(51) International Patent Classification:
H04L 12/28 (2006.01)

(21) International Application Number:
PCT/KR2006/002487

(22) International Filing Date:
27 June 2006 (27.06.2006)

(25) Filing Language:
Korean

(26) Publication Language:
English

(30) Priority Data:

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(81) Designated States (unless otherwise indicated, for every kind of national protection available):

(54) Title: LOCATION REGISTRATION METHOD FOR ADAPTIVE ROUTE OPTIMIZATION IN MOBILE NETWORK AND PACKET TRANSFER METHOD USING THE SAME

(57) Abstract: Provided are a location registration method for adaptive route optimization in a mobile communication network, a packet transmission method using the same, and a computer-readable recording medium storing a program for realizing the methods. The location registration method includes the steps of: a) calculating a session-to-mobility ratio (SMR) defined as a ratio of a session arrival rate to a mobility rate; b) comparing the SMR with a predetermined value; c) determining a mobile node (MN) of the mobile communication network; and d) registering a location of the mobile node (MN) according to the results of the steps b) and c).
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BI, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— with international search report

(48) Date of publication of this corrected version:
5 July 2007

(15) Information about Correction:
see PCT Gazette No. 27/2007 of 5 July 2007

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
LOCATION REGISTRATION METHOD FOR ADAPTIVE ROUTE OPTIMIZATION IN MOBILE NETWORK AND PACKET TRANSFER METHOD USING THE SAME

Description

Technical Field

The present invention relates to a location registration method for adaptive route optimization and a packet transfer method using the same; and, more particularly, to a location registration method in which a visiting mobile node (VMN) and a mobile router (MR) adaptively register their locations and transmit packets in general consideration of their mobility rate and user session rate based on a Hierarchical Mobile Internet Protocol version 6 (HMIPv6) architecture to adaptively optimize a route in a mobile communication network, and a packet transmission method using the same.

Background Art

Many researchers and companies expect that the communication environment will evolve into All-IP network in future. In the All-IP network, terminals have their own Internet Protocol (IP) address, and a calling party and a called party are connected to each other at the IP addresses. Meanwhile, Wireless-Broadband (WiBro) Internet service is scheduled to be demonstrated in South Korea sooner or later.

The WiBro Internet service aims to provide an end-to-end IP communication service to users anywhere anytime. In such an environment, mobility must be supported in an IP layer in order to provide the wireless Internet access to users without any cutoff. As the standard for the mobility, the Internet Engineering Task Force (IETF)
proposed an IP layer mobility scheme, which is called mobile IP. To be compatible with the Internet Protocol version 6 (IPv6), the mobile IPv6 has been standardized based on Request For Comment (RFC).

According to the mobile IPv6, home agents (HA) are provided, and a user terminal registers its location in a home agent to which it pertains whenever it makes move. When a user terminal of one home agent wants to communicate with a user terminal of another home agent, it inquires the location of the user terminal to its home agent (HA), acquires the location and gets into communication with it.

However, when there are many user terminals using mobile IP, the user terminals must register their locations while moving, and this increases the load of a network. To solve this problem, based on the perception that the users mostly remains in a predefined zone, anchor points are placed hierarchically and a local mobility and a global mobility are separately processed, thus reducing a location registration cost. This method was also proposed as RFC HMIPv6 by IETF.

When users use the mobile Internet, it is thought that the users access to the wireless Internet while they are on moving in transportation means such as bus, subway, and automobile. In this case, when the transportation means is crowded with many users who are also using the wireless Internet service at mobile IPs and moves from one cell to another, all the users should have their location information registered.

To solve this problem, the IEFT formed a "Network Mobility" (NEMO) working group to prepare for the standardization.

"NEMO basic support" scheme proposed by the IEFT introduced a mobile router (MR) concept. According to the NEMO basic support scheme, the motion of a
transportation means with the mobile router (MR) is considered as a motion of an entire network, and location information is updated in a home agent (HA) corresponding to the mobile router (MR).

The scheme using the mobile router (MR) can reduce the cost of updating the location information, compared with the HMIPvβ.

According to the NEMO basic support protocol, when a mobile node (MN) under the mobile router (MR) visits, an external node must pass through a home agent (HA) of the mobile node (MN) and a home agent of the mobile router (MR) in order to transmit data to the mobile node (MN). In addition, another mobile router (MR) under the mobile router (MR) visits to form a nesting, the node passes through much more home agents (HAs). Thus, a packet transmission delay time becomes longer. Further, the NEMO basic support protocol has a problem that it cannot adaptively cope with the motion of the transportation means or data transmission characteristics.

Disclosure

Technical Problem

It is, therefore, an object of the present invention to provide a location registration method for adaptive route optimization, a packet transmission method using the same, and a computer-readable recording medium for storing a program realizing the methods. A visiting mobile node (VMN) and a mobile router (MR) adaptively register their locations and transmit packets in general consideration of their mobility rate and user session rate based on a HMIPvβ architecture. Thus, total cost including a location registration cost and a packet transmission cost can be reduced, and NEMO and HMIPvβ specifications can be effectively combined without much
Technical Solution

In accordance with one aspect of the present invention, there is provided a location registration method for adaptive route optimization in a mobile communication network, including the steps of: a) calculating a session-to-mobility ratio (SMR) defined as a ratio of a session arrival rate to a mobility rate; b) comparing the SMR with a predetermined value; c) determining a mobile node (MN) of the mobile communication network; and d) registering a location of the mobile node (MN) according to the results of the steps b) and c).

In accordance with another aspect of the present invention, there is provided a packet transmission method for adaptive route optimization in a mobile communication network, including the steps of: a) calculating a session-to-mobility ratio (SMR) defined as a ratio of a session arrival rate to a mobility rate; b) comparing the SMR with a predetermined value; c) determining a mobile node (MN) to which a packet is to be transmitted in the mobile communication network; and d) transmitting transmission the packet to the mobile node (MN) according to the results of the steps b) and c).

In accordance with yet another aspect of the present invention, there is provided a computer-readable recording medium storing a program for executing a location registration method for adaptive route optimization in a mobile communication network system with a processor, including the steps of: a) calculating a session-to-mobility ratio (SMR) defined as a ratio of a session arrival rate to a mobility rate; b) comparing the SMR with a predetermined value; c) determining a mobile
node (MN) of the mobile communication network; and d) registering a location of the mobile node (MN) according to the results of the steps b) and c).

In accordance with still another aspect of the present invention, there is provided a computer-readable recording medium storing a program for executing a location registration method for adaptive route optimization in a mobile communication network system with a processor, including the steps of: a) calculating a session-to-mobility ratio (SMR) defined as a ratio of a session arrival rate to a mobility rate; b) comparing the SMR with a predetermined value; c) determining a mobile node (MN) to which a packet is to be transmitted in the mobile communication network; and d) transmitting the packet to the mobile node (MN) according to the results of the steps b) and c).

Advantageous Effects

To solve the pinball routing problem of the NEMO basic support protocol by using HMIPvβ architecture, a visiting mobile node (VMN) and a mobile routing (MR) adaptively register their locations according to their SMRs. Therefore, the total communication cost including a location registration cost and a packet transmission cost can be reduced. In addition, NEMO and HMIPvβ specifications can be effectively combined without much modification.

Description of Drawings

The above and other objects and features of the present invention will become apparent from the following description of the preferred embodiments given in conjunction with the accompanying drawings, in which:
Fig. 1 is a view illustrating a conventional location registration process in a mobile IPv6 suggested by the IETF;

Fig. 2 is a view showing a general hierarchical mobile Internet Protocol (HMIP);

Fig. 3 is a view illustrating a basic operation of an NEMO basic support protocol;

Fig. 4 is a flowchart illustrating a method for registering a location of an MR for adaptive route optimization in a mobile communication network in accordance with an embodiment of the present invention;

Fig. 5 is a flowchart illustrating a method for registering a location of an MR for adaptive route optimization in a mobile communication network in accordance with another embodiment of the present invention;

Fig. 6 is a flowchart illustrating a method for registering a location of a VMN for adaptive route optimization in a mobile communication network according to an embodiment of the present invention;

Fig. 7 is a flowchart illustrating a method for registering a location of a VMN for adaptive route optimization in a mobile communication network in accordance with another embodiment of the present invention;

Fig. 8 is a flowchart illustrating a method for transmitting a packet to an MR for adaptive route optimization in a mobile communication network in accordance with an embodiment of the present invention;

Fig. 9 is a flowchart illustrating a method for transmitting a packet to an MR for adaptive route optimization in a mobile communication network in accordance with another embodiment of the present invention;

Fig. 10 is a flowchart illustrating a method for
transmitting a packet to a VMN for adaptive route optimization in a mobile communication network in accordance with an embodiment of the present invention; and

Fig. 11 is a flowchart illustrating a method for transmitting a packet to a VMN for adaptive route optimization in a mobile communication network in accordance with another embodiment of the present invention.

Best Mode for the Invention

Other objects and aspects of the invention will become apparent from the following description of the embodiments with reference to the accompanying drawings, which is set forth hereinafter.

Fig. 1 is a view illustrating a process of registering a location in a mobile IPv6 proposed by IETF.

In Fig. 1, "CN" is a corresponding node 101, "HA" is a home agent 102, "AR" is an access router 103 and 104, "MN" is a mobile node 105, "HoA" is a home address 106, and "CoA" is a care of address 107.

The CN 101 represents the nodes communicating with the MN 105. The HA 102 represents a router of home network that has registration information of the MN 105 and transmits datagram to a current location of the MN 105 located in an external network. The ARs 103 and 104 represent routers that provide a service to a mobile host. The MN 105 represents a host or router that changes its network access location.

In the mobile IP, the HoA 106 is an address used for uniquely identifying the MN 105. The CoA 107 is an address containing location information of the MN 105.

Meanwhile, when the MN 105 located in a subnet managed by the old AR 103 moves to a subnet managed by
the new AR 104, the MN 105 receives a router advertisement (RA) message from the new AR 104 to configure the new CoA 107, and transmits a binding update (BU) to the HA 102 to notify the new CoA 107. That is, the MN 105 uses the BU to notify its own CoA 107 to the HA 102 and the CN 101.

The HA 102 receives the BU from the MN 105 and stores "HoArCoA" entry in its own binding cache.

When the external CN 101 wants to communicate with the MN 105, the CN 101 sends a packet to the HA 102 of the MN 105 by using the HoA 106. The HA 102 receiving the packet searches the corresponding CoA 107 of the HoA 106 with reference to the binding cache. Then, the HA 102 encapsulates the corresponding IP into a new IP packet destined to the CoA 107, and sends the new IP packet to the MN 105. The MN 105 encapsulates the received packet and processes the original packet transmitted to its own HoA 106. At this point, since the MN 105 can know the address of the CN 101, it directly communicates with the CN 101 without passing through the HA 102. However, the CN 101 must pass through the HA 102 in order to communicate with the MN 105. That is, even when the CN 101 is very close to the MN 105, the packet transmitted from the CN 101 to the MN 105 must pass through the HA 102. This is called "Triangular Routing Problem". This problem can be solved by making the MN 105 directly transmit its own CoA 107 to the CN 101. This is called a "route optimization (RO)". At present, there are two specifications for the mobile IP: MIPv4 for Internet version 4 and MIPv6 for Internet version 6. MIPv6 contains the RO as default.

Fig. 2 is a schematic diagram of a hierarchical mobile IP (HMIP).

In a mobile IP, an MN 203 must register its location in an HA 202 over the Internet 201 whenever the MN 203
moves from one subnet to another. Therefore, when there exist a plurality of MNs 203, the load applied on the core Internet increases. To solve this problem, HMIP was proposed.

The HMIP solves the above problem by separating a local mobility from a global mobility.

Meanwhile, the HMIP introduces mobility anchor points (MAPs) 211 and 221 as an anchor point in order to manage the local mobility. When the MN 203 arrives at the new MAPs 211 and 221, it generates two CoAs 214 and 215. One is regional CoAs (RCoAs) 214 and 231 containing information about the corresponding MAP domains 210 and 202, and the other is on-link CoA (LCoA) 215 containing information about a subnet managed by the corresponding ARs 212 and 213.

After generating the RCoAs 214 and 231 and the LCoA 215, "RCoA: LCoA" is registered in the corresponding MAPs 211 and 221, and "HoA: RCoA" is registered in the corresponding HA 202. By managing the location information using different hierarchy, when the MN 203 moves to another subnet located in the MAP domains 210 and 220, the RCoA 214 does not change, but only the LCoA 215 changes. Therefore, the MN 203 registers the RCoA 214 and the newly acquired LCoA 215 in the MAPs 211 and 221. Through these procedures, the location registration is finished. Consequently, when the MN 203 moves in the MAP domains 210 and 220, it does not have to transmit the BU to the HA 202 over the Internet 201 thereby reducing the load of the network.

Fig. 3 is a schematic diagram illustrating a basic operation of an NEMO basic support protocol.

In Fig. 3, "VMN" is a visiting mobile node 301, "LFN" is a local fixed node 302, "MR" is a mobile router 303, and "VAN" is a vehicular area network 304.

The VMN 301 means an MN that has not been contained
in the VAN 304 but is temporarily contained in the VAN 304 as a result of movement. The LFN 302 means an MN that is connected to the MR 303 and its access point with the MR 303 is not changed within the VAN 304.

When the MR 303 moves from the VAN 304, in which the VAN 304 is originally registered, to a new subnet, the MR 303 registers the new CoA in its own HA (HA_MR) 304.

Since the LFN 302 has a limited communication function, it cannot directly transmit the BU message. Instead, the MR 303 sends the BU to the HA_MR 304 on behalf of the VAN 304. Therefore, the BU message contains a network prefix of the MR 303 together with the CoAs obtained at the ARs 305 and 306.

To send the network prefix of the MR 303 is optional. When the network prefix of the MR 303 is not sent, an administrator adds the prefix information to the HA directly. When the VMN 301 enters the VAN 304 from the outside, it receives an RA message of the MR 303 to generate the CoA, and registers the CoA in its own home agent (HA_VMN) together with its own HoA.

When an external CN 308 wants to communicate with the VMN 301, the CN 308 sends a packet destined to the HoA of the VMN 301. The packet is routed to the HA_VMN 307 and is encapsulated into a packet destined to the CoA of the VMN 301.

The packet arrives at the HA_MR 304 and is again encapsulated into a packet destined to the CoA of the MR 303 by the binding information contained in the binding cache. The packet is routed to the MR 303, and the MR 303 decapsulates the packet destined to the MR 303, and sends the decapsulated packet to the VMN 301.

If the communication is performed through the above procedures, the packet must pass through several HAs. Therefore, packet transmission delay time increases and packet size increases due to the packet encapsulation.
In the NEMO, this is called a pinball routing problem. To solve this problem, various RO schemes are proposed.

Fig. 4 is a flowchart illustrating a method for registering a location of an MR for adaptive route optimization in a mobile communication network in accordance with an embodiment of the present invention.

The adaptive route optimization method for the mobile communication network is performed based on a NEMO basic support protocol.

The location registration method in accordance with the present invention can be classified into two cases, that is, the MR and the VMN.

The location registration is performed considering both the user's mobility rate and the user's session rate.

To this end, a session-to-mobility ratio (SMR) is used. The SMR is defined as the ratio of the session arrival rate to the mobility rate. A high SMR means that the node hardly moves and the session is maintained for a long time. At this point, the session transmission rate is more important than the node mobility.

Therefore, in order to reduce a total cost for the communication of the MN, it is necessary to reduce a packet transmission cost rather than a location registration cost. On the other hand, a low SMR means that the node moves fast whereas it hardly performs the communication. To reduce the communication cost of the MN, it is more effective to reduce the location registration cost.

The method for registering the location of the MR will be described below. When the SMR is greater than or equal to a threshold value t1, it is more efficient to reduce the packet transmission cost. Therefore, in step S411, the MR 401 receiving the RA message from the MAP 402 registers the RCoA, the LCoA and the NEMO prefix in the MAP 402 of the MR 401. In step S412, the MR 401
registers the NEMO prefix and the LCoA in the HA_MR 403. Therefore, when the MR 401 communicates with the CN 404 located in the outside, it can skip the MAP 402, thereby reducing the packet transmission cost. Whenever the LCoA changes, the MR 401 must notify the changed LCoA to the HA_MR 403. Thus, the location registration cost increases. However, the packet transmission cost is a more important factor than the location registration cost in terms of the total cost, resulting in the reduction of the total cost. In step S411, it should be noted that the NEMO prefix is transmitted together with the RCoA and the LCoA of the MR 401 when the BÜ message is sent to the MAP 402. These information are used for the route optimization without passing through the HA_MR 403 with respect to the RCoA and LCoA of the VMN 405 and the packet destined to the RCoA of the VMN 405. This process will be described in more detail together with the packet transmission process of the VMN 405.

Fig. 5 is a flowchart illustrating a method for registering a location of an MR for adaptive route optimization in a mobile communication network in accordance with another embodiment of the present invention. On the contrary to the case of Fig. 4, when the SMR is less than the threshold value t1, it is more efficient to reduce to the location registration cost. In step S510, the MR 501 receiving the RA message from the MAP 504 registers the NEMO prefix, the RCoA, and the LCoA. In step S511, the MR 501 registers the NEMO prefix and the RCoA in the HA_MR 502.

When the MR 501 wants to communicate with the CN 503, it must receive and transmit the packet through the MAP 504, thus increasing the packet transmission cost. However, when the RCoA is registered and the MR 501 moves within the MAP domain, the location of the MR 501 need
not be registered in the HA. Consequently, the location registration cost can be reduced. When the SMR is low, the ratio of the location registration cost is high in the total cost. Therefore, the total cost is reduced.

Fig. 6 is a flowchart illustrating a method for registering a location of a VMN for adaptive route optimization in a mobile communication network according to an embodiment of the present invention. The location registration of the VMN 601 is different from that of the MR 602.

When the SMR is greater than or equal to a threshold value t2, the VMN 601 receiving the RA message from the MR 602 registers the RCoA and LCoA of the VMN 601 in the MAP 603 in step S611. In step S612, the VMN 601 registers the HoA and the RCoA in the HA_VMN 604.

When the SMR is high, it is advantageous to reduce the packet transmission cost. By registering the RCoA in the HA_VMN 604, the packet is transmitted to the MAP 603 without passing through the HA_MR 605. Thus, the packet transmission cost can be reduced. Although the location registration cost increases because the RCoA changes in each MAP domain, the total cost is reduced.

Fig. 7 is a flowchart illustrating a method for registering a location of a VMN for adaptive route optimization in a mobile communication network in accordance with another embodiment of the present invention.

Referring to Fig. 7, in step S710, when the SMR is less than the threshold value t2, the VMN 701 receiving the RA message from the MR 702 registers the RCoA and LCoA of the VMN 701 in the MAP 703. In step S711, the VMN 701 registers the HoA and the LCoA in the HA_VMN 704.

In this case, the LCoA of the VMN 701 does not change even when it moves together with the MR 702. Thus, the position registration is performed only one time. On
the other hand, when the MR 702 registers the RCoA in the HA_MR 706, the packet must pass through the HA_VMN 704, the HA_MR 706 and the MAP 703, thus increasing the packet transmission cost. However, since the high SMR means the fast movement of the node, the gain from the location registration cost is much larger, thus reducing the total cost.

The summary of the location registration method for the adaptive route optimization in the mobile communication network is as follows. In the case of the MR, when the SMR is less than the threshold value t1, the BU having the HoA and the RCoA is transmitted to the HA_MR, and the BU having the RCoA, the LCoA and the NEMO prefix is transmitted to the MAP.

When the SMR is greater than or equal to the threshold value t1, the BU having the LCoA is transmitted to the HA_MR, and the BU having the RCoA, the LCoA and the NEMO prefix is transmitted to the MAP.

In the case of the VMN, when the SMR is less than the threshold value t2, the BU having the HoA and the LCoA is transmitted to the HA_VMN, and the BU having the RCoA and the LCoA is transmitted to the MAP.

When the SMR is greater than or equal to the threshold value t2, the BU having the HoA and the RCoA is transmitted to the HA_VMN, and the BU having the RCoA and the LCoA is transmitted to the MAP.

Fig. 8 is a flowchart illustrating a method for transmitting a packet to an MR for adaptive route optimization in a mobile communication network in accordance with an embodiment of the present invention. The packet transmission method in accordance with the present invention is performed according to the above-described location registration method. The packet transmission method is classified into two cases. The first case is to transmit the packet to the MR and the
second case is to transmit the packet to the VMN. Since the two cases perform the adaptive location registration according to the SMR, the packet transmission methods are different according to the SMR.

The method for transmitting the packet to the MR 802 will be described below. This embodiment is applied to the case where the MR 802 registers the RCoA in the HA_MR 805 when the SMR is less than the threshold value t1.

In the case where the external CN 807 wants to communicate with the LFN 801 fixed to the MR 802, if the packet destined to a HoA_LFN is transmitted, the HoA_LFN packet is transmitted to the HA_MR 805 by the routing in step S811.

The HA_MR 805 searches the RCoA of the MR 802 with reference to the HoA_LFN packet and the binding cache, and encapsulates the corresponding packet into an RCoA_MR I HoA_LFN packet destined to the RCoA.

In step S812, since the RCoA is generated based on the location of the MAP 804, the RCoA_MR I HoA_LFN packet is routed to the MAP 804 in which the MR 802 is currently located.

The MAP 804 searches the LCoA of the MR with reference to the binding cache entry and encapsulates the packet into an LCoA_MR I RCoA_MR I HoA_LFN packet. In step S813, the LCoA_MR I RCoA_MR I HoA_LFN packet is transmitted to the MR 802 in step S813. In step S814, the MR 802 decapsulates the LCoA_MR I RCoA_MR I HoA_LFN packet two times to obtain the original packet, and transmits the HoA_LFN packet to the LFN 801.

Fig. 9 is a flowchart illustrating a method for transmitting a packet to an MR for adaptive route optimization in a mobile communication network in accordance with another embodiment of the present invention. This embodiment is applied to the case where the MR 902 registers the LCoA in the HA_MR 905 when the
In step S911, the HA_MR 905 receives the HoA_LFN packet from the CN 907. In step S912, the HA_MR 905 receiving the HoA_LFN packet searches the LCoA of the MR 902 in the binding cache, encapsulates the packet into the LCoA_MR I HoA_LFN packet destined to the LCoA. Since the LCoA contains the location information of the AR 903 associated with the MR 902, the LCoA_MR I HoA_LFN packet is routed up to the AR 903.

In step S913, the MR 902 decapsulates the LCoA_MR I HoA_LFN packet and transmits the decapsulated packet to the LFN 901.

Fig. 10 is a flowchart illustrating a method for transmitting a packet to a VMN for adaptive route optimization in a mobile communication network in accordance with an embodiment of the present invention. The packet transmission method for the adaptive route optimization is performed according to the location registration method. The method for transmitting the packet to the MR has been described with reference to Figs. 8 and 9.

Next, a method for transmitting a packet to a VMN will be described below. When the SMR is less than the threshold value t2, the VMN 1001 registers the LCoA in the HA_VMN 1006. In step 1011, the CN 1007 transmits the HoA_VMN packet, which is destined to the HoA of the VMN 1001, to the HA_VMN 1006.

In step S1012, the HA_VMN 1006 encapsulates the HoA_VMN packet into the LCoA_VMN I HoA_VMN packet destined to the LCoA of the VMN, and the LCoA_VMN I HoA_VMN packet is transmitted to the HAJVIR 1005 because the LCoA of the VMN 1001 is generated using the prefix received from the MR 1002.

The HA_MR 1005 stores the LCoA or the RCoA of the MR 1002 according to whether the SMR is greater or less than
the threshold value tl.

In step S1021, when the SMR is less than the threshold value tl, the HA_MR 1005 stores the RCoA of the MR 1002, encapsulates the LCoA_VMNI HoA_VMNI packet into the RCoA of the MR 1002, and transmits the RCoA_MR I LCoA_VMNI I HoA_VMNI packet to the MAP 1004. In step S1022, the MAP 1004 encapsulates the RCoA_MR I LCoA_VMNI I HoA_VMNI packet into the LCoA_MR I RCoA_MR I LCoA_VMNI I HoA_VMNI packet destined to the LCoA, and transmits the encapsulated packet to the MR 1002. In step S1040, the MR 1002 decapsulates the LCoA_MR I RCoA_MR I LCoA_VMNI I HoA_VMNI packet two times and transmits the decapsulated packet to the VMN 1001.

Meanwhile, in step S1030, when the SMR is greater than or equal to the threshold value tl, because the HA_MR 1005 stores the LCoA of the MR 1002, the LCoA_VMNI I HoA_VMNI packet destined to the LCoA of the VMN is encapsulated into the LCoA_MR I LCoA_VMNI I HoA_VMNI packet, and the encapsulated packet is transmitted to the MR 1002. In step S1040, the MR 1002 decapsulates the LCoA_MR I LCoA_VMNI I HoA_VMNI packet and transmits the decapsulated packet to the VMN 1001.

Fig. 11 is a flowchart illustrating a method for transmitting a packet to a VMN for adaptive route optimization in a mobile communication network in accordance with another embodiment of the present invention. When the SMR is greater than or equal to the threshold value t2, the VMN 1101 registers the RCoA of the VMN 1101 in the HA_VMNI 1106.

In step S1111, the CN 1107 transmits the HoA_VMNI packet, which is destined to the HoA of the VMN 1101, to the HA_VMNI. In step S1112, the HA_VMNI 1106 encapsulates the HoA_VMNI packet into the RCoA_VMNI I HoA_VMNI packet destined to the RCoA of the VMN 1101, and the RCoA_VMNI I HoA_VMNI packet is routed to the MAP 1104 because the RCoA
of the VMN 1101 is an address generated based on the location of the MAP 1104.

The MAP 1104 searches the LCoA of the VMN 1101 corresponding to the RCoA of the VMN 1101 with reference to the information stored in the binding cache. However, when the packet is encapsulated using the LCoA of the VMN 1101, the packet in which the LCoA is generated from the prefix of the MR 1102 must pass through the HA_MR 1105, which is the HA of the MR 1102.

If the MR 1102 registers the prefix as well as the location in the MAP 1104, the MAP 1104 can know that the LCoA of the VMN 1101 corresponds to the prefix of the MR 1102. That is, the relationship of "VMN_RCoA->MN_LCoA->NEMO prefix->MR_RCoA->MR_LCoA" is used.

Therefore, in step S1113, the MAP 1104 encapsulates the packet into the LCoA_VMN I RCoA_VMN I HoA_VMN packet using the LCoA of the VMN 1101 and again encapsulates it into the LCoA_MR I LCoA_VMN I RCoA_VMN I HoA_VMN packet using the LCoA of the MR 1102, and transmits the LCoA_MR I LCoA_VMN I RCoA_VMN I HoA_VMN packet to the MR 1102.

In step S1114, the MR 1102 decapsulates the LCoA_MR I LCoA_VMN I RCoA_VMN I HoA_VMN packet one time and transmits the decapsulated packet, LCoA_VMN I RCoA_VMN I HoA_VMN, to the VMN 1101.

Through these procedures, the route optimization is achieved by skipping the HA_MR 1105.

The methods in accordance with the embodiments of the present invention can be realized as programs and stored in a computer-readable recording medium that can execute the programs. Examples of the computer-readable recording medium include CD-ROM, RAM, ROM, floppy disks, hard disks, magneto-optical disks and the like.

While the present invention has been described with respect to certain preferred embodiments, it will be apparent to those skilled in the art that various changes
and modifications may be made without departing from the scope of the invention as defined in the following claims.
What is claimed is:

1. A location registration method for adaptive route optimization in a mobile communication network, comprising the steps of:
   a) calculating a session-to-mobility ratio (SMR) defined as a ratio of a session arrival rate to a mobility rate;
   b) comparing the SMR with a predetermined value;
   c) determining a mobile node (MN) of the mobile communication network; and
   d) registering a location of the mobile node (MN) according to the results of the steps b) and c).

2. The location registration method as recited in claim 1, wherein a location registration cost is reduced when the SMR is less than the predetermined value, and a packet transmission cost is reduced when the SMR is greater than or equal to the predetermined value in the step b).

3. The location registration method as recited in claim 1, wherein the step c) determines whether the mobile node (MN) is a mobile router (MR) or a visiting mobile node (VMN).

4. The location registration method as recited in claim 1, wherein when the mobile node (MN) is a mobile router (MR) and the SMR is less than the predetermined value, the step d) includes the steps of:
   - transmitting a binding update (BU) with a home address (HoA) and a regional care of address (RCoA) to a mobile router's home agent (HA_MR); and
   - transmitting a binding update (BU) with the regional care of address (RCoA), an on-link care of address (LCoA),
and a NEMO prefix to a mobility anchor point (MAP).

5. The location registration method as recited in claim 4, wherein when the mobile node (MN) is a mobile router (MR) and the SMR is greater than or equal to the predetermined value, the step d) includes the steps of:
   transmitting a binding update (BU) with the on-link care of address (LCoA) to the mobile router's home agent (HA_MR); and
   transmitting a binding update (BU) with the regional care of address (RCoA), the on-link care of address (LCoA), and the NEMO prefix to the mobility anchor point (MAP).

6. The location registration method as recited in claim 4, wherein when the mobile node (MN) is a visiting mobile node (VMN) and the SMR is less than the predetermined value, the step d) includes the steps of:
   transmitting a binding update (BU) with the home address (HoA) and the on-link care of address (LCoA) to a visiting mobile node's home agent (HA_VMN); and
   transmitting a binding update (BU) with the regional care of address (RCoA) and the on-link care of address (LCoA) to the mobility anchor point (MAP).

7. The location registration method as recited in claim 4, wherein when the mobile node (MN) is a visiting mobile node (VMN) and the SMR is greater than or equal to the predetermined value, the step d) includes the steps of:
   transmitting a binding update (BU) with the home address (HoA) and the regional care of address (RCoA) to a visiting mobile node's home agent (HA_VMN); and
   transmitting a binding update (BU) with the regional care of address (RCoA) and the on-link care of address...
8. A packet transmission method for adaptive route optimization in a mobile communication network, comprising the steps of:

a) calculating a session-to-mobility ratio (SMR) defined as a ratio of a session arrival rate to a mobility rate;

b) comparing the SMR with a predetermined value;

c) determining a mobile node (MN) to which a packet is to be transmitted in the mobile communication network; and

d) transmitting the packet to the mobile node (MN) according to the results of the steps b) and c).

9. The packet transmission method as recited in claim 8, wherein the step c) is divided into a case of transmitting the packet to a mobile router (MR) and a case of transmitting the packet to a visiting mobile node (VMN).

10. The packet transmission method as recited in claim 8, wherein the step d) includes the steps of:

at a corresponding node (CN), transmitting a local fixed node's home address (HoA_LFN) packet, which is destined to the local fixed node's home address (HoA_LFN), to the mobile router's home agent (HA_MR), when the mobile node (MN) is a mobile router (MR) and the SMR is less than the predetermined value;

searching the regional care of address (RCoA) of the mobile router (MR) with reference to the local fixed node's home address (HoA_LFN) and a binding cache of the mobile router's home agent (HA_MR), encapsulating the corresponding packet into an RCoA_MR I HoA_LFN packet destined to the regional care of address (RCoA), and
transmitting the encapsulated packet to the mobility anchor point (MAP); at the mobility anchor point (MAP), searching an on-link care of address (LCoA) of the mobile router (MR) with reference to a binding cache entry, encapsulating the corresponding packet into an LCoA_MR I RCoA_MR I HoA_LFN packet, and transmitting the encapsulated packet to the mobile router (MR); and at the mobile router (MR), decapsulating the LCoA_MR I RCoA_MR I HoA_LFN packet to obtain an original packet, and transmitting the HoA_LFN packet to the local fixed node (LFN).

11. The packet transmission method as recited in claim 10, wherein the mobile router (MR) registers the regional care of address (RCoA) in the mobile router's home agent (HA_MR).

12. The packet transmission method as recited in claim 10, wherein the step d) includes the steps of: at the mobile router's home agent (HA_MR), receiving the HoA_LFN packet from the corresponding node (CN), when the mobile node (MN) is the mobile router (MR), the SMR is greater than or equal to the predetermined value, and the mobile router (MR) registers the on-link care of address (LCoA) in the mobile router's home agent (HA_MR); at the mobile router's home agent (HA_MR) receiving the HoA_LFN packet, searching the on-link care of address (LCoA) of the mobile router (MR) in the binding cache, encapsulating the corresponding packet into an LCoA_MR I HoA_LFN packet destined to the on-link care of address (LCoA), and transmitting the encapsulated packet to the mobile router (MR); and at the mobile router (MR), decapsulating the LCoA_MR I HoA_LFN packet and transmitting the decapsulated packet.
to the local fixed node (LFN).

13. The packet transmission method as recited in claim 12, wherein the on-link care of address (LCoA) contains location information of an access router (AR) associated with the mobile router (MR), so that the LCoA_MR I HoA_LFN packet is routed to the access router (AR).

14. The packet transmission method as recited in claim 10, wherein the step d) includes the steps of:

at a visiting mobile node (VMN), registering the on-link care of address (LCoA) in the visiting mobile node's home agent (HA_VMN), when the mobile node (MN) is the visiting mobile node (VMN) and the SMR is less than the predetermined value, and transmitting a visiting mobile node's home address (HoA_VMN) packet, which is destined from the corresponding node (CN) to the home address (HoA) of the visiting mobile node (VMN), from the corresponding node (CN) to the visiting mobile node's home agent (HA_VMN);

at the visiting mobile node's home agent (HA_VMN), encapsulating the HoA_VMN packet into a LCoA_VMN I HoA_VMN packet destined to the on-link care of address (LCoA) of the visiting mobile node (VMN), and transmitting the encapsulated packet to the mobile router's home agent (HA_MR); and

at the mobile router's home agent (HA_MR), encapsulating the LCoA_VMN I HoA_VMN packet using the regional care of address (RCoA) or on-link care of address (LCoA) and transmitting the encapsulated packet to the mobile router (MR), and transmitting the encapsulated packet to the visiting mobile node (VMN).

15. The packet transmission method as recited in
claim 14, wherein the on-link care of address (LCoA) of the visiting mobile node (VMN) is generated using prefix information inputted from the mobile router (MR).

16. The packet transmission method as recited in claim 14, wherein the mobile router's home agent (HA_M) stores the on-link care of address (LCoA) or the regional care of address (RCoA) of the mobile router (MR) according to whether the SMR is greater or less than the predetermined value.

17. The packet transmission method as recited in claim 16, wherein when the SMR is less than the predetermined value, the mobile router's home agent (HA_MR) stores the regional care of address (RCoA) of the mobile router (MR), encapsulates the LCoA_VM I HoA_VM packet into the RCoA_MR I LCoA_VM I HoA_VM packet, and transmits the encapsulated packet to the mobility anchor point (MAP); and

the mobility anchor point (MAP) encapsulates the RCoA_MR I LCoA_VM I HoA_VM packet into the LCoA_MR I RCoA_MR I LCoA_VM I HoA_VM packet destined to the on-link care of address (LCoA) of the mobile router (MR), and transmits the encapsulated packet to the mobile router (MR).

18. The packet transmission method as recited in claim 16, wherein when the SMR is greater than or equal to the predetermined value, the visiting mobile node's home agent (HA_VMN) encapsulates the LCoA_VM I HoA_VM packet, which is destined to the on-link care of address (LCoA) of the visiting mobile node (VMN), into the LCoA_MR I LCoA_VM I HoA_VM packet, which is destined to the on-link care of address (LCoA), by using the on-link care of address (LCoA) of the mobile router (MR) stored
in the mobile router's home agent (HA_MR), and the encapsulated packet is transmitted to the mobile router (MR).

19. The packet transmission method as recited in claim 10, wherein the step d) includes the steps of:

- when the mobile node (MN) is a visiting mobile node (VMN) and the SMR is greater than or equal to the predetermined value, transmitting an HoA_VMN packet, which is destined to a home address (HA) of the visiting mobile node (VMN), from an external corresponding node (CN) and to the visiting mobile node's home agent (HA_VMN);

- at the visiting mobile node's home agent (HA_VMN), encapsulating the received HoA_VMN packet into the RCoA_VMN I HoA_VMN packet destined to the regional care of address (RCoA) of the visiting mobile node (VMN), and transmitting the encapsulated packet to the mobility anchor point (MAP);

- at the mobility anchor point (MAP), encapsulating the RCoA_VMN I HoA_VMN packet into the LCoA_VMN I RCoA_VMN I HoA_VMN packet by using the on-link care of address (LCoA) of the visiting mobile node (VMN) corresponding to the regional care of address (RCoA) of the visiting mobile node (VMN) according to the information stored in the binding cache, encapsulating the encapsulated packet into the LCoA_MR I LCoA_VMN I RCoA_VMN I HoA_VMN packet by using the on-link care of address (LCoA) of the mobile router (MR), and transmitting the LCoA_MR I LCoA_VMN I RCoA_VMN I HoA_VMN packet to the mobile router (MR); and

- at the mobile router (MR), decapsulating the LCoA_MR I LCoA_VMN I RCoA_VMN I HoA_VMN packet into the LCoA_VMN I RCoA_VMN I HoA_VMN, and transmitting the decapsulated packet to the visiting mobile node (VMN).
20. A computer-readable recording medium storing a program for executing a location registration method for adaptive route optimization in a mobile communication network system with a processor, comprising the steps of:

a) calculating a session-to-mobility ratio (SMR) defined as a ratio of a session arrival rate to a mobility rate;

b) comparing the SMR with a predetermined value;

c) determining a mobile node (MN) of the mobile communication network; and

d) registering a location of the mobile node (MN) according to the results of the steps b) and c).

21. A computer-readable recording medium storing a program for executing a location registration method for adaptive route optimization in a mobile communication network system with a processor, comprising the steps of:

a) calculating a session-to-mobility ratio (SMR) defined as a ratio of a session arrival rate to a mobility rate;

b) comparing the SMR with a predetermined value;

c) determining a mobile node (MN) to which a packet is to be transmitted in the mobile communication network; and

d) transmitting the packet to the mobile node (MN) according to the results of the steps b) and c).
### A. CLASSIFICATION OF SUBJECT MATTER

**H04L 12/28(2006.01)1**

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC8 G06F, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patents and applications for inventions since 1975
Korean Utility models and applications for Utility models since 1975
Japanese Utility models and application for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EKIPASS (KIPO internal), IEEE xplor

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No</th>
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<tbody>
<tr>
<td>X</td>
<td>'An Adaptive Mobility Anchor Point Selection Scheme in Hierarchical Mobile IPv6 Networks, Sangheon Pack, Minji Nam, Taekyoung Kwon, and Yanghee Choi, Elsevier Computer Communications (COMCOM), June 2005</td>
<td>1, 2, 8, 20, 21</td>
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<tr>
<td>X</td>
<td>'A Mobility-based Load Control Scheme at Mobility Anchor Point in Hierarchical Mobile IPv6 Networks,' Sangheon Pack, Taekyoung Kwon, and Yanghee Choi, IEEE Global Telecommunications Conference (GLOBECOM) 2004, Dallas, USA, November 2004 pp 3431-3435</td>
<td>1, 2, 8, 20, 21</td>
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Date of the actual completion of the international search

19 OCTOBER 2006 (19 10 2006)

Date of mailing of the international search report

19 OCTOBER 2006 (19.10.2006)

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Form PCT/ISA/210 (second sheet) (April 2005)