes, such as bytes 3-8, may include the node ID of the highest priority node.

**[0030]** For example, the bytes shown in figure 6 are in a TLV field of a G.8032 packet that uses a specific op code to identify that the packet is for owner node selection and that the information for the owner node selection is in the TLV field.

**[0031]** Figures 7A-B illustrate methods for owner node selection according to examples. The methods may be performed by a node in a ring network node, such as the node shown in figure 5, which may be any of the nodes shown in figures 1 and 3. The methods may be performed regardless of whether the nodes are fully connected in the ring network or whether any of the nodes are disconnected. If any of the nodes are disconnected (e.g., there are end link nodes in the network that are not connected to two other nodes in the network), the owner node may be selected but execution of ring protocol in the ring network may cause a failed condition.

**[0032]** A method 600 shown in figure 7A includes, at step 601, the node determines whether a ring network is connected in a ring topology or a linear topology. The determination may be based on information in an owner selection message received from another node in the ring network or based on whether the node is an end link. If the node is an end link node, then the ring network is

connected in a linear topology such as shown in figure 3. If the node receives an ownership message that does not include an end link state set to “true”, then the node assumes that the network is connected in a linear topology; otherwise if the end link state set to “false”, the node assumes the network is connected in a ring topology. At 602, if the ring network is determined to be connected in the ring topology, the node executes a first test to determine whether to select an owner node for the network based on the information in the owner selection message. At 603, if the ring network is determined to be connected in the linear topology, the node executes a second test, different from the first test, to determine whether to select the owner node for the network based on the information in the owner selection message. Examples of the first and second test are described below.

**[0033]** Figure 7B shows a method 700. The method 700 includes the steps of the method 600 and additional steps and provides examples of the steps. At 701, an owner selection message is received at a node and is transmitted from another node in the network. The owner selection message may include a highest priority node ID, an indication of whether an end link state is set to true, and an indication that the message is for owner selection. The end link state is set to true if the sending node or a previous node was an end link node.

**[0034]** At 702, the receiving node determines whether the network is in a ring topology based on information in the received owner selection message. For example, if the end link state is set to “false” then the node determines the nodes are connected in a ring topology. For example, the node assumes that all the nodes in the ring network are connected in a ring.

**[0035]** At 703, in response to determining the network is in the ring topology, the node executes a first test to determine whether to select an owner node for the network based on information in the received owner selection message and the highest priority node information stored in the data storage. For example, as described with respect to figures 1 and 2, if messages are received in the same

epoch that have the same highest priority node ID, then the node with the highest priority node is selected as the owner node. For example, as shown in figure 2, node 6 at T3 receives messages on its right and left ports, both including a node ID of 3. Then, at 704, the node selects an owner node, which is the node with the highest priority node ID (e.g., node ID 3), and sends an owner node identification message to the nodes in the network to indicate that node ID 3 is the owner node. If the node determines not to select the owner node at 703, such as if messages are not received in the same epoch that have the same highest priority node ID, then at 705, the node sends out an owner selection message on at least one of its ports that includes the highest priority node known to the node. The highest priority node known to the node for example is the currently stored highest priority node.

**[0036]** At 706, in response to determining the network is not in a ring topology, the node executes a second test, different from the first test, to determine whether to select the owner node based on information in the received owner selection message and the highest priority node information stored in the data storage. For example, the second test is to determine whether owner selection messages are received on both right and left ports of the node having end link states set to true, during the same epoch. If yes, at 707, the node selects the highest priority node ID as the owner node and at 708 sends an owner assigned message to the highest priority node. For example, figure 6 indicates a state identified at byte 1 of a TLV where the state can be selected as “owner assigned”. At T3, nodes 3 and 4 receive ownership selection messages on both their ports with the end link states set to “true”. Nodes 3 and 4 determine the highest priority node, which is shown in figure 4 as HP-3 (i.e., node ID 3). Nodes 3 and 4 send owner assigned messages identifying node ID 3 is the owner node or is to become the owner node. If the node determines not to select the owner node, such as if messages are not received in the same epoch that have the end link states set to “true”, then at 709, the node sends out an owner selection message on at least one

of its ports that includes the highest priority node known to the node and the end link state is set to true.

**[0037]** Figures 8-10 illustrate owner node selection according to examples if the ring topology is broken after the owner node was previously selected and after the ring network was previously connected as a ring and functional to send traffic in the ring network under a ring protocol, such as the G.8032 protocol. Figures 8 and 9 show an example, whereby the previously-selected owner node remains in the ring network but a link failure occurs, causing signal fail messages to be propagated to the owner node. A signal fail message indicates a failed condition in the ring network, and a node may assume that the ring network is no longer connected in a ring topology if a signal fail message is received. In this example, the owner node detects a signal fail message and sends owner identification messages to the nodes in the ring network that indicate the owner is still connected to the ring network. Figure 8 shows a ring network operational for example under the G.8032 protocol whereby a failure has yet to occur. The ring network includes nodes 1-8, and node 2 is the owner node. Node 2 creates an RPL between nodes 2 and 3 to prevent a loop in the ring network. Figure 9 shows the same ring network as figure 8, except a link failed between nodes 6 and 7. For example, a cable between nodes 6 and 7 is unplugged or the link fails for another reason. According to the G.8032 protocol, the link failure is detected which causes the end link nodes send signal fail messages (shown as SF). For example, nodes 6 and 7 send SF messages which are propagated by each node receiving the SF messages. The SF messages include the node ID of the end link node that sent the initial SF message.

**[0038]** According to an example of the present disclosure, if the node owner receives an SF message, it sends an owner node identification message out its port that indicate the owner node is assigned and is still present in the ring network. Also, the owner node enables the RPL so traffic is not blocked on the RPL. For



example, node 2, which is the owner node, receives the SF message initially sent from node 6 and/or node 7, and enables the RPL and sends an owner node identification message out each of its port, as shown in figure 9. The owner node identification message has a state of "owner identified" to indicate that the owner is still in the network. For example, the state is set to "owner identified" in byte 1 of the TLV shown in figure 6, and the node ID of the owner node is included in the owner node identification message, for example in bytes 3-8, to indicate to other nodes in the network that the owner node is still present in the SF condition. Accordingly, the other nodes are notified that the owner node is still in the network, and when the failed condition is fixed, the owner node enables the RPL and the ring network can operate to send network traffic.

**[0039]** According to another example of the present disclosure, if the owner node is removed, an end link node automatically becomes the owner node. For example, referring to figure 9 whereby node 2 is the owner node, assume node 2 fails. Figure 10 shows the ring network with node 2, which is the owner node, removed from the ring network. Nodes 1 and 3 detect that they are end links (e.g., detect that they are not connected to two other nodes) and send SF messages. The SF messages are propagated by the other nodes and each SF message includes the node ID of the end link node. According to the example, if one of the two end link nodes does not receive an owner node identification message before it receives an SF message (or a predetermined number of multiple SF messages) then it knows that it needs to become the owner node. For example, node 1 eventually receives the SF message initially sent from node 3 and propagated via nodes 4-8 towards node 1. Node 1 determines that is an end link node and determines that it received a predetermined number of SF messages without receiving or before receiving an owner node identification message. Node 1 then compares the node ID in the SF message, which is 10, with its node ID. If the node ID of node 1 is higher priority than node 3, then node 1 becomes the owner

node and sends owner node identification messages indicating that it is the owner node. In this example, the node ID of node 1 is 8, which is less than the node ID of node 3 which is 10, so node 1 is the highest priority end link node and it becomes the owner node and sends owner node identification messages. When the failed condition is fixed, the owner node enables an RPL and the ring network can operate to send network traffic.

**[0040]** Figure 11 shows a method 1100 of determining the owner node according to the examples of figures 8-10. The method 1100 may be performed by a node in a ring network node, such as the node shown in figure 5, which may be any of the nodes shown in figures 8-10. At 1101, an SF message is received at a node in a ring network. The SF message is sent in response to a node detecting a failed condition, which may be in response to a failed link, failed node, etc. The SF node is initially sent by an end link node. At 1102, the node receiving the SF message determines whether it is an end link node. If no, at 1103, the node determines whether it is an owner node. If no, at 1104, the node propagates the received SF message by sending the SF message out its ports. If yes, at 1105, the node sends an owner identification message to indicate that it is the owner node. For example, as shown in figure 9, node 2 is the owner node, and it receives the SF message and sends owner identification messages out its ports. The owner node may repeat sending the owner node identification message until the failed condition is fixed.

**[0041]** As indicated above, at 1102, the node receiving the SF message determines whether it is an end link node. If yes, at 1106, the end link node determines whether it is an owner node. If it is an owner node, at 1107, the owner node sends owner identification messages out its ports. If the end link node is not an owner node, at 1108, the end link node determines whether it received a predetermined number (e.g.,  $\geq 2$ ) of SF messages from the other end link node without receiving an owner identification message. If not, at 1109, the end link

node propagates the received SF message. If yes, at 1110, the end link node determines whether it is the higher priority node when compared to the node ID in the SF message of the other end link node. If the end link node is the higher priority node, then the end link node sends owner identification messages at 1111. For example, as shown in figure 10, node 1 sends owner identification messages because it is higher priority than node 3, after receiving a predetermined number of SF messages from node 3. If the end link node is not the higher priority node, then the end link node propagates the SF message at 1112.

**[0042]** What has been described and illustrated herein are examples of the disclosure along with some variations. The terms, descriptions and figures used herein are set forth by way of illustration only and are not meant as limitations. Many variations are possible within the scope of the disclosure, which is intended to be defined by the following claims, and their equivalents, in which all terms are meant in their broadest reasonable sense unless otherwise indicated.

What is claimed is:

1. A network node in a ring network, the node comprising:  
a data storage to store information for a highest priority node;  
ports to send and receive messages in the network; and  
5 a hardware controller, wherein the controller is to  
receive an owner selection message to select an owner node for the  
network;  
determine whether the network is in a ring topology from information  
in the received owner selection message; and  
10 in response to determining the network is in the ring topology,  
execute a first test to determine whether to select an owner node for the network  
based on information in the received owner selection message and the highest  
priority node information stored in the data storage.
- 15 2. The network node of claim 1, wherein in response to determining the  
network is not in a ring topology, the controller is to execute a second test, different  
from the first test, to determine whether to select the owner node for the network  
based on information in the received owner selection message and the highest  
priority node information stored in the data storage.
- 20 3. The network node of claim 2, wherein the controller is to send an owner  
selection message out at least one of the ports identifying the highest priority node  
or a newly selected highest priority node in response to determining not to select  
the owner node based on the execution of the first test or the second test.
- 25 4. The network node of claim 3, wherein the controller is to compare the  
information for the highest priority node in the data storage to highest priority node  
information from the received owner selection message to determine whether to

include information for the highest priority node or the newly selected highest priority node in the sent owner selection message.

5. The network node of claim 2, wherein the controller is to send an owner assigned message out at least one of the ports in response to selecting the owner node based on the execution of the first test or the second test.

6. The network node of claim 5, wherein after receiving the owner assigned message, nodes in the network execute a ring network protocol regardless of whether the network is determined to be in the ring topology or not.

7. The network node of claim 1, wherein to execute first test, the controller is to determine whether an owner selection message is received on each of the ports in the same epoch, and each owner selection message identifies the same highest priority node.

8. The network node of claim 2, wherein to execute second test, the controller is to determine whether an owner selection message is received on each of the ports in the same epoch, and each owner selection message indicates that an end link state is set to true.

9. The network node of claim 1, wherein to determine whether the network is in the ring topology, the controller is to determine whether the received owner selection message indicates that an end link state is set to true.

10. The network node of claim 9, wherein the end link state is set to true by an end link node that previously sent an owner selection message in response to determining that it is not connected to two other nodes in the network.

11. The network node of claim 1, wherein the network is a ring network, and each node in the network connects to two other nodes in the network to form the ring topology, and the owner node blocks traffic on a link connecting the owner node to another node in the ring network to prevent loops.

5

12. A method comprising:

determining, by a hardware controller for a node in a ring network, whether the ring network is connected in a ring topology or a linear topology based on information in an owner selection message received from another node in the ring network or based on a determination of whether the node is an end link;

10

if the ring network is determined to be connected in the ring topology, executing a first test to determine whether to select an owner node for the network based on the information in the owner selection message; and

15

if the ring network is determined to be connected in the linear topology, executing a second test, different from the first test, to determine whether to select the owner node for the network based on the information in the owner selection message.

13. The method of claim 12, comprising:

20

sending an owner selection message out at least one port of the node identifying the highest priority node or a newly selected highest priority node in response to determining not to select the owner node based on the execution of the first test or the second test.

25

14. A network node in a ring network executing a ring protocol, the node comprising:

a data storage to store information for a highest priority node;

ports connected to other nodes in the ring network; and

a hardware controller, wherein the controller is to  
receive a signal fail message indicating a failed condition and that the  
ring network is no longer connected in a ring topology; and  
determine whether the node is to become an owner node for the ring  
5 network based on the signal fail message.

15. The network node of claim 14, wherein to determine whether the node is to  
become the owner node, the controller is to:

determine whether the node received a predetermined number of signal fail  
10 messages prior to receiving an owner identification message; and  
in response to determining the predetermined number of signal fail  
messages are received prior to the owner identification message;  
determine whether the node is a highest priority end link node; and  
send an owner identification message to other nodes in the network  
15 indicating that the node is the owner node in response to determining the node is  
the highest priority end link node.

|                       | T1                                     | T2                                    | T3                             |
|-----------------------|----------------------------------------|---------------------------------------|--------------------------------|
| Node 1<br>Node ID= 10 | HP-10<br>S-10L,10R<br>R-18L,15R        | HP-10<br>S-10L,10R<br>R-5L, <u>3R</u> | HP-3<br><u>S-3L</u><br>R-5L,3R |
| Node 2<br>Node ID= 15 | HP-15<br>S-15L,15R<br>R-10L, <u>3R</u> | HP-3<br><u>S-3L</u><br>R-3L           | HP-3<br>S-3L<br>R-3R           |
| Node 3<br>Node ID= 3  | HP-3<br><u>S-3L,3R</u><br>R-25L,15R    | HP-3<br>S-3L,3R<br>R-NO               | HP-3<br>S-3L,3R<br>R-NO        |
| Node 4<br>Node ID= 25 | HP-25<br>S-25L,25R<br>R- <u>3L</u> ,5R | HP-3<br><u>S-3R</u><br>R-3L,5R        | HP-3<br>S-3R<br>R-3L           |
| Node 5<br>Node ID= 5  | HP-5<br>S-5L,5R<br>R-25L,18R           | HP-5<br>S-5L,5R<br><u>R-3L</u> ,5R    | HP-3<br><u>S-3R</u><br>R-3L    |
| Node 6<br>Node ID= 18 | HP-18<br>S-18L,18R<br>R-5L,10R         | HP-5<br>S-5R<br>R-5L                  | HP-5<br>S-5R<br><u>R-3L,3R</u> |

HP-Highest Priority  
S - Sent  
R- Received  
R, Right Port  
L , Left Port

Ring Network 100

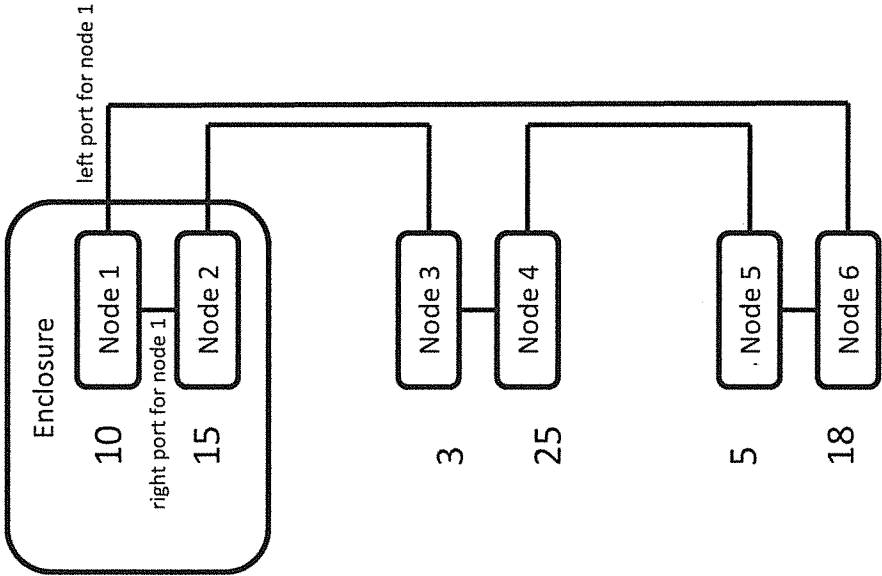


FIG. 1

FIG. 2



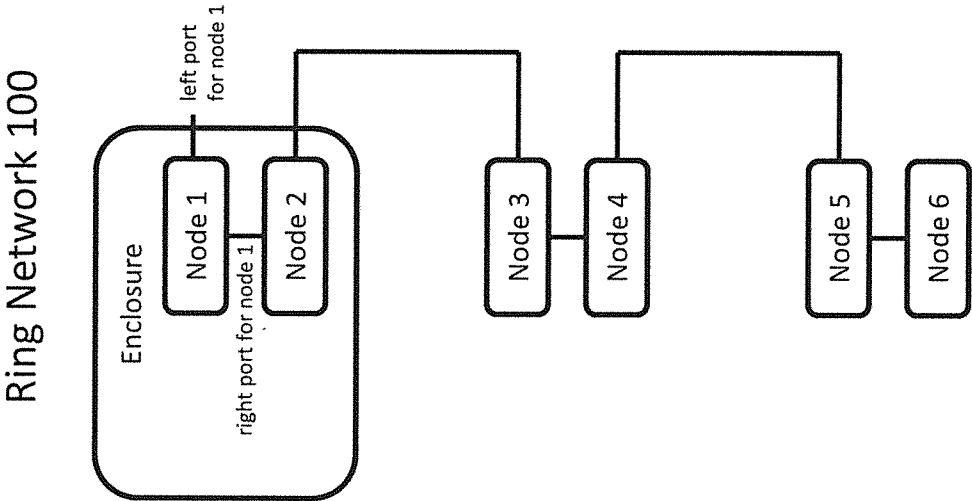


FIG. 3

|                       | T1                                            | T2                                           | T3                                                          |
|-----------------------|-----------------------------------------------|----------------------------------------------|-------------------------------------------------------------|
| Node 1<br>Node ID= 10 | HP-10<br><u>S-10R-EL</u><br>R-15R             | HP-10<br>S-10R-EL                            | HP-10<br>S-10R-EL                                           |
| Node 2<br>Node ID= 15 | HP-15<br>S-15L,15R<br><u>R-10L-EL</u><br>R-3R | HP-10<br><u>S-10R-EL</u><br>R-10L-EL<br>R-3R | HP-10<br>S-10R-EL<br>R-10L-EL                               |
| Node 3<br>Node ID= 3  | HP-3<br>S-3R,3L<br>R-25R,15L                  | HP-3<br>S-3R,3L<br><u>R-10L-EL</u>           | HP-3<br><u>S-3R-EL</u><br><u>R-10L-EL</u><br><u>R-5L-EL</u> |
| Node 4<br>Node ID= 25 | HP-25<br>S-25L,25R<br>R-3L,5R                 | HP-3<br>S-3L<br>R-3L<br><u>R-5R-EL</u>       | HP-3<br><u>S-5L-EL</u><br><u>R-3L-EL</u><br><u>R-5R-EL</u>  |
| Node 5<br>Node ID= 5  | HP-5<br>S-5L,5R<br>R-25L<br><u>R-18R-EL</u>   | HP-5<br><u>S-5L-EL</u><br>R-18R-EL           | HP-5<br>S-5L-EL<br>R-18R-EL                                 |
| Node 6<br>Node ID= 18 | HP-18<br><u>S-18L-EL</u><br>R-5L              | HP-18<br>S-18L-EL                            | HP-18<br>S-18L-EL                                           |

HP-Highest Priority  
S - Sent  
R- Received  
R, Right Port  
L, Left Port  
EL -End Link

FIG. 4

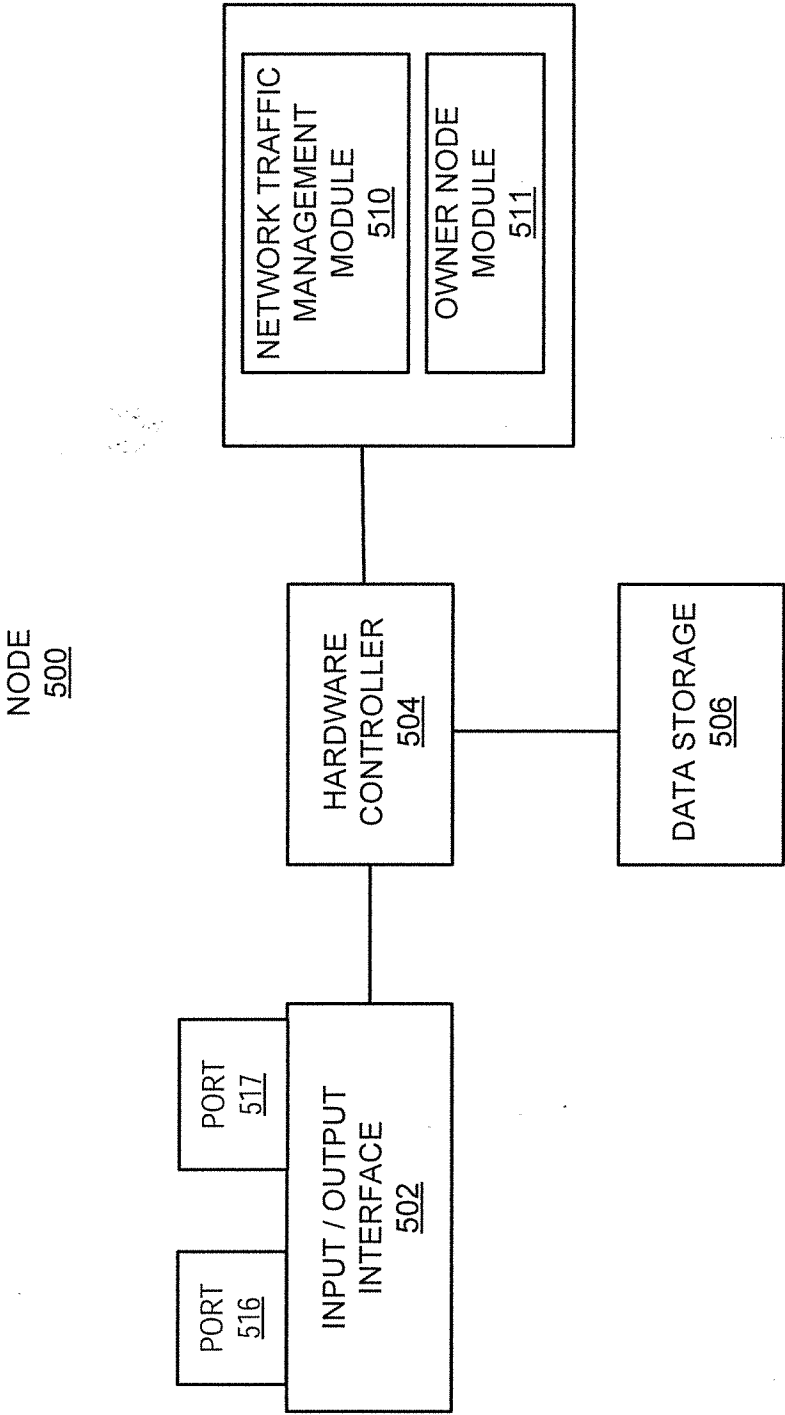


FIG. 5

|         |          |         |         |
|---------|----------|---------|---------|
| Byte 1  | Byte 2   | Byte 3  | Byte 4  |
| State   | End Link | Node ID | Node ID |
| Node ID | Node ID  | Node ID | Node ID |
| Byte 5  | Byte 6   | Byte 7  | Byte 8  |

- State**
- 1 - Owner Selection
  - 2 - Owner Assigned
  - 3 - Owner Identified

- End Link**
- TRUE
  - FALSE
- Node ID**
- MAC Address

FIG. 6

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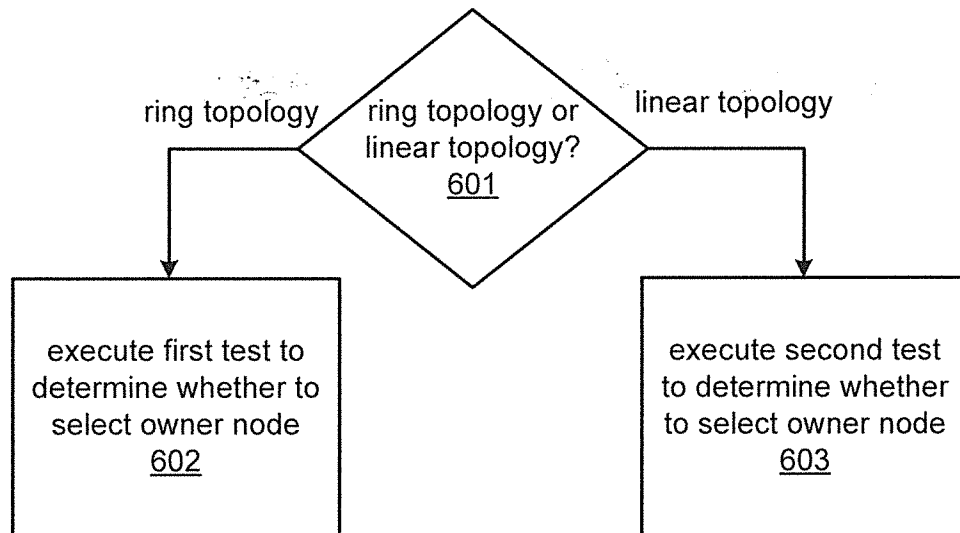
600

FIG. 7A

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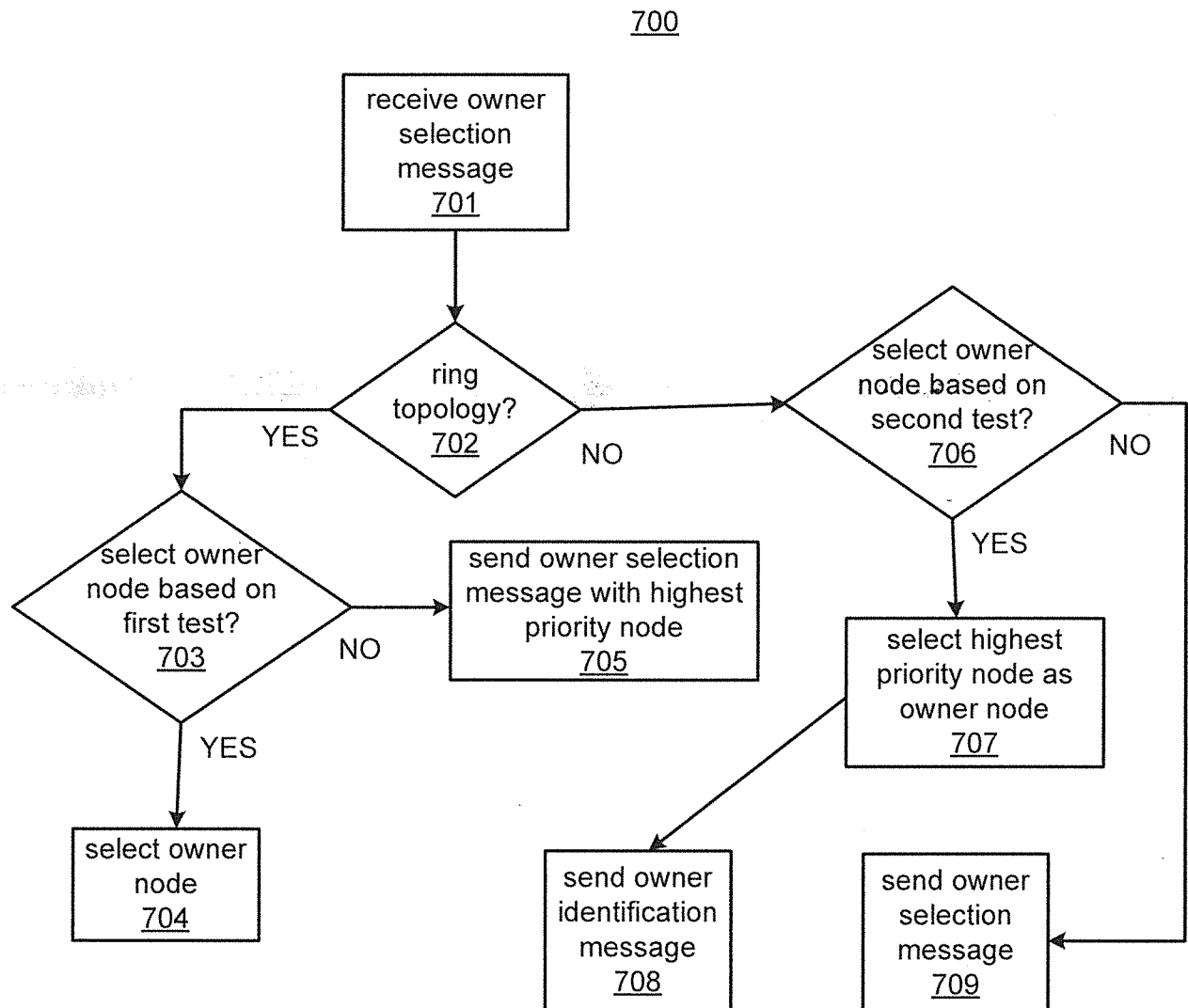


FIG. 7B

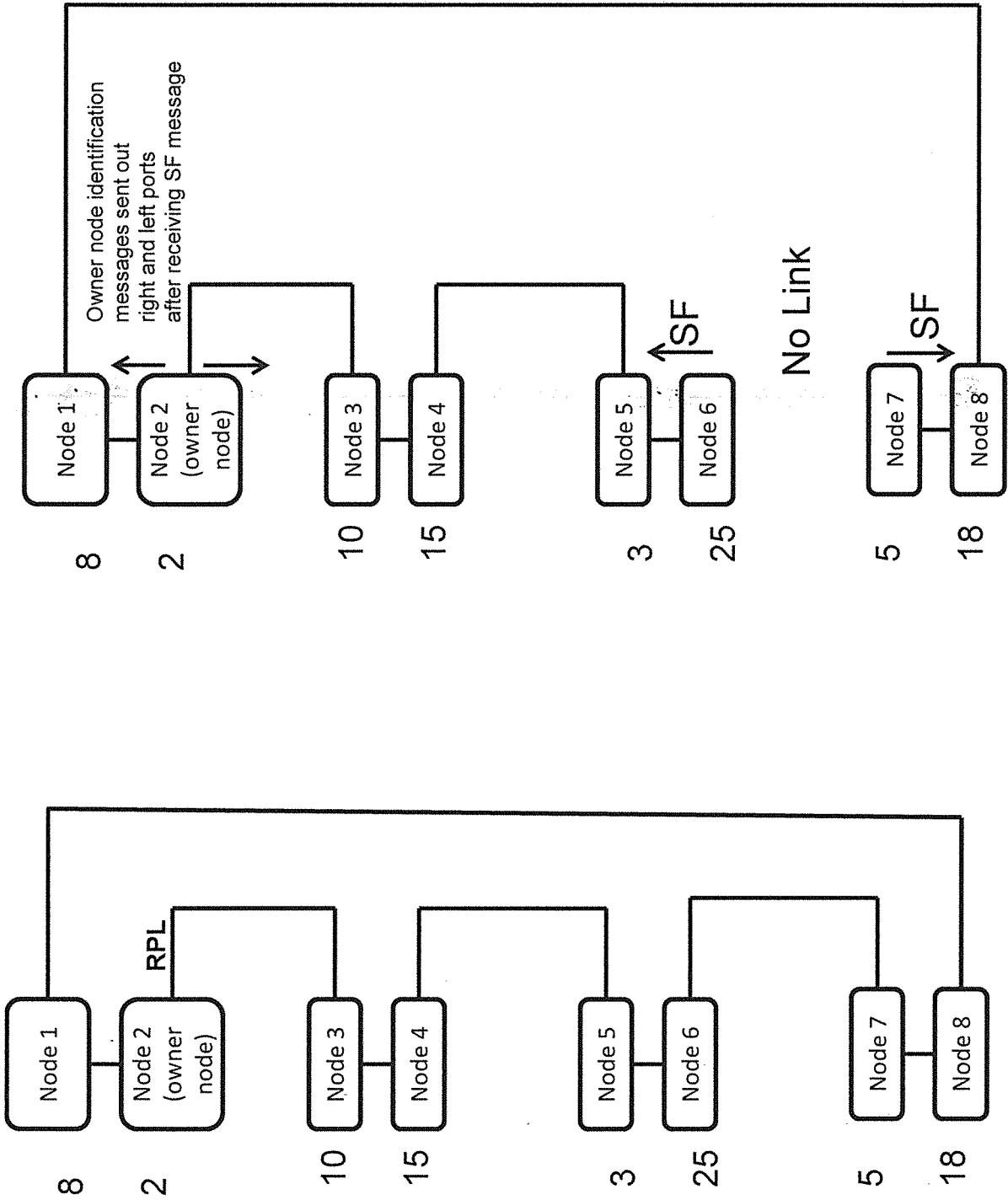


FIG. 9

FIG. 8

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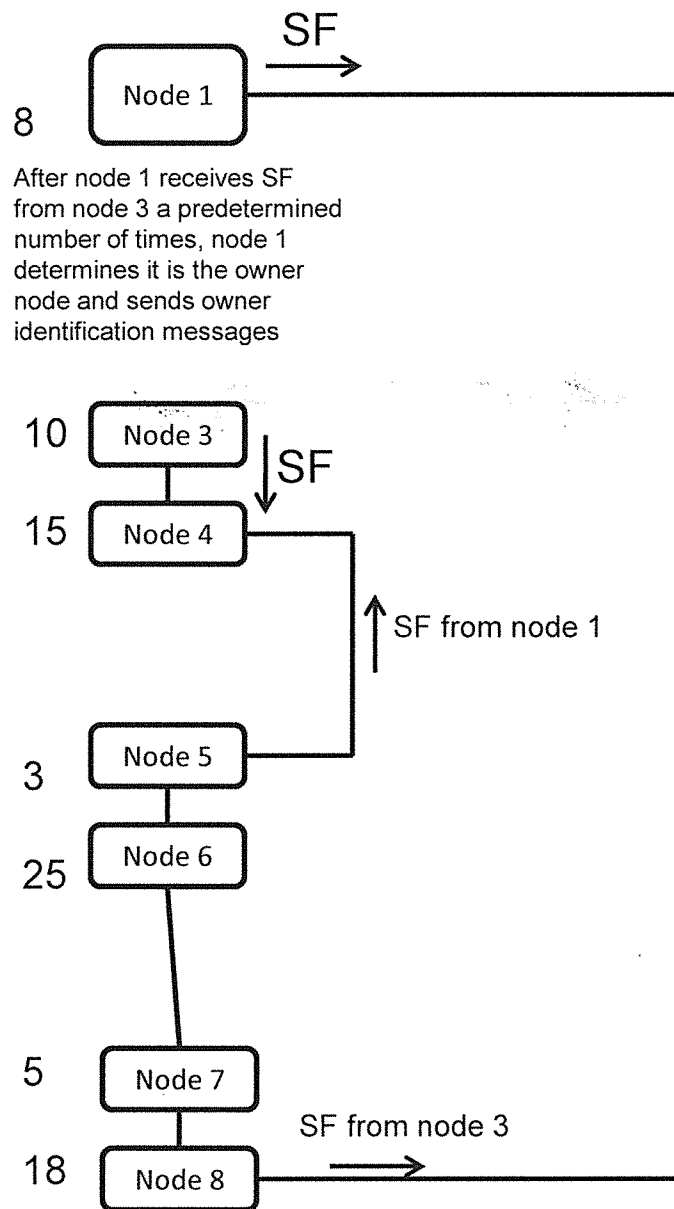
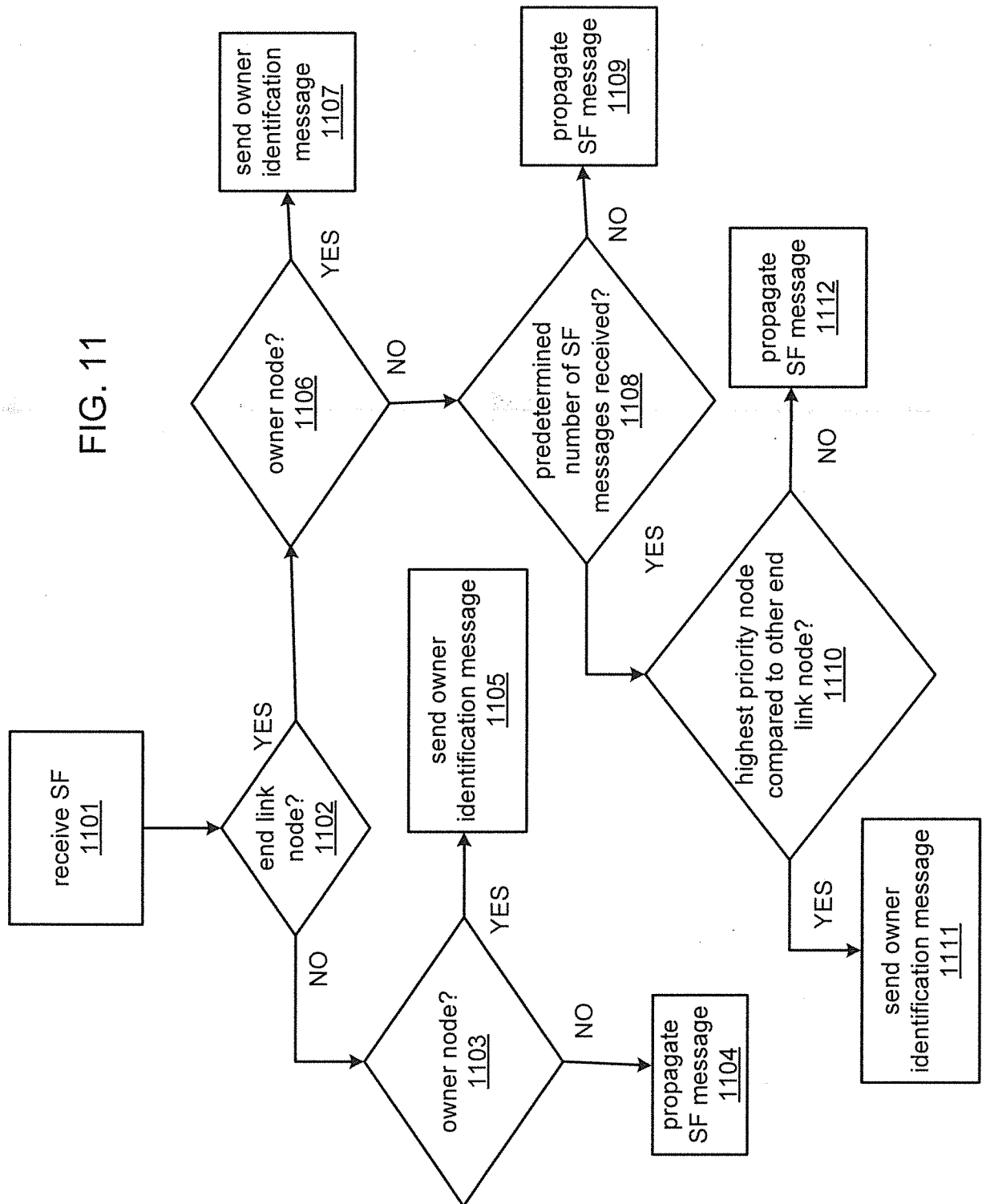


FIG. 10

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1100

FIG. 11





## INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/US2014/063190****A. CLASSIFICATION OF SUBJECT MATTER****H04L 12/42(2006.01)i**

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

H04L 12/42; G08C 15/00; H04J 3/14; H04L 12/26; H04L 12/28

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) &amp; Keywords:ring network, priority node, owner node, linear topology.

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                 | Relevant to claim No. |
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| A         | US 2007-0058648 A1 (TIM MILLET) 15 March 2007<br>See paragraphs [0007], [0024]-[0026]; claim 7; and figure 1.                      | 1-15                  |
| A         | US 2011-0044166 A1 (SANG-MIN LEE et al.) 24 February 2011<br>See paragraphs [0006]-[0008], [0027]-[0039]; and figures 1-4F.        | 1-15                  |
| A         | US 2009-0262643 A1 (LIYAO ZHAO et al.) 22 October 2009<br>See paragraphs [0006]-[0008], [0115]-[0116], [0131]; and figures 4-6.    | 1-15                  |
| A         | US 2011-0026439 A1 (MICHAEL TIMOTHY ROLLINS) 03 February 2011<br>See paragraphs [0018]-[0021], [0031]-[0040]; 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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"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)

"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

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

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

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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

16 July 2015 (16.07.2015)

Date of mailing of the international search report

**16 July 2015 (16.07.2015)**

Name and mailing address of the ISA/KR

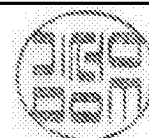
International Application Division  
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Republic of Korea

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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/US2014/063190**

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