WiMax-based Handovers in Next Generation Networks

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ABSTRACT: *Next generation networks will combine various access technologies to enable users to roam freely from one access network to another which is referred as Vertical handovers. Vertical handovers mobility management in next generation all-IP networks is the key factor that determines vertical handovers (HO) performance. Mobility management is generally based on mobility protocols that perform the handovers either horizontally (within the same access network) or vertically (between different access technologies). In this context, many solutions were proposed to provide seamless vertical handovers between WLAN and WiMax networks. These solutions aimed to perform the HO with minimum QoS degradation based on either the coupling architecture method, the mobility management protocol or the handover decision process. Our solution is based on the handover decision process that will make use of the emerging WiMax technology in order to guide the vertical handover to the suitable destination network in terms of network availability and service provisioning. As users in WLAN networks may initiate handovers for better connectivity, WiMax network will be considered as the default destination network that will guide the handover according to the HO context requirements. Our approach consists of adding a context Adjustment Unit CAU to the WiMax Connectivity Service Network CSN to guide the handover, according to the HO context requirements, either horizontally or vertically.*

Keywords: Context Adjustment, Vertical Handovers (VHO), Mobility Management

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1. Introduction

In next generation networks, a mobile user is viewed as seeking always-on connectivity and coverage. Coupling architectures, mobility management protocol and handover decisions are required to perform the HO either horizontally or vertically as seamless as possible. In all cases, HO decision is the main issue of a successful handover.

The European Telecommunications Standards Institute (ETSI) specifies in [1] two generic approaches for inter-working: called loose coupling and tight coupling. These proposed integration architectures are based on the handover decision from WLAN to UMTS and vice versa with no other network intervention that can guide the handover successfully. Their purpose was to perform the HO seamlessly to the destination network with minimum QoS degradation [1].

In addition, there are different strategies to solve the problem of session mobility. At the network layer MIP (Mobile IP) from the IETF (Internet Engineering Task Force) provides a scheme for host mobility, including support for TCP and UDP connections

[2]. Another approach to network mobility is SIP (Session Initiation protocol). Unlike MIP, SIP is an application layer protocol that allows for a host to move networks without interrupting a session [3]. These schemes have long handover latency, causing existing sessions to timeout. This situation is not ideal for the vertical handoff from WLAN to WiMax. In this context, several approaches have been proposed for inter-working between WLANs and cellular networks depending on how much dependence is required between the two wireless networks.

In our approach, a user roaming among different access networks should be able to connect to WiMax networks offering better connectivity to preserve the required handover context parameters.

Thus, forward and backward context adjustments are proposed to adjust the context parameters and guide the HO accordingly.

The proposed WiMax guided handovers checks the context of the current handover request and decide accordingly how to guide the handover. In this case, the requested HO will be, based on the handover context requirements, guided to WiMax or performed horizontally (guided to the same access network). Thus CAU Context Adjustment Unit will have the key effect on the handover HO performance for the purpose of offering mobile users, roaming in the next generation networks, best connectivity and service continuity.

The rest of the paper is organized as follows. Section 2 describes solutions in the context of WLAN to WiMax HO. In section 3, WiMax processing with context adjustment unit functionalities are presented. Section 4 shows Context Adjustment Unit performance based on CAU modeling. In section 5, conclusion and future works are discussed.

2. Handover Solutions

In [4], the paper presents a loose coupling integration architecture of WLAN/WiMax access networks. The authors propose a new QoS mapping solution related to the continuity of service between WLAN/WMAN networks. Figure 1. shows the integration architecture of this solution.

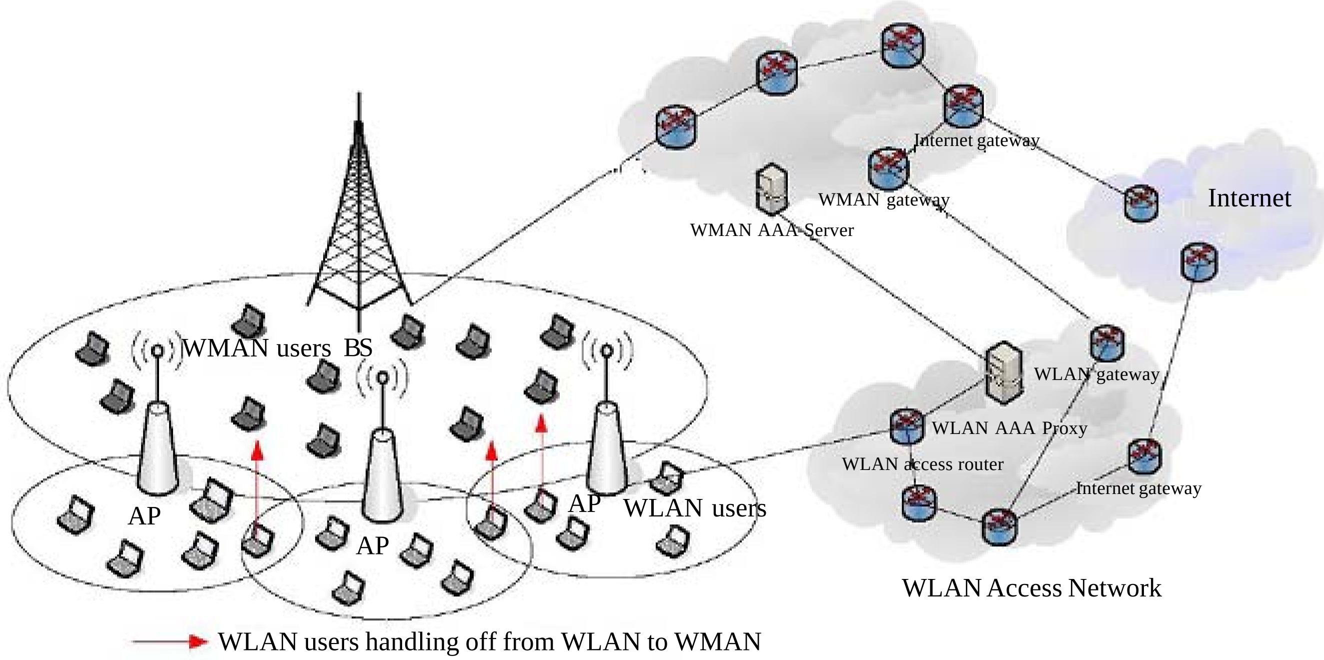

Figure 1. Interworking architecture

The authors in [5] discussed the scenarios of terminal controlled vertical handover for both the WLAN-WMAN which uses L2 parameters to aid the interface selection and handover decision with considering user preferences. The paper exploits the media

Independent Handover (MIH) capabilities to facilitate cross layer information exchange between link layer and upper layers. The proposal also addresses the QoS mapping performed during L2 mobility.

In [6], the paper proposes a proactive QoS based VHO scheme for integrated WLANs and WiMax networks. The paper aims to present a general VHO management (VHOM) scheme to make VHO decisions which has been designed for each station to monitor the quality of connections and proactively detect network conditions. VHOM selects the network which can provide better service to serve the station rather than a preferred network. They also propose two bandwidth estimation algorithms to predict the available bandwidth in WLAN and WiMax networks in order to obtain QoS parameters required for handover decision. The main contribution is a handover process will not only be triggered by unaccepted signal strength but also by unsatisfied QoS parameters. The interworking architecture is shown in Figure 2.

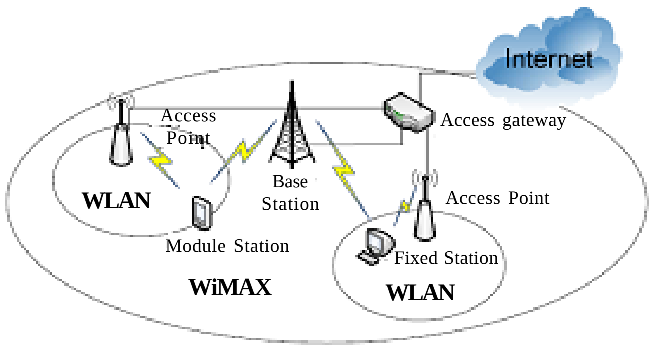

Figure 2. Interworking architecture

In [7], authors introduce a handover decision algorithm by combining MIH QoS model with Multiple Attribute Decision Making (MADM) mechanism to provide seamless mobility between WLAN and WiMax networks. The proposed model defines QoS parameters mapping among heterogeneous networks, and the service primitives defined in MIH constitute a seamless handover process. The results of the implementation show smaller handover times and lower dropping rate than basic vertical handover methods.

Thus most of the solutions in the literature aimed for seamless vertical handover. But this is provided by QoS parameters mapping with the destination network. In this case, the destination network may not satisfy the user's requirements and the mapping should be adapted with the current network conditions for QoS provisioning.

In this paper, we propose a WiMax- based vertical handover approach that considers WiMax network as the default destination network that will guide the handover according to the HO context requirements. Our approach consists of adding a Context Adjustment Unit CAU to the WiMax Connectivity Service Network CSN to guide the handover, according to the HO context requirements, either horizontally (to the same access network) or vertically (to a different access network).

3. WiMax handovers processing

Our proposed WiMax-based handover approach is based on the following:

• The WiMax will be considered as the default destination networks.

• HO will be classified according to its context requirements and thus guided to either the same access network or to WiMax network.

• When the HO requirements could be satisfied within the same access network, the HO call will be considered as low priority handovers by the CAU and thus treated accordingly.

• The horizontal handover will be guided to the same access network offering the required HO parameters. This is the backward context adjustment due to which the HO will be performed horizontally.

• When the handover requirements could not be offered within the same access, the HO will be considered as a high priority HO and will be treated by the CAU accordingly.

• The HO will be guided vertically to WiMax network (from WLAN, for example) offering better HO requirements. This is the forward context adjustment due to which the HO will be performed vertically.

• In the case of vertical handover, before the MN is out of coverage in the current network (WLAN), it will start to initiate the handover operation. The CAU will accept the handover call to be treated if the user profile is allowed to perform the handover. Once accepted, the request is treated by starting the context transfer exchange and mapping the requested QoS parameters into the next selected network. Local calls and handover calls are handled by the CAU, therefore the CAU capacity and its admission control strategy should be carefully examined to decrease the blocking probability and dropping of handover call. Thus the CAU modeling is of high importance in the analysis of handover performance. The VHO flowchart for the CAU unit is shown in Figure 3.

3.1 HO context requirements

In general, guiding the HO according to its context information (data rate, Quality of Service (QoS), SLA's, etc.) will increase the HO performance since it avoids non successful handover or degradation of QoS, because the handover is only carried out according to the adjusted context requirements that better satisfy the current handover requirements.

After the HO initiation phase, the HO request is treated by starting to analyze the HO context requirements so that the adjustment process will be performed as described below:

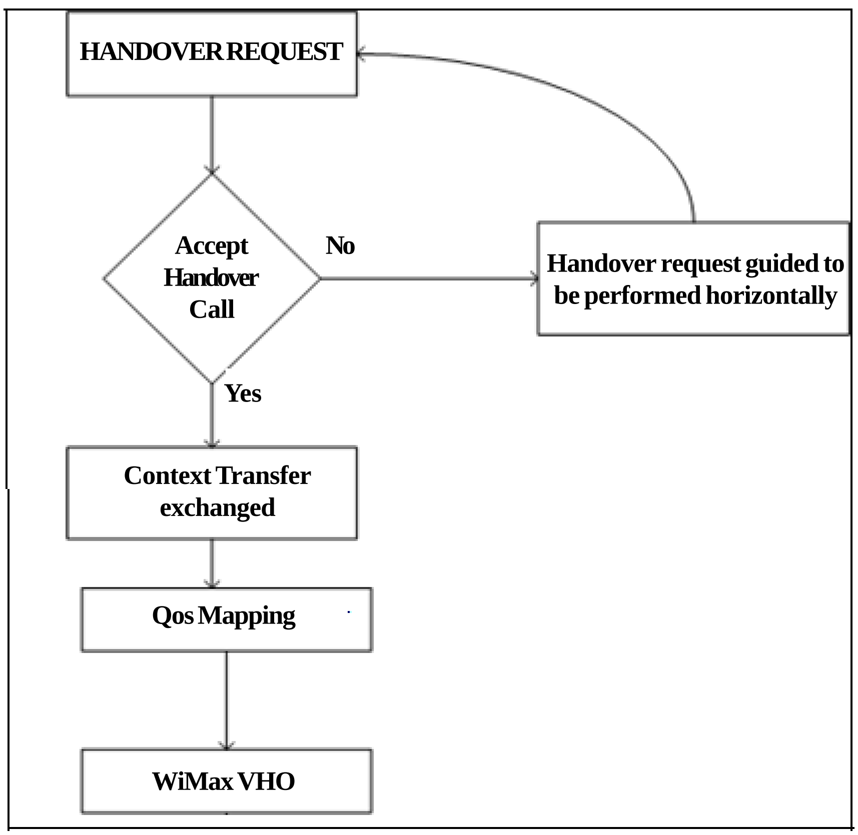

Figure 3. CAU VHO flowchart

• Compare the requested QoS parameters with the target network parameters.

• The request is classified into two classes: high and low-priority handover requests.

The first type is related to applications of high sensitivity and not tolerant to degradation. The high-priority- HO request is fully accepted by forward-adjusting the context requirements so that the HO call and the requested context will be satisfied within the WiMax network providing better connectivity than WLAN.

The second one is related to applications that are tolerant to degradation. In this case, the context is backward-adjusted to perform the handover horizontally. The backward/forward context adjustment scenario is shown in Figure 4.

For the proposed WiMax handover, the following scenario is proposed:

• WiMax will be the default destination network to mobile users unless guided horizontally after context adjustment.

• At the WiMax gateway, a Context Adjustment Unit CAU is coupled with the CSN gateway which is responsible of guiding the HO requests according to its context requirements.

3.2 Context Adjustment Unit CAU

The WiMax architecture shown in Figure 5 has, at the Connectivity Service Network (CSN) node, a Context Adjustment Unit CAU responsible of upgrading the user context based on the current network conditions. Thus if the user is requiring a specific handover parameters (throughput, QoS, etc.), the context is automatically upgraded either backward or forward depending on whether the application is tolerant or not to degradation. The destination network will be selected based on the adjusted context so that the handover will be performed seamlessly.

We assume that the CAU will accept both high and low HO calls up to a predefined threshold *T*. When the HO calls are greater than *T*, all the low-priority HO calls will be guided horizontally. This means that only high-priority HO calls will be accepted within WiMax network and the current low priority calls (low context requirements) do not need to be guided to WiMax but will be backward adjusted to be guided horizontally at the same access network.

As shown in Figure 5, WiMax network architecture is composed of the following components [8]:

• Mobile Stations (MS) used by the end user to access the network.

• The access service network (ASN), which comprises one or more base stations and one or more ASN gateways that form the radio access network at the edge.

• Connectivity service network (CSN), which provides IP connectivity and all the IP core network functions.

• CAU is present at the Connectivity Service Network (CSN) operating to provide a seamless handover and context adjustment in addition to the other main functionalities as defined in [5] which are: providing connectivity to the Internet or other public networks, including AAA servers, IP address management, supporting for roaming between ASN.

3.3 WiMax Hanover scenario

In order for the CAU to guide the HO, the main issue is that the handover should not be performed unless the context information is known and the related messages exchanged. Thus, the HO scenario is viewed as follows:

• The Context Transfer Protocol CTP (as per [9]) is involved in order to send the current context of a HO request

• Re-authentication and re-establishment of the mobile host's authorization in the new network are transferred in the AAA context eliminating the necessity of the MN to perform the AAA check from scratch once mobility is performed [3].

• While processing the handover based on context transfer protocol CTP, the context parameters are checked according to the available network conditions.

• To establish proper QoS treatment for the MN's packets along the new data paths, the proposed context transfer adjustment consists of checking the QoS parameters against the network parameters presented in WiMax so that the resources necessary to serve the mobile user according to the required QoS are checked in order not to receive the default forwarding treatment [3].

4. CAU Performance

4.1 CAU behavior

In this section, the WiMax-based handover approach is evaluated in terms of the CAU behavior which is considered as the main unit in the handover performance processing. CAU context adjustment will have the key effect on the HO performance for the purpose of offering mobile users, roaming in the next generation networks, best connectivity and service continuity. In this section, we are going to analytically study CAU performance.

Each CAU is modeled as an M/M/C/C queuing system with total capacity fixed to C assuming that the WiMax capacity is C.

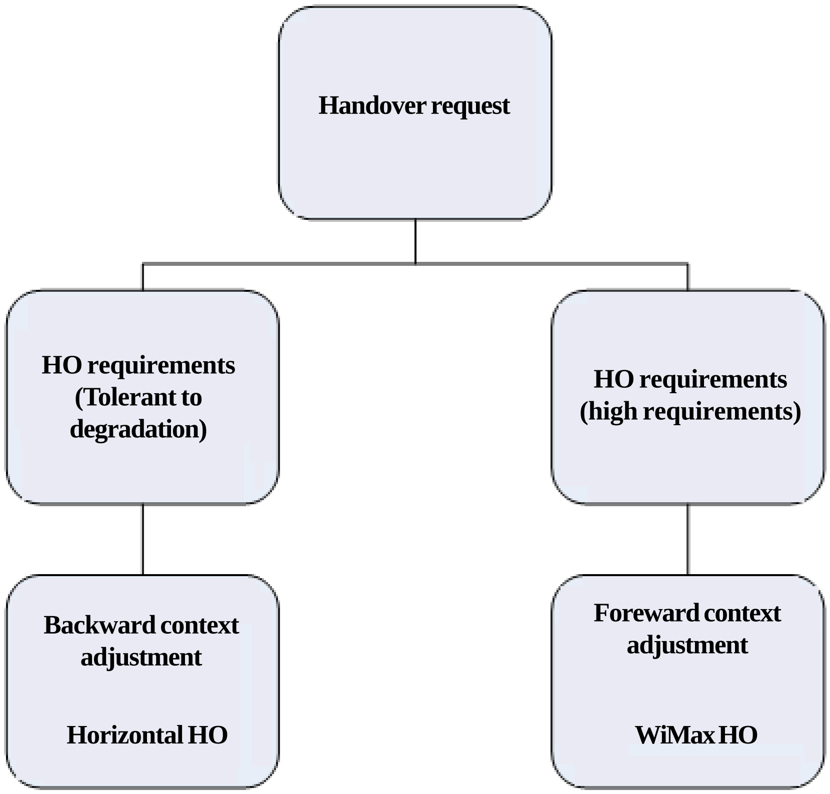

Figure 4. CAU Context adjustments

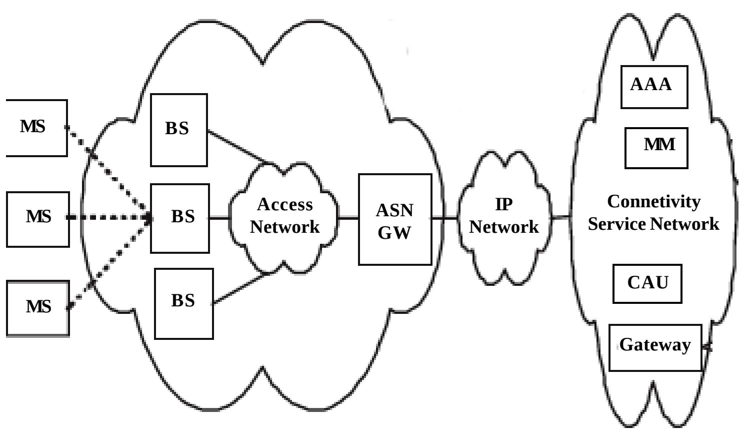

Figure 5. WiMax Network Architecture with CAU

Figure 6 shows the CAU queuing system. In this case, HO calls are admitted if they are less then *C* channels occupied.

Low priority calls are dropped by CAU (but guided horizontally) if all the *T* channels are occupied, where *T* is the threshold used to let the *C-T* interval channels be used only for high-priority handover calls.

The time of stay in CAU is exponentially distributed of rate μ.The low-priority-HO traffic is a Poisson process of rate λ_L. The high-priority HO request is a Poisson process of rate λ_h. We assumed the following:

• Equal service rates ($\mu_h = \mu_l = \mu$)

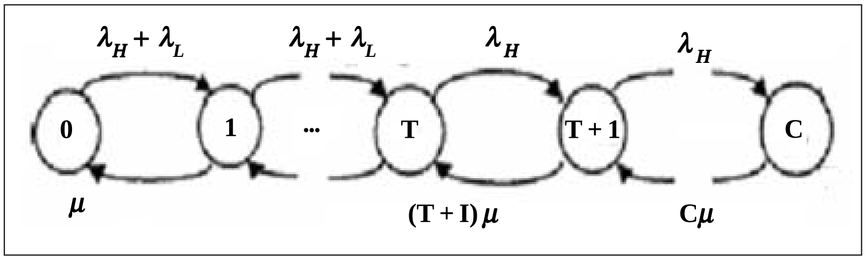

Figure 6. CAU Model

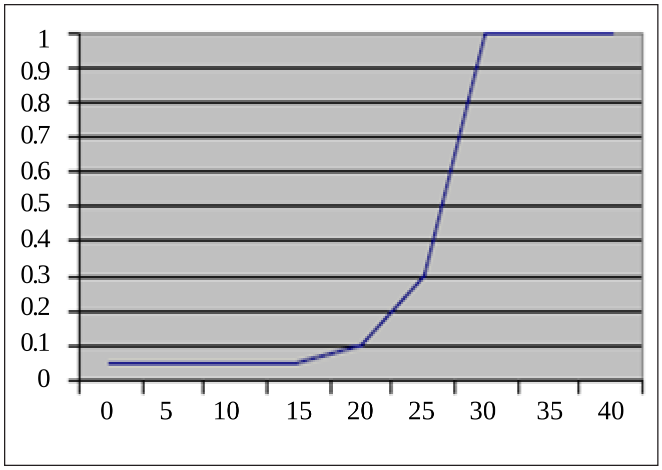

Figure 7. Dropping probability versus threshold T

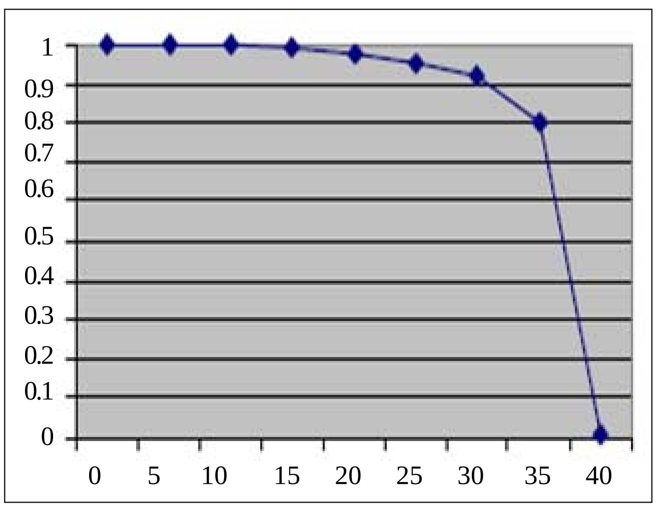

Figure 8. Blocking probability versus threshold T

- High-priority arrival rate is half the low-priority arrivals ($\lambda_H = 0.5 * \lambda_L$)
- The threshold T = 40% C (the choice of the threshold could be made dynamic as well). The blocking and dropping probabilities P_B and P_D are analyzed in function of the threshold T are as shown in Figure 7 and Figure 8.

The stationary probabilities for the different states are as derived according to [10].

4.2 Handover blocking and dropping probababilities

The HO dropping probability is: $P_D = P(C)$. The choice of the threshold will highly affects the handover dropping probability as

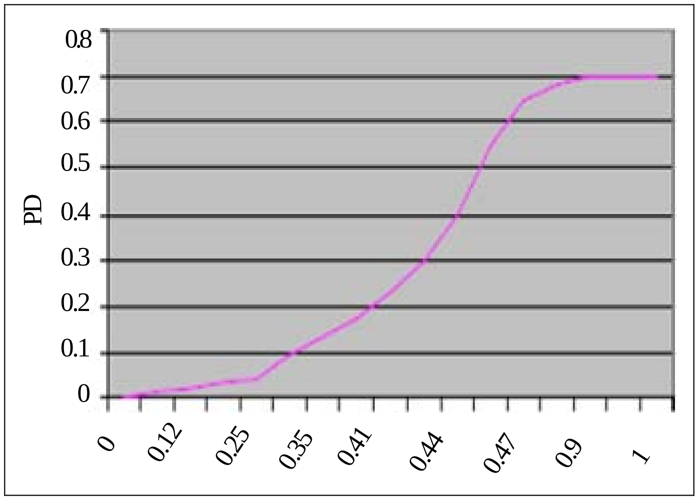

Figure 9. Dropping probability in function of the CAU load

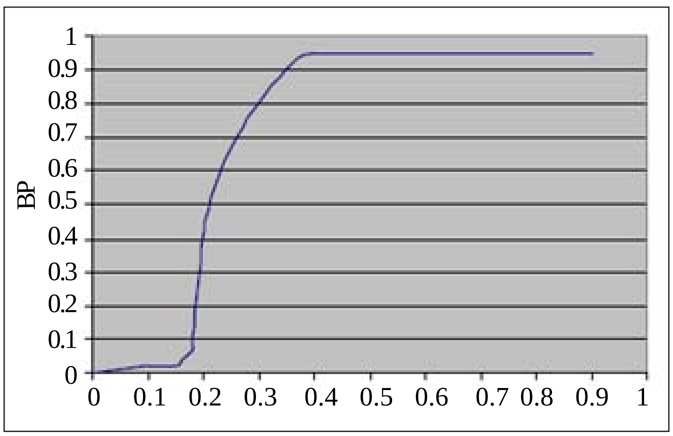

Figure 10. Blocking probability in function of the CAU load

well as the blocking probability of the incoming HO requests as shown in Figure 7 and Figure 8.

The maximum allowed threshold is when $T = C$. As T increases, the blocking probability decreases, since the HO requests with low-priority are accepted until T is reached. Figure 9 shows that the handover dropping probability P_D will increase with the increase of the CAU load.

Thus at the maximum capacity C, the HO calls are dropped from CAU.

It was shown that with the increase of the CAU load, the P_B is increased and it will approach 1 when the CAU load overcomes the threshold T, chosen to be equal to 40% as per Figure 10. This choice of 40% is due to the assumption that the HO calls initiated with low priority should not be severely blocked.

5. Conclusion

Our work consists of presenting a WiMax-based vertical handovers through CAU context adjustment approach for handover requests from WLAN networks. While performing HO in next generation networks, WiMax will be considered as the destination network accepting both low and high-priority handover calls. A CAU will be present at the WiMax CSN node to decide on how to guide the handovers. Performance analysis of the CAU as shown that the probability of accepting high handover calls is increased with the increasing capacity of the WiMax networks by limiting the acceptance of the low priority handover calls (which are guided horizontally).

Having studied the behavior of the CAU, our future work will focus on extending the CAU functionalities with dynamic context adjustment and evaluate the handove scenario in terms of QoS provisioning and network resources.

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