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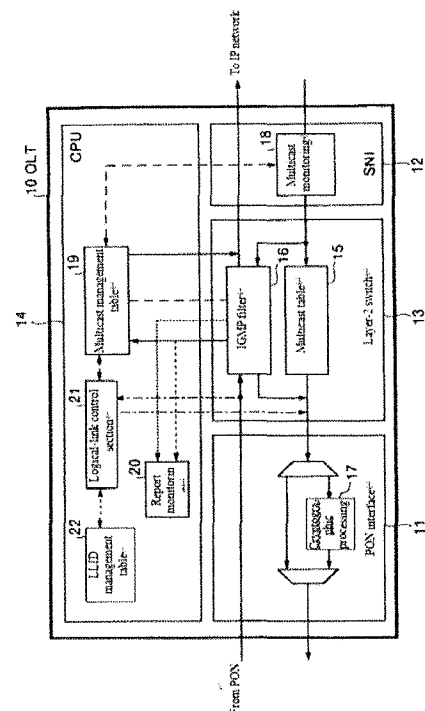
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(54) TITLE OF THE INVENTION: METHOD AND CENTRAL OFFICE UNIT FOR MULTICAST COMMUNICATION IN PON SYSTEM**(57) ABSTRACT**

OBJECTIVE: To provide a PON system that allows efficient multicast communication to be provided in the form linked with an IP multicast protocol without the need to arrange routing function blocks on the subscriber side, doing so while ensuring security.

MEANS FOR ACHIEVING THE OBJECTIVE: In a PON system in which communications are carried out through the use of logical links, ONUs and OLT 10 are connected via an optical transport medium so as to transmit and receive data between the ONUs and OLT 10 using MAC frames. OLT 10 snoops IGMP messages so as to control the setting of logical links for multicasting according to the result of the snooping and distribute encryption keys for use in multicast communication.

SELECTED DRAWING: Figure 1



WHAT IS CLAIMED IS:**CLAIM 1**

A method for multicast communication in a PON system, said PON system connecting — via an optical transport medium — subscriber-side units, which accommodate one or multiple subscriber terminals, and a central office unit, which accommodates one or multiple subscriber-side units mentioned above and is also connected to an IP network, to thereby enable transmission and reception of data between the subscriber-side units and the central office unit using MAC frames, doing so through communication that uses logical links; wherein the aforementioned central office unit snoops messages that use an IP protocol for multicasting, so as to control the setting of logical links for multicasting according to the result of the snooping and distribute encryption keys for use in the multicast communication.

CLAIM 2

The method for multicast communication in a PON system according to Claim 1, wherein the aforementioned central office unit snoops report messages that use the aforementioned IP protocol for multicasting, remembers the multicast addresses contained in the aforementioned report messages, the physical ports on which the report messages arrived, and the subscriber-side units that have transmitted the report messages, and forwards the aforementioned report messages only to the IP-network side.

CLAIM 3

The method for multicast communication in a PON system according to Claim 2, wherein said forwarding of report messages to the IP-network side involves the aforementioned central office unit, upon receipt of multiple report messages, forwarding only one of them to the IP-network side.

CLAIM 4

The method for multicast communication in a PON system according to Claim 2, wherein if the multicast address in a report message does not match any of the previously remembered multicast addresses, the aforementioned central office unit sets up a new multicasting logical link for the subscriber-side unit, from which the aforementioned report message has been transmitted, and then remembers the correlation between the multicast address and the multicasting logical link.

CLAIM 5

The method for multicast communication in a PON system according to Claim 2 or Claim 4, wherein the aforementioned central office unit, after setting up the multicasting logical link, uses a point-to-point logical link pre-set for the aforementioned subscriber-side unit to distribute an encryption key, which is to be used in the aforementioned multicast logical link, and then remembers the correlation between the multicast logical link and the aforementioned encryption key thus distributed.

CLAIM 6

The method for multicast communication in a PON system according to Claim 2 or Claim 5, wherein if the multicast address contained in a report message matches one of the previously remembered multicast addresses, but the subscriber-side unit transmitting the report message does not match any of the subscriber-side units associated with said multicast address, the aforementioned central office unit sets up a multicast logical link associated with the aforementioned multicast address for the aforementioned subscriber-side unit transmitting the report message and also — as part of this setup procedure — distributes an encryption key associated with the multicast logical link.

CLAIM 7

The method for multicast communication in a PON system according to Claim 2, wherein:

The aforementioned central office unit inspects the destination addresses of frames received from the IP-network side, and

If any of the destination addresses thus inspected is a multicast address and a prescribed number of the low bits match a prescribed number of the low bits of any one of the previously remembered multicast addresses, the aforementioned central office unit uses the encryption key associated with the aforementioned multicast address to encrypt the aforementioned frame thus received and then uses the multicast logical link associated with the aforementioned multicast address to transmit the frame thus encrypted.

CLAIM 8

The method for multicast communication in a PON system according to Claim 1 or Claim 2, wherein:

The aforementioned central office unit shall snoop report and query messages that use the aforementioned IP Protocol for multicasting and shall transmit the aforementioned query messages to all subscriber-side units or to subscriber-side units that are currently accessing the multicast communication; and

If any subscriber-side units do not send back report messages for a certain period of time after the transmission of query messages, said central office unit deletes such subscriber-side units from the multicast communication while releasing the multicast logical links for the subscriber-side units that have not returned report messages.

CLAIM 9

The method for multicast communication in a PON system according to Claim 1, wherein the aforementioned central office unit monitors multicast frames received from the IP-network side and, if it does not receive multicast frames for a certain period of time, releases the multicast logical links for all subscriber-side units accessing the multicast communication concerned.

CLAIM 10

The method for multicast communication in a PON system according to Claim 1, wherein the aforementioned central office unit snoops leave messages that use the aforementioned IP protocol for multicast and releases the multicast logical links for subscriber-side units that have transmitted the aforementioned leave messages.

CLAIM 11

The method for multicast communication in a PON system according to Claim 1, wherein:

If a subscriber-side unit accommodates more than one subscriber port, a point-to-point logical link shall be set for each subscriber port beforehand;

If at least one subscriber port is accessing multicast communication, the aforementioned central office unit shall set up a logical link for the multicast communication for the subscriber-side unit concerned, and

The subscriber-side unit remembers which subscriber port is actually accessing the multicast communication and, based on the data thus remembered, transmits the multicast frames received through the logical link for multicast communication only to the subscriber port that is actually accessing the multicast communication.

CLAIM 12

A central office unit in a PON system, said central office unit being characterized by:

Being connected, via an optical transport medium, to and accommodating one or multiple subscriber-side units, each of which accommodates one or multiple subscriber terminals,

Being connected to an IP network,

Transmitting and receiving data to and from the subscriber-side units using MAC frames, and

Using logical links for communication; and

Said central office unit in a PON system, comprises:

A snooping means for snooping messages that use an IP protocol for multicasting, and

A control means for controlling the setting of multicast logical links according to the results of the snooping described above and for distributing encryption keys used for multicast communication.

DETAILED DESCRIPTION OF THE INVENTION

[0001]

TECHNOLOGICAL FIELD OF THE INVENTION

The invention pertains to a method and central office unit for multicast communication in a PON system comprising the central office unit, subscriber-side units, and a transmission medium that connects the central office unit and the subscriber-side units, enabling the transmission and reception of data using MAC (Media Access Control) frames to achieve communication through virtual communication connections referred to as “logical links.”

[0002]

PRIOR ART

The Ethernet (registered trademark) PON system transparently accommodates Ethernet (registered trademark) services in the PON system by connecting its optical line terminal (OLT) and multiple subscriber-side units (ONUs: Optional Network Units) via an optical transport medium and transmitting/receiving data by means of MAC frames. The OLT is installed at the communication network operator's central office, while the ONUs are installed indoors or outdoors on their customers' premises. Each ONU accommodates one or multiple subscriber terminals.

[0003]

Furthermore, an example method widely used to implement multicasting in IP communications uses the IGMP (Internet Group Management Protocol). The IGMP is a protocol used to manage IP multicast groups. It is used by multicast routers that support multicasting and hosts that receive multicast packets. The operation is as follows:

[0004]

A multicast router periodically multicasts query messages (Query messages) and acknowledges its members by the presence or absence of report messages (Report messages) from each host. When a host participates in a group or responds to a query message, it replies with a report message. When the host leaves the group, it provides a notification in the form of a leave message (Leave message). Incidentally, there are V. 1 and V. 2 of the IGMP. The above-mentioned Leave message does not exist in V. 1. When a subscriber terminal leaves multicast communication, it simply does not transmit a report message back.

[0005]

A method for providing such multicast communication over a PON using the IGMP is disclosed in Patent Document 1. In Patent Document 1, the network used to provide multicast communication over PON using the IGMP is configured to accommodate a routing function block (so-called multicast router) in each subscriber-side unit (ONU) while a routing function block is also installed on the data-delivery-unit side so that data delivery requests and data-delivery stop requests are routed from the ONU to the data delivery unit according to the result of the identification of these two routing function blocks. Additionally, upon receipt of a report message from a subscriber terminal, the routing function block on the ONU side delivers multicast data (which have been provided from the data delivery unit) to the subscriber terminal. However, it stops the delivery of multicast data upon receipt of a leave message from the subscriber terminal.

[0006]

Furthermore, Patent Document 2 discloses a method for providing multicast communication in an ATM-PON. According to Patent Document 2, when an ATM cell is multicast to an ONU that belongs to a multicast group, the OLT appends, to the ATM cell, an emulated LAN identifier (ELAN) identifying said group and performs a cryptographic process with the encryption key corresponding to the group to transmit the ATM cell with the identification information conveying that the ATM cell is intended for multicasting, such identification information being appended to the ATM cell as ONU identification information.

[0007]

Now, the IEEE 802.3ah task force (commonly known as EFM: Ethernet(R) in the First Mile) is moving forward with the standardization of the EPON system (GE-PON) of a gigabit transport speed, which appears promising as a system for FTTH (Fiber To The Home) targeting general households.

[0008]

[Patent Document 1]

JP, 2002-232476, A

[Patent Document 2]

JP, H11-215146, A

[0009]

PROBLEMS TO BE RESOLVED BY THE INVENTION

The invention of Patent Document 1 assumes that the network used to provide multicast communication over a PON using the IGMP is configured to accommodate routing function blocks in the ONUs, or the OUNs are provided with routing function blocks. However, there are problems particularly in the case of FTTH (Fiber To The Home) that targets general households because it is unlikely that a router will be installed in each subscriber's home. Even if the ONU is equipped with a routing function, it will lead to a higher ONU cost.

[0010]

The invention in Patent Document 2 is configured to provide multicast communication in an ATM-PON by providing a special identifier for each multicast group and performing a cryptographic process for each group. However, such an invention according to Patent Document 2 poses a problem because it does not contemplate linkage with IP multicast protocols such as the IGMP, making it difficult to apply the invention to a GE-PON, which uses logical links as the unit of communication.

[0011]

The present invention was achieved in view of the above-mentioned points. Accordingly, the purpose is to obtain a method and central office unit for multicast communication in a PON system that realizes multicast communication that ensures security — doing so over a PON system that uses logical links as the unit of communication, without requiring routing functions on the subscriber side or the subscriber-side units (ONUs), and in the form linked with an IP multicast protocol.

[0012]

MEANS FOR ACHIEVING THE OBJECTIVE

In order to achieve the above-mentioned purpose, the method for multicast communication in a PON system according to the present invention is characterized by a PON system that connects — via an optical transport medium — subscriber-side units, which accommodate one or multiple subscriber terminals, and a central office unit, which accommodates one or multiple subscriber-side units mentioned above and is connected to an IP network, so as to allow transmission and reception of data between the subscriber-side units and the central office unit by means of MAC frames, doing so through communication that uses logical links. The aforementioned central office unit snoops messages that use an IP protocol for multicasting, so as to control the setting of logical links for multicasting according to the result of the snooping and distribute encryption keys for use in the multicast communication.

[0013]

The present invention is configured to snoop IGMP messages in the central office unit of a PON system, interlock the result of the snooping with the logical-link control, and further process the multicast data through a cryptographic step. This allows efficient multicast communication to be provided in the form linked with an IP multicast protocol without the need to arrange routing function blocks on the subscriber side, doing so while ensuring security.

[0014]

EMBODIMENT OF THE INVENTION

The following is a detailed explanation of a preferred embodiment of the method for multicast communication in the PON system according to the present invention with reference to the accompanying drawings.

[0015]

A description of the EFM-based gigabit EPON system (GE-PON), to which the present invention is applied, is presented below with reference to figures 8 through 10 as an introductory note before the explanation of the embodiment of the present invention:

[0016]

The GE-PON system basically implements a bridge function in the OLT and applies logical ports as bridge ports as shown in Figure 8 (b). A typical bridge switches on a per physical-port basis as shown in Figure 8 (a). However, in a PON system where multiple ONUs share a single transport path, communication between ONUs requires the bridge to be aware of the port for each ONU. Furthermore, when an ONU accommodates multiple UNIs (User Network Interfaces), communication between the UNIs in the ONU requires the bridge to be aware of the port for each UNI. Such a port for each ONU or each UNI is referred to as logical port 101. Logical ports 101 are present on OLT 102 and ONUs 103, which are connected through logical links 104.

[0017]

Logical links 104 are set up through an automated discovery procedure (Auto Discovery procedure) between OLT 102 and ONUs 103. The message flow in Auto Discovery is shown in Figure 9. The LLID value (Logical Link Identifier) given to a logical link to be set up is notified by means of REGISTER message 110. Then, a message confirming that REGISTER message 110 has been correctly received is communicated by means of REGISTER_ACK message 111.

[0018]

A logical link is identified by an LLID value, which is a unique identifier in PON. The LLID is selected in the OLT and notified to the ONU. The LLID is defined in the preamble for the MAC frame and consists of 16 bits that include a mode bit, as shown in Figure 10. While LLID 120 can be specified for point-to-point or multicasting, the only difference is mode bit 121, as shown in Figure 10, meaning that LLID value 122 itself can be used for both. Also, there is only one defined for broadcast, in which case both mode bit 121 and LLID value 122 are all-ones. It should be noted that the message flow shown in Figure 9 is the flow observed at the time of setting a logical link for point-to-point. EFM discussions indicate that there is no particular need for a specific procedure to set a logical link for multicasting.

[0019]

Embodiment 1.

Figure 1 shows an example of the configuration of OLT (central office unit) 10 used to realize the method for multicast communication in the PON system according to the present invention.

[0020]

OLT 10 is equipped with the following elements:

PON interface 11, which accommodates one or more ONUs (subscriber-side units) via a splitter,

Service node interface (hereinafter referred to as “SNI”) 12, which establishes a connection to the IP network,

Layer-2 switch 13, which switches MAC frames, and

. CPU 14.

Incidentally, a demultiplexer is used when one OLT 10 accommodates multiple subscriber-side units on one physical port of PON interface 11.

[0021]

Layer-2 switch 13 is provided with multicast table 15 used for the switching of multicast frames as well as unicast frames. Multicast table 15 manages, for example, sets of destination MAC address (multicast address) 28 and forwarding-destination PON port 29, as shown in Figure 2. In the example shown in Figure 2, forwarding-destination PON port 29 is represented by a bitmap. In other words, one bit is prepared for each PON port accommodated in OLT 10. If it is 0, no multicast frame will be forwarded to the PON port concerned; whereas, if it is 1, the multicast frame will be forwarded to the PON port concerned. Layer-2 switch 13 uses said bitmap to identify the destination PON port.

[0022]

Layer-2 switch 13 is also provided with IGMP filter section 16 to snoop Report and Leave messages from the PON that uses the IGMP as the IP protocol for multicasting (hereinafter referred to as the “report messages” and “leave messages,” respectively) as well as IGMP Query messages from the data delivery server (described in a later section) via SNI 12 (hereinafter referred to as the “query messages”). The filtering conditions for snooping these messages are described in a later section.

[0023]

PON interface 11 is provided with cryptographic processing section 17 for encrypting multicast data. SNI 12 is provided with multicast monitoring section 18 for monitoring the reception of multicast data.

[0024]

CPU 14 is provided with report monitoring section 20, which manages multicast management table 19 that remembers the combinations of a multicast address, access port (the physical port at which the report message has arrived), an ONU (LLID), a multicast LLID, and an encryption key, doing so while monitoring the reception of report messages from the PON. CPU 14 is also provided with logical-link control section 21 that controls logical links on the PON, so as to manage LLID management table 22 for managing the usage status of LLID values for each PON port.

[0025]

Figure 3 shows an example of multicast management table 19. In this case, there are two access ports (ports 2 and 4) for the multicast communication with the destination IP address of “yyy.yyy.yyy.yyy,” allowing access by a total of four ONUs: two ONUs on port 2 (point-to-point logical links 1 and 3, respectively) and two ONUs on port 4 (point-to-point logical links 2 and 5, respectively). For port 2, the LLID of the multicast logical link is 100, and the encryption key is #1. For port 4, the LLID of the multicast logical link is 110, and the

encryption key is #3. The encryption key managed here is an index. The actual encryption key is managed in cryptographic processing section 17 of PON interface 11. Layer-2 switch 13 can be realized with a commercially available Layer-2 switch. It should be noted that the segmentation of the functions shown in Figure 1 is by way of example only, and details of PON interface 11 and SNI 12 are omitted from the figure.

[0026]

Figure 4 shows an example configuration of a network in which OLT 10 described above is allocated. The PON system comprises one OLT 10 and multiple ONUs 40. OLT 10 accommodates one or more PON interfaces 11 (Figure 4 shows only one PON interface). One PON interface 11 accommodates multiple ONUs 40. And point-to-point logical link 41 is set for each ONU 40. Said point-to-point logical link 41 has a separate cryptographic processing part, and frames are encrypted during the data transmission in the downstream (OLT → ONU) direction. SNI 12 on OLT 10 is connected to multicast router 42 on IP network 43. Suppose that multicast data 45 from data delivery server 44 in IP network 43 reaches multicast router 42 connected to OLT 10.

[0027]

The operation is described below: In OLT 10, report messages received from PON interface 11 are snooped through IGMP filter section 16. Specifically, OLT 10 captures messages that satisfy the following conditions as report messages:

- (1) The destination address of the MAC frame is a multicast address, and
- (2) The Type field in the IGMP message encapsulated in the IP packet is 0x12 or 0x16.

There are V. 1 and V. 2 of the IGMP. In the case of V. 1, the Type field is 0 x 12. In the case of V. 2, it is 0 x 16. IGMP filter section 16 supports both. Such a report message contains the IP group address used for the multicast communication.

[0028]

Figure 5 shows the message format of the IGMP V. 2. The message format of the IGMP V. 2 comprises a type field that identifies whether the message is a query message from multicast router 42 or a message from ONU (a report message or leave message); a field that is used only by query messages, i.e., a maximum response-time field that specifies the maximum amount of waiting time before a report message is received; a checksum field for the checksum; and an IP group address field that specifies an IP group address.

[0029]

OLT 10 searches multicast management table 19 shown in Figure 3, doing so by using the IP group address as the key. If no matching IP multicast address is found, it is recognized as the first access, upon which the IP multicast address, the access port, and the ONU (LLID) are remembered in an unused entry in multicast management table 19. The process executed when a matching IP multicast address is found will be described in a later section. Here, the access port indicates from which PON interface the report message was received. The ONU (LLID) indicates the LLID value stored in the MAC preamble containing the report message.

[0030]

Additionally, OLT 10 transmits the captured report messages only to SNI interface 12, assuming that data delivery server 44 exists in IP network 43. OLT 10 then sets up a multicast logical link for the ONU that has made access. Specifically, logical-link control section 21 refers to LLID management table 22, selects one of the unused LLIDs at the access port, and transmits REGISTER message 110 (see Fig. 9) containing said LLID to point-to-point logical link 41 of the ONU concerned (one point-to-point logical link is set for each ONU).

[0031]

The ONU concerned, upon receipt of the REGISTER message 110, uses the LLID stored in message 110 as the LLID of the multicast logical link and transmits REGISTER_ACK message 111 to the point-to-point logical link 41, also. OLT 10 remembers, in multicast management table 19, the LLID value assigned through this procedure. Furthermore, OLT 10 generates a new encryption key used in this multicast communication and transmits it to the point-to-point logical link 41.

[0032]

Now, said encryption key may be included in REGISTER message 110. For data transfer in the downstream (OLT → ONU) direction on the point-to-point logical link 41, REGISTER message 41 is also encrypted as a result, preventing the stored encryption key from being eavesdropped by another ONU. Only after the notification of said cryptographic key is completed, will OLT 10 store the notified encryption key (an index of the encryption key in actuality) in multicast management table 19 and add the access port to multicast table 15. In this case, the access port is the port of the first access, meaning that a new entry is created in multicast table 15.

[0033]

It should be noted that combinations of destination address 28 and access port (forwarding destination port) 29 are kept as entries in multicast table 15. When OLT 10 is equipped with a Layer-2 switch, it forwards frames according to the destination address of

the MAC frames. With the IGMP, the lower 23 bits of the IP multicast address and the MAC address are the same. Accordingly, in this case, the logical sum of the lower 23 bits of the IP multicast address and “0x01005E000000” are registered as destination address 28 in multicast table 15.

[0034]

Subsequent multicast data arriving from SNI interface 12 are forwarded to the access port according to the contents of multicast table 15, encrypted with the encryption key corresponding to the multicast communication concerned (the encryption key corresponding to the encryption key index in the entry whose destination IP address matches the IP multicast address in the multicast management table), and then transmitted to PON interface 11.

[0035]

The following is an explanation of the process executed when an IP multicast address matching the IP group address included in the report message is found in an entry in multicast management table 19.

[0036]

OLT 10, upon capturing a report message, searches multicast management table 19 using the IP group address as the key. If a matching IP multicast address is found in the table, it is recognized as the second or subsequent access, and a new ONU (LLID) is remembered in the matching entry in multicast management table 19.

[0037]

Additionally, OLT 10 transmits the captured report messages only to SNI interface 12, assuming that data delivery server 44 exists in IP network 43. OLT 10 then sets up a multicast logical link for the ONU that has made access. Specifically, logical-link control section 21 refers to LLID management table 22. If the new ONU is accommodated on the same PON port as that of the ONU which has already made access, REGISTER message 110 containing the LLID already being used is selected; whereas, if the new ONU is accommodated on a different PON port from that of the ONU which has already made access, one of the unused LLIDs on the PON port is selected. Then, REGISTER message 110 containing the LLID thus selected is transmitted to point-to-point logical link 41 of the ONU.

[0038]

The ONU concerned, upon receipt of the REGISTER message 110, uses the LLID stored in said REGISTER message 110 as the LLID of the multicast logical link and transmits REGISTER_ACK message 111 to the point-to-point logical link 41.

[0039]

In the latter case, i.e., if the new ONU is accommodated on a different PON port from that of the ONU which has already made access, OLT 10 remembers, in multicast management table 19, the LLID value assigned through this procedure. Further, OLT 10 generates a new encryption key to be used in this multicast communication in the latter case, or the encryption key already being used in the former case, and transmits it to the point-to-point logical link 41, also.

[0040]

Now, said encryption key may be included in REGISTER message 110. For data transfer in the downstream (OLT → ONU) direction on the point-to-point logical link 41, REGISTER message 110 is also encrypted as a result, preventing the stored encryption key from being eavesdropped by another ONU. Only after the notification of said cryptographic key is completed, will OLT 10 store the notified encryption key (an index of the encryption key in actuality) in multicast management table 19 and add the access port to multicast table 15. In this case, the access port is the port of the second or subsequent access. Accordingly, the entry already included in multicast table 15 is updated. The subsequent operation shall be the same as in the first access.

[0041]

In this way, according to Embodiment 1, OLT 10 of the EPON system snoops IGMP messages, interlocks the result of the snooping with the logical-link control, and further subjects the multicast data to a cryptographic process. This makes it possible to provide efficient multicast communication without the need to arrange routing function blocks on the subscriber side, doing so while ensuring security.

[0042]

Embodiment 2.

Now, when multicast router 42 implementing the IGMP receives even one report message from a certain port, it delivers data to that port. Consequently, if all report messages are transmitted to SNI 12 during the transmission of report messages captured by OLT 10, the second and subsequent report messages will be wasted even though they consume the bandwidth of SNI 12.

[0043]

Accordingly, in the present embodiment 2, if OLT 10 receives multiple report messages, only the first report message received is transmitted to SNI 12 while the rest will not be transmitted from OLT 10.

[0044]

First, OLT 10 snoops query messages received via SNI 12. There are two types of query messages:

- (1) General Query messages, and
- (2) Group-Specific Query messages (V. 2 only).

Thus, only the first report message received after receiving such query messages is transmitted to SNI 12 while subsequent report messages are not transmitted. And in this case, multicast management table 19 is additionally provided with a report transmission flag, as shown in Figure 6. Such a report transmission flag is prepared for each entry. It is set to 1 (already transmitted) upon transmission of a report message to SNI 12 and cleared to 0 (not transmitted yet) upon receipt of a query message. It should be noted that the method for snooping query messages shall be described in a later section.

[0045]

Embodiment 3.

The description of Embodiment 3 below presents an explanation of the departure from multicast communication. In addition to snooping report messages, OLT 10 snoops query messages. It uses IGMP filter section 16 to snoop query messages received from SNI 12.

[0046]

Specifically, OLT 10 captures messages that satisfy the following conditions as query messages:

- (1) The destination address of the IP packet is 224.0.0.1 or a multicast address, and
- (2) The Type field in the IGMP message encapsulated in the IP packet is 0 x 11.

[0047]

As mentioned above, there are two types of query messages: General Query messages and Group-Specific Query messages, both of which are supported in IGMP filter section 16. When OLT 10 receives one of these messages, it forwards the message to all subscribers in the case of a General Query message, or to the accessing subscribers in the case of a Group-Specific Query message.

[0048]

Subsequently, in OLT 10, report monitoring section 20 monitors report messages from subscribers. Subscribers who do not transmit a report message by the time the next query

message is received are deemed to have left the multicast communication so that the multicast logical links set for their areas are released, and their access ports are removed from multicast table 15 and multicast management table 19.

[0049]

To release a logical link, OLT 10 sets the Flags field to Deregister and transmits REGISTER message 110 containing the LLID of the multicast logical link to the point-to-point logical link 41 of the ONU concerned. Then, the ONU, upon receipt of the message, releases the LLID (multicast logical link) specified in the REGISTER message 110 and transmits REGISTER_ACK message 111 to the point-to-point logical link 41, also.

[0050]

In the case in which all ONUs leave the multicast communication, the entry for the multicast communication is deleted from multicast table 15 and multicast management table 19.

[0051]

Embodiment 4.

Even if no report messages are returned from a certain port, multicast router 42 typically continues to transmit multicast data for a while. With the method according to Embodiment 3, if no report message is returned in one query cycle (Query cycle: time from one query message to the next query message), OLT 10 immediately deletes the entry.

[0052]

If multicast data for the deleted entry arrives in this state, OLT 10 will still broadcast them. In other words, once a frame with a multicast address that is not registered in multicast table 15 is discarded, General Query messages cannot be forwarded to the address. Consequently, the data will be broadcast in the case of unregistered multicast addresses. As a result, multicast data that should not be forwarded is forwarded, wastefully consuming the PON bandwidth. Therefore, it will be preferable in such cases if OLT 10 stops data transmission to the subscriber side without deleting entries while multicast router 42 is forwarding data.

[0053]

Thus, according to Embodiment 4, multicast monitoring section 18 in OLT 10 monitors multicast frames for multicast communication that no longer has an access port so that entries are deleted after multicast frames stop arriving. In addition, the multicast logical links are released and the entry is deleted from multicast management table 19 after multicast frames stop arriving. In other words, multicast frames received from the IP-network side are

monitored, and the logical links for multicasting to all subscriber-side units accessing the multicast communication are released if no multicast frames are received for a certain period of time.

[0054]

Embodiment 5.

With the IGMP V. 2, the subscribers transmit leave messages indicating their departures, as mentioned above. In OLT 10, such leave messages are snooped through IGMP filter section 16. Specifically, OLT 10 captures messages that satisfy the following conditions as leave messages:

- (1) The destination address of the IP packet is 224.0.0.2, and
- (2) The Type field in the IGMP message encapsulated in the IP packet is 0 x 17.

[0055]

In OLT 10, subscribers who transmitted leave messages are deemed to have left the multicast communication so that the multicast logical links set for their ONUs are released, and their access ports are removed from multicast table 15 and multicast management table 19. To release a logical link, OLT 10 sets the Flags field to Deregister and transmits REGISTER message 110 containing the LLID of the multicast logical link to the point-to-point logical link 41 of the ONU concerned.

[0056]

Then, upon receipt of the message, the ONU releases the LLID (multicast logical link) specified in REGISTER message 110 and transmits REGISTER_ACK message 111 to point-to-point logical link 41. In the case in which all ONUs leave the multicast communication, the entry for the multicast communication is deleted from multicast table 15 and multicast management table 19.

[0057]

Embodiment 6.

If ONU 40 accommodates multiple UNIs, i.e., subscriber ports, logical link 41 for each UNI 70 must be set beforehand, as shown in Figure 7. Also, if at least one UNI is accessing a multicast communication, OLT 10 shall establish a multicast-communication logical link for the ONU concerned.

[0058]

When the ONU receives a report message from a certain UNI, it informs OLT 10 of the report message through the point-to-point logical link 41 corresponding to that UNI. ONU 40 remembers from which UNI the report message was received. And, based on said data it has remembered, it forwards the multicast data received through multicast logical link 71 only to the UNI that has received the report message, i.e., to the UNI that is actually accessing the communication.

[0059]

In this way, Embodiment 6 can deliver data only to UNIs that are actually accessing multicast communication even if an ONU accommodates multiple UNIs.

[0060]

EFFECTS OF THE INVENTION

As described above, the present invention is configured to snoop IGMP messages in the central office unit of a PON system, interlock the result of the snooping with the logical-link control, and further subject the multicast data to a cryptographic process, making it possible to provide efficient multicast communication in the form linked with an IP multicast protocol without the need to arrange routing function blocks on the subscriber side, doing so while ensuring security.

BRIEF EXPLANATION OF THE DRAWINGS

Figure 1 shows a block diagram that illustrates an example configuration of a central office unit (OLT) to which the present invention is applied.

Figure 2 shows a diagram that illustrates the content of the multicast table.

Figure 3 shows the content remembered in the multicast management table.

Figure 4 shows a diagram that illustrates the configuration of a network to which the present invention is applied.

Figure 5 shows the IGMP message format.

Figure 6 shows a diagram that illustrates another content remembered in the multicast management table.

Figure 7 shows a diagram that illustrates the transmission of multicast data in an ONU.

Figure 8 shows a diagram that illustrates the GE-PON system.

Figure 9 shows a diagram that illustrates the procedure followed when setting a logical link in the GE-PON system.

Figure 10 shows a diagram that illustrates the LLID format in the GE-PON system.

EXPLANATION OF REFERENCE CODING

10	OLT
11	PON interface
12	SNI
13	Layer-2 switch
14	CPU
15	Multicast table
16	IGMP snooping section
17	Cryptographic processing section
18	Multicast monitoring section
19	Multicast management table
20	Report monitoring section
21	Logical-link control section
22	LLID management table
40	ONU
41	Logical link for point-to-point
42	Multicast router
43	IP network
44	Data delivery server
45	Multicast data
70	UNI
71	Logical link for multicasting

Figure 1

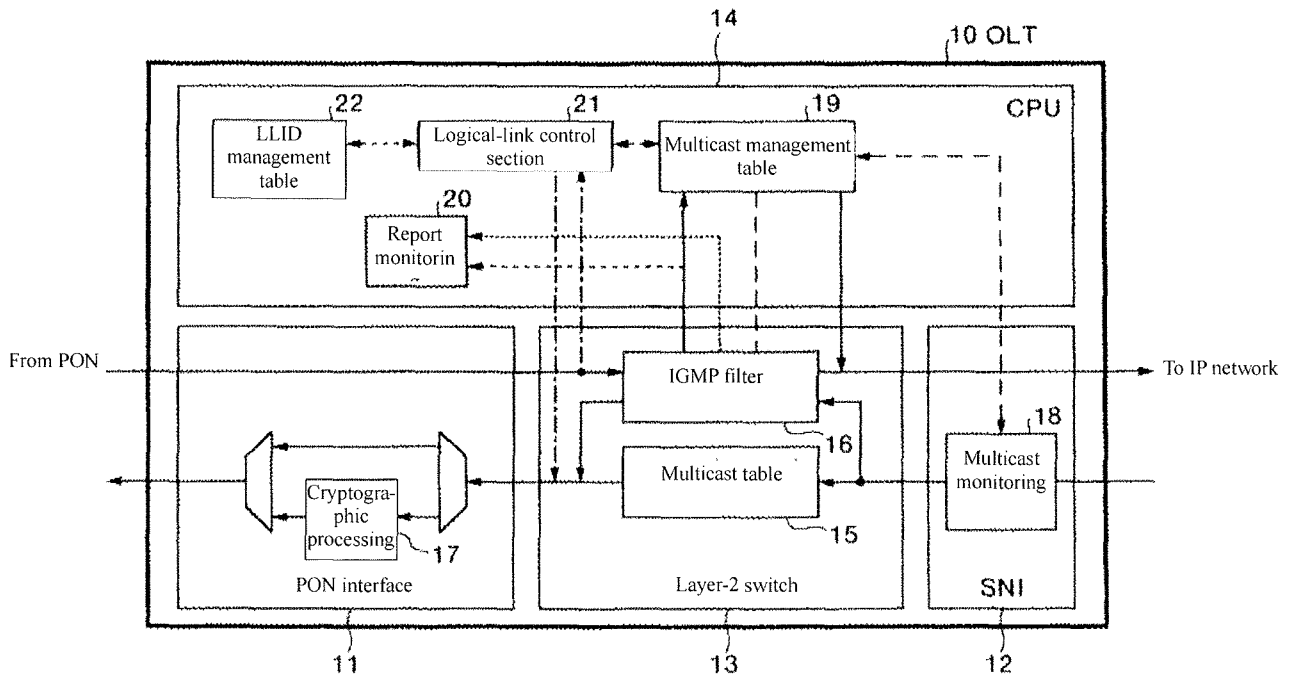


Figure 2

Destination MAC Address (Multicast Address)	Forwarding-Destination Port
XX-XX-XX-XX-XX-XX	0010010011001011
⋮	⋮

Figure 3

Multicast Management Table 19

Multicast Address (IP Group Address)	Access Port	ONU (LLID for P2P)	LLID for multicasting	Encryption key
yyy.yyy.yyy.yyy	2	1	100	#1
		3		
	4	2	110	#3
		5		
⋮	⋮	⋮	⋮	⋮

Figure 4

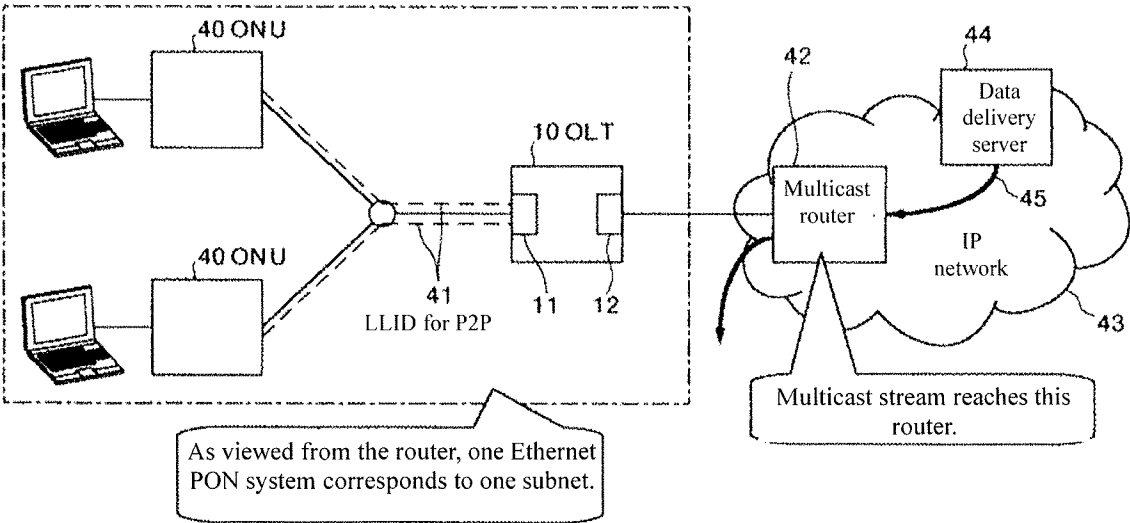


Figure 5

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Type								Maximum response time								Checksum															
IP group address																															

Figure 6

Multicast Management Table

Multicast Address (IP Group Address)	Access Port	ONU (LLID for P2P)	LLID for multicasting	Encryption key	Report transmission flag
yyy.yyy.yyy.yyy	2	1	100	#1	
		3			
	4	2	110	#3	
		5			
⋮	⋮	⋮	⋮	⋮	⋮

Figure 7

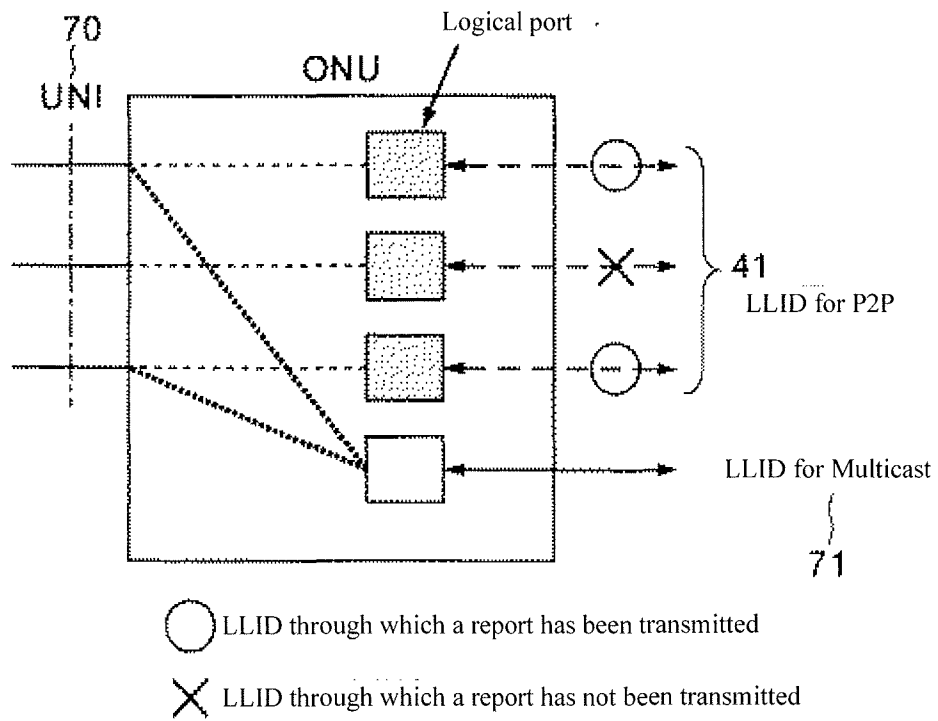


Figure 8

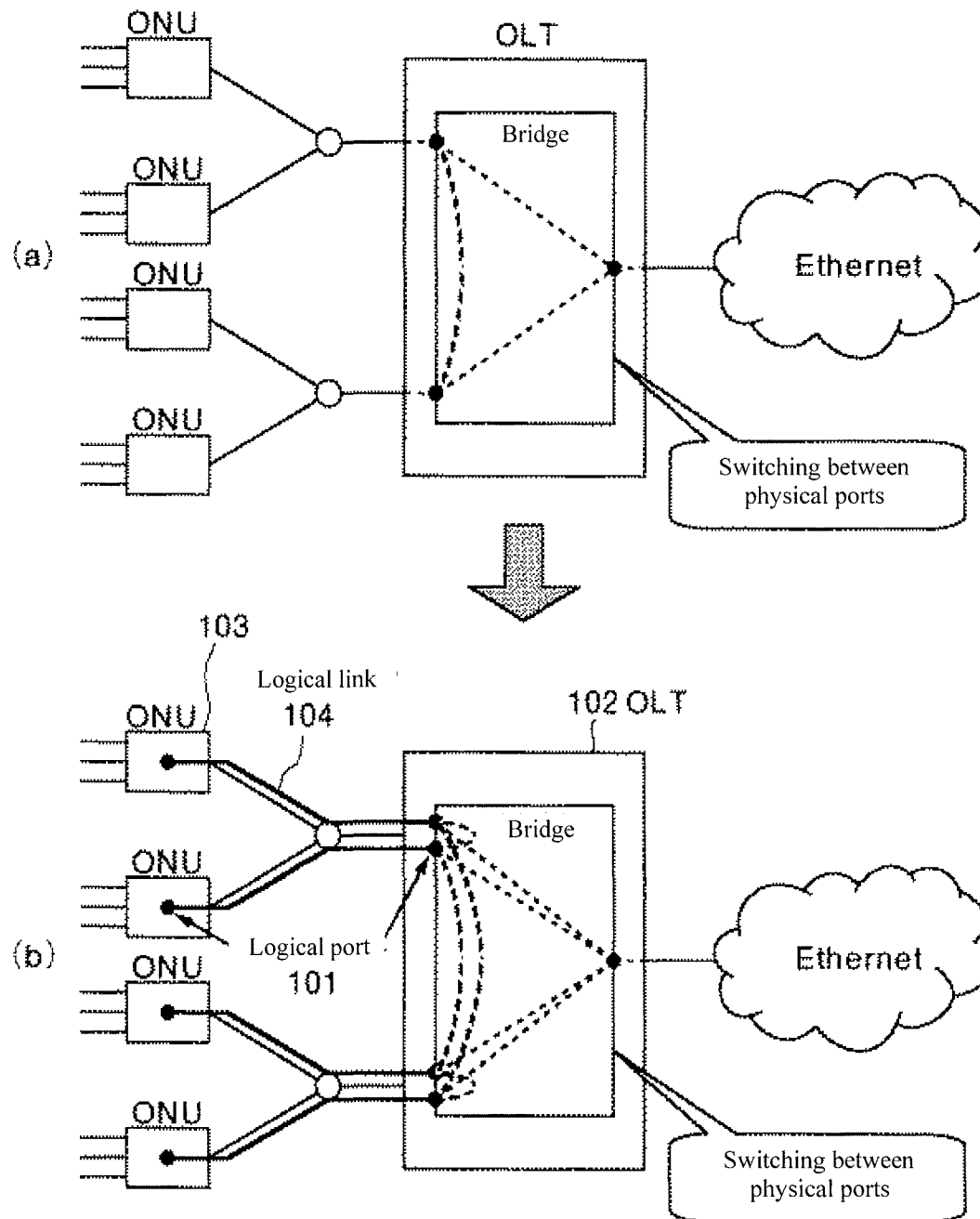


Figure 9

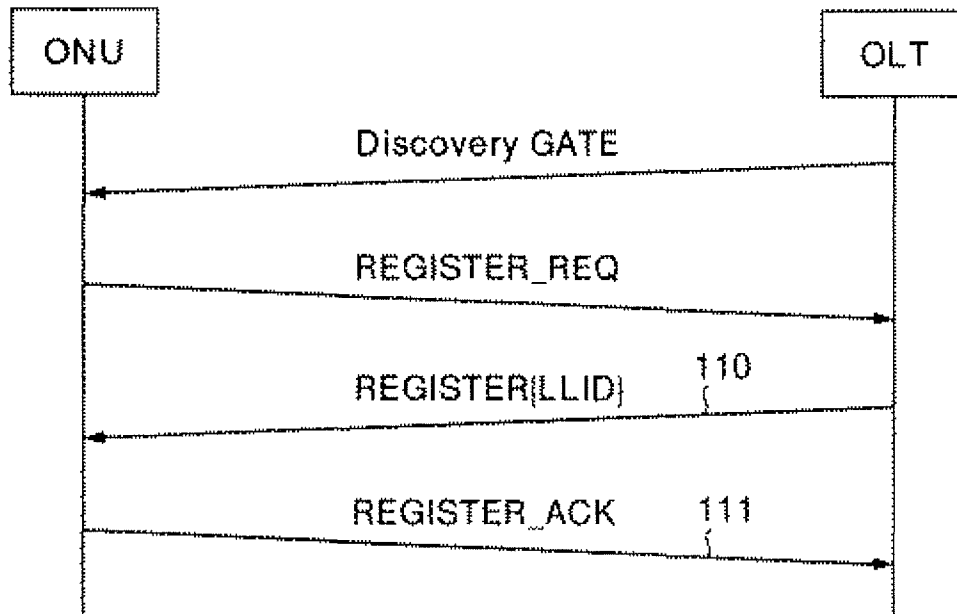
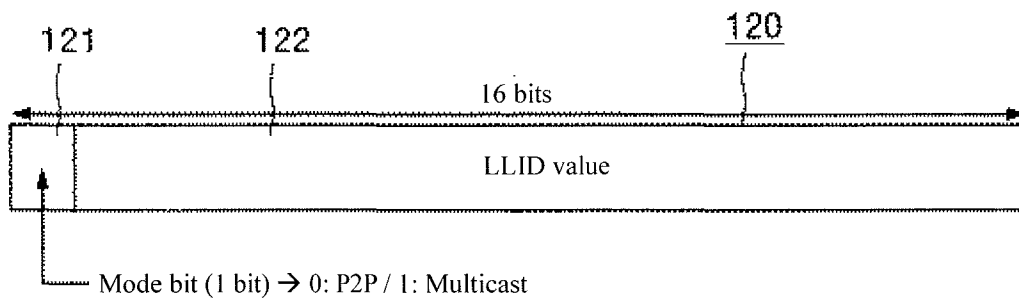


Figure 10



Continuation from the front page . . .

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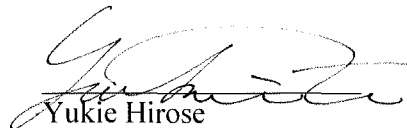
DECLARATION

I, Yukie Hirose, hereby declare as follows:

1. I am a translator employed by Nelles/legaltranslations.biz.
2. I have personal knowledge of the facts contained herein.
3. I am fluent in the English and Japanese languages
4. I have been a translator for over 25 years, specializing in the Japanese to English translation of patents and related intellectual property documents. For example, I have translated over 1,000 patent applications and 300 prior art reference patents from the Japanese Language to the English language.
5. Attached to my declaration is the translation into English of Japanese Patent No. JP2004-343243A filed May 24, 2003. This translation is, to the best of my knowledge and belief, a true and accurate translation of Japanese Patent No. JP20047-343243A from the Japanese language into the English language.
6. In signing this declaration, I have been warned and I understand that that willful false statements and the like are punishable by fine or imprisonment, or both (18 U.S.C. 1001).

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on July 25, 2024


Yukie Hirose