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A Low Latency Inter-System Handover Scheme for Multiple Interfaces Terminal

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***Abstract*- Wireless Internet is expected to consist of many diverse wireless networks. The next generation network architecture will be dominated by the core IP network architecture and interface via access routers with multiple wireless access technologies. Each mobile node that supports multiple access technologies should be able to select the most efficient and cost-effective technology that supports the application QoS requirements. The Multiple Interface Management (MIM) can optimize the handover between different access technologies using the link layer triggers because the inter-system handover process involves both link layer and IP layer re-establishment. In this paper, we discuss the design and implementation of a pre-registration handover strategy in multiple radio access interface equipped terminal to support low latency handover scenarios. We utilize a unit called the MIM that runs on the mobile node to allow Pre-registration Request message to be carried out concurrently with the link layer handover progress. These overlapped operations reduce the latency of the MIP registration messages.**

***Key words*- Inter-System Handover, Pre-Registration, Multiple Interfaces Management, Mobile IP.**

I. INTRODUCTION

The next generation network architecture will be dominated by the core IP network architecture and interface via access routers with multiple radio access technologies (RAT). The co-existence of different radio access technologies needs intelligent selection of different access technologies, which has a significant impact on handovers issue in mobile networks. In particular, the change of access technologies during connections will incur inter-system handover. Contrary to intra-system handover which forwards an active connection from one coverage area to another of the same RAT, an inter-system handover implies switching from a serving area of a given RAT to another RAT. The handover involves several layers starting from the link layer up to the application layer. Its policies can be classified into three categories [1]: network controlled handover; network controlled and MN assisted handover; mobile-controlled handover. In IP-based heterogeneous networks, network controlled handovers have some disadvantages in case of inter-domain handovers, such as the security association, the complexity in network entities. The mobile controlled method gives the user much freedom to potentially select the most suitable service satisfying his needs.

In IP-based framework, handover involve redirecting IP packet flow to the MN's current point of attachment. Mobile IP can allow node mobility involving changes of point-of-attachment to the Internet. This approach, applied to a heterogeneous environment with frequent inter-system handovers, low-latency handovers are essential to avoid performance degradation and signaling overhead.

The multiple interface management can provide greater flexibility and richer variety of services into one terminal. Incorporating multiple Network Interface Cards (NICs) into one terminal is only a matter of time, as the price of NICs is rapidly coming down. The multiple interface management can optimize the handover between different access technologies using the link layer triggers because the inter-system handover process involves both link layer and IP layer re-establishment.

Regarding the disadvantages of network controlled handovers and immense benefit of multiple NICs implementation, in this paper we will consider mobile-controlled handovers initiated by the terminal with multiple interface management functionality, where the mobile terminal conducts the initiation and control of a handover. New algorithm for mobile controlled inter-system handover is presented and the software structure is also discussed. The remainder of this paper is structured as follows. In Section II we propose the MIM controlled Pre-Registration handover scheme, the inter-system handover in the framework incorporating the 3G and WLAN networks is also described in sub section C. In Section III we give a detailed description of the software structure as implemented Pre-Registration handover schemes. Finally Section IV concludes the paper.

II. THE MIM CONTROLLED HANDOVER SCHEME

A. Mobile IP Handover Scheme

The IETF Mobile IP [2] is a well-known approach for mobility support in IP networks. The required functionality for managing mobility information is embedded in three entities, the Home Agent (HA), Foreign Agent (FA), and Mobile Node (MN). There are two different types of care-of address (CoA): FA care-of address and collocated care-of address.

It is widely agreed that Mobile IP provides a good solution for macro mobility management in the network layer. In order to reduce the registration impact on the performance and the signaling overhead, Hierarchical Mobile IP mobility management schemes [3] has been introduced. This scheme defines protocols that allow movements within a domain to be handled locally. In order to reduce the packet losses during handover, new schemes have been defined, such as smooth handover [4]. However, these protocols are designed without any assumption regarding underlying layers. This layer separation results in lower performance during mobile IP handover.

There are two main factors that affect Mobile IP's handover performance: mobility detection, re-registration:

Mobile node need perform mobility detection to deduce whether it has changed the access network. The FAs send router advertisements that are used by the MNs to detect mobility. However, the router advertisement rate is rather low, e.g. the MIP specification [2] establishes a maximum rate of one router advertisement per second. Indeed, the MN can only start the registration process after completion of the L2 handover. Moreover, the normal MN is unreachable during the registration process, a property that may contribute to handover latency and packet loss. With multiple NICs, the mobile host can determine whether an inter-system handover is required or not during existing connection is not lost. It can be notified the incoming handover by the trigger from the candidate link layer while still keeping the current connection, which results in an accelerated handover.

Re-registration phase refers to the time after MN's mobility detection and till HA receiving the registration request. With Pre-Registration algorithm and multiple NICs, the mobile host can communicate via the old FA (oFA) with the new FA (nFA) to make pre-registration during the inter-system handover, which can shorten the Re-registration phase.

B. MIM Controlled Pre-Registration Algorithm

The IETF has proposed a low latency handover scheme relying on layer 2 triggers to be present in the system [5]. This scheme describes methods for a MN to conduct its registration with the nFA while still being connected to the oFA which is called Pre-Registration. The pre-registration handover scheme is based on an anticipated layer 3 handover. The MN can send a registration request to the nFA via the oFA (if the link layer handover is not completed) and the nFA issues a regional registration to the Gateway FA (GFA). Until the MN actually completes the Layer 2 (L2) handover to the nFA and establishes the new L2 link, the nFA can receive packets for which it did not have a link layer connection. The Pre-Registration as defined by the IETF rely on the presence of following layer 2 triggers in [6]:

- AT: Anticipation Trigger, occurs when the MN is about to move to a new AP;
- L2LD: Layer 2 Link Down Trigger, the MN has lost the connection with the old AP;
- L2LU: Layer 2 Link Up Trigger, the MN has made connection with its new AP.

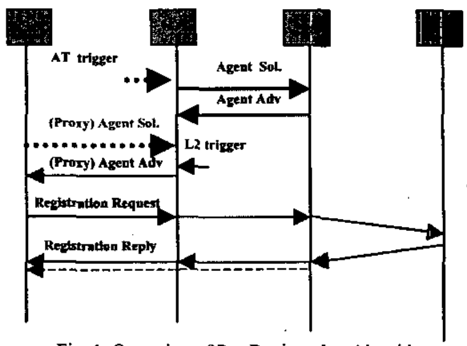

Fig. 1. Operation of Pre-Registration Algorithm

Fig. 1 shows the operation of existing pre-registration scheme in network initialed scenario, where AT is generated or reported to the link layer of network entity. The MN needs a Router Solicitation/Advertisement exchange between oFA and nFA to learn its new CoA. In the proposed MIM-initiated handover, the AT trigger is generated by the link layer of candidate interface in MN, which can notify the above sub-layer MIM of the coming event that it will shortly move to the nFA, dedicated scanning procedures are necessary to detect L2 dependent trigger, such as beacon signal detection from WLAN NIC, BCCH signal detection from UMTS NIC. The CoA can be acquired by a Router Solicitation/Advertisement exchange between oFA and nFA, as mentioned above. An alternative way to speed up CoA configuration is to embed IP addresses and prefixes in L2 broadcast. Then MIM sub-layer can initiate IP layer registration. The following messages are involved in Fig. 2: (We assume that the overlay networks can be deployed under the same GFA)

- Message 1, a Handover Request (HRqst), is issued by the MN as a consequence of the L2 trigger detection.

- Message 2, a forwarding Handover Request (HRqst), is sent by the oFA as a result of the HRqst message from MN.

- Message 3, a Regional Registration Request (Regional RegReq) with the GFA, issued by the nFA upon receiving HRqst from the oFA.

- Message 4, the Regional Registration Reply (Regional RegReply), sent by the GFA to the nFA.

- Messages 5, a solicitation for a Router Advertisement from the MN to the nFA and a reply Router Advertisement from nFA to the MN (Agent AD/Sol).

- Message 6, the Registration request sent by the MN to the nFA soon after the link layer handover finished, just in case the message 1 or 2 is lost, the nFA check whether it is same as the registration request forwarding from oFA, if not, nFA must issue regional registration for MN.

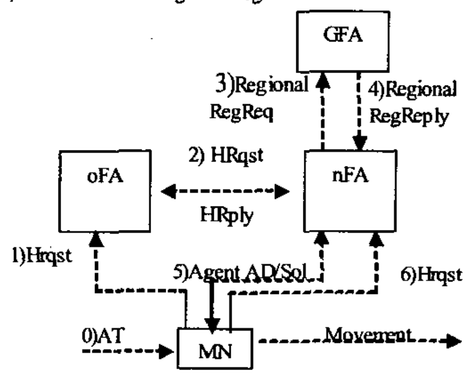

Fig. 2. Operation of MIM Pre-Registration Algorithm

When AT is generated by the link layer, the MN receiving the trigger sends a handover request (HRqst) to the oFA. The oFA extracts the nFA's IP address either from Router Solicitation/Advertisement exchange or MN's HRqst, and this allows the MN to communicate via the oFA with the nFA while still being connected with the oFA. The oFA forwards the HRqst to nFA, the nFA sends a handover reply (HRply) to the oFA. On reception, the nFA sends a normal registration request to the GFA, which subsequently updates its binding table and starts forwarding traffic for the MN along the new path to the nFA. The registration reply generated by the GFA and all following traffic arriving at the nFA before trigger L2LU is buffered until the MN has associated itself with the new AP. When the MN receives the trigger L2LU, it decides to initiate the Mobile IP registration process with the nFA itself. The nFA will check the registration with the buffered one forwarded from oFA, it will discard this message if it is same as the buffered one, otherwise it will issue regional registration to GFA. Once the registration process is complete (through the exchange of a Regional Registration Request and a Regional Registration Reply with the GFA), the nFA takes over the role of oFA. Now the MN completes the inter-system handover.

C. The Scenario of 3G-WLAN Integrating Network

In the following we will describe the proposed technique to support handover in a network architecture incorporating UMTS (3GPP), CDMA2000 (3GPP2) and WLAN access networks. Such an integrated architecture allows mobile users to roam between the 3G and WLAN context for access to their desired services. Mobile host will wish to select a certain underlying radio/wired technology supported by an access network. We assume that the mobile host has multiple network interface cards. Each network interface then communicates with the corresponding network interface in the base station/access point of the proper network.

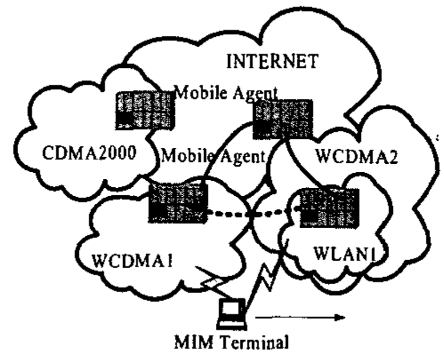

Fig. 3. Integrated 3G-WLAN Network Scenario

Fig. 3 depicts a 3G-WLAN integrated network scenario in hotspots. Before the MIM terminal can send data packets over WLAN, it has to keep connected with 3G network. The mobile node measures the IEEE802.11 beacons sent by the AP in order to decide which AP could provide the best connection. The L2 trigger can be implemented using IEEE802.11 as link layer protocol [7].

The mobility is detected upon receiving the first beacon from the new AP or the pilot signal from WCDMA2 subnet. The L2 beacons sent by new AP produce a L2 trigger at the MN indicating the imminent movement to this AP. Upon reception of this trigger and the possible trigger for imminent WCDMA2 subnet movement, the MN prefers to handover to WLAN than WCDMA2, it sends a registration request (indicated as HRqst) to the oFA (mobile agent in WCDMA1) with destination address of the nFA (mobile agent in WLAN1). Upon receiving this message, oFA in WCDMA1 subnet sends the handover request to the nFA. The signaling delay will decrease to a little extent because the two networks service area is overlapped. Upon receiving the HRqst, the nFA sends the handover reply and make MIP registration. After MN finishes the association with the nAP by receiving association reply from nAP, the MN then completes inter-system handover.

For the handover from WLAN to 3G networks, the handover procedure is similar as mentioned above. The handover triggers defined in [8] can be used to notify the MIM of the coming events for 3G network.

III. SOFTWARE STRUCTURE OF MIM IN MOBILE NODE

In the architecture proposed in this paper, a general scheme is easily derived for MIM terminal behavior:

- Measurements of available access points
- Report of measurement results
- Handover decision algorithm
- Notify higher layer of the decision

First, different measurements are performed in each radio access technology for analyzing the actual situation. These measurements should then be mapped into a common parameter independent from the RAT being used.

The key element of the software architecture is the MIM, which is responsible for monitoring all the network interfaces of the mobile. From the MIM software's point of view all network interfaces offer triggers, which the MIM can use to communicate with the available foreign agents. In order to register with the best foreign agent, MIM can also query the underlying network devices to obtain some parameters about the network, such as bandwidth, price, etc. The operating system may use system calls of application programming interface (API). A system call returns when that particular event is fired from link layer. As decisions involving application layers issues are even more dependent on customers personal preference, user preferences and profiles have to be considered in the decision making process. Fig. 4 shows the proposed MIM software structure in terminal.

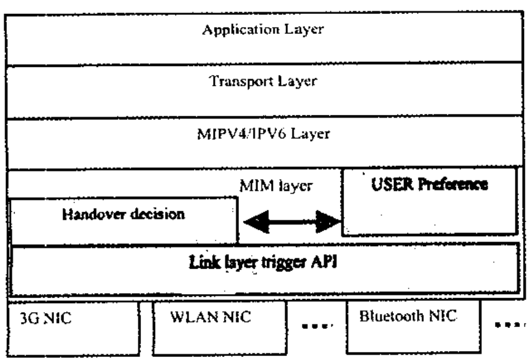

Fig. 4. Proposed Software Structure in MIM Terminal

In downward inter-system handover to smaller cell, MIM should use collocated care–of address which becomes more directly responsible for the packets it send out, and it therefore has more control over such decision. Remember being conservative in this situation, the registration request should only be sent out when nFA is confirmed to be stable. This consideration is to prevent unnecessary frequent handovers.

In upward inter-system handover to larger cell, MIM should use foreign agent allocated care-off address which can avoid decapsulate the packets itself which waste scarce radio resource.

IV. CONCLUSION AND FUTURE WORKS

In this paper we presented a MIM controlled pre-registration algorithm for inter-system handover. In the proposed scheme, pre-registration request messages are carried out concurrently with the link layer handover still in progress, by the help of link layer triggers for different access technologies. These overlapped operations reduce the latency of the MIP registration Request/Reply messages from the new FA to the remote HA or GFA after the link layer handover progress. Furthermore, we have described a possible implementation of this protocol in a 3G-WLAN integrated wireless network. New algorithm's software structure is also discussed in section III.

The proposed overlapped operations in multiple interfaces terminal reduce the latency of the MIP registration messages. The performance of the handover procedures strongly depends on the timing of the triggers. The path from the oFA to the nFA is of importance for the signalization: the smaller the routing distance between the FAs, the sooner registration message will be routed to the nFA. The simulation needs to evaluate how the timing of triggers impacts on the performance during inter-system handover.

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