signed before and after the migration as well as the address assigned before the last migration. Thereby, the hosts attached to the network 1 can communicated with the mobile host directly.

(migration from network 2 to network 3)

When migrating from the network 2 to the network 3, the mobile host 11 obtains m" at the address assigned after the migration. Then the mobile host 11 notifies the gw 2 and a gw 3, both of which are attached to the network 2, that the mobile host 11 has migrated to the network 3 by transmitting thereto a packet comprising the migration post message, referred to as a packet 62 in FIG. 7. FIG. 12 (b) shows a format of the packet 62, which is transmitted to the gw 2. The broadcast address of the network 2 can be employed as the destination address of the packet 62. When the packet 62 is transmitted to the broadcast address of the network 2, every host attached to the network 2, which includes the gw 2 and the gw 3, holds the correspondence of the addresses each assigned before and after the migration.

The gw 2 employs its devices in FIG. 3 to process the packet 62. That is, receiving the packet 62, the gw 2 sends it to the migration post information unit 36 via the communication control unit 4 and the reception packet unit 35, then refers to the data hold unit 1 where m→m' and 0 are still held at the address correspondence and at the address assigned before the last migration respectively. The migration post information post unit 36 obtains from the packet 62 m'-m" as the newly assigned correspondence between the addresses each of which assigned before and after the current migration, the migration from the network 2 to the network 3. Then, it detects whether or not the address m' coincides with the address held in the data hold unit 1 as the address assigned after the last migration. Since the unit 36 detects the coincidence, it replaces the address m' in the unit 1 with the address m" as well as replaces the correspondence m-m' with the correspondence m-m".

Also the migration post information unit 36 sends to the data hold unit 1 the address m assigned before the last migration together with the address correspondence m'-m" obtained from the current migration. Now the data hold unit 1 in the gw 2 holds the address m at the address assigned before the last migration and the address correspondence m'-m" at the correspondence of the addresses each of which assigned before and after the migration as well as the address 0 at the address assigned before the last migration as well as the address correspondence m-m' at the correspondence of the addresses each of which assigned before and after the migration. After updating as well as adding the addresses in the data hold unit 1, the migration post information unit 36 sends to the address conversions post transmission unit 38 m'-m" as the newly obtained correspondence of the addresses before and after the current migration.

The address conversion post transmission unit 38 detects the network satisfying the following conditions with referring to the data hold unit 1 and then transmits the address conversion post message to the broadcast address of the detected network. That is, the address conversion post message is transmitted to the network where the address assigned before the migration, which is held in the data hold unit 1, is other than 0 as well as the migration communication control device employed as the gateway is not attached. Although in the migration from the network 2 to the network 3, the data hold unit 1 holds m at the address assigned before the last migration, the gw 2 is attached to the network 1; therefore, the unit 38 does not transmit the address conversion post to the network 1.

The packet 62 is also received by gw 3. When receiving the packet 62, the gw 3 employs its own devices in FIG. 3 to process the packet 62, which is substantially same as does the gw 2 except the following. That is, the address conversion post transmission unit 38 of the gw 3 detects that tne gw 3 is not attached to the network 1. Also it is detected that the mobile host 11, attached to the network 1, has the address m as the address assigned before the last migration. Therefore, the unit 38 of the gw 3 transmits to the broadcast address of the network 1 a packet comprising the address conversion post message, which is referred to as a packet 63. FIG. 12 (c) shows the packet 63.

The packet 63 is received by the gw 2, the gw 1, both of which are attached to the network 1. Although it is also received by the stationary host 11, this will not be described here. Obtaining the current address correspondence m'-m" from the packet 63, where m' coincides with the address which has been held in the hold unit 1 at the address obtained after the migration, the gw 1 changes the m-m' in the data hold unit 1 into the m-m" by replacing m' with m" as the address assigned after migration.

On the other hand, the data hold unit 1 of the gw 2 had gained from the packet 62 the above information before receiving the packet 63. Therefore the content of the unit 1 of the gw 2 does not change across reception of the packet 63. This is because the gws of the present invention locate on a gateway, which connects a couple of networks. Due to its location, each gw receives packets from two networks. However, actually the packet 62 is destined for the network 2 and the packet 63 is destined for the network 1. Therefore, even though the gw 2, which are attached to both the network 1 and the network 2, receives both the packet 62 and 63 by the gw 2, this will not cause any problem in the communication between the stationary host 12 and the mobile host 11.

FIG. 13 (b) shows the content of the data hold unit 1 in each of the gws.

(migration from network 3 to network 4)

When migrating from the network 3 to the network 4, the mobile host 11 obtains m''' as the address assigned after the migration. Then the mobile host 11 sends to the gw 3 and a gw 4, both of which are attached to the network 3, a packet comprising the migration post message. The packet received by the gw 3 is referred to as a packet 64. The broadcast address of the network 3 can be employed as the destination address of the packet 64. When the packet 64 is destined for the broadcast address of the network 3, every host attached to the network 2, which includes the gw 3 and the gw 4, obtains from the packet the correspondence of the addresses each of which assigned before and after the migration from the network 3 to the network 4.

The gw 3 employs its devices in FIG. 3 to process the packet 34. That is, receiving the packet 64, the gw 3 converts the content of the data hold unit 1 by replacing the address correspondence m-m'' with m-m''', newly holding m''-m''' obtained from the packet 64 as well as the address m' assigned before the last migration. Then, the address conversion post transmission unit 38 of the gw 3 transmits the address conversion post message to the network satisfying the following condition. That is, the address conversion post message is transmitted to the network where the address assigned before the migration, which is held in the data hold unit 1, is other than 0 as well as the gw 3 it self is not attached. The packet including the address conversion post message is referred to a packet 65, and the packet is transmitted to the broadcast address of the network 1. FIG. 7 (c) shows the packet 65.

The packet 64 is also received by gw 4. When receiving the packet 64, the gw 4 renews the content of the data hold unit 1 by replacing m'-m'' with m'-m''' as well as newly holding the address m' as the address assigned before the last migration. Further, the address conversion post transmission unit 38 of the gw 4 detects that the gw 4 is not attached to the network 2 which has the address other than 0 at the address assigned before the last migration; therefore, the unit 38 of the gw 4 transmits a packet comprising the address conversion post message, which is referred to as a packet 66, to the broadcast address of the network 2. FIG. 7 (c) shows the packet 66.

Receiving the packet 65, 65, the gw 2 and the gw 1 renew the content of its data hold unit 1, which is substantially the same as the above.

The gw 3 and the gw 2 receives the same information twice since the former receives the packet 64 and 65 while the latter receives the packet 65 and 66. This is because gws of the present invention locate on a gateway and receives packets from a couple of networks, which is described the above.

FIG. 13 (c) shows the content of the data hold unit 1 in each of the gws. Thus, according to the gws of the present invention, the packet transmitted to any of the addresses m, m', m'' is transferred by the gws to the updated address of the mobile host, the gws also notify the stationary host of the updated address.

For example, when the stationary host is not notified of the updated address of the mobile host and transmits a packet to the address m', the packet is received by the gw 2 and the gw 3, both of which are attached to the network 2. Then, the gw 2 and the gw 3 transfers the packet to the updated address of the mobile host as well as notifies the stationary host of the updated address. Thereby, the stationary host obtains the updated address of the mobile host, so that it will be able to communicate with the mobile host directly. The packet destined for the address m' is received by both the gw 2 and the gw 3, since they are attached to the network 2. Thus, the mobile host receives the same packet twice, once from the gw 2 and the other time from the gw 3, and the stationary host receives the same message twice; however, the repeated packet or the message can be simply ignored, so that this will not cause any problem in the communication between the stationary host and the mobile host. The repeated packet or the message is observed when the two gws are attached to each network in FIG. 7; whereas it is not observed when only one migration communication control device is attached to each network, which will be described later at the operation in FIG. 9.

(operation example in FIG. 8)

In FIG. 6, FIG. 7, the stationary host transmits the data packet to the outdated address after mobile host notifies the gws that it has migrated to another network. Then the gws transmit the address conversion post message to the stationary host. However, in FIG. 8 the gws convert the destination address of data the packet from the outdated address into the updated address assigned after the migration instead of transmitting the address conversion post message.

A packet 71, 72 in FIG. 8 are substantially same as the packet 51, 52 in FIG. 6. The operation conducted before the packet 72 is transmitted by the stationary host 12 and is received by the gateway 13 is substantially same as the first operation in FIG. 6. The operation which follows reception of the packet 72 is described hereunder with referring to FIG. 3.

The gate way 13 employs its units in FIG. 3 to process the packet 72. The communication control unit 4 receives the packet 72 and gives it to the reception packet unit 35 in the migration address unit 3. Detecting that the packet 72 is a general packet, the reception packet unit 35 sends it to the address comparison unit 37. The address comparison unit 37 detects whether or not the destination address of the packet 72 coincides with the address in the data hold unit 1 at the address assigned before the migration.

When no coincides is found, the address comparison unit 37 gives the packet 72 to the application unit 2. On the other hand, a coincidence is found, the address assigned after the migration, which corresponds with the address identical to the destination address of the packet 72, is obtained from the data hold unit 1, and is sent to the marked packet conversion unit 39 together with the packet 72. The marked packet conversion unit 39 generates a packet 72' where the destination address of the packet 72 is replaced with the address assigned after the migration, which is sent by the address comparison unit 37, the destination address of the packet 72 is added as additional address, and a mark is set to indicate that the destination address has converted. Then the packet 72' is sent to the communication control unit 4. FIG. 12 (e) shows a format of the packet 72', where identical numerals denotes the same units in FIG. 11. The packet 72' is sent to the mobile host 11 without fail since its destination address is the updated address thereof.

(operation example in FIG. 9)

In FIG. 9, the mobile host migrates across network 1, 2, 3, and 4. In FIG. 7 the gw 1-gw 4 are employed as the migration communication control devices; whereas in FIG. 9 the gw 1-gw 4 are employed simply as gateways to connect networks, and also another migration communication control device is attached to each network. The operation of the migration communication control device, which is connected to the network alone, at processing the migration post message or the address conversion post message is substantially same as one of the gw 1-gw 4 in FIG. 7. The flow of the migration post message and the address migration post message are mainly described hereunder.

(migration from network 1 to network 2)

When migrating from the network 1 to the network 2, the mobile host 11 sends a packet comprising the migration post message to the migration communication control device, which is attached to the network 1. In FIG. 9 (a) a migration post packet 81 is transmitted to a migration communication control device S1, which is attached to the network 1. The destination address of the packet 81 can be the broadcast address of the network 1.

The device S1 processes the packet 81 by employing its devices in FIG. 3. Receiving the packet 81, the device S1 stores into the data hold unit 1 the correspondence of the addresses each assigned before and after the migration as well as the address assigned before the last migration. The migration post information unit 36 transmits the packet 81 to the address conversion post transmission unit 38; however, since the unit 38 detects that the address assigned before the last migration is 0, it does not transmit the address conversion post message to any network. The content of the data hold unit 1 in the S1-S4 are shown in FIG. 14 (a).

(migration from network 2 to network 3)

When migrating from the network 2 to the network 3, the mobile host 11 notifies the S2, which is attached to the network 2, that it has migrated to the network 3 by transmitting thereto the packet comprising the migration post message, which is referred to as a packet 82 in FIG. 9 (b).

The S2 employs its devices in FIG. 3 to process the packet 82. That is, it converts the content of the data hold unit 1 by renewing and adding new information, and finally holds in the unit 1 the address m'-m" at the correspondence of the addresses each of which assigned before and after the migration as well as the address m assigned before the last migration. Then, the migration post information unit 36 gives the newly obtained correspondence m'-m" to the address conversion post transmission unit 38.

The address conversion post transmission unit 38 detects whether or not the address assigned before the last migration, which is held in the data hold unit 1, is 0. If the address is not 0, the unit 38 transmits the address conversion post message to the broadcast address of the network which includes the detected address. In FIG. 9 (b) the address m is held at the address assigned before the last migration, so that the unit 38 transmits the packet 83 to the broadcast address of the network 1.

When receiving the packet 83, the migration communication control device S1, which is attached to the network 1, renews the content of the data hold unit 1 by newly holding the address correspondence m-m" as well as the address 0 at the address assigned before the last migration. Detecting 0 at the address assigned before the last migration, the address conversion post transmission unit 38 does not transmit the address conversion post to any network. The content of the data hold unit 1 in the S1-S4 are shown in FIG. 14 (b).

(migration from network 3 to network 4)

When migrating from the network 3 to the network 4, the mobile host 11 notifies the communication migration control device S3, which is attached to the network 3, that it has migrated to the network 4 by transmitting thereto a packet comprising the migration post message, referred to as a packet 84 in FIG. 9 (c).

The migration communication control device S3 employs its devices in FIG. 3 to process the packet 84. That is, it newly holds into the data hold unit 1 the address correspondence m''-m''' as well as the address m' assigned before the last migration. Then, the address conversion post transmission unit 38 in the S3 transmits a packet comprising the address conversion post message, referred to a packet 85 in FIG. 9 (c), to the broadcast address of the network 2 since the address m' is held at the address assigned before the last migration in the data host unit 1.

When receiving the packet 85, the migration communication control device S2 employs its devices in FIG. 3 to process it. That is, it newly holds into the data hold unit 1 the address correspondence m'-m'' as well as the address m assigned before the last migration. Then, the address conversion post transmission unit 38 in the S2 transmits a packet comprising the address conversion post message, referred to a packet 86 in FIG. 9 (c), to the broadcast address of the network 2 since the address m is held at the address assigned before the last migration in the data hold unit 1.

When receiving the packet 86, the migration communication control device S1 employs its devices in FIG. 3 to process it. That is, it newly holds into the data hold unit 1 the address correspondence m-m''' as well as the address 0 at the address assigned before the last migration. The address conversion post transmission unit 38 in the S1 does transmit the address conversion post since 0 is detected at the address assigned before the last migration. The content of the data hold unit 1 in each of the S1-S4 are shown in FIG. 14 (c). Thus, according to the migration communication control device S1-S4 of the present invention, the S1-S4 are notified of the updated address of the mobile host at every migration, so that the packet transmitted to any of the addresses m, m', m'' is transferred thereby to the updated address of the mobile host. The S1-S4 also notify the stationary host of the updated address of the mobile host.

The operation in FIG. 9 differs from the operation in FIG. 7 in that each network has just one communication migration control device (one of the S1-S4), so that the migration post and the address conversion transmitted to S1-S4 are not duplicated.

In the format shown in FIG. 11 and 12, the mark 96 or the message type 93 indicates kind of packet. That is, mark 96 indicates whether or not the packet is marked while the message type 93 indicates whether it is the packet comprising the migration post message, the packet comprising the address conversion post message, and the general packet. Further, a protocol type can also be employed to indicate which migration communication control device is employed. For example, when TCP/IP is employed, the protocol number at the IP header thereof distinguishes the packet employed in the embodiment from other packets. That is, when the protocol number in the packet is identical with the one, which has been assigned to the protocol number field, the packet is the one employed in the embodiment.

In the first embodiment of the present invention, a nonvolatile storage can be employed as the data hold unit 1 of the mobile host. If so, the communication can be resumed even after the host or the gateway is turned off as well as after the system is reset.

Also even when the stationary host employs the nonvolatile storage as the data hold unit 1, it can resume the communication, which has interrupted by the switch off or the system reset, rather fast since it obtains from another host the updated address of the mobile host instead of receiving from the gateway the address conversion post message which shows the updated address.

For example, it is supposed in FIG. 7 that the mobile host 11 migrates from the network 1 to the network 4. The data hold unit 1 of the migration communication device holds the address correspondence m-m''' since it has communicated with the mobile host, which is attached to the network 4, at least once. According to the migration communication control device in the embodiment described the above, the packet is transferred from the outdated address to the updated address of the mobile host and the stationary host is notified of the updated address; therefore, even when the address information in the data hold unit is lost by switch off thereof, the stationary host will obtain the updated address. Restart of the communication can also be implemented by employing a specific host such as a server. That is, the server may be constructed to obtain the updated address of the mobile host at every migration, and give it to the stationary host whenever requested. In this case a packet comprising the address inquiry should be generated beforehand.

Also in the fifth operation in FIG. 6, the mobile host 11 employs the application unit 2 and sends to the marked packet conversion unit 21 the address assigned before the migration when transmitting the non-response address to the stationary host after it has migrated to another network. Instead of sending the non-response address, the application unit 2 can transmit a connection identifier to the marked packet conversion unit 21. In this case the data hold unit of the migration communication control device, employed as the mobile host, holds a correspondence between the connection identifier and the address that had been assigned when the connection was established instead of holding the correspondence between the correspondence of the addresses each assigned before and after the migration. Then, the unit 21 obtains the source address of the packet by detecting the address which corresponds to the identifier, which is held in the data hold unit 1.

As is described the above, the mobile host can employ the broadcast address of the network when transmitting the migration post to the migration communication control devices. When the broadcast address is employed, every host attached to the network, to which the migration communication control device is also attached, obtains the updated address of the mobile host. This implements a direct communication between the mobile host and the stationary host, which improves efficiency of the communication.

The address assigned before the last migration, which is held in the hold unit 1, can be replaced with the broadcast address assigned to the network to which the mobile host is attached before the last migration. If the broadcast address is employed, the gateway employed as the migration communication control device (gws) or the migration communication control device (Ss) needs to include the broadcast address in the address conversion post message. In this case both devices can obtain the broadcast address from the data hold unit; therefore, the operation thereof at requesting the broadcast address will be eliminated.

When storage capacity of the data hold unit 1 is limited, the data hold unit 1 holds only the useful data by disposing the unuseful data, which is least recently retrieved therefrom by the address comparison unit.

[Embodiment 2]

In FIG. 15 network A, B, and C are connected in a line via gateways 143 and 143', the gateway 143 placing between the network A and B while the gateway 143' placing between the network B and C.

A home migration communication control device 101 including a migration address unit 144 is attached to the network A; a visitor migration communication control device 109 including a migration address unit 145 is attached to the network B; and a visitor migration communication control device 109' including a migration address unit 145' is attached to the network C. A mobile host 146 including a migration address unit 115 is attached to the network A as its home network, and a stationary host 151 including a migration address unit 125 is also attached to the network A.

The mobile host 146 migrates across the network A, B, and C. It has a home address α assigned when it is attached to the network A, as well as other addresses assigned depending on where it migrates, such as a temporary address β on the network B and a temporary address γ on the network C.

Also each of the home migration communication control device 101, the visitor migration communication control device 109, 109' which are identical in its construction and the stationary host 151 has an address Ha, Va, Va', and Sa respectively assigned on the network.

Detailed function of the above devices 101, 109, 109', 146, and 151 is described hereunder, in which like components are labeled with like reference numerals.

[home migration communication control device 101]

When the mobile host 146 migrates from the home network to another network, it is assigned the temporary address. However if the stationary host 151 is not notified of that migration, it transmits an original data packet (hereinafter referred to as a noncapsulated data packet) to the home address α of the mobile host 146. When the noncapsulated data packet is destined for the outdated address of the home mobile host 146, the home migration communication control device 101 transfers that noncapsulated data packet from there to the updated address, that is the temporary address β or γ of the mobile host. Then, the device 101 posts to the stationary host 151 the temporary address β or γ here, so that the stationary host 151 will be able to communicate directly with the mobile host. The device 101 also posts the same information to the visitor migration communication control device 109, 109', so that the devices 109, 109' will implement the same function with the home migration communication control device 101.

As shown in FIG. 16 the home migration communication control device 101 consists of the migration address unit 144 and a communication control unit 108. The migration address unit 144 further comprises a home mobile host (MH) list hold unit 102, a packet transfer unit 103, a mobile host (MH) transfer unit 104, an address inquiry unit 105, a packet monitoring unit 106, an address post unit 107.

Next the function of each component integrating the device 101 will be described. The communication control unit 108 mainly controls the communication of protocols located in lower layers including a physical layer, such as the protocol lower than IP.

The address post unit 107 receives from the mobile host 146 an data packet including an address post message. The address post message is generated when the mobile host 146 migrates to the network B or C, and posts the temporary address β or γ of the mobile host to the device 101. The unit 107 sends the address post message to the mobile host transfer unit 104 as well as sends a response message to the mobile host 146. FIG. 28 (3) is an example of the address post message, which includes the home address α as well as the temporary address β or γ of the mobile host 146, a value of an autonomous flag F, and a broadcast address Bba, Cba on the network B, C. The autonomous flag F will be described later. FIG. 28 (4) is an example of the response message.

A mobile host transfer unit 104 stores the address post message into the home mobile host list hold unit

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