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A QOS Cognitive Radio based VHOM Scheme in Heterogeneous Wireless Networks for 4G Advancement

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Abstract— The integration of Wi-MAX and WLAN has been seen as a promising approach towards 4G. In this paper, we are going to introduce a novel scheme for the interworking of Mobile Wi-MAX and WLAN networks. We propose a tightly coupled interworking structure that can keep Mobile Terminals (MT) always best connected due to the inherent ad-hoc nature of the network, thus ensuring best Quality of Service (QOS). We have derived an evaluation algorithm to estimate the conditions of both Wi-MAX and WLAN networks in terms of available bandwidth and packet delay.

Index Terms— Ad-hoc Networks, Cognitive Radio, Handover, Nodes, QOS, Wi-MAX, WLAN, WI-FI, Wireless

1 INTRODUCTION

THIS In a Wireless Cellular Communication System, Mobility is a key factor. Normally, continuous service is achieved by supporting handoff (or handover) from one cell to another. An active MT crosses several cells during process of conversation. This active call should be transferred from one cell to another one in order to achieve call continuation during crossing of network boundary. The handover process is transferring an active call from one cell to another. Handover initiation is the process of deciding when to request a handoff. Handoff decision is based on the Received Signal Strength (RSS) from the current Base Station (BS) and the neighboring Base Stations.

Handover can be classified using the network type involved into horizontal and vertical cases (Figure1) as MT moves within or among different overlays of a Wireless Overlay Networks (WON).

Horizontal handoff or intra-system handoff is a handoff that occurs among the Access Points (Aps) or BSs of the same network technology. In other words, a horizontal handoff occurs between the homogeneous cells of a wireless access system. Vertical handoff or inter-system handoff is a handoff that occurs between the different points of attachment belonging to different network technologies. Handoffs can also be classified using the number of connections involved as soft or hard.

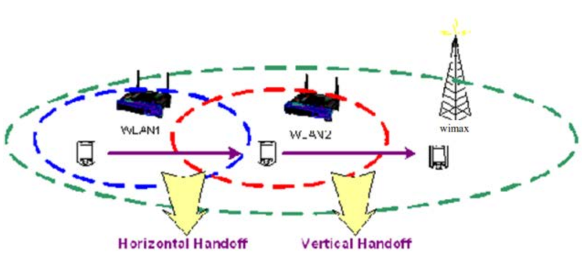

Figure1. Simulation Topology of Wi-MAX/WLAN Handoff System

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A handoff is hard if the MT can be associated with only one point of attachment at a time. In other words, an MT may set up a new connection at the target point of attachment after the old connection has been torn down. A make before break handoff occurs if the MT can communicate with more than one point of attachment during handoff. In this case, mobile terminal connection may be created at the target point of attachment before the old point of attachment connection is released. For example, MT equipped with multiple network interfaces can simultaneously connect to multiple points of attachment in different networks during soft handoff.

Mobile ad hoc networks are dynamic networks in which nodes are free to move. A main performance constraint comes from path loss and multipath attenuation. Many Mobile ad-hoc network routing protocols exploit multi-hop paths to route packets. Probability of successful packet transmission on a path is dependent on the reliability of the wireless channel on each hop. In this paper, we assume that all nodes know their positions and velocities, each and every node can measure the distance from AP and BS. And we are assuming bandwidth by number of users. Whenever number of users increase the bandwidth will reduce, so we have chosen an optimum number of four users in this paper to maximize the bandwidth.

2 EXISTING SYSTEM

In previous QOS based VHO methods for overlay networks [1], Quality of service parameters are considered in handoff decisions. However, the handover procedures are normally started when the stations move across the border of WLANs.

As a result, the fixed stations and the mobile stations within overlapped areas cannot benefit from Vertical Handover (VHO). Various researchers proposed a tightly coupled interworking structure where seamless and proactive vertical handoff scheme is designed based on the architecture with the aim to provide always the best QOS for the users. Due to the newly developed WiMAX, there are some advantages, but still limited proposals are made for VHOs in WiMAX/WLAN overlay networks. Proposed schemes can keep stations always being best connected. But when system is out of the range then no communication is possible in that model.

2.1 Related work

In this paper [2], author presents an overview of issues related to horizontal/ vertical handoffs and also discusses the architecture of integrated WLAN and WAN networks based on Mobile IPv6.

The Overlay Network is considered to improve the different characteristics of wireless access network technologies to satisfy the anytime, anywhere, and any service needs of mobile users but author used the wide area access network in which Setting up a network can be an expensive and complicated, also the bigger the network the more expensive it is and it's security is a real issue.

In this paper [3], author presents efficient handoff schemes to enhance quality of service and provide flawless mobility and it presents different and novel aspects of handoff and discusses handoff related issues of fourth generation systems.

In this paper [4], author presents a novel end-to-end mobility management system for seamless and proactive roaming across heterogeneous wireless networks and this system integrates a connection manager that intelligently detects the condition of the wireless networks and a virtual connectivity based mobility management scheme that maintains connection's continuity using the end-to-end principle.

In this paper [5], author analyzes the most recent research efforts in the area of handover management in integrated WLAN/cellular networks, attempting to categorize and comment on the proposed solutions. The focus is placed mainly on the methods to integrate two different architectures and on the supported functionality of the integrated system.

In this paper [6], author analyzes the most recent research efforts in the area of handover management in integrated WLAN and wireless metropolitan area networks (WMANs). This integrated network will bring a synergetic improvement to the services provided to mobile users.

In this paper [7], author addresses a movement-aware vertical (MAV) handover algorithm between WLAN and Mobile WiMAX for seamless ubiquitous access. MAV handover algorithm is proposed in this paper to exploit movement pattern for avoiding unnecessary handovers in the integrated WLAN and Mobile WiMAX networks.

3 Proposed Method

In our project we are implementing the ad-hoc technology in infrastructure system called as cognitive radio network. In our model, whenever system is out of range of all the BSs and Aps, then it can make the communication through the PU when it is available. In this model we are considering requesting device as the secondary device, which is helping to make communication with the PU.

Cognitive radio has two types of users such as PU and Secondary User (SU). Cognitive radios are cognizant of their surroundings and bandwidth availability and are able to dynamically tune the spectrum usage based on nearby radios, location, time of day and other parameters. This provides for a more efficient use of the spectrum [11] and enables high priority communications to take precedence if needed.

3.1. Algorithm

Our proposed scheme can keep MTs always being best connected even when it's outside the range of WLAN. We have investigated the integration of VHO issues in WiMAX/WLAN overlay networks. The implementation model is as given below.

Step1:
Initializing a mobile node it can access both WiMAX/WLAN.
Initialize WiMAX/ WLAN networks.
Step2:
Node will check the available networks.
Step4: If {network available} {
If {only one network} {
Get communication from that.
} else {
For {each network}
{Checks which are the best networks in terms of Bandwidth and packet delay

Theory of Bandwidth calculation for Wi-MAX is given as follows.

Bandwidth calculation for Wi-MAX

$$\begin{cases} B_d = \left(1 - \frac{AAS_d}{s_d}\right) \frac{\delta_d s_d}{T_f} \\ B_u = \left(1 - \frac{AAS_u}{s_u}\right) \frac{\delta_u s_u}{T_f} \end{cases},$$

Delay calculation Wi-MAX

$$t = t_s + t_q + t_m + t_t.$$

Bandwidth for WI-FI

$$t = t_q + t_a = \frac{\lambda t_a^2}{1 - \lambda t_a} + t_a$$

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$$BW = B_0 - L\frac{NAV}{T_n + \frac{1}{2}T_{n,c}(N-1)}$$

Delay for WI-FI

$$t = t_q + t_a = \frac{\lambda t_a^2}{1-\lambda t_a} + t_a$$

}
Step5:
Mobile node compares both networks,
VHOM selects the best network.
Step6:
If no AP or BS detected,
[Checks whether any other mobile station available with AP or BS connection and have enough bandwidth limit. If Mobile Station is detected with enough quality, then switch to Mobile Station communication]
Step 7:
Else
No communication.

We have divided our proposed system into small modules, they are given as below.

- Network selection
- Fading Detection
- VHO between Wi-MAX/WLAN
- Effective handoff

3.1.1 Network selection

Initially when node is checking for network availability, node always gives the priority to own network type. If the own network is not available then the node selects another network. Here we are using Wi-MAX/WLAN networks, so the node first checks in the two networks based on their respective signal strength [8].

3.1.2 Fading Detection

Fading detection is nothing but the process of checking the signal strength. In our proposed system model, we are checking the fading according to the distance between MT and AP or BS. Long distance causes high fading.

3.1.3 VHO between Wi-MAX/WLAN

We are proposing the VHO according to the fading detection and bandwidth availability (see algorithm).

3.1.4 Effective Handoff

Here, we are implementing the ad-hoc technology in infrastructure system called as cognitive radio network. In our model, whenever system is out of range of all the BSs and APs. Then it can make the communication though the PU when it's free. In this model we are considering requesting device as the secondary device and the one which is helping to make communication as PU.

3.2 Performance Evaluation

For our analyzing purpose, we are using the tools MATLAB and NS2. By using MATLAB, we are calculating the bandwidth and delay [9], [10]. NS2 is for showing the prototype model of VHO with enhancements such as ad-hoc property. The network model parameters are given in Table1.

Parameters	Values
Wi-MAX nodes	1
WI-FI nodes	3
Mobile nodes	11
Routing protocol	AODV
WI-FI coverage	100m
Wi-MAX coverage	400m (for testing only)
Simulation time	10s

Table1. Network Model Values

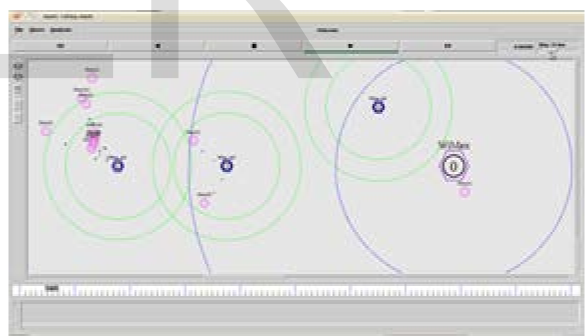


Figure2. Nam output for VHO model

In this Nam window output (Figure2) we are implementing model of Wi-MAX and WLAN. In this model there are the 15 nodes (Wi-MAX and WLAN and Mobile Nodes) available. If mobile node is out of the range of WLAN and Wi-MAX, then it cannot communicate.

In our enhanced prototype model, we have implemented VHO with ad-hoc property (Fig.3). So whenever node is not in the coverage of AP or BS then node can search for another mobile node which is having enough extra bandwidth. If mobile station has extra bandwidth then that node is going to act as a PU and searching node is acting as a SU. If PU is detected by the SU, then the SU can make communication through the PU.

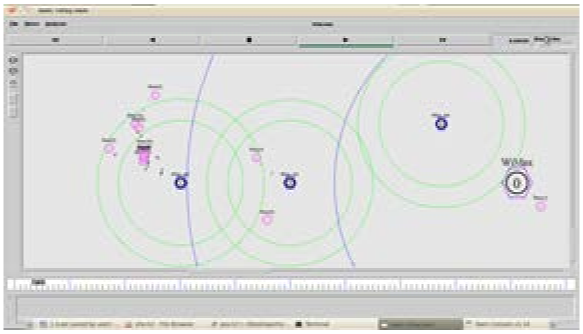
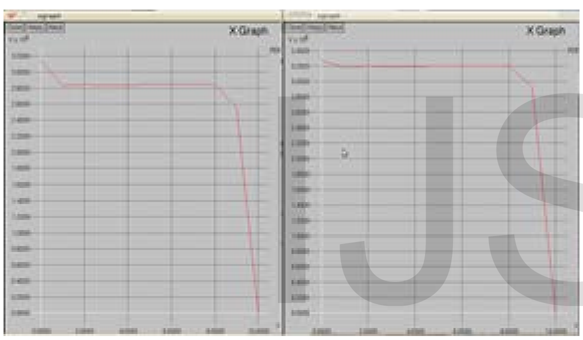


Figure3. Nam output for VHO with Ad-hoc type

We are analyzing performance through the X-Graph (Fig.4). From this graph we can see that the packet delivery function is high for the VHO with ad-hoc network compared to normal VHO operation. The two figures in the X-Graph shown in the above diagram are denoted as Left (A), Right (B). "A" is for showing the quality of only VHO and "B" is for VHO with Ad-hoc property. From the above graph, we can conclude "B" performance is better than "A".



(A) (B)
Figure4. (A) X-Graph output for VHO, (B) VHO with Ad-hoc type

By using the OFDMA technique, the bandwidth is allocated in the form of data bursts where an integer number of slots are admitted. BS determines the number of Download (DL) and Upload (UL) slots that a station obtains in one frame and broadcasts the resource allocation results through DL-MAP/ UL-MAP messages at the beginning of each DL sub-frame. Therefore, mobile stations can easily obtain the utilization of WiMAX link by aggregating the number of allocated slots stated in DL-MAP/UL-MAP messages. AASu and AASd denote the number of allocated DL/UL users.

The summary of the MATLAB Simulation results are presented below in Table2 and Table3 below.

AASu Occupation (us)	Mean Packet Delay (ms)
0.1	9
0.2	10
0.4	12
0.5	14
0.6	15
0.7	17
0.8	19

Table2. Wi-MAX UL Delay

AASu Occupation (us)	Bandwidth (Mbps)
0.1	3.9
0.2	3.5
0.4	2.9
0.5	2.5
0.6	2
0.7	1.5
0.8	0.8

Table3. Wi-MAX Bandwidth

The AASu (AASd) occupation denotes the utilization of the medium, which equals to AASd/su (AASu/su). Simulated results for available bandwidth are shown in Figures 5 and 6 respectively.

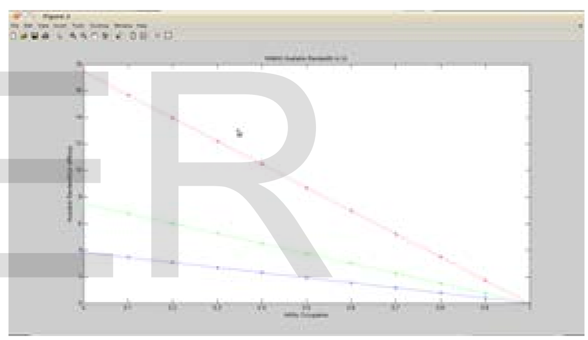


Figure5. Bandwidth available for UL

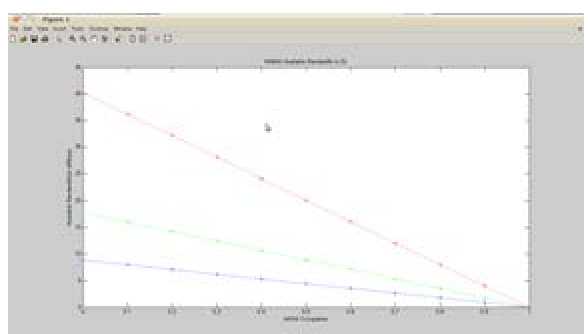


Figure6. Bandwidth available for DL

From Figures 7 and 8, it can be seen that the UL/DL delay increases slowly with the increasing of AASu/AASd occupation respectively.

In Figure9, we showed our result for WLAN bandwidth availability. If Network Allocation Vector (NAV) increases, bandwidth will be reduced.

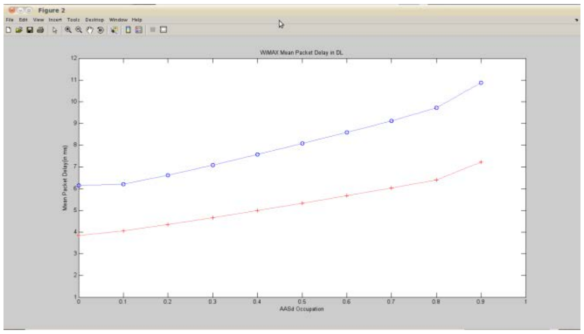


Figure7. Delay in Wi-MAX UL

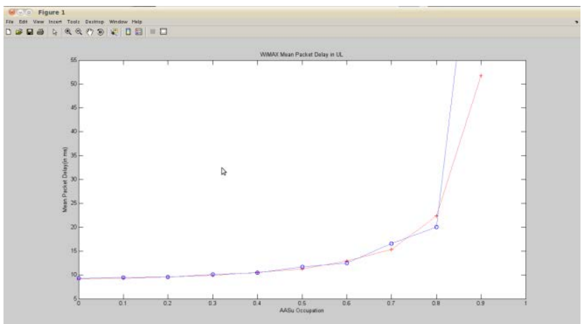


Figure8. Delay in Wi-MAX DL

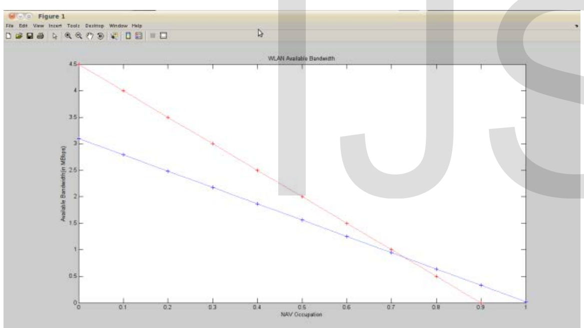


Figure9. WLAN available bandwidth

4 Conclusion

In this paper, we investigate several important issues for the interworking of WLAN and Wi-MAX networks. We resolve a tightly coupled interworking architecture as the platform of our scheme. And we improve the efficiency of the network by including ad-hoc property.

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