Extension of multiple care-of-address registration to support host multihoming

Phuoc Nguyen TRAN[#1], Nadia BOUKHATEM[#2]

Computer Science & Network Department, ENST -Télécom Paris

46 rue Barrault, 75013 Paris, France

[1]ptran@enst.fr

[2]boukhatem@enst.fr

Abstract — **In this paper, we propose an extension to the multiple care-of address registration solution allowing mobile nodes to communicate simultaneously on their various interfaces. This extension defines the M bit (multihoming bit) which is inserted in the router solicitation and router advertisement messages allowing a multi-interface mobile node to exploit host multihoming advantages.**

Keywords: ***multihoming, mobility management, multi-interface mobile terminal.***

I. INTRODUCTION

The evolution of the new generations of mobile networks is based on continuity with the UMTS and CDMA2000 standards, and strongly influenced by a troop of wireless technologies based on the IEEE standards such as 802.11, 802.15, 802.16, 802.20, 802.21 and 802.22.

Every mentioned solution presents its own advantages and drawbacks in term of coverage and service characteristics (bit rates, QoS, etc.) and represents diverse commercial opportunities to the operators. It seems likely that these various technologies have to live together and then solutions of integration and interoperability will be necessary to deal with this technological diversity.

The arrival on the market of terminals integrating several access technologies, in particular wireless technologies, already testify to the evolution towards this type of solution. The interoperability allows to reduce the risks related to the introduction of a new technology and offers the users a permanent and ubiquitous access to a wide range of services.

Once a terminal is equipped with several interfaces, it becomes possible to use simultaneously the various interfaces - and not only to handoff from one to another. The "multihoming", that is, capacity for a mobile terminal to be able to communicate simultaneously on various network interfaces, opens new perspectives.

With the "multihoming", several sessions can be simultaneously used, it is then possible to select at any time the best access technology for every stream, according to the its characteristics, the preferences of the users, the tariff constraints, the operators policies, etc. The multihoming also allows making opportunistic redirection of sessions according to the environment (i.e. possible connections), specific needs of streams and preferences of the user. A load sharing which consists in distributing a stream on several interfaces can be also envisaged to increase the available capacity. Finally, the multihoming provides reliability of the communications since, if a point of attachment (interface or access network) becomes temporarily unavailable, the connectivity can be maintained by redirecting the streams from an interface to the other one.

Currently, the term “host multihoming” has no formal definition in the IETF community [1]. It is used to indicate a situation where a mobile node can use simultaneously multiple IP addresses allocated to either a single interface or multiple interfaces.

In this paper, we define the term “host multihoming” or “multihoming” as the capacity for a mobile host to communicate simultaneously on its various network interfaces and each interface is associated with an IP address.

The Mobile IPv6 [2] specification has mechanism to support mobility management by maintaining a mapping (a binding) between the permanent IP address of the MN (Mobile Node), known as the Home Address (HoA) and a temporary IP address of the MN, known as the Care-of-Address (CoA). The CoA address is obtained, when the mobile node moves to a foreign network.

Once it obtains the CoA, the MN registers this address with a router on its home link, requesting this router to function as the Home Agent (HA). The MN informs its HA of the new CoA by sending a Binding Update (BU). The HA intercepts any packets addressed to the HoA of the mobile node and tunnels them to the mobile node at its registered CoA.

The Mobile IPv6 provides route optimization by enabling direct packet-routing between the MN and the Correspondent Nodes (CN). Route optimization allows the MN to send directly the binding updates to inform the CN about its current CoA.

However, Mobile IPv6 specification lacks support for mobile nodes with multiple interfaces used simultaneously [4].

Mobile IPv6 does not allow a MN to register multiple care-of addresses bound to a single home address. If a MN sends a BU for each care-of address, the HA overwrites the existing binding by the received binding update. The multiple care-of-addresses registration (mCoA) [3] is an extension of Mobile IPv6 that allows a mobile node to bind simultaneously several care-of-addresses to a home address. This helps the mobile node to use multiple network interfaces while being in foreign networks. This solution proposes a new identification called Binding Unique Identification (BID) for each interface. The

MN notifies the BID to both HA and CN by sending a binding update message. The CN and HA record the BID into their binding cache database and are able to distinguish the multiple care of addresses by using the BID. A home address identifies a mobile node itself and the BID identifies each network interface of the mobile node.

However, the drawback of the mCoA is when the mobile node has an interface connected to its home link and some of its interfaces connected to the foreign links. In this situation, it is not possible for the mobile node with the mCoA solution to use simultaneously all interfaces connected to the home link and the foreign link.

In this paper, we propose an extension to the mCoA solution allowing a mobile node to use simultaneously multiple interfaces everywhere (both in home and foreign links) and at anytime. Our solution defines the M bit (Multihoming bit), which is inserted in the router solicitation message and the router advertisement messages, allows the mobile to build CoAs even if it is in home network.

This paper is organized as follows. In section 2, we present the multiple mCoA and discuss its main limits. Our proposal to support multihoming on mobile node with multiples interfaces is given in section 3. Finally, a conclusion and future work is provided in section 4.

II. MULTIPLE CARE-OF ADDRESS REGISTRATION (MCOA)

As mentioned previously, the mCoA solution proposes an identification number (BID) that allows multiple CoAs to be bound to a same HoA. This solution is proposed for a mobile node having multiple CoAs and only one HoA [5].

In mCoA, when the mobile node is in a visited network, it obtains several CoAs on its interfaces. It can bind these addresses to its home agent. Firstly, the mobile node generates a BID number for each care-of address and records this binding into its binding update list. Then, it registers its CoAs to the HA by sending a BU with a Binding Unique Identifier sub-option [5].

As soon as a binding update message containing the BID is received, the HA checks the request and records it to binding cache database: If the HA gets a new BID defined in the suboption, the HA will create a new binding entry for the BID stored in the sub-option and will copy the BID and CoA from the binding update message to the binding entry. Otherwise, the HA will update CoA that corresponds to the BID stored in the sub-option [3].

Figure 1 shows an example of a mobile node with multiple network interfaces and multiple CoAs bound to a home address.

In this example, when the mobile node is in home network, it is registered at the home agent, and obtains its home address (e.g. a:b:c:d IPv6 address).

When the mobile node attaches to the foreign link, it sends a multicast Router Solicitation message on the foreign links. All routers on the foreign link reply with a Router Advertisement message. On receiving the Router Advertisement message, the mobile node can determine that it is connected to a foreign link since the router advertisement contains a new network prefix. The mobile node creates care-of addresses from the advertised prefixes.

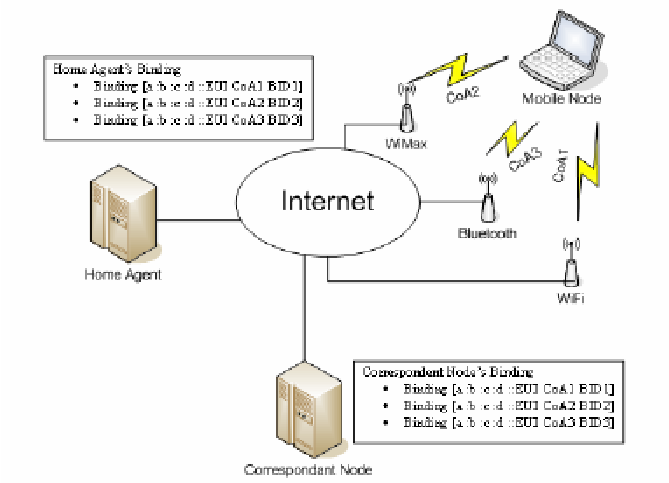

Figure 1 – An example of mCoA solution

Then it registers the care-of addresses at its home agent by generating a BID number for each care-of address and recording it into the binding update list. In addition, it registers its care-of addresses at the binding cache database of HA by sending a Binding Update with BID number in the sub-option. The HA updates the binding between HoA, BID and CoA in the binding cache database (HoA –BiD1 – CoA1, HoA – BID2 – CoA2, and HoA- BID3- CoA3). Whenever the MN moves and changes the CoA for a given interface, it sends a BU with the BID of the changed interface.

When the mobile node returns home, (in the sense that it comes back to the home network), there is a situation where the MN has an interface attached to home link and others interfaces attached to foreign links. In this situation, the MN can not use simultaneously all interfaces attached to both home and foreign links for the following reasons.

When returning home, the MN has multiple CoAs on the foreign links, but it cannot register these CoAs with its HA because the HA knows that the MN is at home link by using the proxy neighbor advertisement. It routes all packets to MN by the direct link through HoA. The links connected to foreign links become useless.

The mCoA solution offers the MN to choose between using the interface attached home link or the interfaces attached to foreign links but not all interfaces at the same time.

When the mobile node wants to use interface attached to the home link, the home agent will route all packets to MN by the direct link through HoA. It does not need to maintain the connectivity of interfaces on the foreign links when all packets are routed directly to MN by the direct link. mCoA forces to the MN to deregister all the Binding Update by deleting all the bindings from binding cache database of HA.

When the mobile node wants to use the interfaces attached to the foreign links, the mCoA solution disables the interfaces attached to home link and routes all packets to CoAs via tunnel. The MN keeps multiple CoAs binding in HA by sending binding update messages via the tunnels.

In the next section, we propose a solution that solves this problem and makes it possible to use multiple interfaces everywhere and at anytime.

III. THE PROPOSAL FOR MULTIHOMING

A. Introduction

In our context, the term *multihoming agent* is defined to refer to a mobility agent (home agent or foreign agent which is a mobility agent at visited network) that allows the MN to generate CoA based on network prefix received from the router advertisement message even if it is home network.

We define the *M bit (multihoming bit)*, which is inserted into *router solicitation message and router advertisement message* to allow the mobility agent to behave as a multihoming agent. The M bit is an additional flag in the router advertisement and router solicitation messages. It is encoded in the *"Reserved"* field (see figure 2).

When a MN wants to become a multihomed MN – it means that MN wants to use simultaneously multiple interfaces, it sends a router solicitation message to the mobility agents with the M bit set in order to inform the mobility agents that it is looking for a multihoming agent.

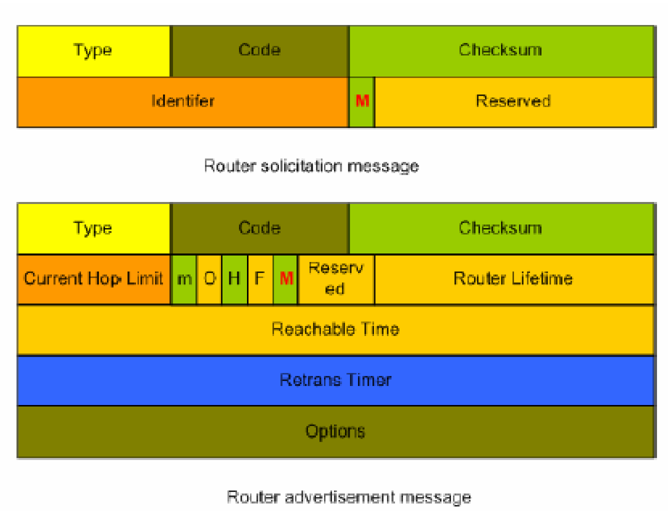

Figure 2 – M bit in router solicitation and advertisement message

As soon as the router solicitation message is received, the mobility agent (home agent or foreign agent) replies to the MN with a router advertisement message containing the M bit:

- If M bit is not set, this means that this mobility agent does not support multihoming. The operation will be the same as the mCoA operation: MN will check H bit (Home agent flag) and F bit (Foreign agent flag) in the router advertisement message. If H bit is set, this mobility agent is a home agent. If F bit is set, this mobility agent is a foreign agent.

- If M bit is set, this mobility agent supports multihoming. MN does not need to know what this mobility agent is (a home agent or a foreign agent); it will generate CoA from the network prefix stored in the router advertisement message and send BU to HA via a tunnel.

In the situation that the mobility agent (home agent or foreign agent) replies to the MN with a router advertisement message without having the M bit. MN understands that this mobility agent does not support multihoming. The operation is the same as the mCoA operation or Mobile IPv6 operation. It means that our solution can cooperate on the mCoA and Mobile IPv6 context.

B. Operation and scenario

We present now a scenario where the MN can use all interfaces attached to home link and foreign links. Figure 3 depicts the scenario: the MN has three interfaces attached to home link and foreign links. The MN has one HoA (e.g. – HoA : fec0:0:0:1). Each interface obtains a CoA. For example, the interface using Bluetooth technology obtains CoA1 (e.g. - fec0:1:0:1) from network prefix of foreign agent 1 (e.g. - fec0:1:0:0/64), the interface using WiMax technology obtains CoA2 (e.g. - fec0:2:0:1) from network prefix of foreign agent 2 (e.g. - fec0:2:0:0/64), and the interface using WiFi technology obtains CoA3 (e.g.- fec0:0:0:2) from network prefix of home agent (e.g.- fec0:0:0:0/64).

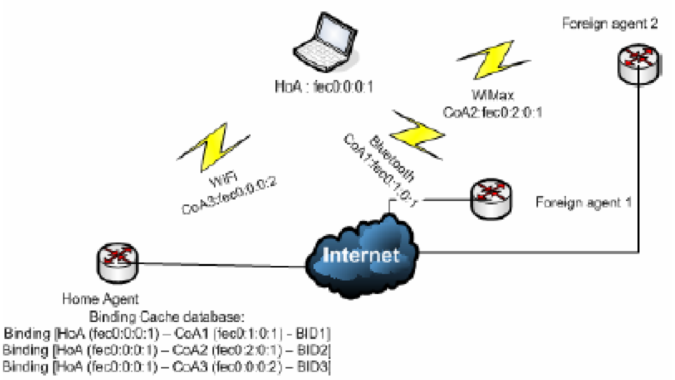

Figure 3 – A scenario of multihoming solution

Figure 4 depicts the operation of our solution:

1. The mobile node sends a multicast Router Solicitation message to all mobility agents. It sends this solicitation message with M bit set to query the mobility agent as to whether it supports multihoming.

2. All routers on the home link and foreign links reply with a Router Advertisement message with M bit set. From the receipt of the Router Advertisement message(s), the mobile node knows that it is connected to multihoming agents because the router advertisements contain M bit set. The mobile node forms care-of addresses from the advertised prefixes. For example, MN generates CoA1 (e.g. - fec0:1:0:1) from network prefix of foreign agent 1 (e.g. - fec0:1:0:0/64), CoA2 (e.g. - fec0:2:0:1) from network prefix of foreign agent 2 (e.g. - fec0:2:0:0/64), and CoA3 (e.g. - fec0:0:0:2) from network prefix of home agent (e.g. - fec0:0:0:0/64)

3. To register multiple care-of addresses at the home agent, the mobile node sends the home agent a binding update with the sub-option storing BID and CoA for each interface via a tunnel. The home agent receives the binding update and

then updates BID and CoA to its binding cache. The binding update operation is the same as the binding update operation of the mCoA solution.

4. The home agent responds with a binding acknowledgement to the MN to confirm that the binding update was done.

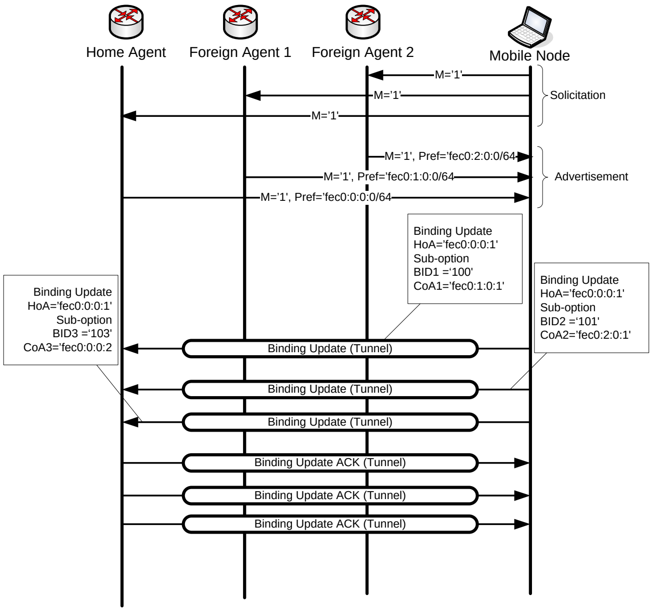

Figure 4 – Operation of multihoming solution

Our solution modifies the mCoA solution to solve the problem where the MN has one interface attached to home link and several interfaces attached to foreign links. However, when the MN sends a binding update to HA, it tunnels the packets to the home agent, even if the home agent is one-hop neighbor. We consider that the overhead due of one-hop tunneling is not significant and we plan to evaluate it in further work.

IV. CONCLUSIONS

In this paper, we propose an extension to mCoA solution to support the simultaneous use of multiple interfaces.

Our solution is based on the definition of M bit (multihoming bit) in the *router solicitation message and router advertisement message* that allows the mobile node to consider all mobility agents as *multihoming agents* and allows the mobile node to use simultaneously the interfaces attached to home link and foreign links.

Our solution extends the mCoA and thus provides an integrated solution for mobility and multihoming management.

This work is part of an overall framework we develop to implement a mobile node able to use simultaneously multiple interfaces to take advantage of *fault-tolerance/redundancy, load sharing* and *policy-routing* capacities provided by the host multi-homing concept and contributes to the workgroup Monami6.

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