QOS SCHEME BASED IEEE 802.21 MIH IN HETEROGENEOUS WIRELESS NETWORKS (HWNS)

Khitem BEN ALI[1], Faouzi ZARAI[1], Mohammad S. Obaidat [2], Fellow of IEEE, and Lotfi KAMOUN[1]

[1] LETI laboratory, University of Sfax, Tunisia
[2] Computer Science and Software Engineering Department, University of Monmouth, NJ 07764, USA and ECE Department, KUSTAR, UAE
faouzi.zarai@isecs.rnu.tn

Abstract

The vision of next generation networks is an all-IP network supporting heterogeneous wireless access technologies to accommodate a variety of services and traffic types and to allow the mobile user to roam within the service area or across the different networks without degrading the Quality of Service QoS provided. An approach to optimize these roaming procedures through the introduction of a standardized framework is followed by the IEEE 802.21 working group. This paper thus involves in Call admission control and handoff scheme to maximize system reward for network providers and to guarantee QoS-aware seamless handoff for mobile users. Thus, we propose a mobile-assisted vertical handover mechanism which exploits the IEEE 802.21 framework and support the provision of QoS and the efficient utilization of radio resources.

Keywords - Heterogeneous Wireless, Call Admission Control, Vertical handover, IEEE 802.21 MIH, QoS.

1 INTRODUCTION

The expected evolution of mobile communications will offer several radio access technologies (RATs) with different characteristics served by a common core network. In this way, it is envisaged that next generation wireless networks (NGWN) will utilize several different radio access technologies, integrated to form a heterogeneous network. These different networks ought to be inter-connected in an optimum manner with the ultimate objective to provide the end-user with the requested services and corresponding QoS requirements. One of the most challenging problems for coordination is vertical handover (VH), which is performed when a mobile node moves between two different wireless networks. Several challenges in VH include: 1) receiving different RSSs from different-type networks, 2) mapping service classes between different-type networks, 3) determining the optimal target network to handoff in and avoiding vibrating data rate. In addition, the Quality of Service measurement is one of the important concerns in the NGWN which are expected to pose many challenges to the researchers with respect to Radio resource management (RRM). The resource management is the key enabler of seamless and transparent user roaming and efficient user personalization in a Wireless Heterogeneous Networks (WHNs) context. There are few main concepts for future resource management implementations envisioned today. They are based on different solutions and algorithms implemented in several architectures: JRRM (Joint Radio Resource Management) [1], MRRM (Multi-access Radio Resource Management) [2] and CRRM (Common Radio Resource Management) [3]. CRRM, devoted to coordinate and optimize the usage of the several heterogeneous radio access interfaces. The idea of CRRM is to co-exist with the given RRM of the different RATs and to coordinate their operation. In addition, currently there is an ongoing effort by the IEEE on standardization of the so called Media Independent Handover (MIH) framework under the IEEE 802.21 standard [13]. The IEEE 802.21 framework enables the optimization of handovers between heterogeneous IEEE 802.11 systems as well as between 802.11 and cellular systems. The IEEE 802.21 standard facilitates the handover between different wireless networks in heterogeneous environments regard less of type of medium. IEEE 802.21 [4] proposes a MIH specification for achieving seamless handoff while mobile stations traverse around mobile wireless networks (MWNs) consisting of various networks: WiMAX and WiFi, and cellular communications (i.e., 3G WCDMA, 3.5G HSDPA/HSUPA, Long Term Evolution LTE/LTE-Advanced, etc.). The goal of the IEEE 802.21

standard is to improve mobile nodes' usage experience by providing uninterrupted handover in heterogeneous networks. Clearly, several keys that should be considered in MIH, including CAC, seamless mobility, power control during handoff, channel selection of physical layer, received signal strength (RSS), etc. This paper proposes a mobile-assisted vertical handover mechanism. Thus involves in CAC and handoff to maximize system reward for network providers and to guarantee QoS-aware seamless handoff for mobile users. Furthermore, we present a network selection architecture and scheme which exploits the IEEE 802.21 standard and support the provision of QoS that provide a resource efficient mobility management that aim at selecting the most suitable network interface for each application. Our proposed architecture intends to resolve some limitations by satisfying user preferences while guaranteeing a best network resources management.

The remainder of this paper is organized as follows: In Section 2, we give some related works. The section 3 discusses the proposed scheme. Section 4 presents the simulation results and finally we conclude the paper in section 5.

2 RELATED WORKS

The dynamic vertical handover during the traffic serving phase is used to make the performance variance smooth and call admission is used to provision static QoS guarantee during the admission phase. However, there is a fairly small amount of research work [1, 5] that specifically addresses this problem. The authors in [1] define a specific approach (based on the JRRM framework) for beyond 3G wireless heterogeneous systems capable of adapting to the resource assignments of the specific system conditions and service QoS demands. In [5], a resource allocation mechanism is also implemented, in which the differentiation between the data and voice calls are made by using different thresholds. RAT selection algorithms are part of the RM algorithms. A number of RAT selection algorithms are available for initial RAT selection and vertical Handover. A good review of RAT selection policies are listed in [6] and [7]: load balancing based RAT selection, service based RAT selection. Under the load balancing based selection policy, a call or a data session is always allocated to the least loaded network to achieve load balance and to prevent the situation that a connection is rejected by a highly loaded network. This research work [7] proposes an algorithmic approach to select the best access network among Wireless Wide Area Network (WWAN) and Wireless Local Area Network (WLAN) under the input criteria Signal Strength of networks, speed of the mobile terminal, and Network coverage of both networks and Quality of Service. In [6], the key parameters considered for RAT selection algorithms are network layer information such as service and mobility type, mobility prediction information, RAT load and data transfer cost. Under the service based RAT selection policy, the RAT is selected based on the service type. Reference [8] proposes two service policy based algorithms: The former always allocate data calls to WLAN, voice calls (and data calls when WLAN is congested) to UMTS, and when all these networks are congested, it sends all calls to General Packet Radio Service (GPRS).To ensure user mobility and service continuity, the authors in [9] propose a new architecture and new network selection scheme that explicitly take into account the current resource usage and the user preferences. Especially focuses on the best network selection architecture and the QoS mapping mechanism in heterogeneous wireless network environments. In this approach, the Common Radio Resources Management (CRRM) is considered simply as a Policy Enforcement Point (PEP) that translates the specific policies into an adequate configuration of the RRM algorithms. The Call admission control is one of the RRM technique which plays instrumental role in ensuring the desired QoS to the users working on different applications which have diversified nature of QoS requirements. In [10], the authors propose a Hybrid CAC scheme (HCACH) in the context of a UMTS-WLAN architecture, which takes into account both the user category and the class of service differentiation. The users' categories are defined according to the call origination point and the anticipated direction, on which depend in part the priorities assigned to them. To assume the priority system, the authors define an optimized resource allocation function which combines the user category and the priority of the class of service to which belongs the application currently in use. The drawback of this HCACH is that only direct access to each network was considered, i.e., the flow in the area where only WLAN access is available can never access cellular. In [11], the authors considered a CAC scheme which is based on one-hop cooperation. In this case, in the area where only cellular access is available, the mobile users not only can directly access cellular network, it can also access a WLAN using a node in the WLAN-covered area as a relay. With this one-hop cooperation, the WLAN is accessible to every mobile user in the cell; it is not limited to users in the WLAN-covered area only. The objective of this idea is to take advantage of the capacity of

WLAN as a release to potential congestion in the cellular network. A first effort to study the heterogeneous handover problem proposing a framework to overcome some limitations is currently undergoing in the IEEE 802.21.Several network selection schemes with QoS provision were proposed in [12-14]. To support QoS continuity between UMTS/802.16e networks, [12] proposed a novel network-initiated handover scheme which includes QoS measurement setup, and passive reservation. Reference [13] and [14] utilize IEEE 802.21 for QoS provisioning in IEEE 802.16 – IEEE 802.11 environment. In [15], the authors propose a solution for seamless load aware RAT selection based on interworking of different RATs in NGWN. In this paper novel load balancing algorithms have been proposed which have been simulated on the target network architecture for TCP data services. The IEEE 802.21 MIH is utilized in load balancing specifically for mobility management, which enable low handover latency by reducing the target network detection time. The proposed method considers the network type, signal strength, data rate and network load as primary decision parameters for RAT selection process and consists of two different algorithms, one located in the mobile terminal and the other at the network side. In [16] load balancing approach has been presented which targets the proxy mobile ipv6 (PMIPV6) domain using MIH for heterogeneous networks. A comparison has been made between the scenario performing load balancing in extended PMIPV6 for handover signaling and the scenario using MIH signaling for load balancing. These works show that the assistance of IEEE 802.21 contributes in decreasing the effects of handover latency, jitter and packet loss, thus improving the user perception.

3 SYSTEM MODEL

In this section, we present our proposed mobile-assisted algorithm for vertical handover based on the IEEE 802.21 framework.

3.1 Design Issues of Our Architecture

This approach is based on the architecture proposed in [3]. This solution introduced a CRRM mechanism in order to combine the respective mechanisms of the different heterogeneous networks and provide all the necessary information for an optimal handover decision. The QoS architecture is required to ensure inter-operability of each access network QoS mechanism with external networks, and to provide a simple and flexible method to guarantee the required service quality. It should be easily extensible with minimum affecting of the inter-operability between access networks. Based on these requirements, we propose the QoS architecture for next generation wireless network based on IEEE 802.21 MIH model. This architecture (see Fig. 1) is composed of the Local QoS Manager controlling QoS in each access network and Inter-QoS Manager controlling QoS between heterogeneous access networks.

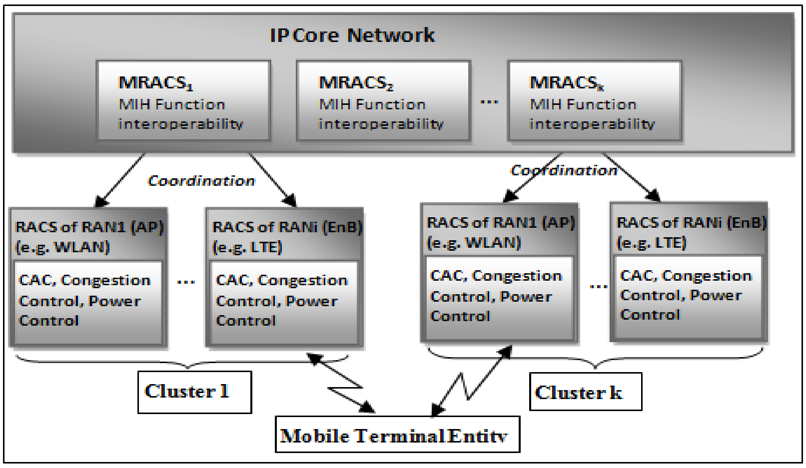

Fig. 1. The proposed architecture

Fig. 1 shows a proposal of WLAN and 3GPP LTE interworking architecture that consists of the following logical nodes and networks:

- User Terminal (UT): This logical node consists of all functionalities necessary for an end user to access either WLAN or 3GPP LTE network.
- Radio Access Control Server (RACS): It consists of local QoS manager and QoS context manager to perform QoS management in specific access network. The local QoS Manager performs resource allocation/management and session management for each service (Call Admission control, congestion control, Scheduling scheme, Power control). And the QoS context manager manages the QoS profile for each service. These nodes are organized into groups called "clusters". For each cluster we assign a MAP to play the role of a coordinator of cluster called «Multi Radio Access Control Server» or MRACS. Thus, this MRACS will contain the base of RACS which belongs to its own cluster. In our system architecture, we opted for load balancing clustering. In fact, it attempts to reduce system throughput and limit the number of mobile nodes in each cluster to a specified range so clusters are of similar size.
- Multi Radio Access Control Server (MRACS): Based on the IEEE 802.21 MIH standard, it performs coordination function for ongoing services between access networks for each cluster in case of inter access network handover. It consists of QoS negotiator and QoS parameter manager to provide service continuity between heterogeneous access networks. It interfaces with RACS located in serving access network to get QoS profile for a specific ongoing service and RACS located in target access network to check network resources for requested ongoing services. In the other hand, it interfaces with other functions in core network to initiate handover preparation procedures such as authorization for requested services. It also maps the optimal QoS parameters to QoS parameters being used in target access network, and transmits them to UE for QoS negotiation in target access network in case of inter access network handover.

A. Modified IEEE 802.21 framework

In our current approach, we exploit the IEEE 802.21 framework, thus there is no need for CRRM functionality. However, the IEEE 802.21 framework needs to be extended in order to support our proposed architecture. It spans multiple layers of the network protocol stack. The basic idea behind proposed architecture is based on resources management to accommodate more calls while satisfying at the same time applications expectations and load balancing between the different networks. Thus, our proposed resource management approach has been designed on the basis of following foundations: Pre-reservation resource is trigger before handover decision and a slight degradation of agreed QoS parameters is acceptable for most of the applications, in case expected resources are not freed. The new functional entities added to the initial IEEE 802.21 framework are depicted in Fig. 2, and described as follows:

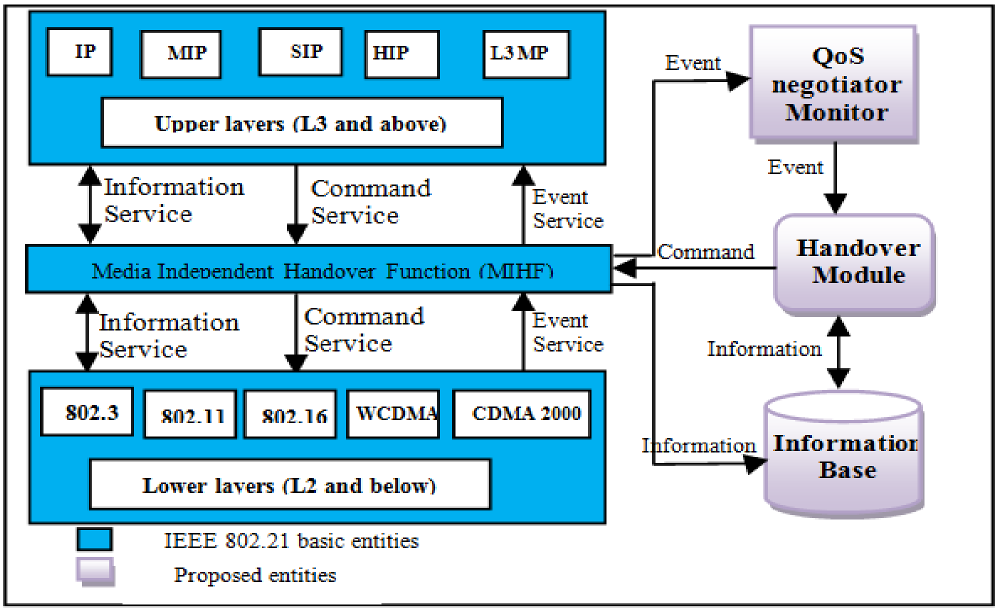

Fig. 2. Modified IEEE 802.21 Framework

- Information Base (IB): The information base exists both in the MN and one in the network side. In the MN, it stores information about the service profile, the user's profile, and the MN's profile. It contains mainly the QoS level required by each application. For example, the useful parameters from the application QoS requirements could be: Minimum necessary bit rate (kb/s), supported bit error rate, required security level and maximum tolerated delay. This information can be either stored permanently in the base, or acquired on demand. At the network, the information base stores information about the network operator's policies, the data related to the available networks performances such as the mean bit rate, the maximum packet size, the packet error rate, the bit error rate, and the average latency to send a packet. The information inside the Information Base is used by the Handover Modules (in the MN and in the Core Network) to make an optimum handover decision. Notice that the information base is introduced in order to store information obtained either from other MIIS resident in the same network or in the exterior or from the broadcast messages sent by neighbor networks. In addition, it stores information that is not currently supported by the MIIS specified in the IEEE 802.21 framework.

- QoS negotiator Monitor (QosNM): It define a mapping between the terminal context of the WiFi and LTE that enables the translation function to define values for WiFi context information-elements (resp., for LTE context information exchange) based on values related to a LTE association (resp., for WiFi association).

- Handover Module (HM): it interacts with IB to introduce vertical handover and inform the handover request to the appropriate access network.

B. Proposed QoS handoff scheme

Handoff control signaling and advance QoS negotiation includes three phases: 'prepare handoff', 'advance resource reservation' and 'handoff execution', shown as Fig. 3.

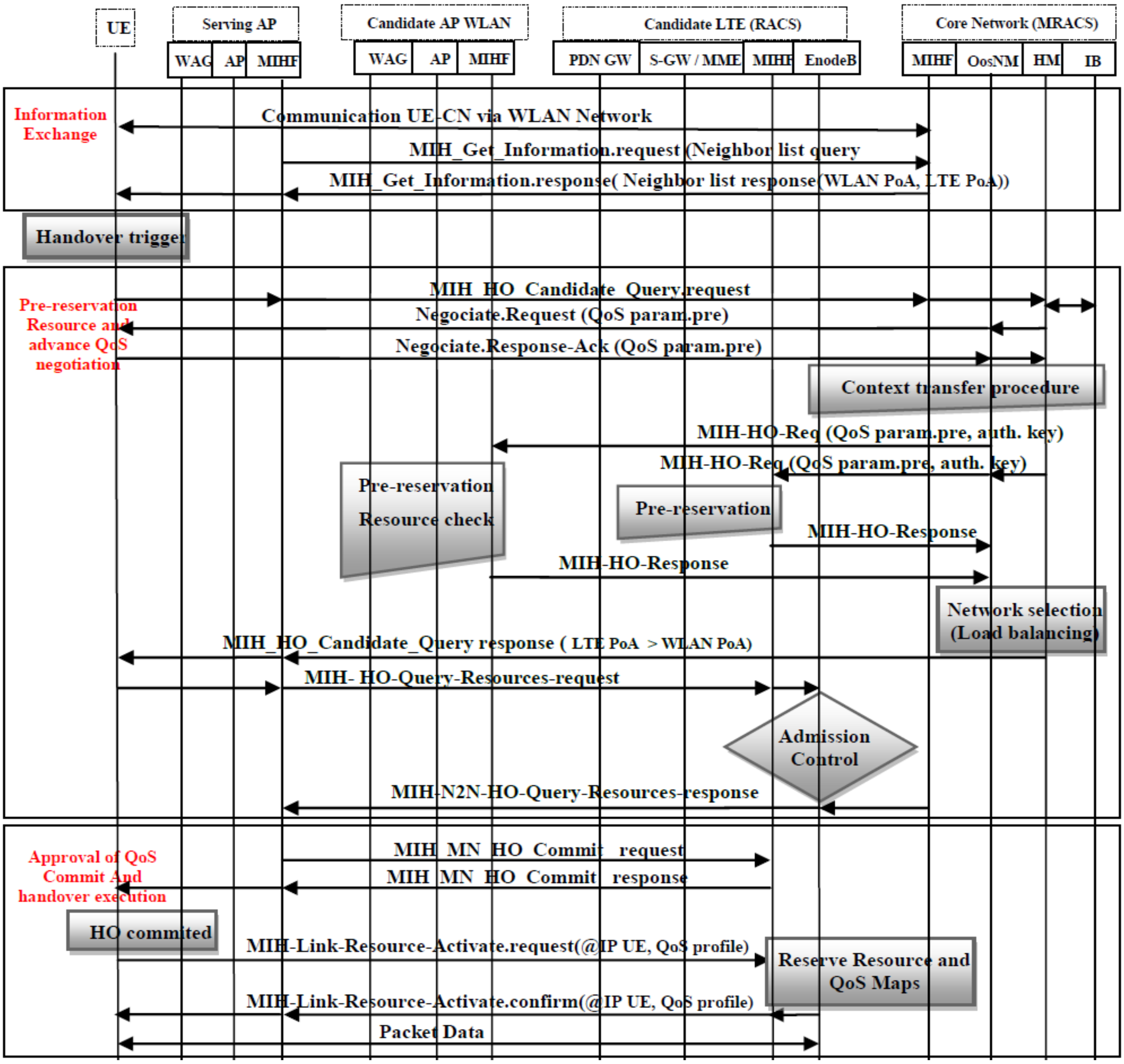

Fig. 3. Signaling chart for our proposed QoS handoff scheme based MIH

QoS-based handover is a decision to perform a handover based on current and expected network conditions, according to the application QoS requirements. Current network conditions are measured using network performance parameters from various layers, such as signal strength from layer 1, packet loss from layer 2, throughput and delay from layer 3, etc. The handoff decision metric calculation is performed among candidate's networks, in order to avoid measures at the mobile terminal side, each RANj computes the network quality value, then this value is sent to the IB.

The call required QoS is depicted as the parameters in the IB, including necessary bandwidth. During the session establishment, these QoS parameters are exchanged by the two communication sides, and negotiated based on the capabilities of the terminal and access networks through the QoSNM. Therefore, QoS negotiation along with resource pre-reservation in the new access network should be performed in advance. In fact, this negotiation will be based on QoS' profile between both RATs through the QoSNM. Upon receipt of HPReq message, the MRACS checks its IB to retrieve information about their neighboring list access network. The QoSNM transmits a Context Transfer message that includes the MN's feature contexts to the candidates PoA. The terminal context includes authentication parameters, service flow parameters. When the new RACS receives a Context Transfer message, it installs the contexts as received from the QoSNM. Based on target point of attachment

(PoA) responses, which indicates the support of terminal requirements, the HO management function builds the PoA List that is forwarded to the serving AP. The serving AP transfers the list to the terminal. In viewpoint of load balancing, the HM carries out a cell selection process consists in allocating the user to the cell with the lowest load level and which is provided that it can fulfil the QoS requirements requested by the UE. In this case, the HM selects LTE PoA as the handover candidate and sends to query resources. Upon receiving the answer and verifying that LTE PoA is able to accommodate the user block, the HM informs the access network to reserve resource before the user enters the new access domain, in accordance with its preference. In fact, the Resource Management Module (RMM) enables QoS mapping, fast transfer of user profile and QoS parameters between different domains during handover. The RMM handles also CAC and operations for bandwidth management that offers resource allocation. In our framework we provide a CAC algorithm that takes into account the separation between incoming traffic for each class (real time and non real time service) and prioritizes handoff calls over new calls. In fact, to satisfy the prioritization between the different classes of services, we propose an adaptive resource reservation algorithm witch give a threshold bandwidth capacity for each service's classes. These threshold values are adjusted dynamically in function of cell's state and the level of the blocking call's type. Finally, when the MT commits its handover to the LTE network; the RACS receives a Link Resource Activate command, carrying the QoS parameters. The parameters are mapped onto one of the radio QoS classes available in the LTE platform and the resource reservation is prepared. Preparing the resource reservation ahead from the actual handover execution improves the handover performance. In the output, after the decision has been made, the call will be allocated to the selected RAT. A Radio Recourse Unit (RRU) and a bit rate will be allocated for this call from the selected RAT.

4 PERFORMANCE EVALUATION

4.1 Simulation Parameters

In this section, we investigate the performance of our proposed method of QoS scheme based IEEE 802.21 MIH in the heterogeneous networks via simulation. We use Matlab to implement our own network simulator that allows the modeling of heterogeneous networks at a simplified level. A scenario with a heterogeneous wireless network consisting of an LTE network and an IEEE 802.11n network with overlapping coverage areas was simulated. Fig. 4 present our simulation environment.

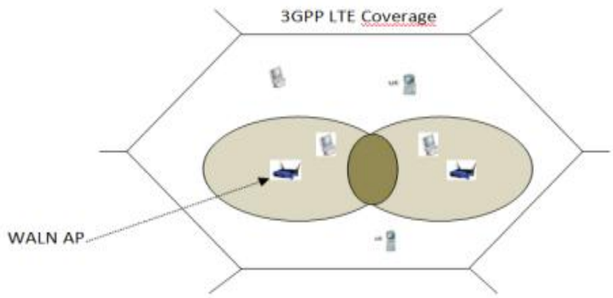

Fig. 4 . Simulation environment

Two types of flows were used in the simulations: VOIP and Data flows. Voice calls were arriving according to a Poisson process with the mean duration of 3 minutes distributed exponentially. General IP flows were sent according to a Poisson process with the mean duration of 5 minutes distributed exponentially. The parameter settings in our simulation are listed in Table1.

Table 1. Simulation Parameters

Parameters	Values
3GPP LTE System bandwidth	50 Mbps
Max eNodeB transmit power	46dbm

Wlan IEEE 802.11n data rate	100 Mbps (Frequency band 2 GHZ)
Bandwidth requirement	Voip : 64kbps
	Data :512kbps
Packet size	Voip: 120bytes
	Data :1500 bytes
Average connection holding time	Voip: 3min
	Data :9min
Movement speed	1m/s
Simulation time	30min

4.2 Simulation Results

Three performance metrics are used in our simulations: blocking ratio which is defined as the ratio of the number of blocked calls and the total number of calls, the packet loss ratio which represents the ratio of the number of lost packets and the total number of sent packets and the Bandwidth utilization which is defined as the ratio of the number of allocated RRU to UE during the whole simulation time.

In this section, we consider that the size of the network is expressed in term of the number of UEs. Fig. 5 illustrates the blocking ratio of the handoff and new calls for RT and NRT traffics by varying the number of UE.

We notice that the blocking ratio of handoff and new calls does not exceed 6% for 3000 user equipment for the RT traffics applications. The two curves start with zero values until arriving at 1000 user where the blocking ratio for RT traffics starts to increase however the NRT traffics increases at 500 user equipment. The blocking ratio of the RT new calls reaches values more important than the RT handoff calls. This result can be explained by the notion of the priority for the handoff service.

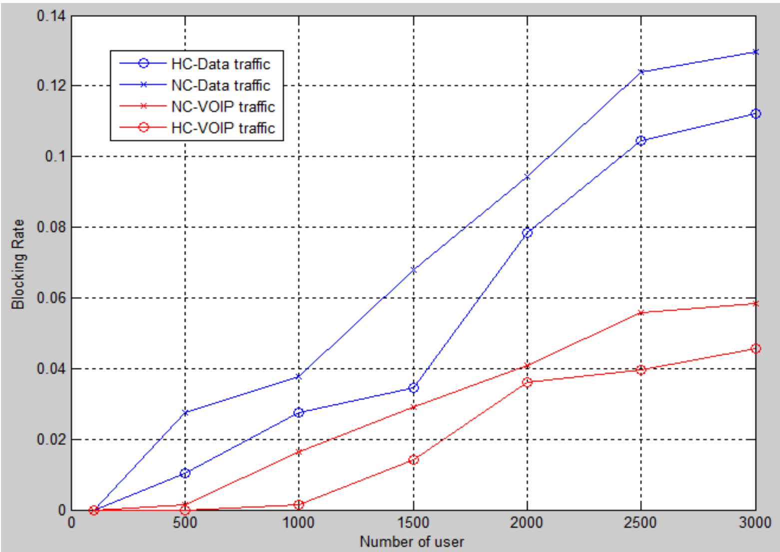

Fig. 5. Call Blocking Probability

Following the increase in the values of blocking rate, mentioned in the preceding paragraph and in Fig. 5, the risk the packets loss grows simultaneously. Fig. 6 shows the packet loss probability of RT and NRT flows of our proposed scheme. As in the case of blocking rate, the curves begin with negligible values. Then, these rates increase gradually with the increase in the population of UEs. Indeed, for 2000 UEs the ratio of packet loss for the real time traffic did not exceed 10% whereas this probability reaches 20% for NRT traffic. The packet loss ratio in the case of NRT applications is more important than the RT applications. This can be justified by the fact that the CAC algorithm serves the RT packets in priority. Consequently, serving RT packets with the highest priority minimize the number of packets dropped due to deadline expiry.

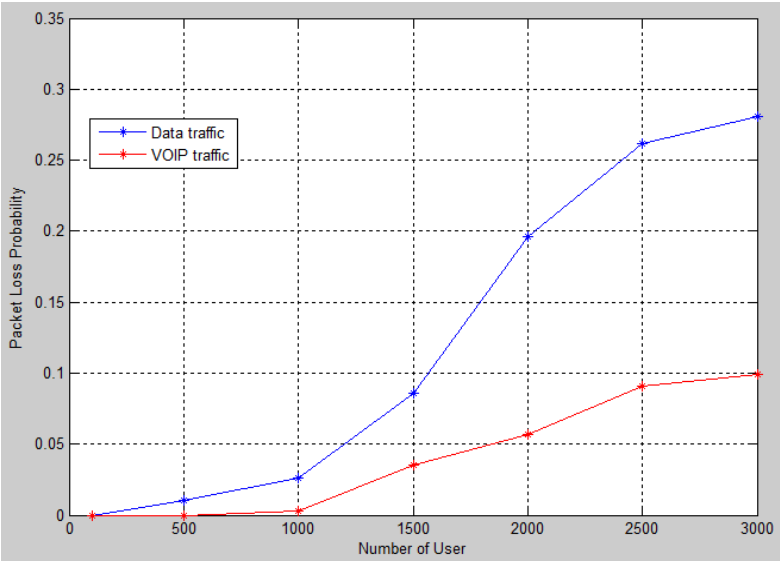

Fig. 6. Packet Loss Probability

From a system's point of view, which can be observed in Fig.7, the network throughput keeps increasing as the offered load increases.

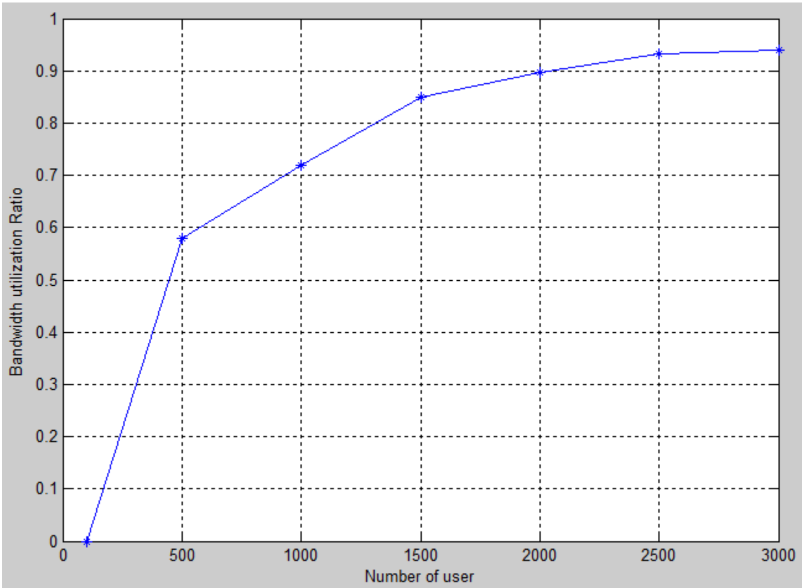

Fig. 7. Bandwidth utilization Ratio

5 CONCLUSION

Major challenges in NGWN are efficient resource utilization, maintaining service quality, reliability and the security. In this paper, we proposed a new scheme based on interworking of different RATs in NGWN witch support the provision of Quality of Service and the efficient utilization of radio resources. This scheme utilizes the IEEE 802.21 Media independent Handover (MIH) to seamlessly handover mobile users between heterogeneous wireless networks for load balancing. Then, we could extract various results following the development of a simulator on which we have tested our solution. According to the results simulation, we noted that our solution can offers high radio links utilization with minimized call/connection blocking and dropping probability and ability to maximize the network availability with uniformly distribution of load in co-located networks.

References

[1] C.Yang et al., “A Novel Scheme and Access Architecture for Joint Radio Resource Management in Heterogeneous Networks,” International Forum on Information Technology and Applications, 2009, Chengdu, China, pp. 24–27, May 2009.

[2] Y. Kai, J. Yang, Z. Ping, Li, V.O.K., Z. Yongjing, “Multi-access Radio Resource Management using Multi-agent System”, IEEE
Wireless Communications and Networking Conference, pp 63-68, 2006.

[3] L. Wu, K. Sandrasegaran, ” A Survey on Common Radio Resource Management”, The 2nd International Conference on Wireless Broadband and Ultra Wideband Communications (AusWireless), Sydney, Australia, pp. 66, 2007.

[4] Draft IEEE Standard, IEEE Standard for local and metropolitan area networks: media independent handoff, Draft IEEE P802.21/D03.00, December 2006.

[5] S.Kokila, R.Shankar, P.Dananjayan, “Analysis of Call Admission Control Schemes for WLAN Coupled to 3G Network”, International Journal of Soft Computing and Engineering (IJSCE), Volume-1, No. 6, pp 402-408, January 2012

[6] A. ALSabbagh, R. Braun, M. Abolhasan, “A Comprehensive Survey on RAT Selection Algorithms for Heterogeneous Networks”, World Academy of Science, Engineering and Technology, pp. 141-145I, 2011.

[7] J. Preethi, S. Palaniswami, “ A Hybrid Modified Particle Swarm Optimization for Heterogeneous Radio Access Technology (RAT) Selection” International Journal of Computer Applications, Volume 43– No.9, pp 0975 – 8887, April 2012

[8] K. Suleiman, H. A. Chan, and M. Dlodlo, “Load Balancing in the Call Admission Control of Heterogeneous Wireless Networks,” Proc. Int’l. International Conference on Wireless Communications and Mobile Computing, Vancouver, Canada, pp 245-250 July 2006.

[9] F. Zarai, I. Smaoui, j.M. Bonnin, L. Kamoun, ‘’Seamless Mobility in Heterogeneous Wireless Networks’’, International Journal of Next-Generation Networks (IJNGN) Vol.2, No.4, December 2010

[10] Y. Zhang, E. Salari, “Modeling and Analysis of a Hybrid CAC Scheme in Heterogeneous Multimedia Wireless Networks”, International Journal of Handheld Computing Research, pp 23-36, January-March 2012

[11] W. Ouyang, L. Fu, X. Wang, E. Hossain, “One-Hop Call Admission Control in Heterogeneous Wireless Networks: A Queueing Analysis”, IEEE "GLOBECOM" 2009 proceedings.

[12] J. Baek, D. Kim, Y. Suh, E. Hwang, and Y. Chung, Network-Initiated Handover Based on IEEE 802.21 Framework for QoS Service Continuity in UMTS/802.16e Networks, Proceedings of the IEEE VTC 2008, May 2008.

[13] L. Gavrilovska, V. Atanasovski, V. Rakovic, O. Ognenoski, A. Momiroski, “Performance of Vertical Handovers in Heterogeneous Wireless Systems utilizing IEEE 802.21,” Workshop “Cognitive Radio Technology and Reconfigurable Wireless Communications”, IEEE Communications 2008 Conference, Bucharest, Romania, June 5-7, 2008.

[14] J. Shyr, H. Huang ”A Vertical Media-Independent Handover Decision Algorithm across WiFi and WiMAX Networks,”
Wireless and Optical Communications Networks, Indonesia, pp 1-5, May 2008

[15] M. Ali, P Pillai, Y.F.Hu, "Load-aware Radio Access Selection in Future Generation Satellite-terrestrial Wireless Networks'', International Journal of Wireless & Mobile Networks (IJWMN), Volume- 4, No. 1, pp 35-54, February 2012.

[16] M.S. Kim, S. Lee, "Load balancing and its performance evaluation for layer 3 and IEEE 802.21 frameworks in PMIPv6-based wireless networks", Wireless Communications and Mobile Computing, 2009.