A Novel Middleware for the Mobility Management Over the Internet

Lei Zhang, Patrick Sénac, Emmanuel Lochin
ISAE - LAAS/CNRS
Université de Toulouse
Toulouse, France
{firstname.lastname}@isae.fr

Michel Diaz
LAAS/CNRS
Université de Toulouse
Toulouse, France
diaz@laas.fr

Abstract

The features of mobility, which enormously impact on how communication is evolving into the future, represent a particular challenge in today's wireless networking research. After an identification and evaluation of the gap between the discontinuities of the communication service inherent to the physical layer of mobile networks and the continuity requirements issue from the stream centric multimedia applications, we propose a novel middleware 3MOI (Middleware for the Mobility Management Over the Internet) which can support efficient and context-aware mobility management and satisfy new mobility requirements such as dynamical location management, fast handover, and continuous connection support.

1 Introduction

Mobility management has become one of the most challenging topics. In [5], we have already introduced a cross-layer based communication architecture for end to end mobility management over the Internet. Based on the current advances on mobility management, we have developed a middleware composed of innovative configurable mechanisms that aim to satisfy advanced mobility requirements and make the mobility management more efficient. This paper briefly details the different configurable modules of our proposed middleware (3MOI) developed in Java framework and presents demonstration scenarios showing the benefits for the user in terms of QoS enhancement and seamless communication support.

2 Mobility Management Middleware

In today's wireless access networks, the most challenging issues to provide efficient management of wireless mobile communication focus on the following aspects: the capacity of supporting continuous connection; efficient physical and logical location management; efficient handover management; awareness of the dynamic mobility context; and finally establishing the interaction between the upper layers and the lower layers.

Keeping the above concerns in mind, we propose a middleware for the mobility management over the Internet (3MOI) which involves both end to end and cross layer mechanisms. Figure 1 presents the 9 modules of the global structure of 3MOI: the Signal Analysis module (SA); the Energy Control module (EC); the MAC layer Optimization module (MO); the Geo-Location module (GL); the Location Management module (LM); the Mobility Prediction module (MP); the HandOver module (HO); the QoS Management module (QM); and finally the Seamless Streaming support module(SS). We briefly detail the purpose of each module in the following sections.

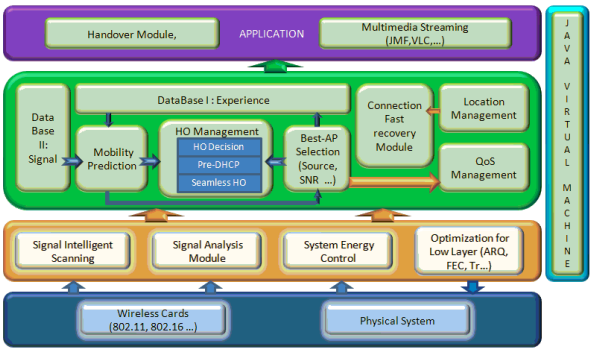

Figure 1. Structure of 3MOI

2.1 Signal Analysis Module (SA)

The SA Module allows an intelligent collection and analysis of the signal information (SNR, Rx power, MAC layer parameters, etc.) from lower layers. It is composed by 3

978-1-4244-2100-8/08/$25.00 ©2008 IEEE

sub-modules: 1) *Dynamic Monitoring Interval Engine:* this sub-module manages the optimal interval to collect the signal information from the associated and surrounding visible BS or APs. For instance, the collection frequency of signal information becomes higher when MN moves to the edge of the BS or AP, since the collected information is more useful in the critical points for the procedure of handover management. 2) *Signal Evolution Prediction engine:* this sub-module integrates an intelligent signal filtration process to synthesize the collected signal information and estimates the future evolution of signals. Cooperating with the HO decision engine (see 2.7), it helps to estimate an optimal moment to start the handover procedure. 3) *Detection of Environment Signal Distribution:* this sub-module processes and analyses the signals vectors from all the APs visible around the mobile node and is useful for the Geo-location management.

2.2 Energy Control module (EC)

This module collects system resources (battery, CPU utilization, etc.) in real time. In case of battery save mode and the capacity of the MN to access concurrently to heterogeneous access networks; it estimates the optimal wireless network to be associated with according to the available QoS and the power level. It also allows optimizing the CPU utilization and disabling services/modules which are not indispensable when energy is critical.

2.3 MAC layer Optimization (MO)

In the context of wireless networks, the upper layers are blind to the available bandwidth resource available at the MAC layer; this discrepancy results in the degradation of the quality of transmission. In order to ameliorate this deficiency, this module makes the upper layers aware of the characteristics of the MAC layer, QoS is then improved with the help of cross layer based flow control engine. According to the dynamic signal evolution, this module is also capable of applying various error control mechanisms (FEC, ARQ, etc.) for enhancing the QoS delivered to upper layers.

2.4 Geo-Location module (GL)

This module currently works in the context of WLAN, two techniques are involved: Signal Propagation Model (e.g. Signal Triangulation Model) and technique of Fingerprinting [1]. The later requires a data base of n-uplet signal power associated with different geo-positions.

2.5 Location Management module (LM)

This module delivers end to end location management support. It makes the dynamical addresses of mobile nodes be transparent to other nodes across the Internet. Two options have been studied and integrated: Dynamic DNS (DDNS) [4] and HIP Rendezvous server mechanism (RVS) [2]. Dynamic DNS is more adapted to infrequently moving nodes, while RVS fits better with frequently moving nodes. This service prevents transport connection from being cut off even when both corresponding mobile nodes migrate simultaneously.

2.6 Mobility Prediction module (MP)

The MP module provides mobile nodes a context-aware environment and helps to take proactive measures in order to guarantee different services. Our mobility prediction module is based on several interlaced techniques: 1) the second-order Markov model from [3]; 2) the mobile users' profiles in time and spatial scale and 3) the geo-Location module (GL) to improve the precision of the prediction. Based on this mobility prediction module, some pre-reservation based services (e.g. adaptive buffering, network resource pre-reserving and DHCP pre-reserving, see 2.7) can greatly improve the performance of the handover and transmission quality.

2.7 HandOver module (HO)

The handover module is composed by 4 sub-modules: 1) *HO decision engine:* this sub-module determines the optimal moment to start handover procedure based on the Signal Evolution Prediction Engine of module SA and the current transmission QoS with module QM. 2) *Best AP selection engine:* this engine chooses an optimal AP according to the Detection of Environment Signal Distribution engine of the SA module and the QoS observed from the BS around mobile nodes. 3) *Handover delay minimization engine:* Minimize HO delay with an in-advance address reservation mechanism (Pre-DHCP) which pre-acquire an IP address of the next subnet via the current AR and some intelligent HO mechanisms (i.e. RTT Estimation based mechanism). 4) *Handover awareness engine:* Full visibility of wireless connections and the related management of Handoff robustness.

2.8 QoS Management module (QM)

This module monitors in real time the QoS parameters (application requirements, bandwidth, latency, loss rate, network available resources) of the current and adjacency wireless network (with the help of a light ambient QoS service delivered by the access networks). The adapted services and control mechanisms (congestion control, error control, etc.) can be dynamically configured according to the varying QoS. It also can cooperate with the HO module to improve the quality of handover management.

2.9 Seamless Streaming module (SS)

Finally, the module SS can be considered as a multimedia based extension to JMF (Java Media Framework) and VLC [1], it cooperates with the other 8 modules to provide performance enhanced streaming transmission. The main object of the mobility management, which is to support as far as possible seamless communication over wireless access networks, has been validated by this module.

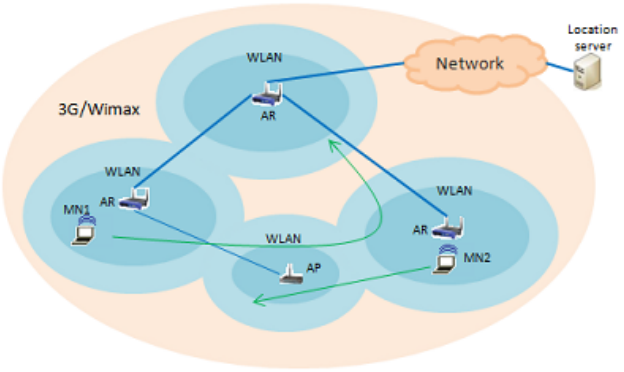

Figure 2. Scenario 2

3 Demonstration scenarios

The middleware is implemented in Java and offers a user-friendly graphical interface to users. In our demonstration, through two typical scenarios, we will show how 3MOI induces important improvements in mobility management performances. More precisely, the first scenario demonstrates that, by applying at the transport layer various error control (FEC, ARQ, etc.) and intelligent rate control mechanisms which are aware of the WLAN MAC layer QoS from cross layer information exchange, the QoS delivered to upper layers is greatly enhanced and the fairness issues as well as the performance anomaly syndrome are substantively improved. The second scenario considers two mobile nodes (equipped with our JAVA based middleware) that transmit/receive multimedia flows to/from each other are migrating across different WLAN networks (Figure 2); this scenario demonstrates that our end to end communication architecture for mobility management can significantly enhance handover performances and deliver seamless communication support which cannot be achieved with traditional solutions. Moreover, all the fundamental parameters exploited by our agile, context-aware and adaptive communication architecture, such as the signal power, low layers' parameters, mobility prediction results, position of mobile nodes according to an imported map, network resource and status, etc are displayed in real time through a graphical interface (Figure 3). For the purpose of this demonstration, our networking infrastructure will be based on at least two access routers and a mobile node equipped with media server.

[1] http://videolan.org/

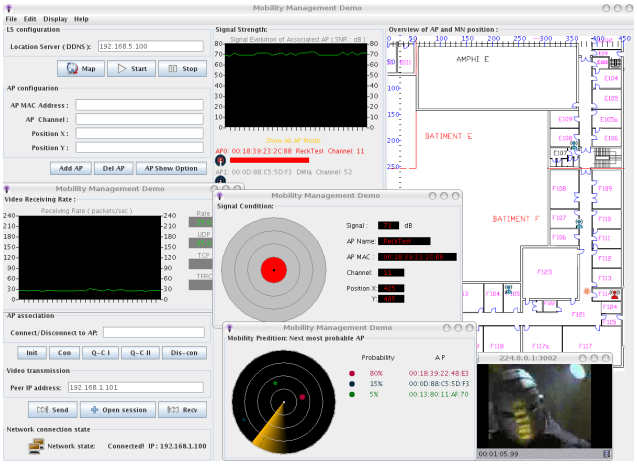

Figure 3. Graphical interface of 3MOI

4 Conclusion

In this paper, we present a middleware for the mobility management over the Internet (3MOI) as well as several integrated novel mechanisms which have been proposed in the framework of our research on the efficient management of mobile multimedia communication. In particular, we experimentally demonstrate through various scenarios how the different modules involved in the 3MOI can closely cooperate to significantly enhance QoS of mobile communications.

References

[1] R.-H. Jan and Y. R. Lee. An Indoor Geolocation System for Wireless LANs. In *International Conference on Parallel Processing Workshops*, 2003.

[2] J. Laganier and L. Eggert. Host Identity Protocol (HIP) Rendezvous Extensions. Internet Draft (Work in Progress) draft-ietf-hip-rvs-05.txt, IETF, 2006.

[3] M. H. Sun and D. M. Blough. Mobility Prediction Using Future Knowledge. In *ACM Symposium on Modeling, Analysis, and Simulation of wireless and mobile systems*, 2007.

[4] S. Thomson, Y. Rekhter, and J. Bound. Dynamic Updates in the Domain Name System (DNS UPDATE). Request For Comments 2136, IETF, 1997.

[5] L. Zhang, P. Sénac, and M. Diaz. A Generic Communication Architecture for End to End Mobility Management in the Internet. In *AusWireless2007*, 2007.