New Software Architecture for Mobility and Handoff Management in Mobile IPV6 Networks

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Abstract

This paper addresses the problem of overall network signaling and packet delivery cost in Mobile Internet Protocol (MIP) systems for serving mobility and service management related operations. In MIP, a Mobile Node (MN) interacts with its home agent, when it is connected to a foreign agent to manage the mobility and packet delivery in a bidirectional tunneling mode. This paper proposes new software mobility management service architecture with the goal to handle the heavy burden on the home network and to minimize the cost of network signaling and packet delivery. Under the proposed architecture, a MN creates a Mobile Remote Object (MRO) and transfers it to the router of the hosted network. The MRO registers itself with a naming service server. The MRO handles all services engaged by the MN without relying on centralized traffic.

1. Introduction

The wide proliferation of portable devices increased the need for efficient mobility management solutions. The internet protocol (IP) will become the base of next generation wireless networks [1]. IP-based wireless networks will profit from the existing and emerging IP-related technologies and services. The mobile version of next generation internet protocol (IPv6) will support global mobility, and deliver services independently of user's geographical location [2]. This section sets up additional information about mobile IP mobility management. If a mobile node (MN) of its home network away is, a router on that home network admits as home agent (HA), pursues the current binding of the MN. If a handoff takes place, the MN sends a Binding Update (BU), to the HA and to each possible communicating node, which is it, normally indicated as Correspondent Node (CN).

The Mobile IPv6 (MIPv6) protocol is a work in progress by the Internet Engineering Task Force (IETF) for supporting network layer mobility in IPv6 [3]. MIPv6 lets mobile nodes move within the IP based networks with maintaining on going the connections. MIPv6 was marked as mobility management protocol for future universe IP mobile systems. It is from fundamental importance to investigate to the effective and scalable network management schemes, which is based on MIPv6. MIPv6 is centralized mobility architecture. This centralized mobility architecture does not only lack the flexibility to the development and limits the transition efficiency, but also throws the heavy load on the home network, with the result of the instability of the reticulated systems on (e.g. the home network single point of failure). In order to solve this lack from MIPv6, this paper suggests new architecture based on Mobile Remote Object (MRO) for IPv6-based systems. In this schema, the MRO represents the MN. The MRO lives on routers on the hosting network and works on behalf of the MN. The advantage of this schema is to eliminate the need to maintain the location at the HA, thus reduces the registration signaling cost. In addition, the proposed architecture provides a mechanism to perform handoff based on *make-before-break* principle. The connection to the new network is established and a new MRO is created to represent the MN before breaking the connection with the old network. This paper is organized as follows. Section 2 presents the works relevant to the proposed architecture. Among these are the MIPv6, HMIPv6, DMAP, and decentralized mobility management. Section 3 clarifies the proposed architecture which efficiently supports mobility in MIPv6. Section 4 compares the proposed architecture with related solutions. Finally, section 5 concludes the paper and outlines future work.

2. Related Work

Next-generation mobile IPv6 networks are supposed to support mobility on the future internet. Mobile nodes may cross subnets with high mobility rate, resulting in high costs for signaling overhead for the MN to inform HA and CNs of the Care of Address (CoA) change. Many researches on overall network signaling and packet delivery cost have been done [4]. This section gives a brief overview of related researches. The basic idea in MIPv6 is the care of address (CoA), which is a pointer to the mobile node's location [5, 6]. This concept allows a mobile node to keep its home address while it moves from a network to another. When a mobile node is in a foreign network (FN), it acquires another address (CoA). The MN uses a binding update message to register with the correspondent node and the home agent. The HA maps the home address to the CoA acquired from a foreign network. A CN can access a MN by its home IP address without caring about the MN's current location. There is a high overhead cost due to signaling the HA of CoA changes in regards to MN's movement between foreign networks. MIPv6 solves the problem of triangular routing (CN-HA-FN) as follows, a MN informs the CN of its CoA, so the CN delivers packets directly to the MN.

Hierarchical MIPv6 (HMIPv6) [7] is proposed to tone down the high volume of network signaling cost for mobility management. HMIPv6 uses a regional CoA (RCoA) in addition to the CoA as long as the MN moves within a region. In a foreign Network, the HMIPv6 allocates to a MN in addition to a CoA, an RCoA whenever it enters a new service area. If the MN moves on a new region, the HA is informed about the regional CoA change. The HA and CNs only know the MN's RCoA, the RCoA points to the service area where the MN takes place. So whenever the MN moves across a service area, it gets a new RCoA address, which the MN propagates to the HA and CN. Whenever, a MN moves from one subnet to another but is still within a service area, the CoA change is only propagated to the service area router instead of to the HA and CN, thus saving the signaling cost for mobility management. In HMIPv6, the number of sub networks is static.

The dynamic mobility anchor point (DMAP) scheme [8] extends HMIPv6 by taking both mobility and service management into consideration. Based on MN's mobility and service characteristics at runtime, the MN dynamically changes the size of the service area, to minimize the total cost of signaling.

Proxy-based Regional Registration for Integrated Mobility and Service Management in Mobile IP Systems [1] extends DMAP to dynamically determine the service area size. In addition, a client-side proxy is created on a per-user basis to serve as a gateway between the MN and the servers. When the MN crosses the service area, the proxy moves to the new FN and informs the HA and CN about the location and address change.

New decentralized mobility management service architecture for ipv6-based networks [9] treats the costly signaling of managing data traffic from/to the MN through the home network. The paper introduces a new entity in the SHIM6 protocol [10] called mobility agent (MA). This MA can be distributed in any local access network and is responsible on establishing the connection between the new and old networks. When the MN sends a packet containing an external IP address as source address, the MA intercepts the packet and creates a context with the old MA to direct the packets to the old CN.

A Cross-Layer Handoff Management Protocol for Next-Generation Wireless Systems [11] is developed to support seamless intra and intersystem handoff management in next generation wireless network. In this mechanism, the MN predicts the base station that it is going to move. The MN uses some techniques [12][13] to estimate the delay between the MN and the networks involved in the handoff process. Based on this delay estimation, the MN predicts which network it is moving towards and performs the required signaling.

3. SMMS architecture

This section elucidates the proposed software mobility management service (SMMS) architecture based on software components. The proposed architecture introduces a mobile remote object (MRO) as a representative of the MN. The purpose is to minimize the cost of network signaling due to location update at the home network. Actually, this solution eliminates the need for informing the HA about the new CoA each time the MN performs handoff.

3.1 Overview

An MN visiting a network creates an MRO and transfers it to the router (The denomination mobile arises from the transfer of the remote object to the router). The MRO works on behalf of the MN. That is, a CN must access the MRO in order to communicate the MN. The created MRO has to acquire a CoA from the DHCP server and register itself in naming service (NS) server with a globally unique name. The CN looks up this MRO and obtains a reference to it. When the MN moves to a new access network (hosting network), it creates a new MRO (nMRO) and informs the old MRO (oMRO). The nMRO will be inactive, i.e. not registered in the NS. Since there may be more than one hosting network that the MN is moving to, the MN creates a new MRO on each of these networks and

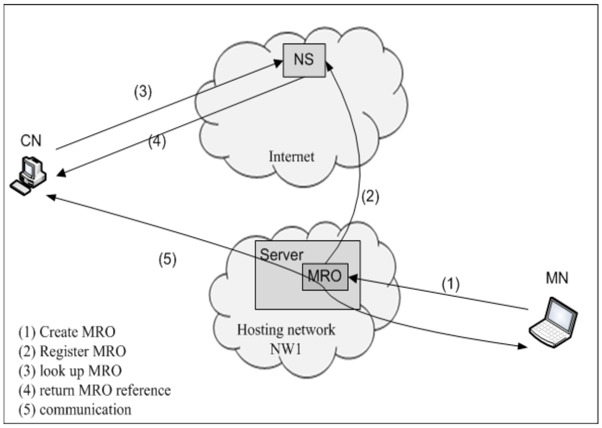

Figure 1. SMMS architecture

informs the oMRO about each nMRO. During the handoff period, each MRO monitors the quality of communicating the MN and sends this quality information to the oMRO. The oMRO maintains a list of the new MROs. Each entry in this list contains the quality information and the status (active/inactive) of the MRO. Based on the quality of service; the oMRO determines to which network the MN is moving. That is, the oMRO selects the nMRO, which has highest quality to represent the node. Then the nMRO registers itself in the NS with the same name of oMRO and informs the MN. Then oMRO directs the ongoing packets to the MN through nMRO. When the oMRO loses the connection to the MN, the oMRO sets a timer t_w. The oMRO waits t_w before destroying itself to ensure that the MN will not return back to the old network. This helps to avoid ping-pong effects.

3.2 SMMS Software Components

Figure 1 shows the software components for the proposed architecture which has the following software components:

3.2.1. Naming Service

The Naming Service (NS) is a server, which stores remote references to RMOs. Each binding stored by the Name Service is a mapping between a textual name and an object reference. For a CN to contact a MN on any network, that CN must first obtain a reference to the MN's RMO. Any CN on the same (inter or intra) network can obtain a remote reference to any RMO in the naming service server by contacting the NS.

3.2.2. Mobile Remote Object

The mobile remote object is a remote object that represents the MN. The MN creates the MRO and transfers it to the hosting network router. Figure 2 shows the class diagram of the MRO. The following methods are defined:

MRO (String name, Boolean reg)
This is the constructor of the MRO object. The inputs are a globally unique name and a Boolean *reg* which controls the registration process in the NS.

IPAddress acquireIPAddress ()
This method acquires an IP address (CoA) from the visited network DHCP server.

bind (String name, Remote obj)
It is a method for registering the MRO in the NS. The parameters are a string that represents the globally unique name and a reference to the MRO object. If there's already an object registered to that name within the NS, this method will update the registration.

long monitor()
This method monitors the communication quality between the MRO and the MN. It returns a value that represents the degree of the quality.

maintainMROs (MRO nMRO, Boolean status, long q)
This method is to keep a list of the MROs the MN created. The inputs are reference about each MRO, a Boolean indicates the status (active/inactive), and the quality value.

informMN (MRO nMRO)
This method passes a reference of the newly selected server MRO to the MN.

MRO
reg: boolean ip: IPAddress tw: int MROlist: List
MRO (CoA:IPAddress, reg:Boolean) bind (name:String, obj:Remote) monitor():long rebind (name:String, nMRO:Remote) maintainMROs (nMRO:MRO, status:Boolean, q:long) informMN (nMRO:MRO) redirect (nMRO:MRO) wait (tw:long) destroy()

Figure 2. MRO class diagram

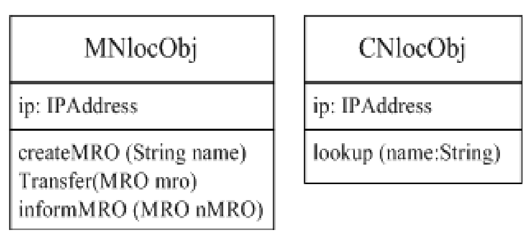

Figure 3. local objects class diagrams

redirect (MRO nMRO)

The MRO invokes this method to redirect the ongoing packet to the MN through the nMRO.

wait (long t_w)

This method causes the oMRO to wait for t_w. The parameter t_w is the time to wait in milliseconds.

destroy ()

The MRO invokes this method to destroy itself.

3.2.3. Local object

Each of the CN and the MN maintains a local object (locObj) to interact with the NS and the MRO. Figure 3 shows the class diagram of the locObj which defines the following methods:

createMRO (String name, Boolean reg)

The MN invokes this method to create a MRO. The inputs are a unique name and a Boolean *reg* which controls the registration process in the NS.

Transfer(MRO mro)

The MN invokes this method to transfer the created MRO to the network router.

informMRO (MRO nMRO)

This method passes a reference of the created MRO to the oMRO.

lookup (String name)

The CN invokes this method to obtain a reference to the MRO, which represents the MN. The input string represents the globally unique name of the MRO that corresponds to the MN.

3.3 Operation

3.3.1 Communication management

Figure 1 shows the proposed architecture for managing communication initiation between the CN and MN. Figure 4 illustrates the detailed message flow in the proposed architecture. The following steps achieve communication between the CN and MN:

a) When an MN attaches to some access network (NW1), MN acquires a new IP address CoA. Then, MN creates an MRO and transfers it to the router. The *reg* parameter is set to true to allow MRO to register itself in the NS.
b) Once created; the MRO acquires a CoA from the DHCP server and registers itself in the NS with a globally unique name.
c) The MRO assigns the MN the acquired IP address.
d) When a CN wishes to communicate a MN, the CN contacts the NS and looks up the MRO that represents the MN.
e) The NS returns a reference of the MRO to the CN.

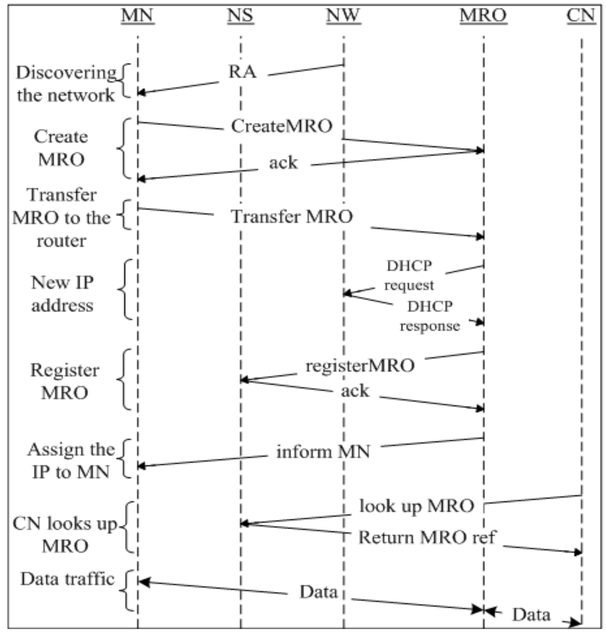

Figure 4. Detailed message and data flows for Communication initiation

f) Now the CN can communicate to the MN through the MRO and the NS bows out of the conversation.

3.3.2 Handoff management

Some handoff management solutions tend to predict the mobility of the MN to perform handoff based on *make-before-break* principle [11]. The proposed solution incorporates *make-before-break* without a need for mobility prediction. Figure 5 shows the proposed architecture for managing handoff. Figure 6 illustrates the detailed message flow in the proposed architecture. In the proposed architecture, the following steps achieve handoff management:

a) Movement detection

In the proposed architecture, when a MN moves, it must detect its current location. Assume an MN attaches to NW1. When MN moves towards NW2, MN starts to receive router advertisements (RA) from NW2 and possibly from other networks (NW3). By comparing the network ID of the received RA and its network ID, MN detects its movement.

b) Creating new representatives

If an MN receives a new RA from a network, it creates a new MRO in this network. For the sake of simplicity, the MROs are named sequentially. (e.g. MRO1 instead of oMRO, MRO2 on NW2 and MRO3 on NW3 routers in figure 5). The *reg* parameter is set

Table 1: Status of MROs

Object	Status	Quality
MRO1	Active	Q1
MRO2	Inactive	Q2
MRO3	Inactive	Q2
⋮	⋮	⋮

to false to prevent the new MROs from registering themselves in the NS.

c) Maintain MROs list

MN informs MRO1 about the creation of the new MROs and passes a reference of each nMRO to MRO1. MRO1 maintains a list of them. Initially, the list entries indicate that MRO1 is active while nMROs are inactive. Each of the MRO1 and nMROs monitor the communication quality with the MN. MRO1 contacts the nMROs and exchanges with them quality information on the communication between each of them and the MN. This quality of service information is also maintained in the list as shown in table 1.

d) Assigning new representative

MRO1 selects the MRO that has best quality as the new representative of the MN, (e.g. MRO2 in figure 5). Then the selected MRO registers itself with the NS with the same name and informs the MN of it as a new representative.

e) Redirecting ongoing packets

If an ongoing connection between a CN and the MN is on, MRO1 will direct the ongoing packets to the new MRO, which will pass them to the MN.

f) Destroying old MRO

When MRO1 loses the connection to MN completely, MRO1 sets the timer t_w. If t_w expires and MN is still unreachable, MRO1 destroys itself. The advantage here is to avoid ping-pong effects since MN may return to NW1.

4. Comparison with related work

An overview of recent proposals in this area suggests mathematical models based on stored parameters calculated from previous behavior of MNs and other current measured parameters in order to manage location and handoff mobility. The main drawback in MIPv6 is the occupation of a centralized home agent in the network for maintaining location information and data communication. In addition, a drawback of related algorithms is the high cost of keep tracking of MNs behavior regarding location and time, and extracting the dynamic parameters and dynamic computation at runtime. The contribution of this paper is a conceptual architecture based on Mobile remote objects and local objects. The proposed architecture has the advantage of eliminating the need for centralized home agent. Moreover, in the handoff phase, the optimal registration network for the MN is determined by the intelligent cooperating distributed objects. The MN performs light processing which is more efficient with respect to energy consumption. The MN hosts only simple local object. The MRO, which requires more processing, is hosted on powerful network routers.

5. Conclusion and future work

This paper investigated the complexity of handling mobility and handoff in mobile IP networks. The paper proposed using SW infrastructure to locate a MN and marking the optimal remote mobile object for performing service handoffs to so that the best QoS is made available. Suggested architecture should lower effectively the overall signaling and packet delivery

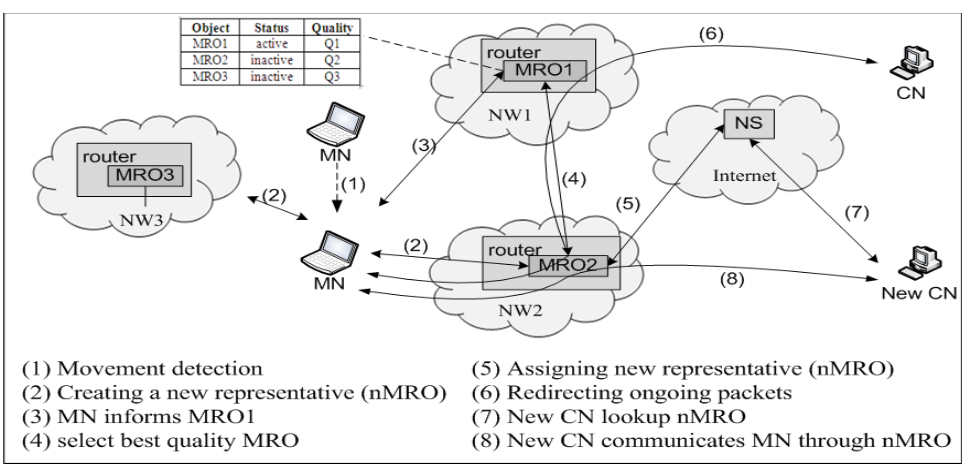

Figure 5. Handoff management

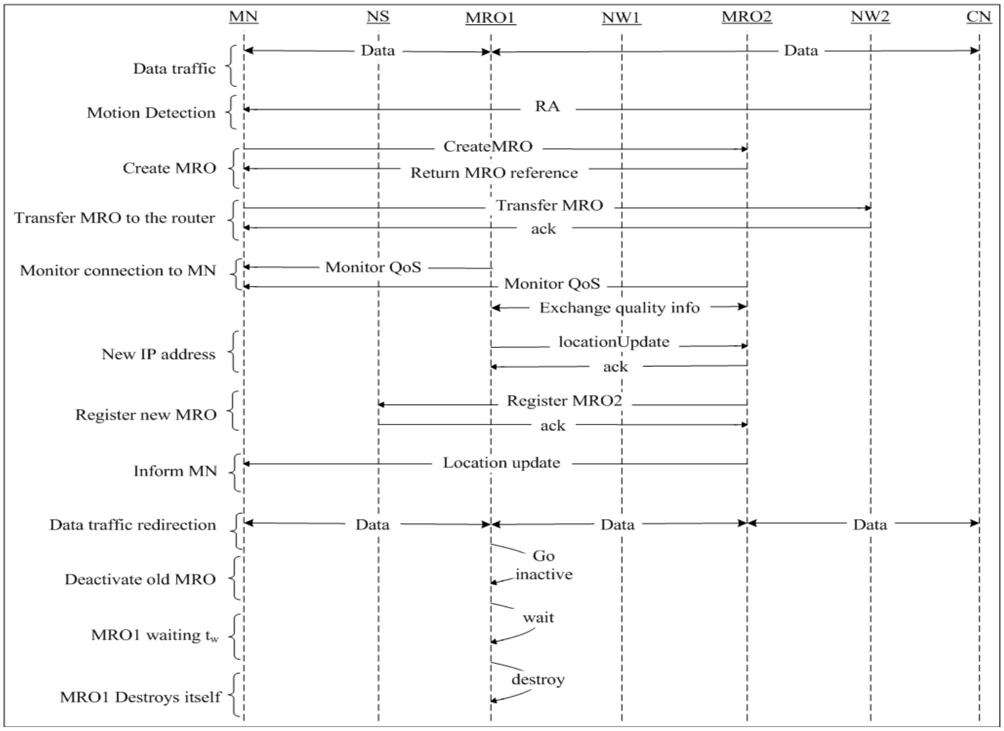

Figure 6. Detailed message and data flows for handoff management

cost due to eliminating the home agent and using RMO, which co-operates, in order to handle data delivery in the optimal way to the MN. In the proposed algorithm, a MN deploys a Mobile remote object in the hosting network and in all further networks, which can serve it. Therefore, suggested architecture should have the advantage of stability and efficiency mobility of the management. Since my work is in the original stage, there are many challenges to be overcome in the future work. Firstly, one next work item will be to develop the SW architecture and to make performance evaluation of this architecture through network simulations.

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