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I, Toyu Yazaki, hereby declare that I am a professional interpreter and translator, with over thirty-five (35) years of professional experience, and am knowledgeable of and well acquainted with the Japanese language and the English language.

The document in the English language attached hereto is to the best of my ability, knowledge and expertise the correct English translation of the original document written in the Japanese language identified as Laid-Open Patent Application Publication Number P2001-53772A with a laid-open publication date of February 23, 2001.

I translated the original document into the English language. I declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 or Title 18 of the United States Code. Signed April 11, 2025.

Toyu Yazaki

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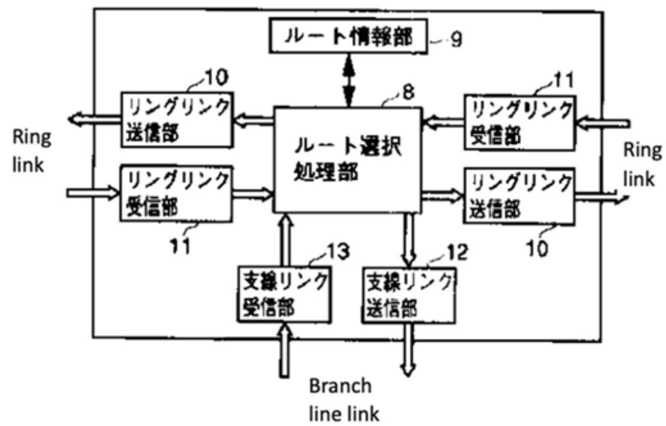
EB05

(54) Name of the Invention: Branch insertion node, ring network comprising a plurality of branch insertion nodes and method of failure recovery of ring network

(57) [Abstract]
[Problem] To provide a branch insertion node that can quickly perform failure recovery when a failure occurs in a ring network.
[Means of Solution] A branch insertion node comprises: branch line link transmission part 12 and branch line link reception part 13 for communicating information via a branch line link; ring link transmission part 10 and ring link reception part 11 for communicating information via a ring link; and route selection processing part 8 for receiving, via a ring link reception part 11, notification of occurrence of failure in a ring link and for causing ring link transmission part 10 to transmit information in an opposite direction to virtual paths that are affected by the failure in a ring link. Because route selection processing part 8 causes ring link transmission part 10 to transmit information in the opposite direction to the virtual paths that are affected by the failure in a ring link, a rapid recovery from failure becomes possible.



8. Route selection processing part
9. Route information part
10. Ring link transmission part
11. Ring link reception part
12. Branch line link transmission part
13. Branch line link reception part

[Claims]

[Claim 1] In a branch insertion node of a ring network,
a branch insertion node comprising:
a branch line link communication means for communicating information via a branch line link;
a ring link communication means for communicating information via a ring link; and
a route selection means for receiving, via said ring link communication means, notification of occurrence of a failure in a ring link and causing said ring link communication means to transmit information in an opposite direction to virtual paths that are affected by said failure in a ring link.

[Claim 2] The branch insertion node according to claim 1 wherein said route selection means comprises:
a first table for holding the location of a ring link where said failure occurred;
a second table that is provided for each virtual path and identifies ring links that are used as a working path;
a route switching flag that is provided for each virtual path and switches the direction for a route that is used as a working path; and
a processing means that uses the information regarding the location of the ring link where a failure has occurred that is held in said first table, the information regarding the ring link to be used as a working path that is set in said second table and the route direction that is set by said route switching flag to determine whether or not a virtual path is affected by a failure in said ring link, and, if a virtual path is affected, causes said ring link communication means to transmit information in an opposite direction.

[Claim 3] The branch insertion node according to claim 2 wherein all bits that are set in the second tables and route switching flags of some virtual paths are inverted.

[Claim 4] The branch insertion node according to claim 2 or 3 wherein the ring link numbers of the ring links that are set in said second table and used as a working path are non-sequential numbers.

[Claim 5] In a ring network comprising:
a plurality of branch line nodes;
a plurality of branch insertion nodes that are connected via branch line links to each of said plurality of branch line nodes; and
ring links for connecting said plurality of branch insertion nodes in a ring shape;
a ring network wherein each of said plurality of branch insertion nodes comprises:
a branch line link communication means for communicating information via said branch line links;
a ring link communication means for communicating information via said ring links; and
a route selection means for receiving, via said ring link communication means, notification of occurrence of a failure in a ring link and for causing said ring link communication means to transmit information in an opposite direction to virtual paths that are affected by a failure in said ring link.

[Claim 6] A failure recovery method for a ring network comprising:

a plurality of branch line nodes;
a plurality of branch insertion nodes that are connected to each of said plurality of branch line nodes via branch line links; and
ring links that connect said plurality of branch insertion nodes in a ring shape;
wherein said failure recovery method comprises:
a step for causing said branch insertion node to receive notification of the occurrence of a failure in a ring link; and
a step for causing said branch insertion node to transmit information in an opposite direction to virtual paths that are affected by said failure in a ring link.

[Detailed Description of the Invention]
[0001]
[Technical Field of the Invention] The present invention relates to a ring network used for communicating digital information and, in particular, to a method for recovery from failures in communication paths of a ring network that comprise a plurality of branch insertion nodes.
[0002]
[Prior Art] What with the widespread use of networks such as local area networks (LANs) and the larger size of networks, the impact on users of failures in communication paths has also become larger.
[0003] A wiring topology that has been widely used from the past in networks such as LANs is the ring topology. Examples of technologies related to failures in ring networks include the invention disclosed in Laid-Open Patent Application Publication H04-172035 and the invention disclosed in NTT R&D, Vol. 42, No. 3, 1993 “OAM (Operation, Administration and Maintenance) Technology for Virtual Paths.”
[0004] According to the method for failure recovery in a ring network disclosed in Laid-Open Patent Application Publication H04-172035, a monitoring node analyzes a cell that stores failure information that is sent from a plurality of branch insertion nodes and issues instructions to individual branch insertion nodes to change the routes of virtual paths. Branch insertion nodes are instructed to reroute the virtual path as a way to recover from a failure.
[0005] According to the virtual path OAM function disclosed in “OAM Technology for Virtual Paths,” when a transmission path failure occurs in an asynchronous transfer mode (ATM) network, all users on the virtual paths who are affected by the failure are notified of the failure.
[0006]
[Problem to Be Solved by the Invention] However, with the failure recovery method for a ring network disclosed in Laid-Open Patent Application Publication H04-172035, the number of virtual paths that are affected by a failure increases as the number of virtual paths that are used in a ring network increases. Because the virtual path route has to be changed for each branch insertion node, changing the routes for all virtual paths requires much time, creating the problem of an inability to effect a quick failure recovery.
[0007] Furthermore, although the virtual path OAM function disclosed in “OAM Technology for Virtual Paths” discusses notification of users of transmission path failures that occur in an ATM network, it does not describe how failure recovery is performed.
[0008] The present invention was made to solve the afore-described problems, and a first object of the present invention is to provide a branch insertion node that is capable of quickly recovering from failures that occur in a ring network.

[0009] A second object is to provide a branch insertion node that uses link bands efficiently and thus allows a ring network to accommodate a greater number of virtual paths.
[0010] A third object is to provide a ring network that is capable of quickly recovering from failures that occur in the ring network.
[0011] A fourth object is to provide a method for the quick recovery of ring networks from failures that occur in the ring network.
[0012]
[Means for Solving the Problems] The branch insertion node according to claim 1 is a branch insertion node that constitutes a ring network and comprises: a branch line link communication means for communicating information via branch line link; a ring link communication means for communicating information via the ring link; and a route selection means for receiving, via the ring link communication means, notification of occurrence of failures in a ring link and causing the ring link communication means to transmit information in an opposite direction to the virtual paths that are affected by the failure in a ring link.
[0013] Because the route selection means receives, via the ring link communication means, notifications of occurrence of failures in a ring link and causes the ring link communication means to transmit information in an opposite direction to the virtual paths that are affected by the failure in a ring link, quick recovery becomes possible from a failure.
[0014] The branch insertion node according to claim 2 is a branch insertion node according to claim 1 wherein the route selection means comprises: a first table for holding the location of a ring link where a failure occurred; a second table that is provided for each virtual path and identifies the ring links that are used as a working path; and a route switching flag that is provided for each virtual path and switches the direction for a route that is used as a working path; and a processing means that uses the information regarding the location of the ring link where a failure has occurred that is held in the first table, the information regarding the ring link to be used as a working path that is set in the second table and the route direction that is set by the route switching flag to determine whether or not a virtual path is affected by a failure in the ring link, and, if a virtual path is affected, causes the ring link communication means to transmit information in an opposite direction.
[0015] Because the processing means uses the values set in the first table, the second table and the route switching flag to determine whether or not a virtual path is affected by the failure of a ring link, whether or not a virtual path is affected by a failure of a ring link can be determined quickly, thus enabling a quick recovery from a failure.
[0016] The branch insertion node according to claim 3 is a branch insertion node according to claim 2 wherein all bits that are set in the second table and route switching flags of some virtual paths are inverted.
[0017] Because all bits that are set in the second table and route switching flags of some virtual paths are inverted, the amount of traffic in a ring network is reduced, thus allowing a greater number of virtual paths to be accommodated.
[0018] The branch insertion node according to claim 4 is the branch insertion node according to claim 2 or 3 wherein non-sequential numbers are set in the second table and are used as the ring link numbers of ring links that are used as working paths.
[0019] The use of non-sequential numbers in the second table as rink link numbers for the ring links that are used as working paths eliminates the need to change the settings in the second table of existing branch insertion nodes as branch insertion nodes are added, thus allowing branch insertion nodes to be added in a short amount of time.

[0020] The ring network according to claim 5 comprises: a plurality of branch line nodes; a plurality of branch insertion nodes that are connected via branch line links to each of the plurality of branch line nodes; and ring links for connecting the plurality of branch insertion nodes in a ring shape wherein each of the plurality of branch insertion nodes comprises: a branch line link communication means for communicating information via the branch line links; a ring link communication means for communicating information via the ring links; and a route selection means for receiving, via the ring link communication means, notification of occurrence of a failure in a ring link and for causing the ring link communication means to transmit information in an opposite direction to virtual paths that are affected by a failure in the ring link.
[0021] Because the route selection means receives notification of the occurrence of a failure in a ring link via the ring link communication means and causes the ring link communication means to transmit information in the opposite direction to the virtual paths that are affected by the failure in a ring link, rapid recovery is possible from a failure.
[0022] The failure recovery method according to claim 6 relates to a ring network comprising: a plurality of branch line nodes; a plurality of branch insertion nodes that are connected to each of the plurality of branch line nodes via branch line links; and ring links that connect the plurality of branch insertion nodes in a ring shape, and comprises: a step for causing the branch insertion node to receive notification of the occurrence of a failure in a ring link and a step for causing the branch insertion node to transmit information in an opposite direction to virtual paths that are affected by the failure in a ring link.
[0023] Because the branch insertion node is caused to transmit information in an opposite direction to the virtual paths that are affected by a failure in a ring link, rapid recovery is possible from a failure.
[0024]
[Embodiments of the Invention] (Embodiment 1) FIG. 1 shows a schematic view of the configuration of Embodiment 1 of a ring network according to the present invention. This ring network comprises a plurality of branch insertion nodes 1a through 1d that are arranged in a ring shape, ring links 2a through 2d that respectively connect adjacent branch insertion nodes 1a through 1d, branch line links 3a through 3d that are respectively connected to branch insertion nodes 1a through 1d, and branch line nodes 4a through 4d that are respectively connected to branch insertion nodes 1a through 1d via branch line links 3a through 3d.
[0025] Ring links 2a through 2d that respectively connect adjacent branch insertion nodes 1a through 1d as shown in FIG. 1 are bidirectional physical transmission paths and constitute clockwise ring transmission paths and counterclockwise ring transmission paths. These ring links 2a through 2d are used as information transmission paths between branch insertion nodes 1a through 1d.
[0026] Branch insertion nodes 1a through 1d determine the transmission destination of the information received via connected ring links 2a through 2d or the information received via connected branch line links 3a through 3d based on information held in branch insertion nodes 1a through 1d and transmit the information to ring links 2a through 2d or branch line links 3a through 3d.
[0027] Branch line link 3a through 3d are bidirectional physical transmission paths and are used as information transmission paths between branch line nodes 4a through 4d and branch insertion nodes 1a through 1d. Furthermore, branch line nodes 4a through 4d communicate information with other branch line nodes via branch line links 3a through 3d, branch insertion nodes 1a through 1d and ring links 2a through 2d.

[0028] FIG. 2(a) shows one example of a virtual path that is used as a virtual information communication path. Virtual paths VP1 through VP4 are respectively routes from branch line node 4a to branch line node 4c, from branch line node 4a to branch line node 4d, from branch line node 4d to branch line node 4a and from branch line node 4d to branch line node 4c. In this way, ring links 2a through 2d and branch line links 3a through 3d allow a plurality of virtual paths to be accommodated on a single transmission path.
[0029] Virtual paths are established between branch line nodes 4a through 4d via a ring network and serve as communication paths for variable-length-size frames and fixed-length-size ATM cells which contain information. FIG. 2(b) and FIG. 2(c) show the structure of a frame and an ATM cell. As FIG. 2(b) shows, frame 5 comprises a 4-byte header section that includes a virtual path number and an information section that stores information ranging from 60 to 1518 bytes. Furthermore, as FIG. 2(c) shows, ATM cell 6 includes a 5-byte header section that includes a virtual path number and an information section that stores a 48-byte information.
[0030] FIG. 3 describes the working path of a virtual path. A working path is a virtual path that is normally used. In FIG. 3, virtual path VP1, a route that extends from branch line node 4a to branch line node 4c, is shown as an example of a working path.
[0031] FIG. 4 is used to describe a protection path for a virtual path. A protection path is a virtual path that is used to circumvent a failure when a failure occurs on a ring network. In FIG. 4, because a failure has occurred on ring link 2b between branch insertion node 1b and branch insertion node 1c, virtual path VP1, which is a protection path that is not routed over ring link 2b, is used.
[0032] The failure that occurred in ring link 2b is detected by branch insertion node 1b or 1c. Other branch insertion nodes are notified of the failure. Branch insertion node 1a, which receives the failure notification, determines which of the virtual paths connected to it from branch line node 4a are affected by the failure and sends either frame 5 or ATM cell 6 to ring link 2d in the opposite direction for the virtual paths that are affected by the failure, thus circumventing the failure. To explain, branch insertion node 1a circumvents the failure by switching the route of virtual path VP1 from the counterclockwise direction (working path) shown in FIG. 3 to the clockwise direction (protection path) shown in FIG. 4. The details of the switching of the protection path are described below.
[0033] FIG. 5 is a block diagram showing the configuration of branch insertion nodes 1a through 1d. The branch insertion nodes 1a through 1d comprises: route selection processing part 8, which determines the transmission direction and transmits frame 5 or ATM cell 6 that is received; route information part 9 for storing route information; ring link transmission part 10 for transmitting frame 5 or ATM cell 6 via a ring link; ring link reception part 11 for receiving frame 6 or ATM cell 6 via a ring link; branch line link transmission part 12 for transmitting frame 5 or ATM cell 6 via a branch line link; and branch line link reception part 13 for receiving frame 5 or ATM cell 6 via a branch line link.
[0034] Route information part 9 stores information that is used for determining the transmission direction of frame 5 or ATM cell 6 that is received by route selection processing part 8. As further described in detail below, for each virtual path, information that is stored in route information part 9 includes tables and flags that are set before the start of communication.
[0035] When frame 5 or ATM cell 6 is received from ring link reception part 11 or branch line link reception part 13, route selection processing part 8 references the information stored in route information part 9 and determines the transmission direction for frame 5 or ATM cell 6 and transmits frame 5 or ATM cell 6 to ring link transmission part 10 or branch line link transmission

part 12.
[0036] FIGS. 6(a) through FIG. 6(c) show the tables that are stored in route information part 9. The ring link failure table shown in FIG. 6(a) is used to hold information that indicates whether or not a failure has occurred in a ring link. The ring link failure table has a bit width equal to the maximum number of ring links in the ring network, and the bit number corresponds to the ring link number. A particular bit with a value of “0” indicates that there is no failure in the corresponding ring link. A value of “1” indicates a failure in the corresponding ring link. Thus, there is no failure anywhere, and all bits in the ring link failure table are “0.” However, if a failure occurs in a ring link, a branch insertion node 1a through 1d that receives the failure notification sets the value to “1” for the bit number corresponding to the ring link number where a failure has occurred.
[0037] The used ring link table shown in FIG. 6(b) is provided for each virtual path and identifies the ring link that is used as a working path. The used ring link table has a bit width that corresponds to the maximum number of ring links in the ring network, and the bit number corresponds to the ring link number. A value of “0” for a bit shows that the corresponding ring link is used as a protection path. A value of “1” shows that the corresponding ring link is used as a working path.
[0038] The route switching flag shown in FIG. 6(c) is set for each virtual path and shows whether the working path is clockwise or counterclockwise. A route switching flag of “0” shows that the working path is clockwise. A value of “1” shows that the working path is counterclockwise.
[0039] FIG. 7 is a flowchart showing the processing sequence of a branch insertion node according to the present embodiment. First, upon receipt of frame 5 or ATM cell 6 from branch line link reception part 13 (S1), route selection processing part 8 references the header section of frame 5 or ATM cell 6 to identify the virtual path number (S2).
[0040] Next, route selection processing part 8 determines whether or not the route switching flag that corresponds to the virtual path number that was specified in step S2 is “0” (S3). If the route switching flag is “0” (S3, 0), the used ring link table that corresponds to the virtual path number that was specified in step S2 is compared against the ring link failure table, and a determination is made as to whether or not there are bits having the same bit number and whose contents are both “1” (S4). If there are no bits having the same bit number and whose contents are both “1” (S4, No), this means either that no failure has occurred in the ring network or that even if a failure has occurred, the working path does not include a ring link where a failure has occurred. [Route selection processing part 8] then causes ring link transmission part 10 to transmit frame 5 or ATM cell 6 in the clockwise [direction] (S5).
[0041] If there are bits having the same bit number and whose contents are both “1” (S4, Yes), because this means that the working path includes a ring link where a failure has occurred, ring link transmitting unit 10 is made to transmit frame 5 or ATM-cell 6 in the counterclockwise direction. That is, frame 5 or ATM-cell 6 is transmitted using the protection path (S6).
[0042] Furthermore, if, in step S3, the route switching flag is “1” (S3, 1), the used ring link table that corresponds to the virtual path number that was specified in step S2 is compared against the ring link failure table, and a determination is made as to whether or not there are bits having the same bit number and whose contents are both “1” (S7). If no bits have the same bit number and content of “1” (S7, No), this means either that no failure has occurred in the ring network or that even if a failure has occurred, the working path does not include a ring link where a failure has

occurred. [Route selection processing part 8] then causes ring link transmission part 10 to transmit frame 5 or ATM cell 6 in the counterclockwise [direction] (S8).
[0043] Furthermore, if there are bits having the same bit number and whose contents are both “1” (S7, Yes), the working path includes a ring link where a failure has occurred. The ring link transmission part 10 is then made to transmit frame 5 or ATM cell 6 in the clockwise direction. In other words, frame 5 or ATM cell 6 is sent using the protection path.
[0044] When a ring link recovers from a failure, the branch insertion node that detects the recovery from the failure notifies the other branch insertion nodes of the recovery from the failure. The branch insertion nodes that are notified of the recovery from the failure then set the corresponding bit in the ring link failure tables to “0.” When all bits in the ring link failure tables are cleared, the virtual paths that were replaced by protection paths are all switched back to using working paths so that the ring network is operated in a state with no failures.
[0045] As afore-described, with a ring network according to the present embodiment, because a branch insertion node does not need to perform route switching for each virtual path when a failure occurs on a ring network, quick failure recovery becomes possible.
(Embodiment 2) The ring network of Embodiment 2 differs from the ring network of Embodiment 1 only in the manner in which the used ring link tables and route switching flags are set. No detailed description is provided where the configuration or function is the same.
[0046] With the ring network of Embodiment 1, for all used ring link tables of every virtual paths, “0” indicated the use of the corresponding ring link as a protection path, and “1” indicated the use of the corresponding ring link as a working path. As for the route switching flags, “0” identified a clockwise direction for the working path while “1” identified a counterclockwise direction for the working path.
[0047] With the present embodiment of the ring network, the same settings are used as in Embodiment 1 for the used ring links and the route switching flags for some of the virtual paths. As for the used ring links and the route switching flags of the other virtual paths, the values of each of the bits are inverted. For example, in the used ring link table shown in FIG. 6(b), the value of each bit from b16 through b9 is set to “1” for use as a working path, and the value of each bit from b8 through b1 is set to “0” for use as a protection path. Furthermore, the route switching flag shown in FIG. 6(c) is set to “0” for use in the clockwise direction.
[0048] As afore-described, with the ring network according to the present embodiment, the values for the used ring link tables and route switching flags are suitably inverted and set, allowing traffic on a ring network to be dispersed and to make more efficient use of the link band. Furthermore, a greater number of virtual paths can be accommodated in a ring network.
(Embodiment 3) The ring network of Embodiment 3 according to the present invention differs from the ring network of Embodiment 1 only in the manner in which the used ring link tables are set. No detailed description is provided where the configuration or function is the same.
[0049] In the initial stage of use of a rink network, it is expected that the number of ring links that are actually used would often turn out to be fewer than the maximum number of ring links. With the present embodiment, non-sequential numbers are set as the ring link numbers. As for the settings of the used ring link tables in a branch insertion node for each virtual path, a value of “1” is set for the bit that corresponds to the used ring link number. Furthermore, a value of “1” is also set in advance for the bit that is between the bits for which a value of “1” is set. When a new branch insertion node is added to the ring network, a new ring link number is set so that the number falls between the ring link numbers on either sides of the insertion position.
[0050] FIG. 8 is used to describe the addition of a branch insertion node. As FIG. 8(a) shows, at

the initial stage of the use of the ring network, four branch insertion nodes 1a through 1d are installed. The number “1” is set for the ring link that is situated between branch insertion nodes 1a and 1b. The number “5” is set for the ring link between branch insertion nodes 1b and 1c. The number “9” is set for the ring link between branch insertion nodes 1c and 1d. The number “13” is set for the ring link between branch insertion nodes 1d and 1a. Furthermore, as for virtual path VP1 that is shown in FIG. 8(a), so that the working path operates in a counterclockwise direction and the protection path operates in a clockwise direction, the values shown in FIG. 6(b) and FIG. 6(c) are set in the used ring link table and the route switching flag, respectively.

[0051] As FIG. 8(b) shows, to insert a new branch insertion node 1e between branch insertion nodes 1a and 1b, a value of “3” is set as the number for the added ring link. Thus, even when branch insertion node 1e is added, because the value of “1” is already set for b3 in the used ring link table shown in FIG. 6(b), the addition of the new branch insertion node does not require a change in the settings.

[0052] As afore-described, with the ring network according to the present embodiment, because non-sequential ring link numbers are set at the start of use of the ring network, the modification required to the settings of the existing branch insertion nodes due to the addition of a new branch insertion node is simplified, and the time required for the addition of new branch insertion nodes is shortened.

[0053] All embodiments disclosed herein are illustrative in all respects and are not limitations. The scope of the present invention is defined not by the above description but by the claims and is intended to include all modifications that fall within the scope of the claims and their equivalents.

[Brief Description of the Figures]

[FIG. 1] Shows a schematic view of the configuration of Embodiment 1 of a ring network according to the present invention.

[FIG. 2] (a) shows one example of a virtual path that is used as a virtual information communication path; (b) shows one example of a frame; and (c) shows one example of an ATM cell.

[FIG. 3] Shows a working path for a virtual path.

[FIG. 4] Shows a protection path for a virtual path.

[FIG. 5] Block diagram showing a schematic configuration of a branch insertion node.

[FIG. 6] Shows the tables and flags that are stored in route information part 9.

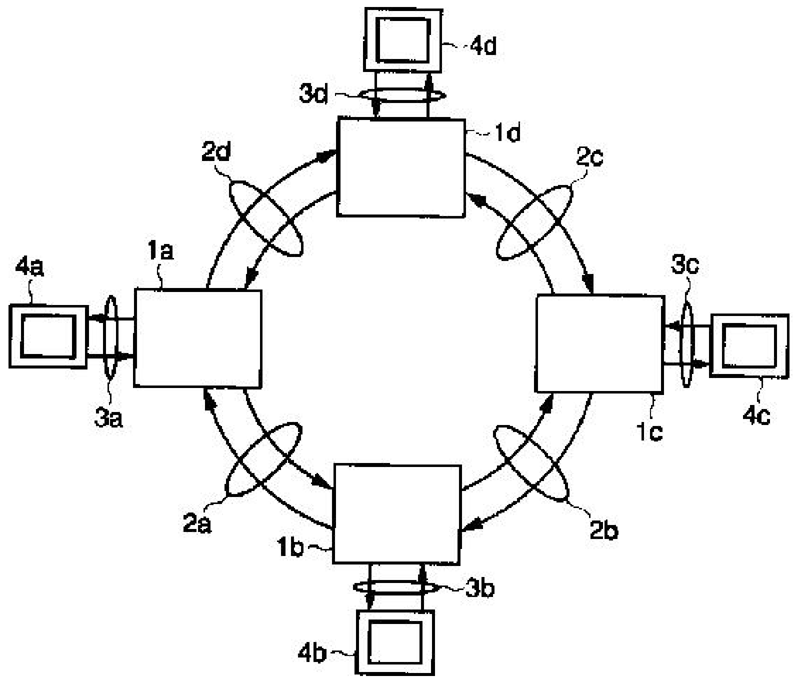
[FIG. 7] Flowchart showing the processing sequence in Embodiment 1 of a branch insertion node according to the present invention.

[FIG. 8] Showsd the addition of a branch insertion node.

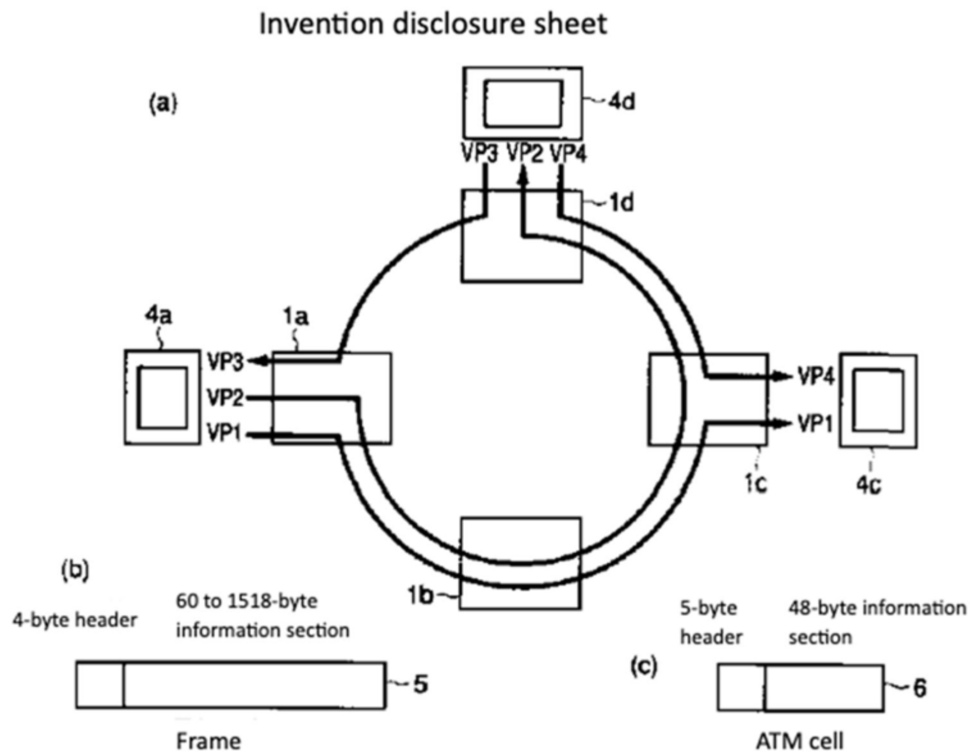
[Legend]

1a through 1d: Branch insertion nodes; 2a through 2d: Ring links; 3a through 3d: Branch line links; 4a through 4d: Branch line nodes; 5: Frame; 6: ATM cell; 8: Route selection processing part; 9: Route information part; 10: Ring link transmission part; 11: Ring link reception part; 12: Branch line link transmission part; 13: Branch line link reception part

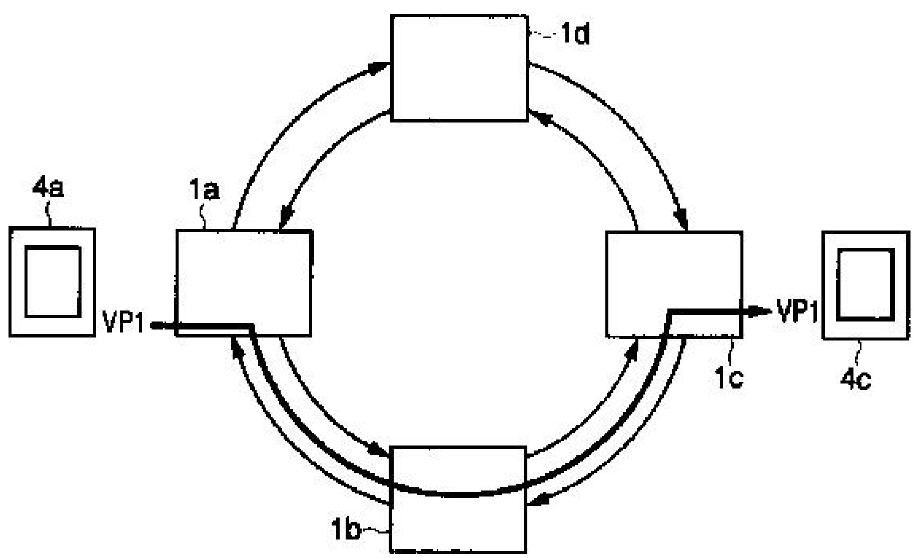
[FIG. 1]



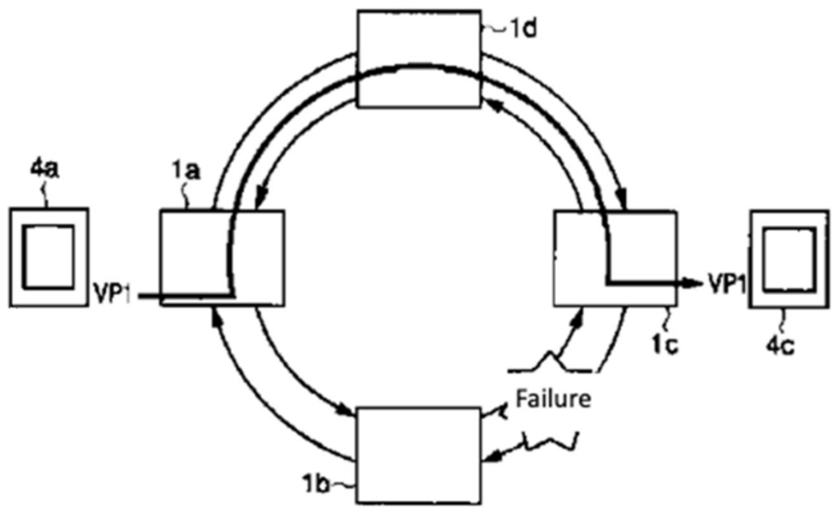
[FIG. 2]


Invention disclosure sheet
(a)
4d
VP3 VP2 VP4
1d
4a
1a
VP3
VP2
VP1
VP4
VP1
1c
4c
(b)
1b
4-byte header
60 to 1518-byte information section
5
Frame
5-byte header
48-byte information section
(c)
6
ATM cell

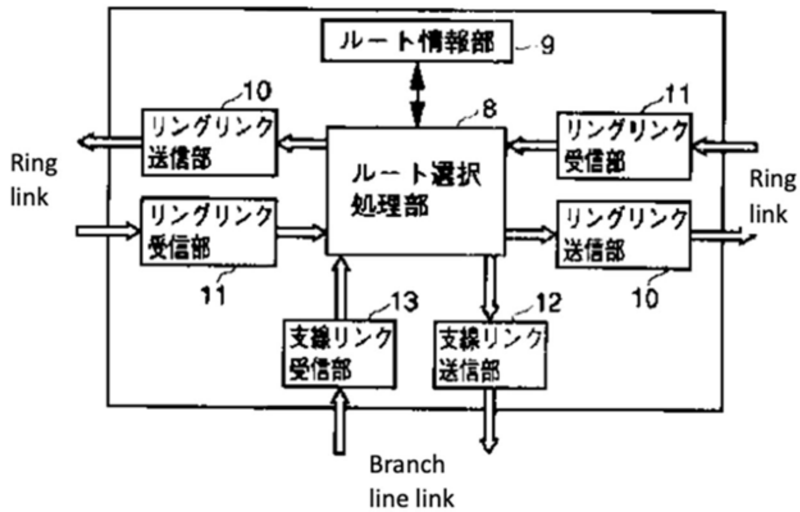
[FIG. 3]


1d
4a
1a
VP1
VP1
1c
4c
1b

[FIG. 4]

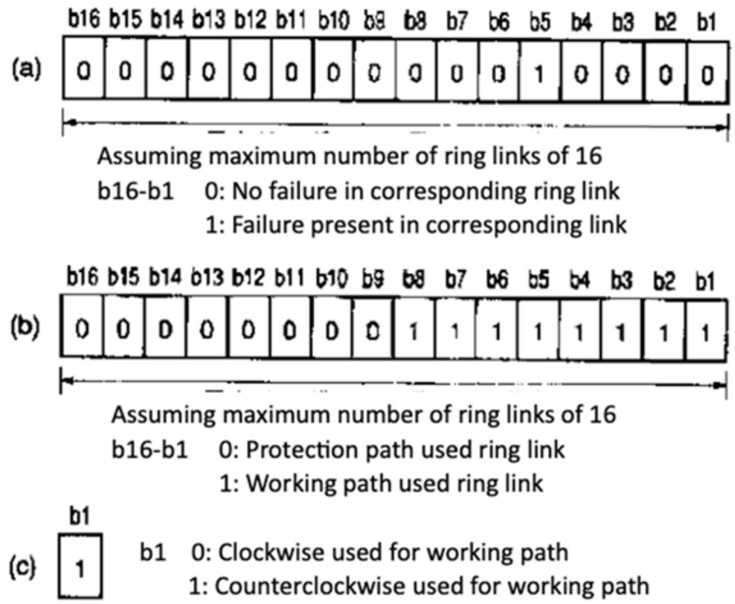


[FIG. 5]

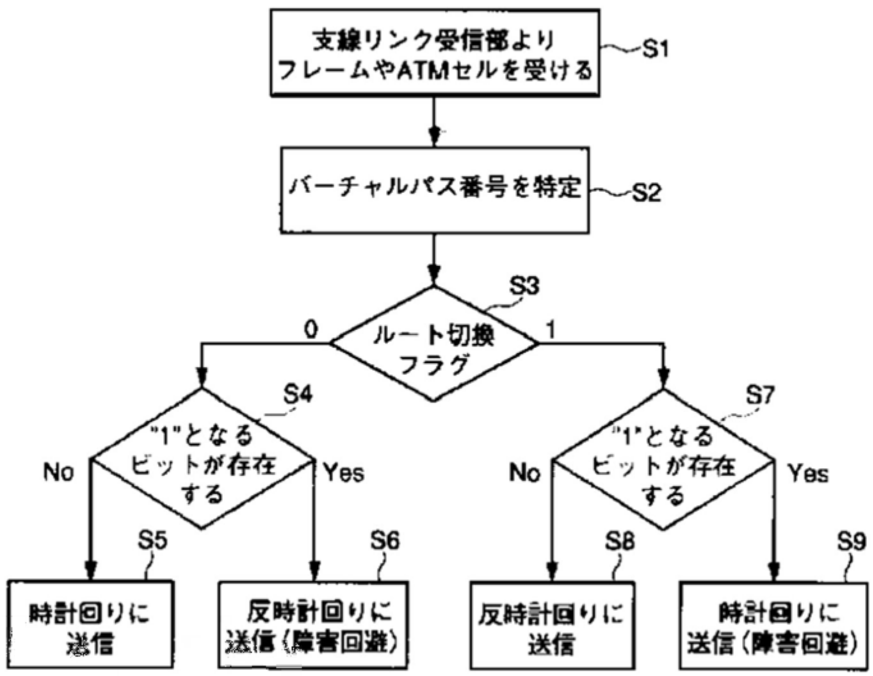


8. Route selection processing part
9. Route information part
10. Ring link transmission part
11. Ring link reception part
12. Branch line link transmission part
13. Branch line link reception part

[FIG. 6]

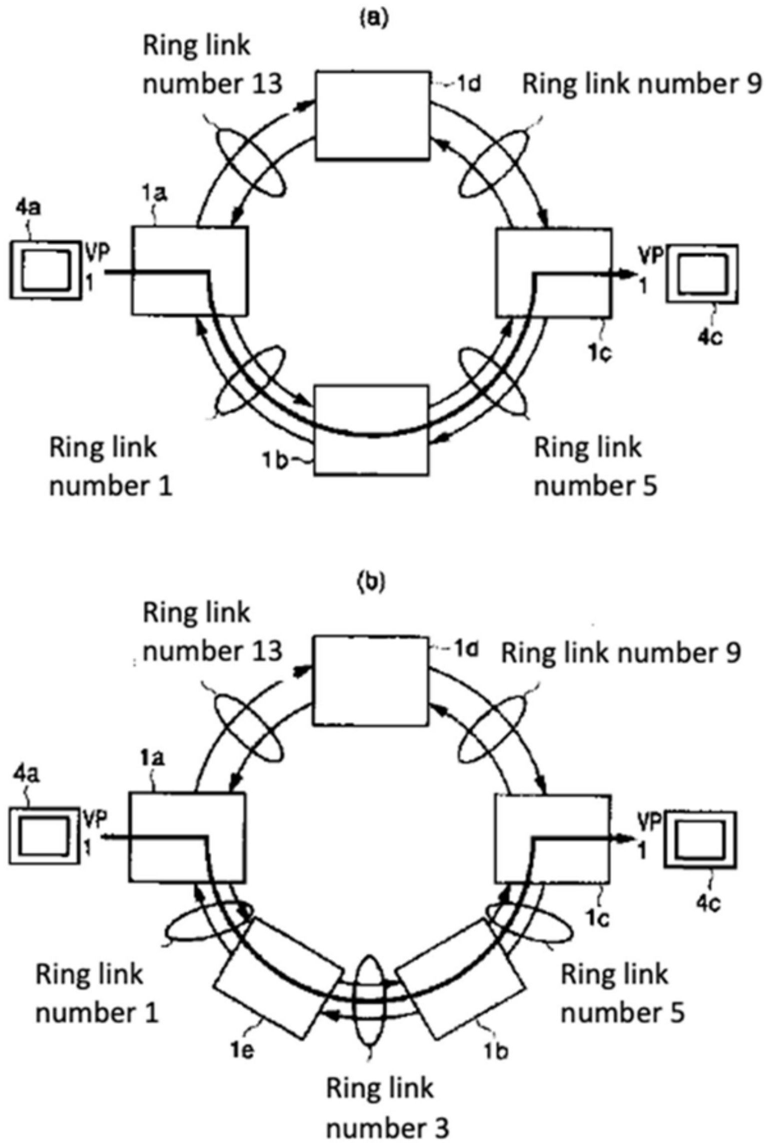

b16 b15 b14 b13 b12 b11 b10 b9 b8 b7 b6 b5 b4 b3 b2 b1
(a)
0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
Assuming maximum number of ring links of 16
b16-b1 0: No failure in corresponding ring link
1: Failure present in corresponding link
b16 b15 b14 b13 b12 b11 b10 b9 b8 b7 b6 b5 b4 b3 b2 b1
(b)
0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1
Assuming maximum number of ring links of 16
b16-b1 0: Protection path used ring link
1: Working path used ring link
b1
(c)
1
b1 0: Clockwise used for working path
1: Counterclockwise used for working path

[FIG. 7]



S1. Receive frame or ATM cell from branch line link reception part
S2. Specify virtual path number
S3. Route switch flag
S4. Bit with value of "1" exists
S5. Transmit in clockwise direction
S6. Transmit in counterclockwise direction (circumvent the failure)
S7. Bit with value of "1" exists
S8. Transmit in counterclockwise direction
S9. Transmit in clockwise direction (circumvent the failure)

[FIG. 8]


(a)
Ring link number 13
1d
Ring link number 9
1a
4a
VP 1
VP 1
4c
1c
Ring link number 1
1b
Ring link number 5
(b)
Ring link number 13
1d
Ring link number 9
1a
4a
VP 1
VP 1
4c
1c
Ring link number 1
Ring link number 5
1e
1b
Ring link number 3