An Enhanced Media Independent Handover Framework for Heterogeneous Networks

Wang Ying[1,2], Zhou Yun[1,2], Yuan Jun[1,2], Zhang Ping[1,2]
1: Key Laboratory of Universal Wireless Communications, Ministry of Education
2: Wireless Technology Innovation Institutes, Beijing University of Posts and Telecommunications
P.O. Box 92, BUPT, Beijing, China
wangying@bupt.edu.cn

Abstract—**Seamless Mobility in heterogeneous networks is difficult to be achieved because of various QoS requirements and complex heterogeneous network environments. Media Independent Handover (MIH) is used to handle such problem in IEEE 802.21 standard. However, only link layer dependent information is involved for the mobility decision. In this paper, an Enhanced Media Independent Handover(EMIH) framework and mobility management mechanism are proposed, in which new function entities(FEs) and modules are defined and used to provide link layer and application layer information from client side and network side to mobility decision engine. Compared with MIH, the EMIH provides more sufficient and comprehensive trigger events. The static and dynamic information are collected flexibly at mobile node (MN) and within the network infrastructure. Various handover types are designed to make use of such information to optimize the handover, which is illustrated by an example in this paper. The proposed EMIH architecture can benefit not only mobile users, but also network operators.**

Keywords- EMIH; 802.21; mobility management; heterogeneous networks

I. INTRODUCTION

The converged network can provide better services to the subscribers, and meet various requirements about coverage, high data rate etc. However, traditional horizontal handovers within a single network could not meet the seamless mobility requirement. Vertical handovers among heterogeneous networks should be supported to guarantee the service continuity. Furthermore, many factors disregarded by horizontal handover are useful for the trigger of vertical handover, such as load balancing among networks and better QoS experiences. Therefore, it is a promising topic on how to provide fast, seamless and intelligent mobility management mechanism in heterogeneous network environments.

Lots of efforts are devoted to interworking and seamless mobility techniques on the integrated all-IP network. In Europe, the relevant studies have been carried out in several projects such as Ambient Networks[1] and WINNER(Wireless World Initiative New Radio)[2]. In Asia, Ubiquitous Japan (u-Japan)project was evolved from e-Japan in 2004[3], which focused on the new society driven by extended information and communication technologies. And Mobile Ubiquitous Service Environment (MUSE) concept was proposed as a vision in China[4]. Moreover, System Architecture Evolution(SAE) in 3rd Generation Partnership Project(3GPP) dedicates itself to cope with interworking and handover signalling, which aims to solve seamless mobility between different packet-switched domains belonging to existing and evolving 3GPP access networks and non-3GPP access networks [5].

However, seamless mobility is a many-faceted challenge that needs to be addressed to alleviate today's restrictions on supported media, access technologies, devices or vendors. Recently a new specification namely IEEE 802.21 (Media Independent Handover) [6], is emerging to provide link layer intelligence and other related network information to upper layers to optimize handovers between heterogeneous media. The purpose is to enhance user experience of mobile devices by supporting handovers between heterogeneous networks. Furthermore it intends to provide as much generic link layer intelligence as possible without being tied into the features or specifics of particular terminals or radio networks. However, there still exist several limitations in MIH architecture as follows:

- In MIH, the handover process is typically based on measurements and triggers supplied from link layers, which disregards the influence of the application and user context information on mobility management.
- The network information provided by MIH lacks of flexibility since only less dynamic and static information is derived.

To solve the above-mentioned problems, an enhanced media independent handover (EMIH) is proposed in this paper. EMIH architecture adopts more comprehensive trigger events and abundant information to help handover decision making. Moreover, integrated all-IP networks can be divided into different administrative domains in heterogeneous environments. Two types of handovers are involved, that is, intra-domain and inter-domain handover. Centralized management may be necessary when inter-domain handover happens. Thus more information could be obtained to facilitate handover decision making, network selection and resource negotiation. The EMIH architecture supports different handover types to improve the performance of users and network operators.

The remainder of this paper is organized as follows. Section II gives a brief description of the proposed EMIH architecture. Then various trigger event criteria are

This paper is financed by Huawei Company and Project 60772112 supported by National Natural Science Foundation of China.

introduced to facilitate handover decision making in section III. Three steps to realize the handover procedure are described in section IV. Finally, the paper concludes.

II. Enhanced MIH Framework

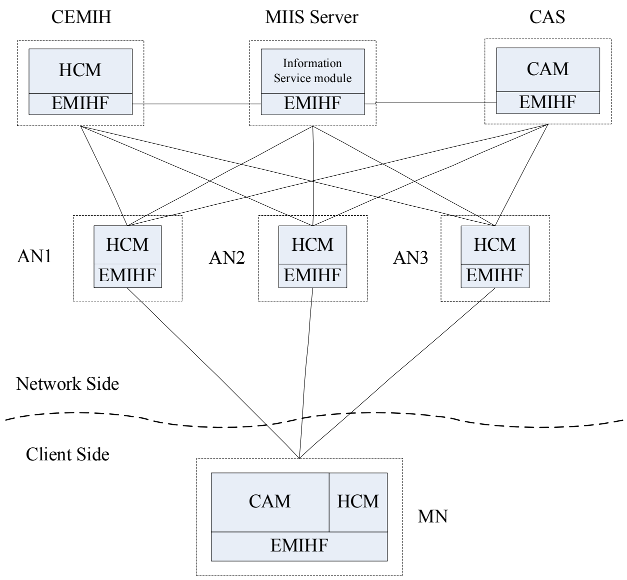

Fig. 1 Enhanced Media Independent Handover Framework

An enhanced media independent handover framework is proposed to improve the performance of mobility management between heterogeneous networks in this study, which is shown as Fig. 1. The motivation is to make use of the maximal available information in both client side and network side to optimize handovers. New function entities and modules are introduced to provide link layer, application layer, user and network information to mobility decision engine. EMIH deploys comprehensive trigger event criteria and flexibly collects the static and dynamic information available at mobile node (MN) and within the network infrastructure, which will be used to optimize the handover decision making in the proposed framework. It should be emphasized that overall mobility management architecture possibly includes Mobile IP infrastructure (client, HA and so on) or any other mobility schemes. EMIH benefits from the application dependent information and user-aware information on mobility. Fig. 1 illustrates the key entities both in client side and network side.

Client Side

EMIH consists of three important entities in Mobile Node (MN) as follows:

- EMIHF (EMIH Function): EMIHF is a logical entity that facilitates handover decision making. It not only provides link layer intelligence to higher layer, but also offers a unified interface between different access schemes and different upper layer applications. The services provided include MIIS, MIES and MICS.
- CAM (Context-Aware Module): CAM identifies information of MN and then generates trigger events accordingly. The information consists of the application information, user context and the capability of MN. The trigger events include Application_QoS_Change and User_Aware_Change.
- HCM (Handover Control Module): HCM has capabilities to support MN controlled handover in client side. The trigger events and related information are then transferred to HCM through EMIHF to facilitate the handover decision.

There are two sub-modules in HCM, namely trigger FE and handover FE. The trigger FE provides the functions as follows:

- Subscribing trigger events from CAM, CAS (context-aware server) or link layer;
- Collecting and identifying various triggers;
- Filtering events according to trigger criteria;
- If triggered, preparing necessary events for handover FE.

Trigger mechanism is intelligently realized in trigger FE. The handover decision is then made in the handover FE. Finally handover is performed and some mechanisms are adopted to maintain service continuity (e.g. context transfer, resource reservation).

Various trigger events are transmitted into trigger FE by EMIHF. Once the trigger FE makes a decision to initiate a handover, it will notify the handover FE and then handover FE selects a favorite network intelligently.

Network Side

Main entities include Access Network (AN), Media Independent Information Service Server (MIIS Server), Context-Aware Server (CAS), Control EMIH (CEMIH).

- Access Network (AN): The basic entity in network side is EMIHF. HCM used in AN has capabilities to support network controlled handover. There are also two components in HCM of MN. The trigger FE receives the trigger events and the handover FE controls intra-domain handover. The signaling is terminated at AN so that the handover procedure is simplified without participation of core network.
- MIIS Server: MIIS Server is a function entity including two entities: EMIHF and Information Service module. The network related information is collected in MIIS and can be accessed by EMIHF in other entities.
- CAS: CAS dynamically identifies network context and then generates trigger events accordingly. The trigger event offers the information of network context change, which is denoted by Network_Context_Change. The generated trigger event is transmitted from CAS to subscribers (e.g. HCM in AN) through EMIHF.
- CEMIH (Control EMIH): CEMIH includes EMIHF and HCM. In the heterogeneous environment, the network is divided into different administrative domains. Centralized management may be necessary when inter-domain handover happens. CEMIH belongs to a centralized control entity and provides some controlling functions. There are several functions in CEMIH including collecting trigger events, initiating a handover, controlling handover signaling to pass core network, and selecting a target network. In addition, CEMIH may reserve resources for a handover and provide users necessary guidance for handover. The centralized management mode ensures a comprehensive information collection and a reasonable

decision within the whole domain. More flexibility can be obtained by combining with different mobility protocols and location management.

In summary, all logical entities communicate with each other through EMIHF, which is implemented in either client side or network side. CAM or CAS identifies the useful information (e.g. application layer information, user context or network context). New trigger events are generated and then transmitted to HCM through EMIHF. HCM makes used of information of Lower (L2/L1) layer and higher layers from client side or network side. A reasonable decision can be obtained thereafter.

III. TRIGGER EVENT CRITERIA

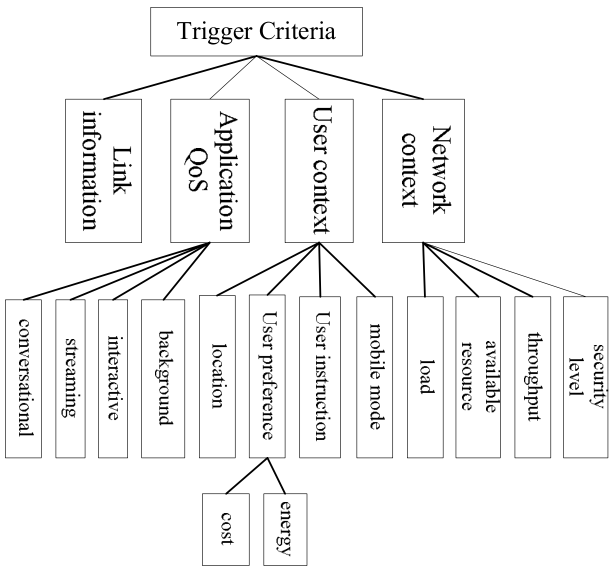

Fig. 2 Event Categories

In general handovers may be initiated either by mobile node or by network side. The current 802.21 specification explicitly defines events that may be relevant to handover, which may originate from MAC, PHY or MIHF either at the mobile node or at the network point of attachment. Thus, the source of these events may be either local or remote. In addition, the specification defines several categories of events, such as MAC and PHY State Change events, Link Parameter events, Predictive events, Link Synchronous events, Link Transmission events. All of these events are related with link quality information. Thus, these events are generated according to link information criteria. However, in heterogeneous network environments, handover may be triggered not only by link quality information, but also by other factors, such as application QoS, user context, network context. As an example, when the type of service is changed from voice to video, it is preferable to use a new network with high data rate. In this case, network selection and handover is decided by QoS requirement. Events may originate from upper layer. In this paper, a set of trigger events is proposed, which is more sufficient than MIH.

Fig. 2 shows all event criteria defined in EMIH. The Media Independent Event service detects events and delivers triggers from both local and remote interfaces. All these events could be originated locally or remotely. The criteria include link quality, application QoS, user context and network context. Some criteria can be further categorized. Unlike MIH, EMIH defines some new trigger events for the trigger criteria besides link layer triggers, which are Application_QoS_Change, User_Aware_Change and Network_Context_Change. These new trigger events are generated by some sources such as the application layer, which are disregarded in MIH but can provide valuable information for handover decision.

IV. MOBILITY MANAGEMENT IN EMIH FRAMEWORK

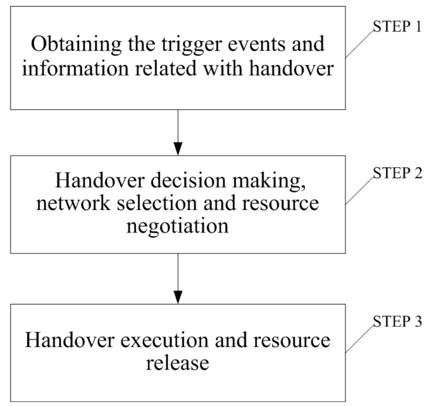

Fig. 3 Procedure of Mobility Management

The process of providing effective mobility management in EMIH architecture mainly includes three steps, shown in Fig. 3. The procedure is described as follows.

STEP 1 Obtaining the trigger events and information related with Handover

The handover process may be conditioned by the measurements and triggers offered by different sources, such as the link layer or application layer, or network context from network side. There are two methods to obtain the required trigger events and the related information for EMIH users (HCM or upper layers).

The first method is registration mechanism. The registration mechanism enables an endpoint to register its interest in particular event type. After registration, the EMIH users may specify a list of events for which they wish to receive notifications from the EMIH Function. MIH users may specify additional parameters during the registration process in order to control the behavior of the Event Service.

The second method is query/response mechanism. The query/response mechanism is to retrieve the available information. EMIH users may send a request to CAM, CAS or MIIS Server with additional parameters. In this case, the prior registration is unnecessary. The corresponding response includes either application/user information in client side or the static or dynamic information in network side.

Event registration provides a mechanism for upper layer entities to receive events selectively:

- In network controlled handover, HCM in the network (Access Network or Core Network) can register trigger events with CAM in MN or CAS in network through EMIHF. The specific events are transmitted to HCM at any proper time to optimize the handover decision.

- In MN controlled handover, HCM in MN can register trigger events with CAS in network or CAM in MN through EMIHF. Then events are transmitted to HCM to assistant handover decision when some specific conditions happen.

When the event originates at any layers of the protocol stack within an MN or network entity, EMIHF on that entity obtains the event locally through the service primitives of the SAPs that define the interface of EMIHF with the layer. When the event originates at a remote network element, the EMIHF on the local network element obtains event through MIH message exchanges with a peer EMIHF instance that resides in the remote network element. And then events are dispatched to EMIH users that have subscribed or queried these events in the local stack.

STEP 2 Handover decision making, network selection and resource negotiation

If a handover is triggered, a target network should be selected. Most of the existing network selection algorithms are classified into three types: policy-based, fuzzy logic based and multiple attribute decision making(MADM)-based. The aims of these algorithms are to find an optimal network from the point of users. The available bandwidth from the candidate network is a key factor in network selection. Generally maximum available bandwidth is a performance matric for end users. However, few algorithms consider the benefit of network operators. For example, IEEE 802.16e system is more suitable for data users, while for voice users it works with low efficiency. In this situation, 802.16e network operators prefer data users to voice users. And this should be considered in network selection algorithm. In this paper, a reference network is defined in the EMIH architecture to avoid wasting resources. Reference network is a virtual target network and set by MN/network according to the requirements of current service type. The aim is to find an appropriate network, but not an optimal one. The reference network and other candidate access networks will be ranked according to certain policy. And finally the one before the reference network will be selected as the target network. Therefore, both user experiences and resource efficiency could be guaranteed in this mechanism.

Then current network sends handover preparation request to target network, with the information of MN capability and context. The MN context includes a permanent user identity and other information, e.g. security and IP bearer parameters. The target network will reserve resources for MN command to reduce interruption time.

STEP 3 Handover execution and resource release

Mobile IP (MIP) may be adopted for mobility management in 4G mobile system [8]. After link layer handover, MIP signaling will be exchanged over radio interface to update route. Bi-casting or data forwarding mechanism may be deployed to minimize packet loss. Finally, the resources in source network will be released.

EMIH supports various handover types. For example, handover can be controlled by MN or Network. The type of handover can be selected when the signaling needs to be centralized by CEMIH.

In addition, handover can be initiated either by MN or by network. In general, for intra-domain handover, signaling usually terminates at access network in order to achieve faster processing and lower handover delay. While for inter domain handover, CEMIH located in core network may be necessary to provide a unified control.

Fig. 4 gives an example of MANC (Mobile assistant network control) handover, where there is no unified control by CEMIH and handover is initiated by MN. The procedure possibly needs some modifications in some other handover types.

The Mobile-initiated Handover Procedure, shown in Fig. 4, is as follows:

1) MN is associated to AN1. CAM of MN identifies application layer and user context continually;
2) CAS in network side identifies network context of AN1;
3) CAS identifies network context of AN2 simultaneously;
4) According to collected information, CAM or CAS makes decision on generating trigger event;
5) Application_QoS_Change event is triggered due to higher bandwidth requirement of a new application. The related user context is carried by this trigger and transmitted to HCM of AN1 through EMIH Function;
6) After received trigger event, HCM queries dynamic network information from CAS accordingly;
7) CAS responds to HCM with related information;
8) After received trigger event, HCM queries static network information from MIIS server accordingly;
9) MIIS server responds to HCM with related information;
10) Then handover happens.

In this procedure, the trigger can be anyone of the events defined in section III. Thus, effective mobility management decision is achieved in EMIH.

After handover is performed, maybe there are some changes of network status (e.g. data rate, available bandwidth). Therefore, in order to guarantee users experience, related QoS information in application layer should be adjusted accordingly. A new command service named Application_QoS_Adjust is defined in this paper. It can be used to adjust the QoS information of application before or after handover. This command service will be transferred through EMIHF from network side to client side.

Given such command service, the application layer in MN will prepare for the incoming adjustment. If handover has not been finished yet, the receiver may degrade the QoS level and adjust coder/decoder rate accordingly. Here, QoS level means QoS class and ARP (Allocation and Retention Parameters) class. There are three priority classifications in all QoS classes, known as Allocation/Retention priority classification. That is, new priority levels are introduced by ARP. If handover procedure is over, the receiver may resume the original QoS level. Moreover, if Session Initiation Protocol (SIP) is adopted [9], the session setup requests some characteristics (e.g. bandwidth) of end terminals by using Session Description Protocol (SDP) [10].

V. CONCLUSION

This paper discusses an enhanced media independent handover framework and its mobility management mechanism based on IEEE 802.21. In this architecture, some new FEs (e.g. CAS, CEMIH) and modules (e.g. CAM) are presented. In addition, comprehensive trigger criteria are defined and various flexible handover schemes are designed to provide seamless and effective mobility management. This mechanism provides adaptive adjustment according to application change, user and network information. All of events defined in this paper follow the basic criterion of IEEE 802.21 standard. Therefore, the proposed EMIH framework and its mobility management mechanism are easy to implement in IEEE 802.21 standard.

ACKNOWLEDGEMENT

The authors of this paper thank Yao Zhonghui, He Cheng from Huawei company for their helpful discussions and suggestions. Their support is gratefully acknowledged.

REFERENCES

[1] N. Niebert et al., Ambient Networks: An Architecture for Commun. Networks Beyond 3G, IEEE Wireless Commun., vol. 1, no. 2, Apr. 2004, pp. 14–22.

[2] http://www.ist-winner.org/ "Impact of cooperation schemes between RANs" final deliverable, IST-2003-507581 WINNER D4.4 v1.0.

[3] http://www.itu.int/osg/spu/ni/ubiquitous/Papers/UNSJapanCaseStudy .pdf.

[4] Ji Yang; Zhang Ping, MUSE: a vision for 4G service and architecture, IEEE 60th VTC2004-Fall, Volume 7, 26-29 Sept. 2004 Page(s):4842 – 4845.

[5] 3GPP Technical Specification Group Services and System Aspects, 3GPP System Architecture Evolution: Report on Technical Options and Conclusions (TR 23.882), v1.3.0 Aug. 2006.

[6] IEEE P802.21/D05.00, Draft Standard for Local and Metropolitan Area Networks: Media Independent Handover Services, April 2007.

[7] 3GPP TS23.107, Quality of Service(QoS) Concept and Architecture, v.7.1. 0, September 2007.

[8] D. B. Johnson, C. Perkins and J. Arkko, "Mobility Support in IPv6," IETF RFC3775, June 2004.

[9] J. Rosenberg et al., "SIP: Session Initiation Protocol," IETF RFC 3261, June 2002.

[10] M. Handley and V. Jacobson, "SDP: Session Description Protocol," IETF RFC 4566, July 2006.

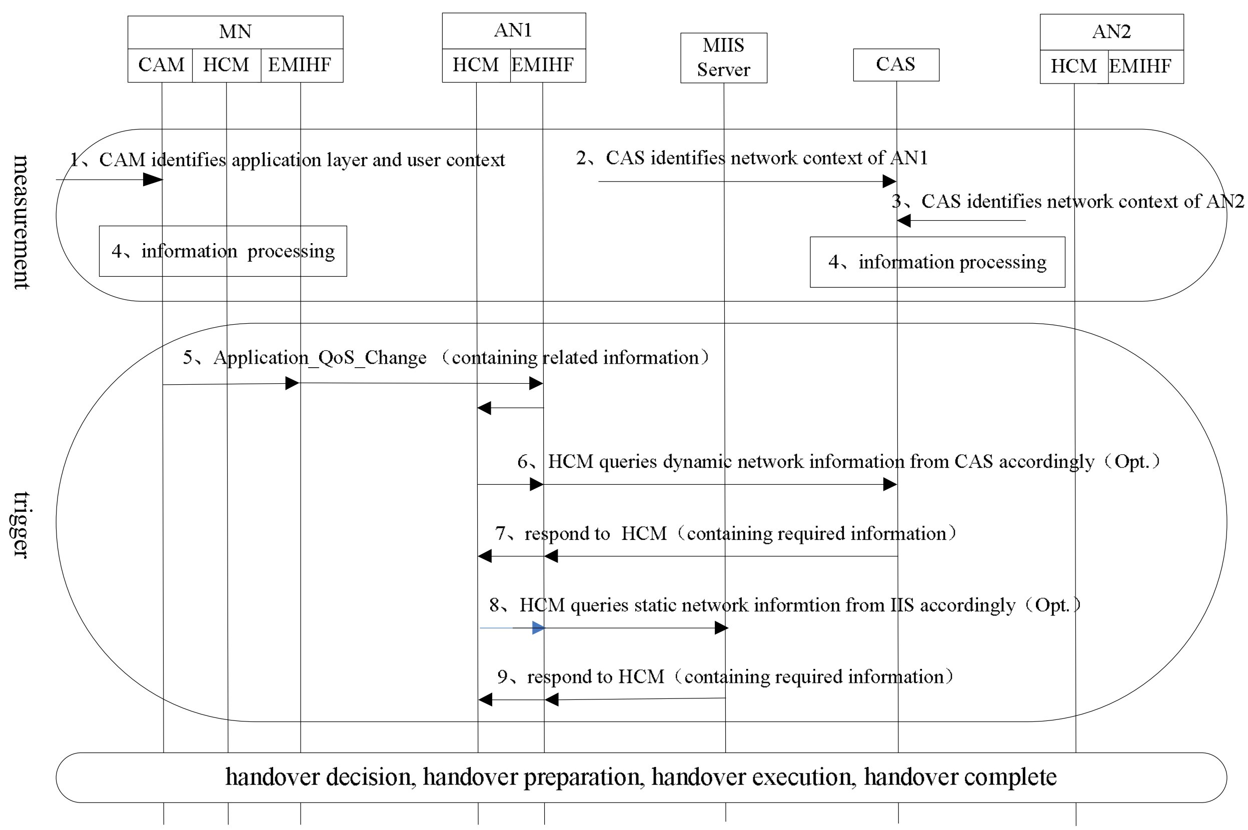

Fig. 4 Examples of MANC Handovers