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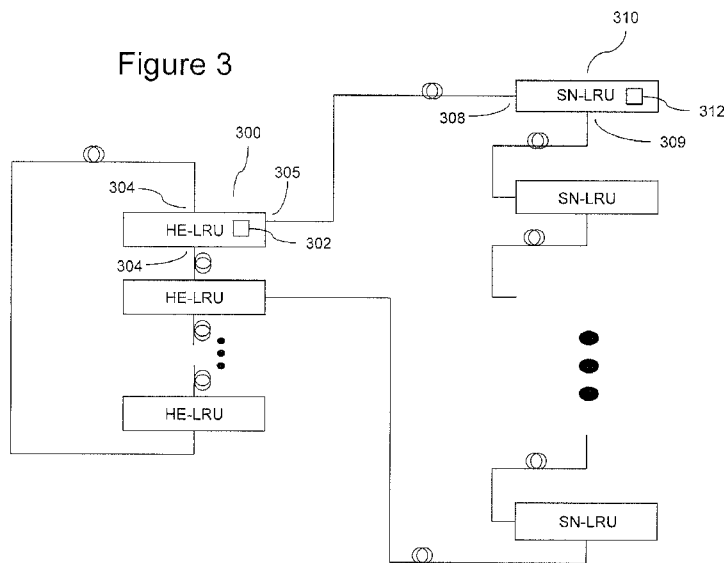
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(54) **Title:** SERIAL NETWORKING FIBER OPTIC INFLIGHT ENTERTAINMENT SYSTEM NETWORK CONFIGURATION



(57) **Abstract:** Serial networking dedicated fiber optic inflight entertainment (IFE) systems, methods therefor and components thereof, that exhibit improved configuration and failover attributes through implementation of novel network configuration protocols. In some aspects of the invention, such an IFE system comprises a plurality of head end line replaceable units (HE-LRUs) and a plurality of serial networking line replaceable units (SN-LRUs), wherein each of the SN-LRUs individually detects that a closed system network has been formed between the plurality of HE-LRUs and the plurality of SN-LRUs based on a plurality of packets sourced by at least one of the HE-LRUs and received on a plurality of ports of each of the SN-LRUs, and wherein in response to detecting that the closed system network has been formed one of the SN-LRUs blocks one of its ports based on further detecting that the SN-LRU is a middle SN-LRU.

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**SERIAL NETWORKING FIBER OPTIC INFLIGHT  
ENTERTAINMENT SYSTEM NETWORK CONFIGURATION**

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**CROSS-REFERENCE TO RELATED APPLICATION**

This application claims the benefit of U.S. provisional application number 61/274,726 entitled "SERIAL NETWORKING FIBER-TO-THE-SEAT INFLIGHT ENTERTAINMENT SYSTEM NETWORK MANAGEMENT," filed on August 20, 10 2009, the contents of which are incorporated herein by reference in their entirety.

**BACKGROUND OF THE INVENTION**

Inflight entertainment (IFE) systems have evolved significantly over the last 25 years. Prior to 1978, IFE systems consisted of audio-only systems. In 1978, Bell and Howell (Avicom Division) introduced a group viewing video system based on VHS 15 tapes. In 1988, Airvision introduced the first inseat video system allowing passengers to choose between several channels of broadcast video. In 1997, Swissair installed the first interactive video on demand (VOD) system. Currently, several IFE systems provide VOD with full digital video disc-like controls.

The commercial viability of an IFE system generally depends on its line 20 replaceable units (LRUs). The term "LRU" is a term of art generally describing a complex component (e.g. "black box") on an airplane that is designed to be replaced quickly on the flight line or airport ramp area. LRUs can be beneficial because they are generally self-contained units that can be rapidly swapped-out in the event that maintenance is required thus allowing the airplane to continue to operate with little down 25 time. Before being installed on an airplane, an LRU design should be approved by the Federal Aviation Administration by means defined in Title 14 of the Code of Federal

Regulations. An IFE system's installation costs, operating costs, maintenance costs and passenger comfort depend greatly on the size, form factor, number and weight of its LRUs, as well as the number of distinct LRUs deployed in a single aircraft and across an airline's entire fleet of aircraft.

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## SUMMARY OF THE INVENTION

The dedicated fiber optic IFE system architecture described in U.S. Patent Application Publication No. 2007/0077998, for example the system marketed under the tradename FIBER-TO-THE-SCREEN™ (FTTS™) by Lumexis, Inc., has provided the airline industry with a modular, scalable, extensible, and future proofed IFE system that leverages terrestrial VOD hardware and software advances and is packaged to minimize the number of distinct LRU not only in a single aircraft but across an airline's entire fleet of aircraft (e.g. regional jets to jumbo jets). In some dedicated fiber optic IFE systems, such as the system shown in FIG. 1, head end servers are interconnected in a ring using bidirectional fiber optic links and communicate with passenger seat video display units (VDUs) over respective bidirectional links. This architecture offers advantages over traditional IFE systems in eliminating distribution area LRUs (i.e. there are no active components between the head end and the seat end). However, this architecture has certain drawbacks. First, a head end server is single point of failure for all passenger seat VDUs and cabin management terminals that connect directly to that head end server. Second, the implementation of a star wired network topology wherein each passenger seat VDU has a dedicated optical fiber "home run" to a head end server adds cost and complexity to the system. For example, over two miles of fiber are required on a typical narrow body aircraft installation and over four miles of fiber are required on a typical

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wide body aircraft installation. The high cost of aircraft grade fiber and fiber optic connectors, coupled with the cost and complexity of installing these fiber components, make this architecture very expensive to implement.

This architecture can be enhanced as generalized in FIG. 2, wherein reliability can be improved and costs reduced by providing a serial networking dedicated fiber optic IFE system wherein “chains” of passenger seat VDUs are connected on both ends to a “ring” of head end servers. In this enhanced architecture, rather than communicating with the head end over a dedicated data path, each passenger seat VDU communicates with the head end over a shared loop-free data path of a serial network established on selected redundant physical connections. This architecture reduces fiber component requirements relative to the architecture generalized in FIG. 1 and has the potential to exhibit superior failure recovery characteristics. However, known network configuration protocols that create loop-free network topologies, such as Rapid Spanning Tree Protocol (IEEE Std. 802.1w), are not well-suited for use in serial networking dedicated fiber optic IFE systems.

Accordingly, in some embodiments, the present invention provides serial networking dedicated fiber optic IFE systems, methods therefor and components thereof, that exhibit improved configuration and failover attributes through implementation of novel network configuration protocols. In various aspects of the invention, head end LRUs (HE-LRUs) may be head end servers of an IFE system and serial networking LRUs (SN-LRUs) may be passenger seat VDUs of an IFE system, by way of example.

In some aspects of the invention, an IFE system comprises a plurality of HE-LRUs and a plurality of SN-LRUs, wherein each of the SN-LRUs individually detects

that a closed system network has been formed between the plurality of HE-LRUs and the plurality of SN-LRUs based on a plurality of packets sourced by at least one of the HE-LRUs and received on a plurality of ports of each of the SN-LRUs, and wherein in response to detecting that the closed system network has been formed at least one of the

5 SN-LRUs blocks at least one of its ports based on further detecting that the SN-LRU is a middle SN-LRU. The SN-LRU may determine that it is a middle SN-LRU based on a comparison of hops to head end values contained in the plurality of packets. The SN-LRU may determine that it is a middle SN-LRU based on the comparison indicating a difference between the hops to head end values of no greater than one. The SN-LRU

10 may clear a topology database on the SN-LRU in response to detecting that the closed system network has been formed and based on further detecting that the SN-LRU is a middle SN-LRU. The SN-LRU may transmit a topology change packet on an unblocked at least one of its ports in response to detecting that the closed system network has been formed and based on further detecting that the SN-LRU is a middle SN-LRU. Moreover,

15 each of the HE-LRUs may individually detect that a closed head end network has been formed between the plurality of HE-LRUs based on a packet transmitted by the HE-LRU on a first port and received by the HE-LRU on a second port, wherein in response to detecting that the closed head end network has been formed at least one of the HE-LRUs block at least one of the first or second port based on further detecting that the HE-LRU

20 is a designated break LRU. The HE-LRU may clear a topology database on the HE-LRU in response to detecting that the closed head end network has been formed and based on further detecting that the HE-LRU is a designated break LRU. The HE-LRU may transmit a topology change packet on an unblocked at least one of its ports in response to

detecting that the closed head end network has been formed and based on further detecting that the HE-LRU is a designated break LRU.

In other aspects of the invention, a SN-LRU for an IFE system having a plurality of HE-LRUs and a plurality of SN-LRU comprises a processor and a plurality of ports  
5 communicatively coupled with the processor, wherein under control of the processor the SN-LRU selectively blocks at least one of the ports based on a comparison of a first hops to head end value contained in a first packet sourced by a HE-LRU and received on a first one of the ports and a second hops to head end value contained in a second packet sourced by a HE-LRU and received on a second one of the ports. The SN-LRU may  
10 under control of the processor block at least one of the ports if the comparison indicates that a difference between the hops to head end values is no greater than one. The SN-LRU may under control of the processor block at least one port over which the packet containing the higher hops to head end value was received. The SN-LRU may under control of the processor selectively clear a topology database on the SN-LRU based on  
15 the comparison. The SN-LRU may under control of the processor selectively transmit a topology change packet on an unblocked at least one of the ports based on the comparison.

In yet other aspects of the invention, a HE-LRU for an IFE system having a plurality of HE-LRUs and a plurality of SN-LRU comprises a processor and a plurality of  
20 ports communicatively coupled with the processor, wherein under control of the processor the HE-LRU blocks at least one of the ports based on detecting that a packet transmitted on a first one of the ports has been received on a second one of the ports and based on further detecting that the HE-LRU is a designated break LRU. The HE-LRU

may under control of the processor clear a topology database on the HE-LRU based on detecting that a packet transmitted on a first one of the ports has been received on a second one of the ports and based on further detecting that the HE-LRU is a designated break LRU. The HE-LRU may under control of the processor transmit a topology change packet on at least one unblocked port based on detecting that a packet transmitted  
5 on a first one of the ports has been received on a second one of the ports and based on further detecting that the HE-LRU is a designated break LRU.

In yet other aspects of the invention, a network configuration method performed by a SN-LRU of an IFE system having a plurality of HE-LRUs and a plurality of SN-  
10 LRUs comprises the steps of receiving on a first port of the SN-LRU a first packet sourced by a HE-LRU and having a first hops to head end value, receiving on a second port of the SN-LRU a second packet sourced by a HE-LRU and having a second hops to head end value, comparing the first and second hops to head end values, and selectively blocking at least one of the ports based on the comparison. The method may further  
15 comprise blocking at least one of the ports if the comparison indicates that a difference between the first and second hops to head end values is no greater than one. The method may further comprise blocking at least one of the ports over which the packet containing the higher hops to head end value was received. The method may further comprise selectively clearing a topology database on the SN-LRU based on the comparison. The  
20 method may further comprise selectively transmitting a topology change packet on an unblocked port based on the comparison.

In yet other aspects of the invention, an IFE system comprises a plurality of HE-LRUs and a plurality of SN-LRUs, wherein each of the SN-LRUs individually detects

that a closed system network has been formed between the plurality of HE-LRUs and the plurality of SN-LRUs based on a plurality of packets sourced by at least one of the HE-LRUs and received on a plurality of ports of each of the SN-LRUs, and wherein in response to detecting that the closed system network has been formed at least one of the  
5 SN-LRUs provides a logical break point for the network based on historical break information.

In still other aspects of the invention, a network configuration method performed by a SN-LRU of an IFE system having a plurality of HE-LRUs and a plurality of SN-LRUs comprises the steps of receiving on a first port of the SN-LRU a first packet  
10 sourced by a first HE-LRU, receiving on a second port of the SN-LRU a second packet sourced by a second HE-LRU, determining by the SN-LRU that a closed system network has been formed between the plurality of HE-LRUs based on the first and second packet, determining by the SN-LRU that the SN-LRU provides a logical break point for the network based on historical break information and providing by the SN-LRU a logical  
15 break point for the network.

These and other aspects of the invention will be better understood when taken in conjunction with the detailed description of the preferred embodiment and the drawings that are briefly described below. Of course, the invention is defined by the appended claims.

## 20 BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a known dedicated fiber dedicated fiber optic system architecture

FIG. 2 shows a known serial networking dedicated fiber optic system architecture.



FIG. 3 shows a serial networking dedicated fiber optic system architecture in which the present invention may be operative.

FIG. 4 shows network configuration packets transmitted in a serial networking dedicated fiber optic system in some embodiments of the invention.

5 FIG. 5 shows a LRU presence packet generation flow in some embodiments of the invention.

FIG. 6 shows a HE-LRU hops packet generation flow in some embodiments of the invention.

10 FIG. 7 shows a method performed by a SN-LRU packet handler in some embodiments of the invention.

FIG. 8 shows a method performed by SN-LRU decision logic in some embodiments of the invention.

FIG. 9 shows a method performed by a HE-LRU packet handler in some embodiments of the invention.

15 FIG. 10 shows a method performed by HE-LRU decision logic in some embodiments of the invention.

FIGS. 11A and 11B show a method performed by SN-LRU decision logic in some embodiments of the invention.

#### DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

20 FIG. 3 shows a serial networking dedicated fiber optic system architecture in which the present invention may be operative. The architecture includes HE-LRUs 300, which may be head end servers, and SN-LRUs 310, which may be seat VDUs. Each HE-LRU has at least two HE-LRU ports 304 that each connect to an adjacent HE-LRU and

zero or more SN-LRU ports 305 that each connect to an adjacent SN-LRU. Each of the HE-LRU ports 304, 305 can be communicatively coupled with a processor on the HE-LRU (e.g. processor 302). Each SN-LRU has at least two ports 308, 309 that can each connect to an adjacent HE-LRU or SN-LRU. The ports 308, 309 can be  
5 communicatively coupled with a processor on the SN-LRU (e.g. processor 312). Moreover, each HE-LRU and SN-LRU can have a topology database, such as a forwarding table that associates media access control (MAC) addresses of other LRUs with output ports of the HE-LRU or SN-LRU. The topology database in each HE-LRU and SN-LRU can be communicatively coupled with the processor on the HE-LRU or SN-  
10 LRU.

In the architecture illustrated, a HE-LRU 300 is connected to SN-LRUs at the edge of a serial chain of SN-LRUs 310 over a bidirectional link, e.g. fiber optics. Generally, the edge SN-LRUs connect back to different HE-LRUs 300. At the head end, HE-LRUs 300 are connected to adjacent HE-LRUs over bidirectional links to form a ring  
15 of HE-LRUs. At the seat end, SN-LRUs 310 are connected to adjacent SN-LRUs over bidirectional links to form a serial chain of SN-LRUs. The system can employ most any type of bidirectional link, such as fiber optics, copper wire, coaxial cable, wireless communication, or the like. In several embodiments, fiber optic links are employed to, among other advantages, increase data transfer rate and/or capacity.

20 Network configuration protocols described herein are generally run to create and maintain a loop-free network topology on top of the architecture through selective transmission and processing of configuration packets and selective blocking and unblocking of HE-LRU and SN-LRU ports.

FIG. 4 shows some of the types of network configuration packets transmitted in a serial networking dedicated fiber optic system in some embodiments of the invention. Network configuration packets may pass through both blocked and unblocked HE-LRU and SN-LRU ports, whereas data packets (e.g. entertainment packets) may pass through unblocked ports but may not pass through blocked ports.

A LRU presence packet 400 contains a packet type identifier indicating that packet 400 is a LRU presence packet. Packet 400 is used by a LRU to determine whether a port is connected to a live LRU.

A HE-LRU hops packet 410 contains at least three fields. A first field is a packet type identifier indicating that packet 410 is a HE-LRU hops packet. A second field is an identifier uniquely associated with the HE-LRU that originated packet 410. This field is used by a HE-LRU to determine whether a received packet was originated by the HE-LRU itself (i.e. whether the packet has looped-back). A third field is a hops to head end (HHE) value that is used to track the number of LRU hops packet 410 has completed over a serial network chain.

A SN-LRU topology change packet 420 contains a packet type identifier indicating that packet 420 is a SN-LRU topology change packet. Packet 420 is transmitted over a serial network chain and each SN-LRU that receives packet 420 clears its topology database and forwards packet 420 along the chain. HE-LRUs convert received SN-LRU topology change packets into HE-LRU topology change packets that are circulated at the head end of the system.

A HE-LRU topology change packet 430 contains at least two fields. A first field is a packet type identifier indicating that packet 430 is a HE-LRU topology change

packet. A second field is an identifier uniquely associated with the HE-LRU that originated packet 430. Packet 430 is circulated at the head end of the system in response to a detected topology change. In some embodiments, each HE-LRU that receives packet 430 clears its topology database.

5           FIG. 5 shows a LRU presence packet generation flow in some embodiments of the invention. After startup (500), an originating LRU (e.g. HE-LRU and/or SN-LRU) under local processor control generates and sends a LRU presence packet out all the originating LRU's ports (510). The originating LRU delays for a period of time equal to the inverse of a configured refresh rate for the presence packet (520) after which it  
10 repeats the process in loop. In some embodiments, each HE-LRU and SN-LRU include a processor and execute this presence packet generation flow method under local processor control.

          FIG. 6 shows a HE-LRU hops packet generation flow in some embodiments of the invention. After startup (600), an originating HE-LRU under local processor control  
15 generates and sends a HE-LRU hops packet out all the originating HE-LRU's ports (610). The originating HE-LRU delays for a period of time equal to the inverse of a configured refresh rate for the HE-LRU hops packet (620) after which it repeats the process in loop. In some embodiments, each HE-LRU executes this hops packet generation flow method under local processor control.

20           FIG. 7 shows a method performed by a SN-LRU packet handler in some embodiments of the invention. Upon reception of a management packet, a packet handler executed by a processor on the SN-LRU determines the packet type by inspecting the packet type identifier field in the packet (700). In some arrangements, the packet handler

processes three packet types: LRU presence packet, HE-LRU hops packet, and SN-LRU topology change packet. If the packet is a LRU presence packet, the packet handler sets a current state variable of the ingress port (i.e. the port on which the packet was received) to active (710). The current state variable informs decision logic executed by the processor that the ingress port is connected to a live LRU. If the packet is a HE-LRU hops packet, the packet handler increments the HHE value in the packet, sets the ingress port HHE count to the HHE value in the packet, and forwards the updated HE-LRU hops packet to the non-ingress port (720). If the packet is a SN-LRU topology change packet, the packet handler clears the topology database on the SN-LRU and forwards the packet out the non-ingress port (730).

FIG. 8 shows a method performed by SN-LRU decision logic in some embodiments of the invention. After startup (800), logic executed by a processor on the SN-LRU blocks both ports of the SN-LRU and sets a last state variable of both ports to blocked (810). The flow then proceeds to the main processing loop. At the start of each pass through the main processing loop, the logic sets a current state variable of both ports to inactive and sets the HHE count for both ports to zero (820). The logic then delays for a period greater than the presence loop and hop loop periods to afford the packet handler ample time to perform the steps shown in FIG. 7 on packets generated in accordance with FIGS. 5 and 6, which updates port state variables and HHE count based on the current network topology. After the delay, the logic determines whether the serial network chain of which the SN-LRU is a part is closed or open by inspecting the HHE count for both ports. If either count is zero, then the network is open (i.e. paths do not exist in both

directions to a HE-LRU). If both counts are non-zero, the network is closed (i.e. paths exist in both directions to a HE-LRU) (830).

If the network is closed, the flow proceeds to Step 840 where the logic first determines whether the SN-LRU on which the logic is operative is a middle LRU of a serial network chain. This is determined by comparing the HHE count for both ports. If  
5 the HHE count for both ports is the same or differs by only one hop, the SN-LRU is a middle LRU; otherwise, the SN-LRU is not a middle LRU. If the SN-LRU is a middle LRU, the SN-LRU has responsibility to break the chain and create a loop-free network topology. In that event, the logic blocks the port with the higher HHE count (i.e. longer  
10 path to the head end) and unblocks the other port. If the HHE count for both ports is identical, the logic blocks a predetermined at least one of the ports and unblocks the other port. The logic next determines whether the last state variable of the blocked port is unblocked. If the last state variable of the blocked port is unblocked, the network topology changed in a way that put the SN-LRU at the end of a chain and thus the SN-  
15 LRU should inform the system of the topology change. Accordingly, the logic clears the topology database and generates and transmits on the unblocked port a SN-LRU topology change packet, forcing relearning of the network topology. The logic next sets the last state variable of the blocked port to blocked, and sets the last state variable of the unblocked port to unblocked. If the SN-LRU determines it is not a middle LRU, the  
20 logic unblocks both ports and sets the last state variable of both ports to unblocked.

If the network is open, the flow proceeds to Step 850 where the logic determines for each port whether the current state variable is active or inactive and takes appropriate action. If the current state variable is active, the logic unblocks the port and sets the last

state variable to unblocked. If the current state variable is inactive, the logic blocks the port and, if the last state variable is unblocked, clears the topology database and transmits a SN-LRU topology change packet on the unblocked port, forcing relearning of the network topology. Finally, the logic sets the last state variable to blocked.

5           FIG. 9 shows a method performed by a HE-LRU packet handler in some embodiments of the invention. Upon reception of a management packet, a packet handler executed by a processor on the HE-LRU determines the packet type by inspecting the packet type identifier field in the packet (900). In the embodiment shown, the HE-LRU packet handler processes four packet types: LRU presence packet, HE-LRU hops packet, 10 SN-LRU topology change packet, and HE-LRU topology change packet. If the packet is a LRU presence packet, the packet handler sets the current state variable of the ingress port to active (910). The current state variable generally informs decision logic executed by the processor that the ingress port is connected to a live LRU. If the packet is a HE-LRU hops packet, the packet handler first determines whether the ingress port is a SN- 15 LRU port and, if so, discards the packet. The packet handler then determines if the packet was originated by the HE-LRU itself (i.e. whether the packet has looped-back). If the HE-LRU is the originating HE-LRU for this packet, the network is closed and the packet handler sets a network state variable to closed and discards the packet. If, on the other hand, the HE-LRU is not the originating HE-LRU for this packet, the packet 20 handler forwards the packet on the non-ingress HE-LRU port (920). Upon reception of a SN-LRU topology change packet, the packet handler clears the topology database and transmits a HE-LRU topology change packet on both HE-LRU ports to inform other HE-LRUs of the topology change (930). Upon reception of a HE-LRU topology change

packet, the packet handler first determines if the packet was originated by the HE-LRU itself (i.e. whether the packet has looped-back). If the HE-LRU is the originating HE-LRU for this packet, the packet handler discards the packet; otherwise, the packet handler clears the topology database and forwards the packet to the non-ingress HE-LRU port  
5 (940).

FIG. 10 shows a method performed by HE-LRU decision logic in some embodiments of the invention. After startup (1000), logic executed by a processor on the HE-LRU generally blocks both HE-LRU ports, unblocks all SN-LRU ports, and sets a last state variable of both HE-LRU ports to blocked (1010). The flow then proceeds to  
10 the main processing loop. At the start of each pass through the main processing loop, the logic sets a current state variable of both HE-LRU ports to inactive and sets the network state variable to open (1020). The logic then delays for a period greater than the presence loop and hop loop periods to afford the packet handler ample time to perform the steps shown in FIG. 9 which updates port state variables and the network state  
15 variable based on the current network topology. After the delay, the logic determines whether the head end ring network of which the HE-LRU is a part is closed or open by reference to the network state variable (1030).

If the network is closed, the logic at Step 1040 first determines whether the HE-LRU on which the logic is operative has been designated to break the loop. This is  
20 determined by referencing a unique break LRU identifier available to the HE-LRU. If the HE-LRU is the designated break LRU, the HE-LRU has responsibility to break the ring and create a loop-free head end network topology. In that event, the logic blocks a predetermined at least one of the HE-LRU ports and unblocks the other HE-LRU port.



The logic next determines whether the last state variable of the blocked port is unblocked. If the last state variable of the blocked port is unblocked, the HE-LRU should inform the system of the topology change. Accordingly, the logic clears the topology database and generates and transmits a HE-LRU topology change packet on the unblocked HE-LRU port, forcing relearning of the network topology. The logic next sets the last state variable of the blocked HE-LRU port to blocked, and sets the last state variable of the unblocked HE-LRU port to unblocked. If the HE-LRU determines it is not the designated break LRU, the logic unblocks both HE-LRU ports and sets the last state variable of both HE-LRU ports to unblocked.

If the network is open, the logic at Step 1050 determines for each HE-LRU port whether the current state variable is active or inactive and takes appropriate action. If the current state variable is active, the logic unblocks the port and sets the last state variable to unblocked. If the current state variable is inactive, the logic blocks the port and, if the last state variable is unblocked, clears the topology database and transmits a HE-LRU networking topology change packet on the unblocked port, forcing relearning of the network topology. Finally, the logic sets the last state variable to blocked.

FIGS. 11A and 11B show a method performed by SN-LRU decision logic in some embodiments of the invention. In these embodiments, after an SN-LRU chain recovers from a fault, the break point in an SN-LRU chain is maintained at the initial break point rather than reverting to the middle of the SN-LRU chain. The initial break point is kept in these embodiments to avoid "ping ponging" between the initial break point and a break point at the middle of the SN-LRU chain when failure at the initial break point is a recurring problem. As shown in FIG. 4, in these embodiments historical

break information is shared between SN-LRUs using a logical break port identifier that is carried in HE-LRU hops packets 410, as will be explained now in greater detail.

Referring to Step 720 of FIG. 7, an SN-LRU that has detected a physical break at one of its ports applies to an HE-LRU hops packet that it receives on its ingress port a  
5 logical break port identifier identifying its physical break port before forwarding the HE-LRU hops packet on its non-ingress port, replacing any logical break port identifier contained in the packet as received. SN-LRUs in an SN-LRU chain reference the logical break port identifiers (or absence thereof) in received HE-LRU packets to identify an appropriate physical break point for the chain, as will now be explained in conjunction  
10 with FIGS. 11A and 11B.

After startup (1100), logic executed by a processor on the SN-LRU blocks both ports of the SN-LRU, sets a last state variable of both ports to blocked, and sets its logical break port identifier to undefined (1110). The flow then proceeds to the main processing loop. At the start of each pass through the main processing loop, the logic sets a current  
15 state variable of both ports to inactive and sets the HHE count for both ports to zero (1120). The logic then delays for a period greater than the presence loop and hop loop periods to afford the packet handler ample time to perform the steps shown in FIG. 7 on packets generated in accordance with FIGS. 5 and 6, which updates port state variables and HHE count based on the current network topology. After the delay, the logic  
20 determines whether the serial network chain of which the SN-LRU is a part is closed or open by inspecting the HHE count for both ports. If either count is zero, then the network is open (i.e. paths do not exist in both directions to a HE-LRU). If both counts

are non-zero, the network is closed (i.e. paths exist in both directions to a HE-LRU) (1130).

If the network is closed, the flow proceeds to Step 1140 where the logic first determines whether a logical break port exists in the network as a result of a previous failure from which recovery has been made. If either of the ports on the SN-LRU on which the logic is operative is a logical break port (due to a previous physical break at that port) and no other logical break port exists in the network, the flow returns to Step 1120 without further action, resulting in a blocked port on the SN-LRU remaining blocked.

If either of the ports on the SN-LRU on which the logic is operative is a logical break port and another logical break port exists in the network, a further check is made to determine which of the logical break ports is closer to the middle of the SN-LRU chain, which can be determined by reference to HHE counts. In that event, if the logical break port on the SN-LRU on which the logic is operative is closer to the middle, or is the same distance from the middle and indicated to win in the event of a tie, the flow returns to Step 1120 without further action, resulting in a blocked port on the SN-LRU remaining blocked. On the other hand, if the logical break port on the SN-LRU on which the logic is operative is further from the middle, or is the same distance from the middle and indicated to lose in the event of a tie, the logic unblocks both of the ports on the SN-LRU.

In some embodiments, if neither of the ports on the SN-LRU on which the logic is operative is a logical break port and another logical break port exists in the network, the logic unblocks both of the ports on the SN-LRU.

In certain arrangements, if neither of the ports on the SN-LRU on which the logic is operative is a logical break port and no other logical break port exists in the network, the SN-LRU on which the logic is operative determines if it is a middle LRU of a serial network chain. This is determined by comparing the HHE count for both ports. If the  
5 HHE count for both ports is the same or differs by only one hop, the SN-LRU is a middle LRU; otherwise, the SN-LRU is not a middle LRU. If the SN-LRU is a middle LRU, the logic blocks the port with the higher HHE count (i.e. longer path to the head end) and unblocks the other port. If the HHE count for both ports is identical, the logic blocks a predetermined at least one of the ports and unblocks at least one other port. If the SN-  
10 LRU determines it is not a middle LRU, the logic unblocks both ports.

Generally, if the last state variable of any blocked port was unblocked, the logic clears the topology database and generates and transmits on the unblocked port a SN-LRU topology change packet, forcing relearning of the network topology. The logic also sets the last state variable of any blocked port to blocked, and sets the last state variable  
15 of unblocked ports to unblocked.

If the network is open, the flow proceeds to Step 1150 where the logic determines for each port whether the current state variable is active or inactive and takes appropriate action. If the current state variable is active, the logic unblocks the port and sets the last state variable to unblocked. If the current state variable is inactive, the logic sets the  
20 logical break port identifier to the current port, blocks the port and, if the last state variable is unblocked, clears the topology database and transmits a SN-LRU topology change packet on the unblocked port, forcing relearning of the network topology. Finally, the logic sets the last state variable to blocked.

It will be appreciated by those of ordinary skill in the art that the invention can be embodied in other specific forms without departing from the spirit or essential character hereof. The present description is therefore considered in all respects to be illustrative and not restrictive. The scope of the invention is indicated by the appended claims, and  
5 all changes that come with in the meaning and range of equivalents thereof are intended to be embraced therein.

What is claimed is:

1. An inflight entertainment (IFE) system, comprising:  
a plurality of head end line replaceable units (HE-LRUs); and  
a plurality of serial networking line replaceable units (SN-LRUs),

5           wherein each of the SN-LRUs individually detects that a closed system network has been formed between the plurality of HE-LRUs and the plurality of SN-LRUs based on a plurality of packets sourced by at least one of the HE-LRUs and received on a plurality of ports of each of the SN-LRUs, and

          wherein in response to detecting that the closed system network has been formed  
10       one of the SN-LRUs blocks one of its ports based on further detecting that the one of the SN-LRUs is a middle SN-LRU.

2. The system of claim 1, wherein the one of the SN-LRUs determines that it is a middle SN-LRU based on a comparison of hops to head end values contained in the plurality of packets.

15           3. The system of claim 2, wherein the one of the SN-LRUs determines that it is a middle SN-LRU based on the comparison indicating a difference between the hops to head end values of no greater than one.

4. The system of claim 1, wherein the one of the SN-LRUs clears a topology database on the one of the SN-LRUs in response to detecting that the closed system  
20       network has been formed and based on further detecting that it is a middle SN-LRU.

5. The system of claim 1, wherein the one of the SN-LRUs transmits a topology change packet on an unblocked port of the one of the SN-LRUs in response to detecting

that the closed system network has been formed and based on further detecting that it is a middle SN-LRU.

6. The system of claim 1, wherein each of the HE-LRUs individually detects that a closed head end network has been formed between the plurality of HE-LRUs based on  
5 a packet transmitted by each HE-LRU on a first port and received by each HE-LRU, respectively, on a second port, wherein in response to detecting that the closed head end network has been formed one of the HE-LRUs blocks one of its first or second port based on further detecting that the one of the HE-LRUs is a designated break LRU.

7. The system of claim 6, wherein the one of the HE-LRUs clear a topology  
10 database on the one of the HE-LRUs in response to detecting that the closed head end network has been formed and based on further detecting that it is a designated break LRU.

8. The system of claim 6, wherein the one of the HE-LRUs transmits a topology change packet on an unblocked one of its ports in response to detecting that the closed  
15 head end network has been formed and based on further detecting that it is a designated break LRU.

9. The system of claim 1, wherein the HE-LRUs comprise servers.

10. The system of claim 1, wherein the SN-LRUs are video display units (VDUs).

11. A SN-LRU for an IFE system having a plurality of HE-LRUs and a plurality  
20 of SN-LRUs, said SN-LRU comprising:

a processor; and

a plurality of ports communicatively coupled with the processor,

wherein under control of the processor the SN-LRU selectively blocks one of the ports based on a comparison of a first hops to head end value contained in a first packet sourced by a HE-LRU and received on a first one of the ports and a second hops to head end value contained in a second packet sourced by a HE-LRU and received on a second one of the ports.

12. The SN-LRU of claim 11, wherein the SN-LRU under control of the processor blocks one of the ports only if the comparison indicates that a difference between the hops to head end values is no greater than one.

13. The SN-LRU of claim 11, wherein the SN-LRU under control of the processor blocks the one of the ports over which the packet containing the higher hops to head end value was received.

14. The SN-LRU of claim 11, wherein the SN-LRU under control of the processor selectively clears a topology database on the SN-LRU based on the comparison.

15. The SN-LRU of claim 11, wherein the SN-LRU under control of the processor selectively transmits a topology change packet on an unblocked one of the ports based on the comparison.

16. The SN-LRU of claim 11, wherein the SN-LRU is a VDU.

17. A HE-LRU for an IFE system having a plurality of HE-LRUs and a plurality of SN-LRU, said HE-LRU comprising:

a processor; and

a plurality of ports communicatively coupled with the processor,



wherein under control of the processor the HE-LRU blocks one of the ports based on detecting that a packet transmitted on a first one of the ports has been received on a second one of the ports and based on further detecting that the HE-LRU is a designated break LRU.

5           18. The HE-LRU of claim 17, wherein the HE-LRU under control of the processor clears a topology database on the HE-LRU based on detecting that a packet transmitted on a first one of the ports has been received on a second one of the ports and based on further detecting that the HE-LRU is a designated break LRU.

10           19. The HE-LRU of claim 17, wherein the HE-LRU under control of the processor transmits a topology change packet on an unblocked one of the ports based on detecting that a packet transmitted on a first one of the ports has been received on a second one of the ports and based on further detecting that the HE-LRU is a designated break LRU.

20. The HE-LRU of claim 17, wherein the HE-LRU comprises a server.

15           21. A network configuration method performed by a SN-LRU of an IFE system having a plurality of HE-LRUs and a plurality of SN-LRUs, comprising the steps of:

receiving on a first port of the SN-LRU a first packet sourced by a HE-LRU and having a first hops to head end value;

20           receiving on a second port of the SN-LRU a second packet sourced by a HE-LRU and having a second hops to head end value;

comparing by the SN-LRU the first and second hops to head end values; and

selectively blocking by the SN-LRU one of the ports based on the comparison.

22. The method of claim 21, wherein the selectively blocking step comprises blocking one of the ports only if the comparison indicates that a difference between the first and second hops to head end values is no greater than one.

23. The method of claim 21, wherein the selectively blocking step comprises  
5 blocking the one of the ports over which the packet containing the higher hops to head end value was received.

24. The method of claim 21, further comprising the step of selectively clearing a topology database on the SN-LRU based on the comparison.

25. The method of claim 21, further comprising the step of selectively  
10 transmitting a topology change packet on an unblocked one of the ports based on the comparison.

26. An IFE system, comprising:

a plurality of HE-LRUs; and

a plurality of SN-LRUs,

15 wherein each of the SN-LRUs individually detects that a closed system network has been formed between the plurality of HE-LRUs and the plurality of SN-LRUs based on a plurality of packets sourced by at least one of the HE-LRUs and received on a plurality of ports of each of the SN-LRUs, and

20 wherein in response to detecting that the closed system network has been formed one of the SN-LRUs provides a logical break point for the network based on historical break information.

27. The system of claim 26, wherein the historical break information comprises an indication of a break on the one of the SN-LRUs from which a recovery has been made.

28. The system of claim 26, wherein the historical break information comprises  
5 an indication of a break on another one of the SN-LRUs from which a recovery has been made.

29. The system of claim 28, wherein the indication of a break on another one of the SN-LRUs from which a recovery has been made is received in at least one of the plurality of packets.

10 30. The system of claim 26, wherein the one of the SN-LRUs provides the logical break point based on a determination that the one of the SN-LRUs is closer to being a middle SN-LRU than another SN-LRU that has recovered from a break.

31. The system of claim 26, wherein the one of the SN-LRUs provides the logical break point based on a determination that the one of the SN-LRUs is as close to being a  
15 middle SN-LRU as another SN-LRU that has recovered from a break and has been designated to provide the logical break point in the event of a tie.

32. A network configuration method performed by a SN-LRU of an IFE system having a plurality of HE-LRUs and a plurality of SN-LRUs, said method comprising the steps of:

20 receiving on a first port of the SN-LRU a first packet sourced by a first HE-LRU;  
receiving on a second port of the SN-LRU a second packet sourced by a second HE-LRU;

determining by the SN-LRU that a closed system network has been formed between the plurality of HE-LRUs based on the first and second packet;

determining by the SN-LRU that the SN-LRU provides a logical break point for the network based on historical break information; and

5 providing by the SN-LRU a logical break point for the network.

33. The method of claim 32, wherein the historical break information comprises an indication of a break on the SN-LRU from which a recovery has been made.

34. The method of claim 32, wherein the historical break information comprises an indication of a break on another SN-LRU from which a recovery has been made.

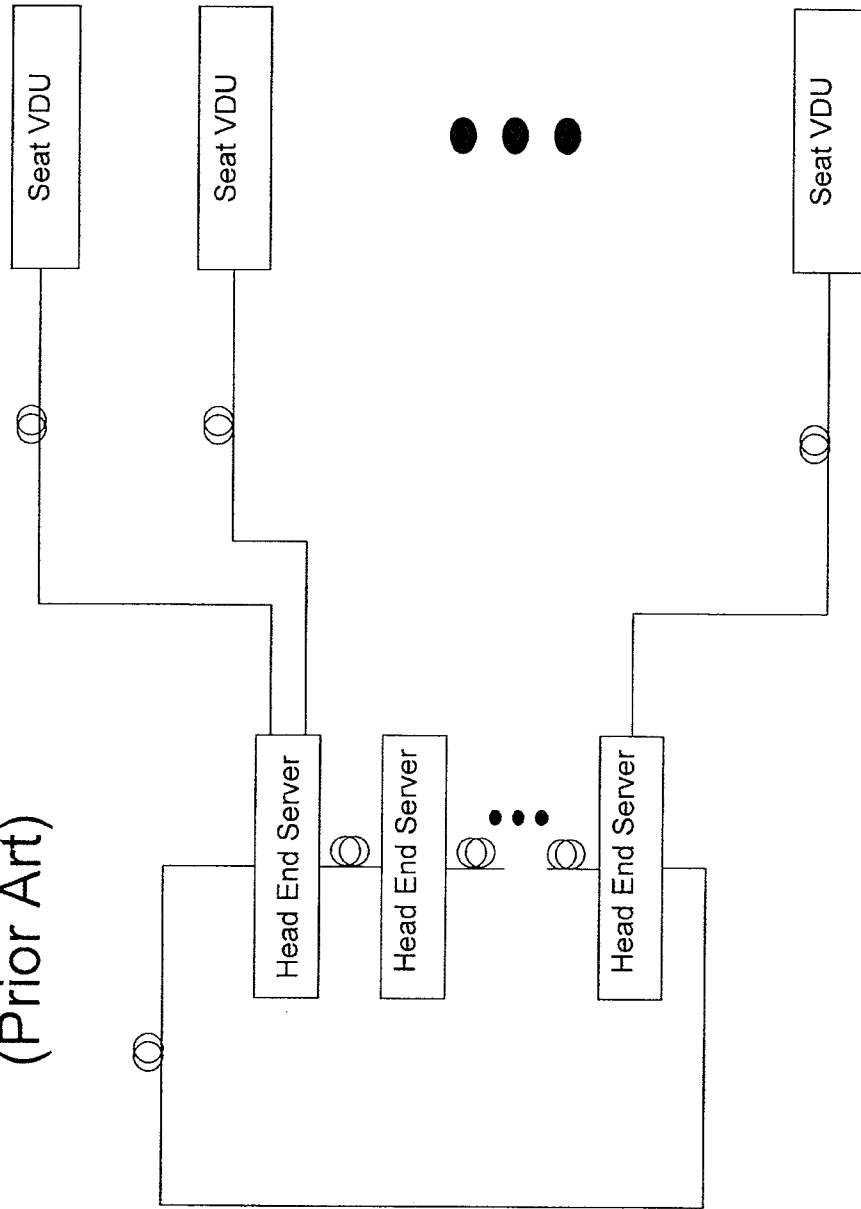
10 35. The method of claim 32, wherein the indication of a break on another SN-LRU from which a recovery has been made is received in at least one of the first or second packet.

36. The method of claim 32, wherein the second determining step comprises determining that the SN-LRU is closer to being a middle SN-LRU than another SN-LRU  
15 that has recovered from a break.

37. The method of claim 32, wherein the second determining step comprises determining that the SN-LRU is as close to being a middle SN-LRU as another SN-LRU that has recovered from a break and has been designated to provide the logical break point in the event of a tie.

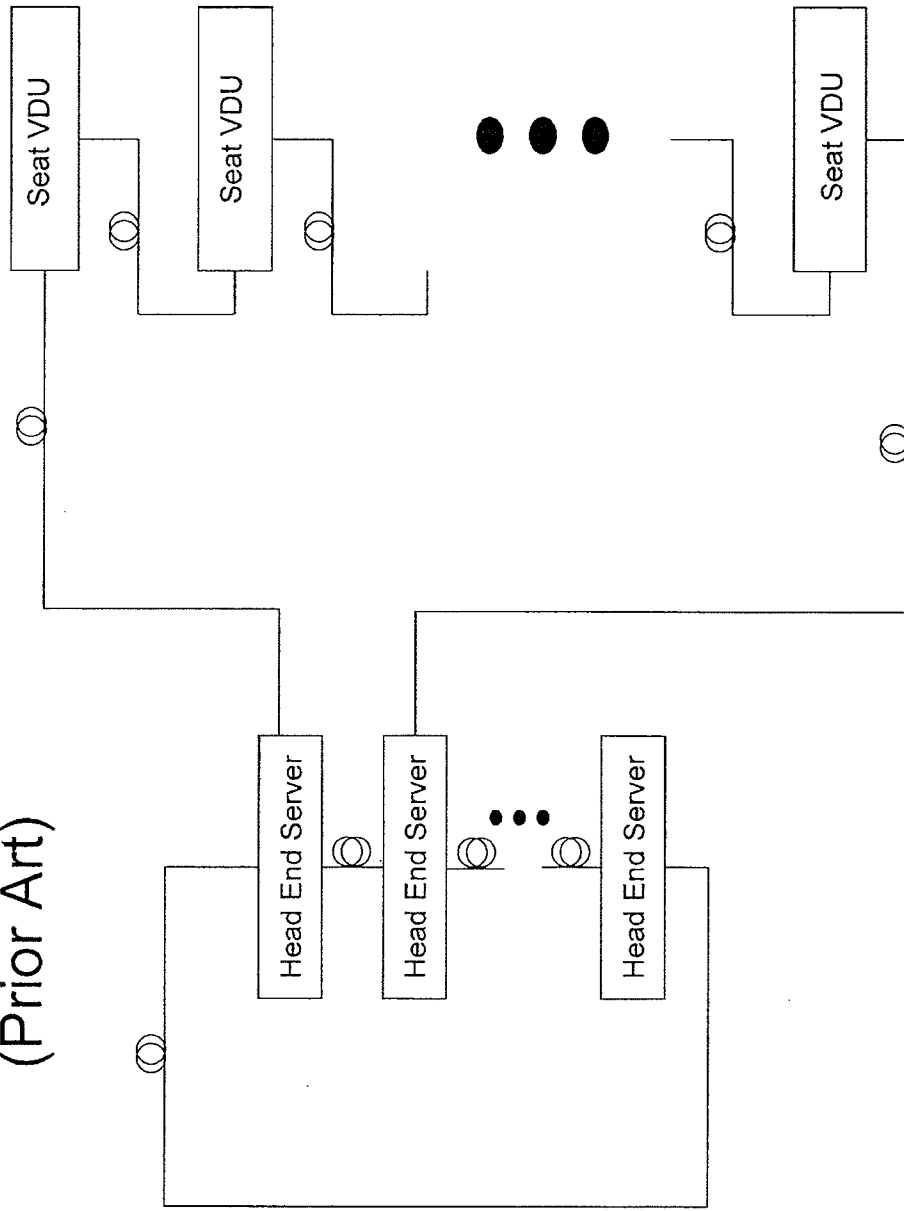
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Figure 1  
(Prior Art)



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Figure 2  
(Prior Art)



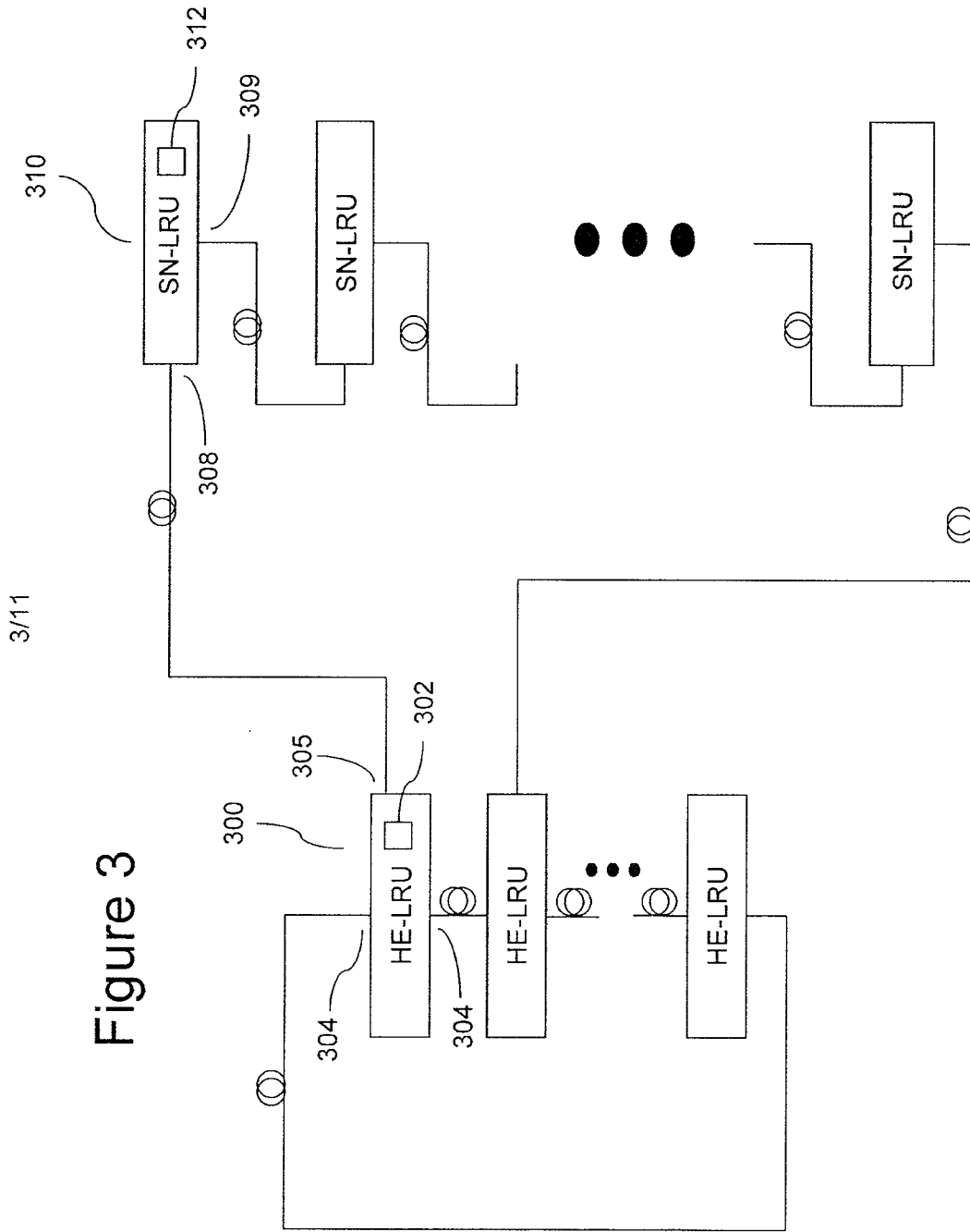


Figure 3

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Figure 4

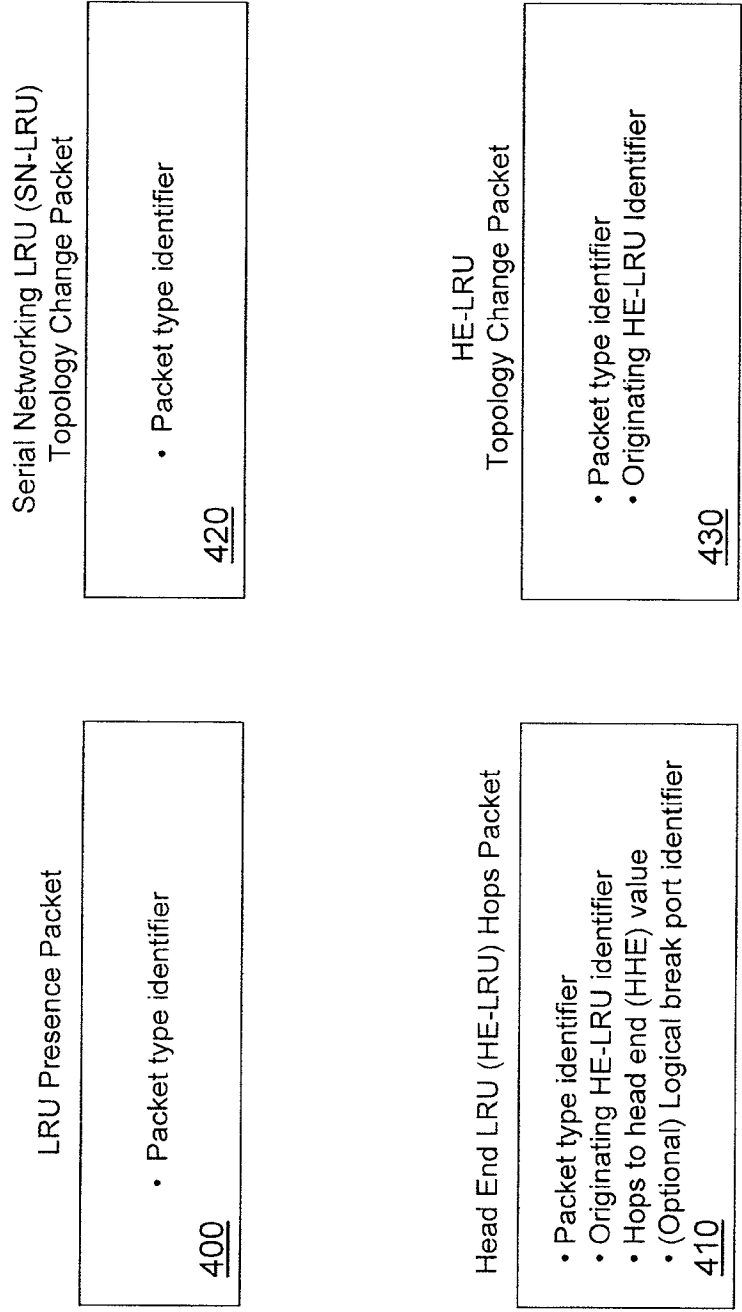




Figure 5

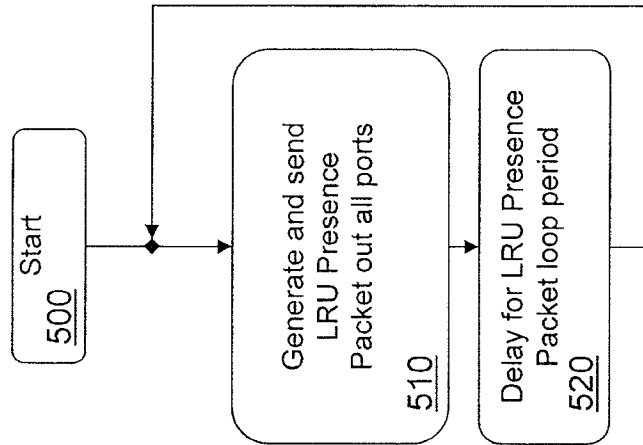


Figure 6

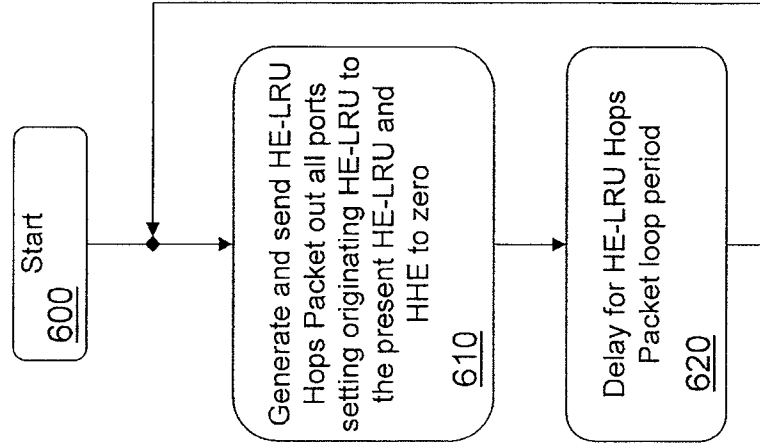
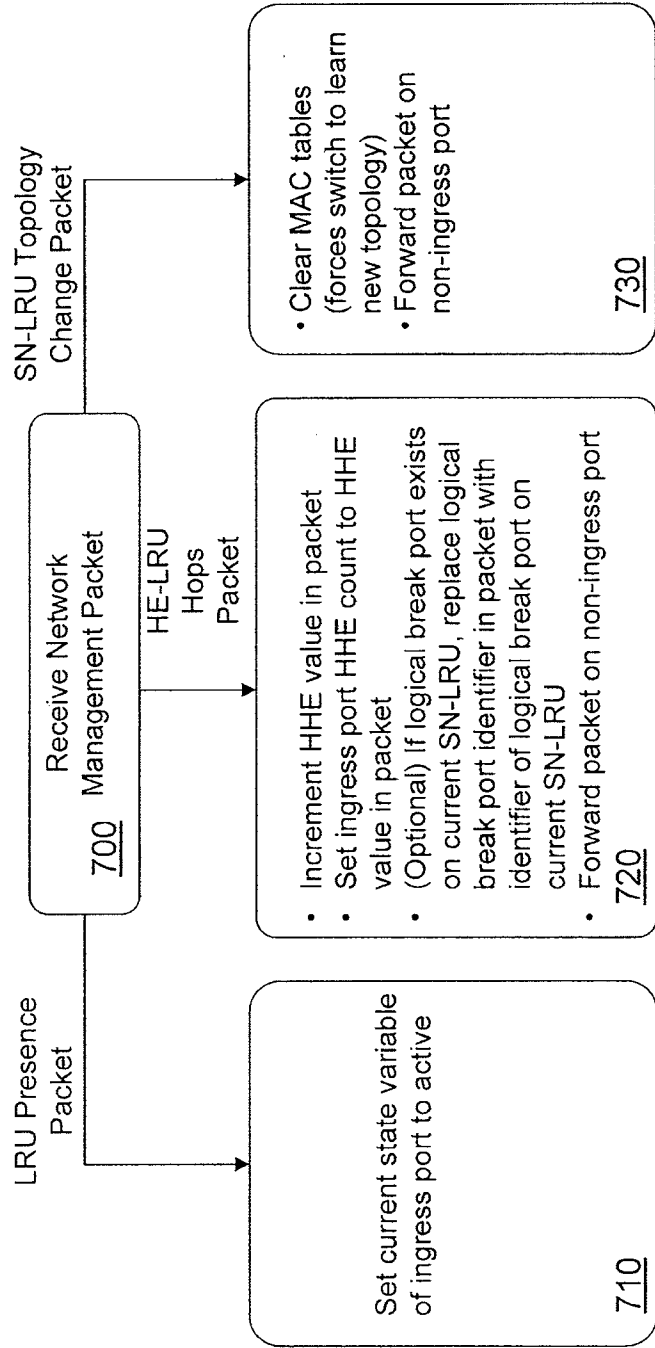
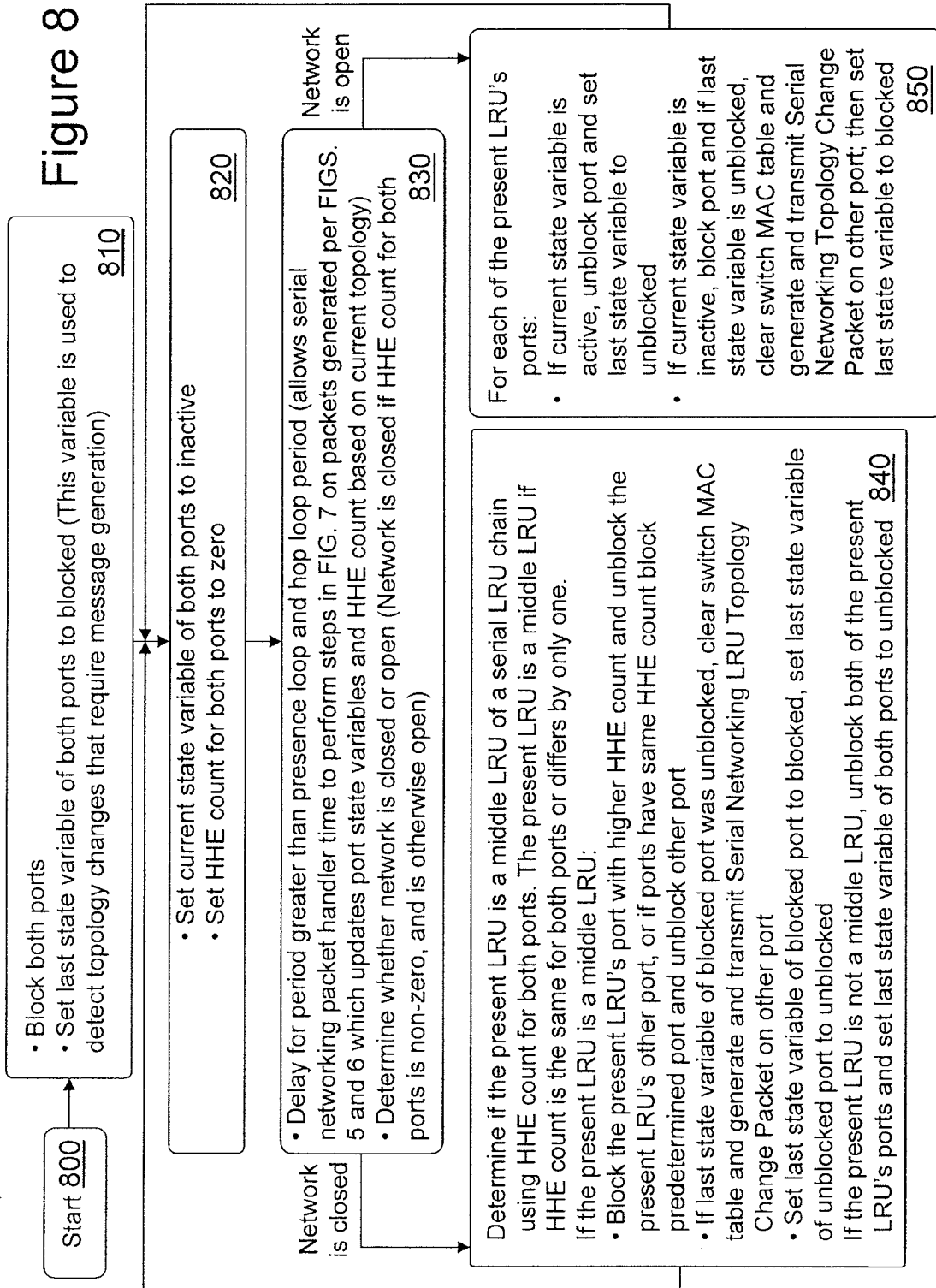


Figure 7



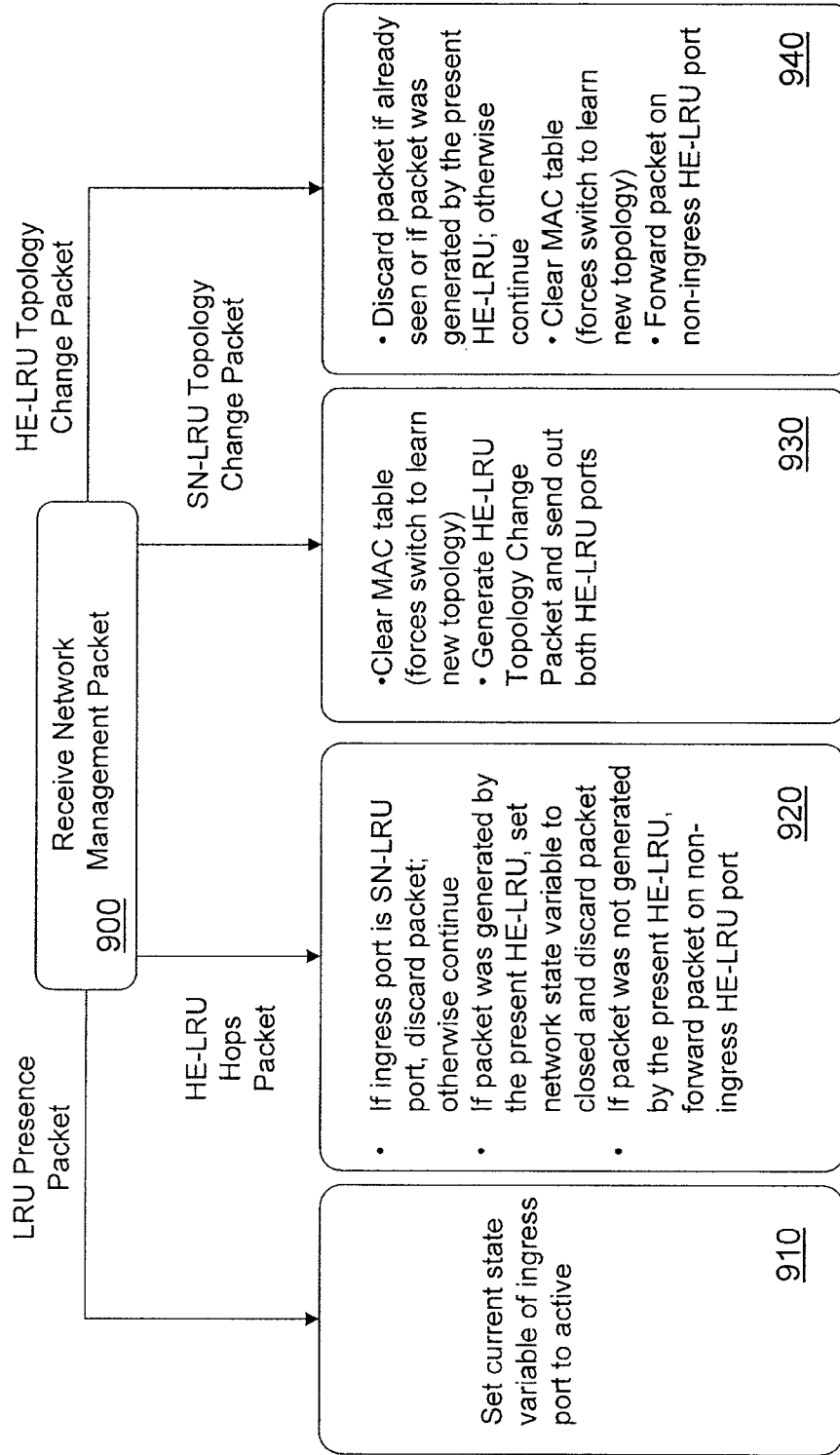
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Figure 8



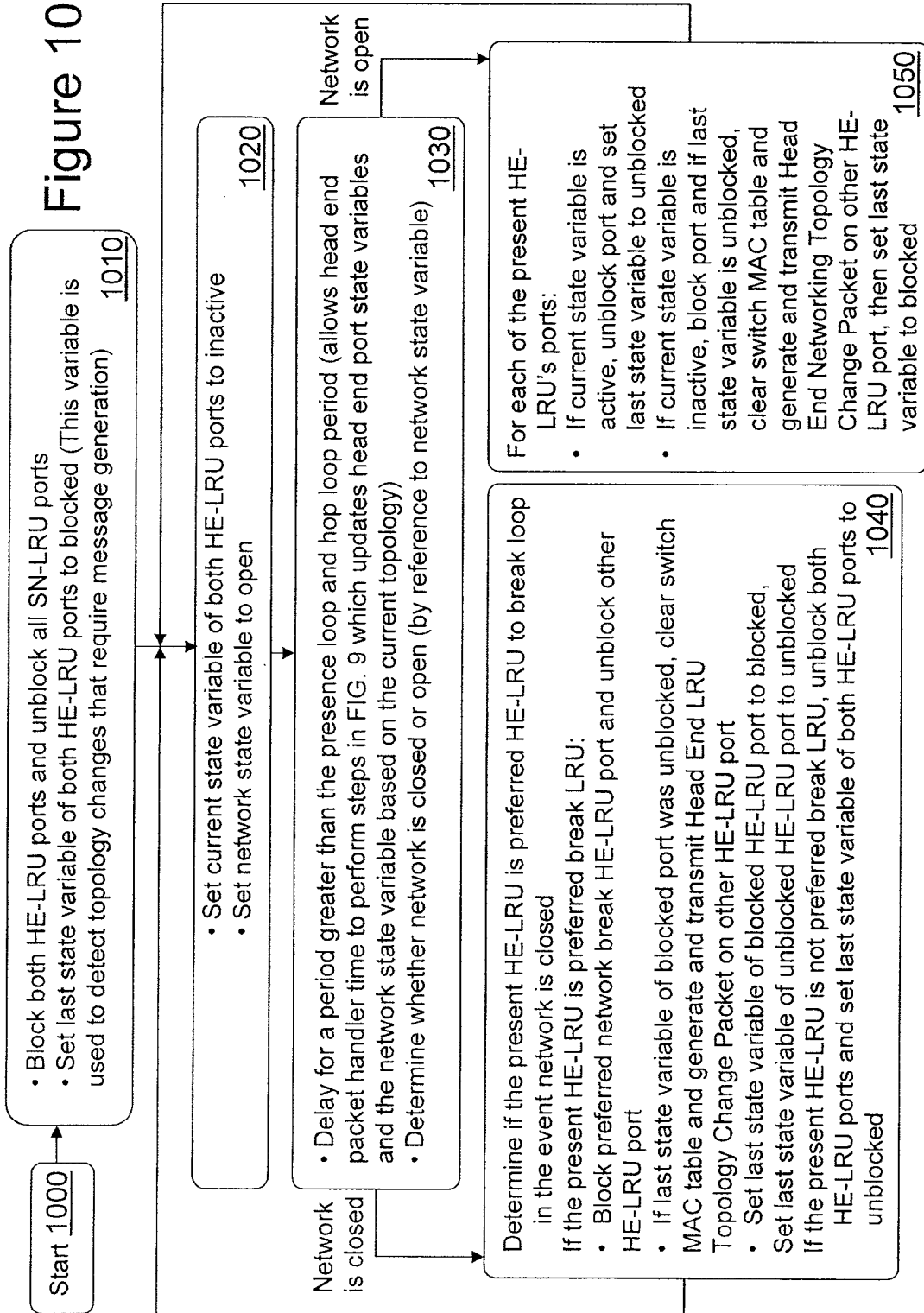
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Figure 9



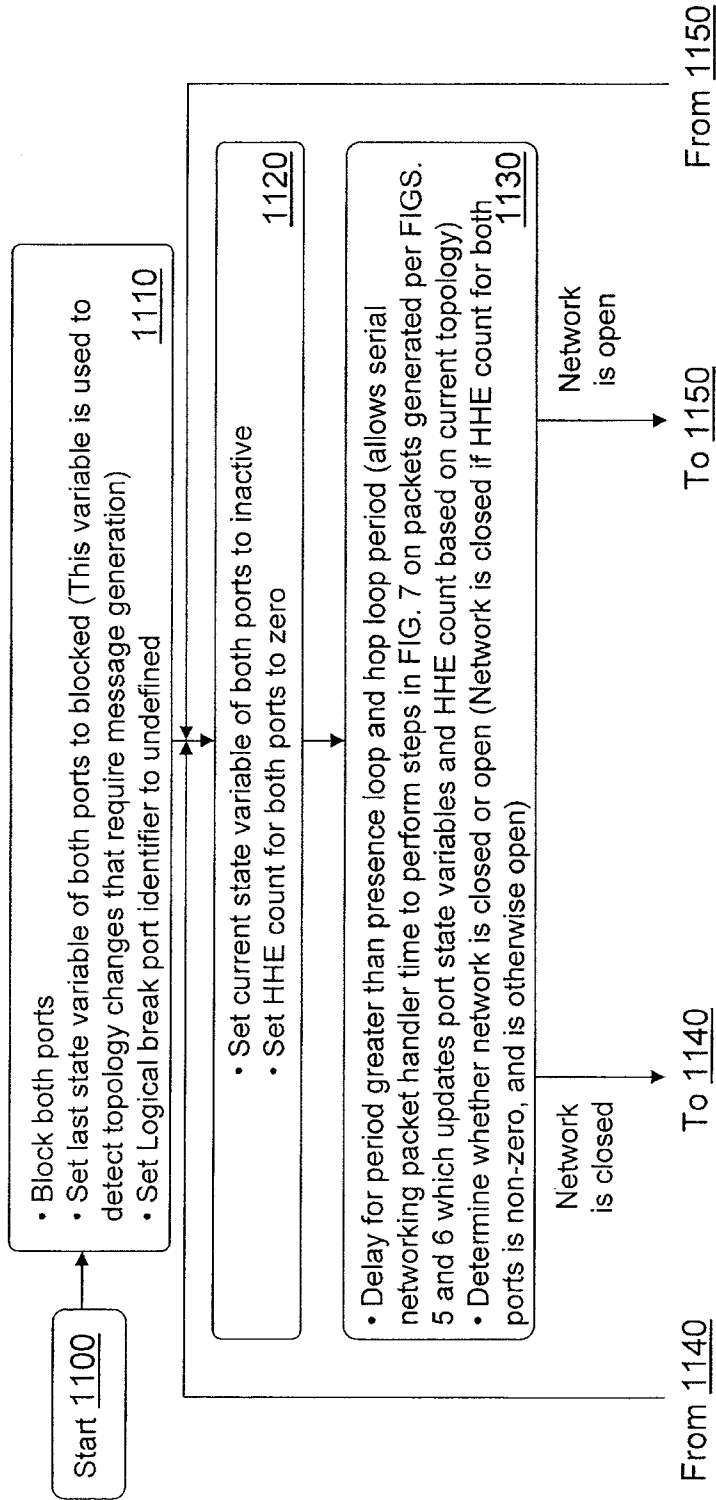
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Figure 10



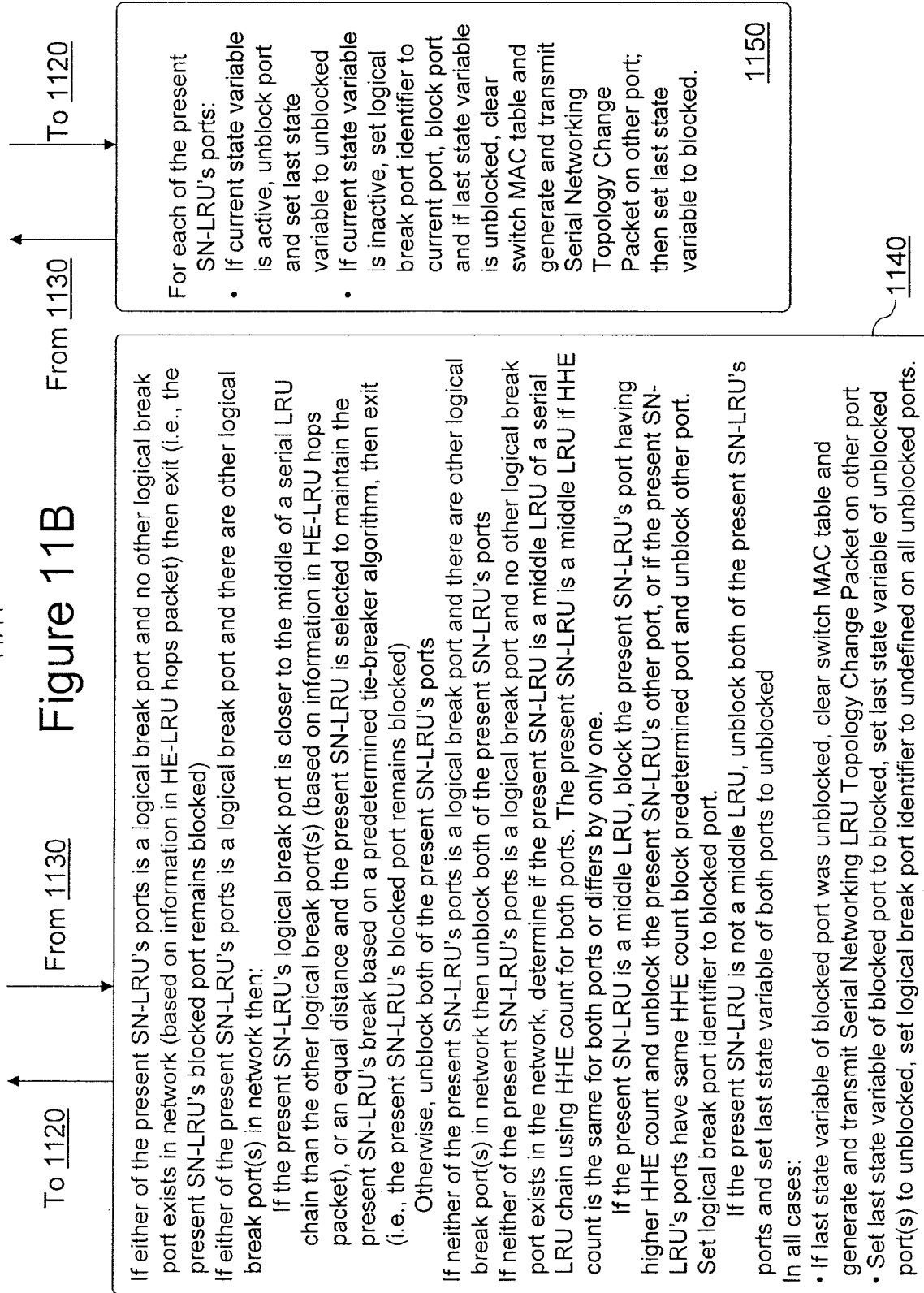
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Figure 11A



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Figure 11B



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 10/46246

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC(8) - H04N 7/173 (2010.01) USPC - 725/101 According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) IPC(8) - H04N 7/173 (2010.01) USPC - 725/101 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched 725/86; 725/144; 725/148 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PubWEST (PGPB, USPT, EPAB, JPAB) Google Scholar Search terms used: in-flight entertainment, video distribution, LRU, head-end, network, topology, ring, loop, port, blocking, hop		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009/0034540 A1 (Law) 05 February 2009 (05.02.2009), para. [0012], [0054]-[0056], [0148]-[0156]	1-37
Y	US 2008/0285459 A1 (Diab et al.) 20 November 2008 (20.11.2008), para. [0023], [0027], [0037]	1-37
Y	US 2007/0280199 A1 (Rong) 06 December 2007 (06.12.2007), para. [0020]-[0021], [0047]	2, 3, 11-16, 21-25
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/>		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "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 "&" document member of the same patent family		
Date of the actual completion of the international search 15 November 2010 (15.11.2010)		Date of mailing of the international search report <b>29 NOV 2010</b>
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201		Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774