EXHIBIT 52

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Nagami et al.

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(54) **IP OVER ATM SYSTEM USING CONTROL MESSAGES TO SET UP CUT-THROUGH PATHS OR BYPASS PIPES IN ROUTERS**

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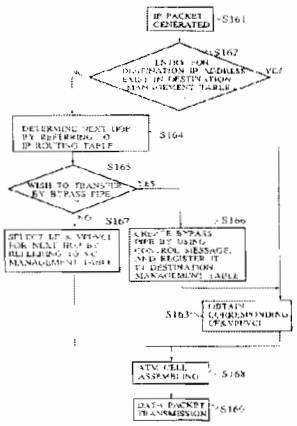
(57) **ABSTRACT**

A packet transfer scheme for transferring packets at a boundary of a plurality networks is disclosed. A network interconnection apparatus (router) communicates with a previous hop node in one of the plurality of networks by a first control message including a first identification information for identifying an upstream path from the previous hop node and a specification information for specifying a group of packets to be transferred on the upstream path, and with a next hop node in another of the plurality of networks by a second control message including a second identification information for identifying a downstream path to the next hop node and a specification information for specifying a group of packets to be transferred on the downstream path. Then, the network interconnection apparatus stores a first identifier at a layer lower than layer **3** of the upstream path and a second identifier at a layer lower than layer **3** of the downstream path corresponding to the upstream path, according to the first and second control messages, and transfers a packet from the upstream path to the corresponding downstream path, referring to the memory.

23 Claims, 53 Drawing Sheets



router 11C to the router 11A are both connected to the bypass pipe 131 from the router 11C to the router 11A by using a table in the add/drop and header conversion unit within this router 11C (or a switch table in a case of a multi-port router).

Similarly, when the bypass pipe set up request message for a bypass pipe in a direction from the router 11E to the router 11A is received from the router 11E, the router 11B utilizes the bypass pipe 131 to the router 11A that has already been established in this router 11B, by merging the VC for the bypass pipe from the router 11E to the bypass pipe 131 by an appropriate setting of a table in the add/drop and header conversion unit within this router 11B (or a switch table in a case of a multi-port router), such that the datagram from the router 11E can reach to the router 11A by only the ATM layer processing.

Thus, in this case, as shown in FIG. 55, the bypass pipes from the router processing units in the routers 11E and 11F are merged at the router 11B to effectively form a spanning tree with the router 11A as a root and the other routers as nodes.

Hence, the multi-point to point connection obtained in this procedure is obtained by the merging of the connections in the routers, and not by a use of a multi-point connection of the ATM-LAN. Consequently, this multi-point to point ATM connection can be realized by the protocol among the routers alone, and the datalink layer is not necessarily required to have a function of a multi-point connection.

As described, in this procedure, it is possible to form the multi-point to point ATM connection as shown in FIG. 55 in which each router functions as a root (destination) and the other routers functions as leaves (start point).

Here, the cell flow from this multi-point to point ATM connection is merged at each router functioning as a node, the multiplexing of the datagram is necessary, and the following should be taken into account.

First, in a case of using the ALL type 3/4, a different MID (Multiplex Identifier) should be assigned to the source of each datagram. By means of this, it becomes possible for the router 11A to identify each transmission source.

Second, in a case of using the AAL type 5, the transmission source identification at the cell level is impossible at the router 11A, so that the add/drop function in the router or the ATM switch should be provided with such a function that, in a given VC, until a transmission of one AAL-PDU (datagram) is finished, the other PDUs are not allowed to flow into that given VC.

In the multi-point to point ATM connection obtained by this procedure, each router functions as a root (destination) and the branch points (nodes) of this multi-point to point ATM connection are located at the routers. In this manner, it becomes possible to realize the dedicated Vc with a smaller number of VCs (or more specifically, a smaller number of ATM-LANs inter-networked to one ATM-LAN).

Thus, in this procedure, the spanning tree for the datagram transfer which is generated by the routing protocol operating among the routers is directly realized by the multi-point to point connection formed by the ATM connections. Note here that, within each ATM-LAN, each of these multi-point to point VCs is basically the point to point VC, which may be a VC associated with QoS.

In this procedure, as a plurality of datagrams from a plurality of locations are multiplexed into one VC at the router, there is a possibility for an overflow of the VC capacity or a cell loss within the ATM switch to occur, in a case of the traffic concentration. Such an overflow or a cell loss can be prevented by any of the following measures.

(1) For the VC in which the congestion or the cell loss is likely to occur, the relay of the cell to that VC by only the ATM layer processing can be temporarily or partially interrupted and the routing to the router processing unit is used instead.

(2) For the lower stream of the spanning tree (i.e., at a side closer to the terminal point router), a larger bandwidth resource can be secured in advance compared with the upper stream.

(3) Basically, the cell loss occurs at the router which becomes a node of the spanning tree. Consequently, an ATM switch in such a router can be selectively formed by a high performance switch capable of realizing the lower cell loss rate compared with the ATM switch in the ATM-LAN.

It is to be noted that, besides those already mentioned above, many modifications and variations of the above embodiments may be made without departing from the novel and advantageous features of the present invention. Accordingly, all such modifications and variations are intended to be included within the scope of the appended claims.

What is claimed is:

1. A network interconnection apparatus for transferring packets at a boundary of a plurality of networks, the apparatus comprising:

a control message processing unit configured to communicate with a previous hop node in one of the plurality of networks by a first control message including a first identification information for identifying an upstream path from the previous hop node to the network interconnection apparatus and a specification information for specifying a group of packets to be transferred on the upstream path, and configured to communicate with a next hop node in another of the plurality of networks by a second control message including a second identification information for identifying a downstream path from the network interconnection apparatus to the next hop node and a specification information for specifying a group of packets to be transferred on the downstream path;

a memory unit configured to store a first identifier at a layer lower than layer 3 of the upstream path and a second identifier at a layer lower than layer 3 of the downstream path corresponding to the upstream path, according to the first and second control messages used by the control message processing unit; and

a transfer unit configured to transfer a packet from the upstream path to the corresponding downstream path, referring to the memory unit.

2. The apparatus according to claim 1, further comprising:

another memory unit configured to store a destination information including a layer 3 address regarding a destination and a corresponding next hop information,

wherein the control message processing unit communicates with the next hop node according to the destination information and the corresponding next hop information stored in said another memory unit.

3. The apparatus according to claim 2, wherein the control message processing unit starts to communicate with at least one of the next hop node and the previous hop node when said another memory unit indicates a new information based on a routing protocol.

4. The apparatus according to claim 2, further comprising a transfer processing unit configured to transfer a packet to the next hop node, referring to said another memory unit according to a layer 3 address regarding a destination of the packet.

5. The apparatus according to claim 4, further comprising a receiving unit configured to receive a packet through a virtual connection, and to transfer the packet to the transfer unit when said memory unit stores an identifier of the virtual connection as the first identifier that corresponds to the second identifier and otherwise transfer the packet to the transfer processing unit.

6. The apparatus according to claim 5, wherein the receiving unit transfers a packet to the transfer processing unit when the packet is received through a prescribed virtual connection, and the control message processing unit processes the first control message indicating another virtual connection other than the prescribed virtual connection as the upstream path.

7. The apparatus according to claim 1, wherein the transfer unit uses a first virtual connection as the upstream path and a second virtual connection as the downstream path.

8. The apparatus according to claim 7, wherein the memory unit stores an identifier of the first virtual connection as the first identifier and an identifier of the second virtual connection as the second identifier.

9. The apparatus according to claim 8, wherein, when at least one of the first and second virtual connections pass through a switch for switching virtual connections, the control message processing unit uses an identification information for identifying said at least one of the first and second virtual connections uniquely in a corresponding one of the plurality of networks.

10. The apparatus according to claim 9, further comprising a setup unit configured to set up said at least one of the first and second virtual connections by signaling before the memory unit stores a corresponding one of the first and second identifiers as available for the transfer unit.

11. The apparatus according to claim 1, wherein the control message processing unit uses at least one of addresses regarding a source or a destination of the group of packets to be transferred as the specification information.

12. The apparatus according to claim 1, wherein the transfer unit transfers another packet from the upstream path to the corresponding downstream path, said packet being toward one destination and said another packet being toward another destination, both said packet and said another packet belonging to the group of packets.

13. The apparatus according to claim 1, wherein the control message processing unit uses the first identifier to be stored in the memory unit as the first identification information, and uses the second identifier to be stored in the memory unit as the second identification information.

14. The apparatus according to claim 1, wherein the control message processing unit starts to communicate with one of the next hop node and the previous hop node when the other of the next hop node and the previous hop node starts to communicate with the network interconnection apparatus.

15. The apparatus according to claim 1, wherein the control message processing unit starts to communicate with one of the next hop node and the previous hop node when the network interconnection apparatus receives a packet from the previous hop node or transmits a packet to the next hop node.

16. The apparatus according to claim 1, wherein the control message processing unit starts to communicate with one of the next hop node and the previous hop node according to statistical information regarding transferring packets to the next hop node.

17. The apparatus according to claim 1, wherein the control message processing unit communicates with another previous hop node by a third control message including a third identification information for identifying another upstream path from said another previous hop node to the network interconnection apparatus and a specification information for specifying a group of packets to be transferred on said another upstream path, and the memory unit stores a third identifier at a layer lower than layer 3 of said another upstream path, such that the first and third identifiers are stored in correspondence with the second identifier.

18. The apparatus according to claim 17, wherein the transfer unit transfers all packets of one protocol data unit from the upstream path of the first identifier or said another upstream path of the third identifier to the downstream path of the second identifier before starting to transfer a packet of another protocol data unit.

19. The apparatus according to claim 1, wherein the memory unit stores the second identifier while communication regarding the second control message is repeated and deletes the second identifier when the communication regarding the second control message stops for a predetermined period.

20. The apparatus according to claim 1, wherein the memory unit deletes the second identifier when a delete control message is received from at least one of the next hop node and the previous hop node.

21. The apparatus according to claim 1, wherein the memory unit deletes the first identifier when a packet from the upstream path of the first identifier is not received for a predetermined period.

22. A method of transferring packets at a boundary of a plurality of networks, the method comprising the steps of:

communicating with a previous hop node in one of the plurality of networks by a first control message including a first identification information for identifying an upstream path from the previous hop node and a specification information for specifying a group of packets to be transferred on the upstream path;

communicating with a next hop node in another of the plurality of networks by a second control message including a second identification information for identifying a downstream path to the next hop node and a specification information for specifying a group of packets to be transferred on the downstream path;

storing, in a memory, a first identifier at a layer lower than layer 3 of the upstream path and a second identifier at a layer lower than layer 3 of the downstream path corresponding to the upstream path, according to the first and second control messages; and

transferring a packet from the upstream path to the corresponding downstream path, referring to the memory.

23. The method according to claim 22, further comprising:

storing, prior to the step of communicating with the next hop node, a destination information including a layer 3 address regarding a destination and a corresponding next hop information in another memory,

wherein the step of communicating with the next hop node communicates according to the destination information and the corresponding next hop information stored in said another memory.

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