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AN INTEGRATED WLAN AND WiMAX ARCHITECTURE WITH QoS-BASED VERTICAL HANDOFF SCHEME

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ABSTRACT

The evolution of today's wireless network lean to combine different wireless access technologies for the purpose of offering users the Always Best Connected(ABC) service. The devices have multiple heterogeneous interfaces to offer services from different networks simultaneously. It is an important and demanding issue to support seamless handover in this integrated architecture. Handover refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another. The process of handovers requires a number of parameters e.g. what is the handover scheme we are using, how many channels are free. The handover process should also keep the QoS up to the standard. Here, the issue of vertical handovers in heterogeneous wireless networks is investigated. Integrated WLAN and WiMAX architecture with QoS-Based vertical handoff scheme is proposed to provide seamless handoff. The article investigate a simple and efficient method to calculate the available bandwidth in WLAN and WiMAX networks to evaluate the real-time status of the overlay networks and make a handoff decision based on the information. Power consumption module is proposed to calculate remaining power of the neighbouring node as if it is above threshold we will get best connected service. This application will initiate a handoff only when it satisfied the QoS parameters that is available bandwidth and power. The simulation study has revealed that the proposed scheme can keep stations always best connected with their QoS requirements.

KEYWORDS: QoS, Vertical Handoff, VHOM, Wi-Fi, WiMAX

INTRODUCTION

Next generation wireless network is envisioned as a union of different wireless access technologies providing the user superior connection any where any time to improve the systems resource utilization. Many new architectures or schemes have been proposed for seamless integration of various wireless networks. These networks allow mobile users to stay connected as they move through different networks. The IEEE 802.11 wireless local area network(WLAN) have been deployed widely and 802.11 access point can cover area of few hundred meters ,making them suitable for enterprise networks and public hotspot networks. Recently 802.16 standards (WiMAX) can provide high data rate and wide area of coverage. Integration of these two technologies raises several challenges.

When MN changes its current point of access technology handoff occurs. There can be two different types of handoff: horizontal handoff and vertical handoff. Horizontal handoff refers to switching between point of attachment or base station that belongs to same network. Vertical handoff refers to switching between stations that belong to different networks. Process of vertical handoff can be divided into three steps, namely system discovery, handoff decision and handoff execution. During system discovery phase MN search networks and what are the available services in each network. During handoff decision phase MN determines which network it should connect to. Handoff decision may depend on various parameters such as bandwidth, delay, access cost, and transmission power, current battery status of mobile node and user preferences. During handoff execution phase connections are transferred from existing network to new network in seamless manner. This involves authentication, authorization as well as transfer of user's context information.

The main aim of this paper is to design an effective QoS-based VHO scheme for a wireless overlay network consisting of WLANs and WiMAX heterogeneous wireless networks. The major contributions of this paper can be summarized as follows. 1) A general VHO management (VHOM) scheme to make VHO decisions in WLANs and WiMAX interworking networks has been designed for each station to intelligently monitor the quality of connections and proactively detect network conditions. VHOM always selects the network which can provide better service to serve the station rather than a preferred network. 2) In order to obtain QoS parameters to make a handoff decision; two bandwidth estimation algorithms have been given in existing system to predict the available bandwidth in WLAN and WiMAX networks [10]. 3) Power consumption module is proposed to calculate remaining power of the neighbouring node as if it is above threshold we will get best connected service.

The rest of the paper is organized as follows. In Section II, the system architecture and the framework of the VHO scheme of our design is described. In Section III, two bandwidth estimation algorithms are given. In Section IV, proposed power saving module is described. In Section V, expected results are presented to show the effectiveness and the feasibility of our solution. And in Section V, a summary is presented to conclude the paper.

SYSTEM MODEL AND PROPOSED VHOM SCHEME

Interworking Architecture

Here, the interworking architecture of WLAN and WiMAX networks are discuss as shown in Figure 1. [10] The BS and overlaid APs has access to the same gateway and they belong to the same subnetwork at the IP layer. One IP address is given to each station but two medium access control (MAC) addresses for each of two interfaces. Any station will be in the connection with either a WLAN AP or a WiMAX BS at a time. The sleep mode station is that interface which is not serving.

In the system, the WiMAX network is either supported by IEEE 802.16d or IEEE 802.16e standard without restriction on the physical and MAC layer of the networks. The WLAN can be supported by IEEE 802.11 standards, where the network allocation vector (NAV) mechanism has been employed at the MAC layer. When mobility is supported in the interworking system, a VHO can be triggered by either a station moving out of the coverage of one cell of WLAN or the lack of available bandwidth to meet the QoS requirement in the current network. Otherwise, when mobility is not supported by the interworking system, a station can perform VHO when bandwidth is insufficient.

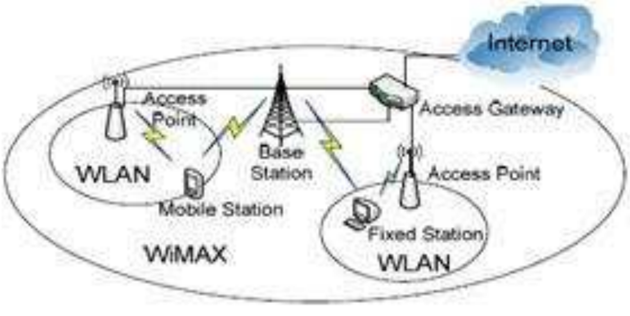

Figure 1: Interworking Architecture of WLAN and WiMAX [10]

VHO Management Scheme

Here we propose and design a VHOM scheme, which works on the MAC layer protocols of IEEE 802.11 and IEEE 802.16 standards. This is based on the interworking architecture, in order to enable stations to intelligently monitor the quality of current connections and make an accurate handoff decision; the main functions of proposed VHOM include traffic measurement, network status detection, handoff decision, and connection transition illustrated in Figure 2:

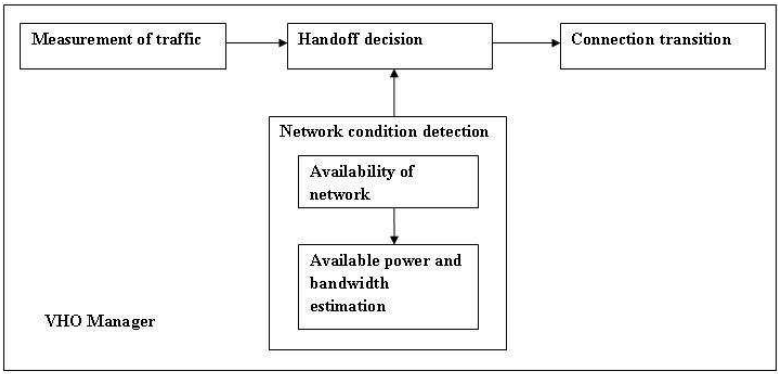

Figure 2: Overview of VHOM

The operation of the proposed VHOM scheme is described in figure 3.and figure 4. When HDM receives information regarding the performance of the current network from TMM, which indicate the throughput of the uplink or downlink connections cannot satisfy the QoS requirement of the traffic at the station, it will inform the NCDM to detect the performance of the other network. The network availability is detected first. If the other network cannot be found, HDM will terminate this handoff attempt and restart after a period if the measured traffic still cannot meet QoS requirement. Otherwise, if the network can be detected, NCDM estimate the bandwidth of the detected network domain using the algorithms presented in section III. After estimating available bandwidth, NCDM detect the available power. It search for neighbouring nodes having enough power. Subsequently, the estimated reports will be submitted to HDM to make a decision on handoff. If the estimated available bandwidth and available power can satisfy the QoS requirement of the traffic at the station, HDM will decide the new network domain as the target network and inform CTM to perform a handoff operation. Otherwise, NCDM will be started to detect the bandwidth and power again after a period of time. Once CTM receives information to initiate a handoff, the data destined to the station will be transmitted by access gateway via the target network. Since the IP address is not changed, the VHO process is transparent to upper layers.

Algorithm

The algorithm illustrates operation of the proposed VHOM scheme.

1 Check if the QoS requirements are satisfied or not.
2 If satisfied
  2.1 Stay with current network
3 Else
  3.1 Detect the performance of the other network
  3.2 If the network can be detected
    3.2.1 Estimate the bandwidth of the detected network domain
    3.2.2 If estimated available bandwidth can satisfy the QoS
      3.2.2.1 If neighbouring nodes having enough power
        3.2.2.1.1 Perform a handoff operation.
      3.2.2.2 Else
        3.2.2.2.1 Go to step 3.1
    3.2.3 Else
      3.2.3.1 Evaluate the bandwidth again after a period of time.
  3.3 Else
    3.3.1 Terminate this handoff attempt and restart after a period if the measured traffic still cannot meet QoS requirement.

Figure 3: Algorithm Illustrates Operation of the Proposed VHOM Scheme

When making a handoff decision, it should be noticed that the resource allocation approach in WiMAX systems is different from that in WLANs. In WLANs, the medium is shared by multiple stations in a contention manner. And only the total available bandwidth can be estimated.

However, the wireless resource in WiMAX networks is scheduled by BS and is partitioned into downlink and uplink sections. Then the available bandwidth should be estimated for downlink and uplink directions, respectively. Therefore, the handoff direction should be considered when making a VHO decision. For the scenario of the handoff from the WiMAX system to the WLAN, the condition to trigger a handoff is

$$Total_{BW} \geq DOWN_{THR} + UPLINK_{THR} + H1$$

where $Total_{BW}$ is the estimated total available bandwidth of the WLAN domain, $DOWN_{THR}$ and $UPLINK_{THR}$ are the expected downlink and uplink throughput, H1 is the hysteresis which is used to improve performance in synchronous Networks . For the scenario of the handoff from the WLAN to the WiMAX system, both the downlink and uplink available bandwidth should satisfy the given conditions

$$DOWN_{BW} \geq DOWN_{THR} + H2$$

$$UPLINK_{BW} \geq UPLINK_{THR} + H3$$

Where $DOWN_{BW}$ and $UPLINK_{BW}$ denote the downlink and uplink available bandwidth of WiMAX network, H2 and H3 are hysteresis for the downlink and uplink connections respectively.

BANDWIDTH ESTIMATION

In [6], a broad expression for available bandwidth has been presented, which is the difference between the total capacity and aggregated utilized bandwidth. The following presented solutions develop from this definition and take into account the characteristics of WLANs and WiMAX networks.

Bandwidth Estimation in WLANs

The primary access method of the IEEE 802.11 MAC is Distributed Coordination Function (DCF) commonly known as carrier sense multiple access with collision avoidance (CSMA/CA) [7]. The carrier sense at MAC layer can be achieved by promotion reservation information announcing the impending use of the medium.

The exchange of request to send/clear to send (RTS/CTS) frames is one means of this medium reservation. Prior to the data transmission, the source station sends RTS and the destination station replies with CTS.

Other stations that hear RTS/CTS will update their NAV to be busy state for a period of time given in the RTS/CTS frames. During this period, the station will defer its own data transmission as shown in Figure 4.

A station determines avaibility of medium in two cases. One case is that NAV is set, which indicate the medium is occupied by another station.

The other case is that the medium is occupied by this station itself as a sender or receiver. Therefore, by aggregating these busy intervals, the station can estimate the utilization of the medium and the available bandwidth in succession.

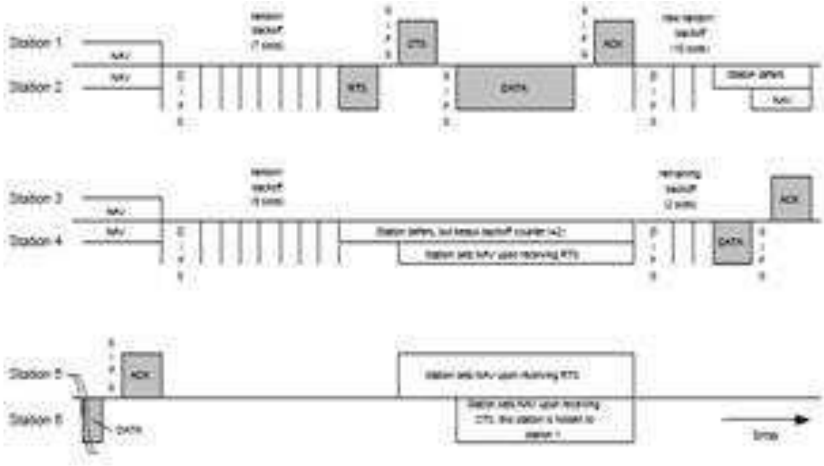

Figure 4: IEEE 802.11 Frame Exchange Sequence

The estimation period is assumed to be τ. The period that the medium is occupied by data transmission during τ can be expressed as,

$$Data_T(t-\tau,t) = \sum_{t-\tau}^{t} Data\_Nav_T + \sum_{t-\tau}^{t} Data\_Trans_T$$

Where $Data\_Nav_T$ denote the data transmission time in a NAV interval, $Data\_Trans_T$ denote the data transmission time in a transmission opportunity obtained by the desired station. Then the average utilization of the medium can be written as

$$U(t-\tau,t) = \frac{Data_T(t-\tau,t)}{t}$$

However, as shown in Figure 3, the reserved medium is not only used for data transmission in every busy interval. Time intervals between frames such as interframe space (IFS) are mandated by CSMA/CA algorithm and every transmitted data frame should be acknowledged by acknowledgement (ACK) frame. The proportion of the reserved resource that can be used purely for data transmission is

$$R(t) = \frac{Data_\mu}{Data_\mu + R/C/A_\mu + \left(3SIFS_T + DIFS_T + BACKOFF_T(t)\right)C(t)/8}$$

Where $Data_\mu$ is the mean data packet size in bytes of the desired station, $R/C/A_\mu$ is the sum of RTS/CTS/ACK frames size, $SIFS_T$ and $DIFS_T$ are time durations of SIFS and DIFS. $BACKOFF_T$ (t) denote the average random backoff time, and C (t) is the data rate at time t.

Based on the above information, we can calculate the available bandwidth through the expression

$$Available_{BW}(t) = \left(R(t) - U(t-\tau,t)\right)C(t)$$

Note that if RTS/CTS mechanism is disabled, the proposed scheme can still work well after making minimal modification in the formulations. The methodology is similar.

Bandwidth Estimation in WiMAX Systems

In IEEE 802.16 protocols, the frame consists of a downlink subframe and an uplink subframe as illustrated in Figure 5. The bandwidth resources will be allocated in the form of data bursts. And each burst constitutes an integer number of physical slots (PSs). Based on the resource demands and QoS parameters, BS determines the bandwidth that a station can obtain in one frame for receiving downlink data or transmitting uplink data, and then broadcasts this allocation information through information element (IE) in the DL-MAP and UL-MAP messages at the beginning of each frame [8].For different

PHY specifications, the bandwidth allocation information in DL-MAP/UL-MAP messages is expressed in different granularities, such as mini slot in Wireless MAN-SC PHY specification and sub channel-symbol pair in Wireless MAN-OFDMA PHY specification. But all these granularities can be specified as a function of PS. For simplicity and explicitness, we use PS as a uniform unit.

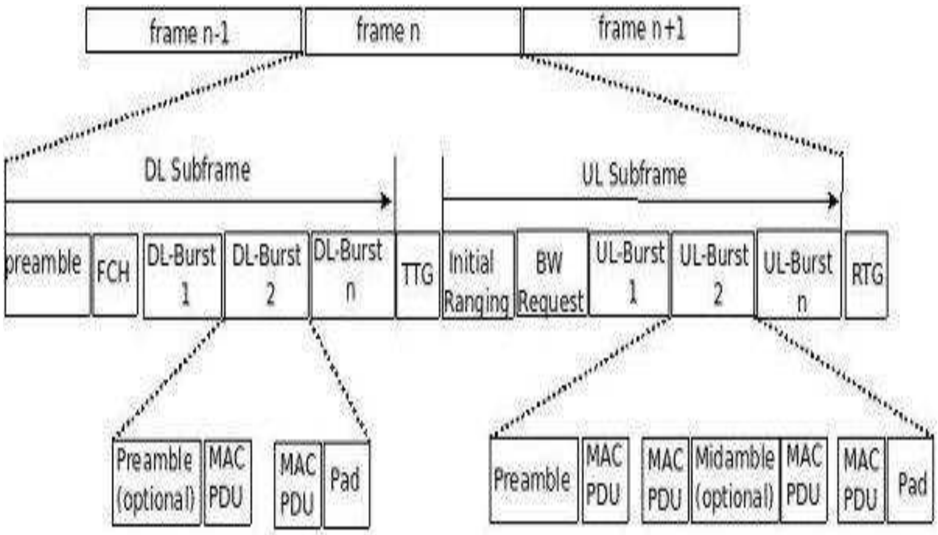

Figure 5: TDD Frame Structure of IEEE 802.16

In the proposed scheme, desired stations are expected to check all the IEs in the DL-MAP/UL-MAP messages and aggregate the number of allocated downlink and uplink PSs, respectively. $Frame_T$ denote the time duration of a frame. PSDown-total and PSUp-total denote the number of PSs in a downlink/uplink subframe, respectively. Assume that there are an integer number of frames during the probing period τ, which can be given by

$$N = \frac{\tau}{Frame_T}$$

Then the number of unused PSs of this period is equal to

$$PS_{Up-free}\,(t-\tau,t) = N * PS_{Up-total} - \sum_{i=1}^{N} PS_{Up-used}\,(i)$$

$$PS_{Down-free}\,(t-\tau,t) = N * PS_{Down-total} - \sum_{i=1}^{N} PS_{Down-used}\,(i)$$

where PSDown-used(i) and PSUp-used(i) denote the utilized PSs in the ith downlink and uplink subframe.

Based on the parameters introduced above, the available bandwidth can be estimated by the following expressions

$$DL - Available_{BW}(t) = \frac{1}{\tau}\, PS_{Down-free}\,(t-\tau,t)\; C_{DL-Slot}\,(t)$$

$$UL - Available_{BW}(t) = \frac{1}{\tau}\, PS_{Up-free}\,(t-\tau,t)\; C_{UL-Slot}\,(t)$$

where CDL-slot(t) and CUL-slot(t) are the number of bits that can be transmitted in one downlink or uplink PS. We further define the utilization of the resource in WiMAX as:

$$U_{DL}(t-\tau,t)=\frac{\sum_{i=1}^{N}PS_{Down-used}(i)}{N*PS_{Down-total}}$$

$$U_{UL}(t-\tau,t)=\frac{\sum_{i=1}^{N}PS_{Up-used}(i)}{N*PS_{Up-total}}$$

PROPOSED POWER SAVING MODULE

Wireless devices running on battery, so they have limited power consumption. If the battery level decreases, switching for a network to another network with low power consumption can provide a longer usage time. For example, if a device with the battery almost exhausted, switching from a WLAN to a WiMAX network would be a smart decision. This is because, when they operate in a WiMAX network, the device is inactive for an extended period of time.

However, given the unpredictable and chaotic nature of wireless trans-mission, the terminals are able to wait between transport activities in the form of packages, because there is no predefined set of times of arrival and transmission of data and packets.

The Power requirements become a critical issue especially if the hand held battery is low. In such situations, it is preferably transferred to an attachment point, and this will extend battery life [9].

So before doing handoff we first find out list of neighbouring nodes and check there remaining power. If it will be below threshold value ie. 10% of total energy, we set flag to 1 otherwise to 0. If flag set at neighbouring node is 0 then avoid switching to that particular network otherwise initiate handoff.

The remaining energy of the node can be expressed as:

$$\mathrm{R_{energy}} = \mathrm{I_{energy}} - \mathrm{C_{energy}}$$

Where, R_{energy} means Remaining energy, I_{energy}, is Initial energy and C_{energy} is Consumed energy. We further define Consumed energy as:

$$\mathrm{C_{energy}} = \mathrm{RecvI_{packets}} * \mathrm{Recv_{energy}} + \mathrm{Trans_{packets}} * \mathrm{Trans_{energy}}$$

Where, $Recv_{packets}$ is received packets, $Recv_{energy}$ Receiving power, $Trans_{packets}$ is Transmitted packets and $Trans_{energy}$ is Transmission power.

RESULTS

To demonstrate the effectiveness and feasibility of proposed approach, results are shown as simulation model based on the architecture illustrated in Figure 1 by the simulation software NS2.

The Simulation Results of Available Bandwidth and Power Consumption in WLAN and WiMAX Heterogeneous Wireless Networks

Graphs are plotted for our proposed work and existing method. In the existing method handoff were done based on available bandwidth factor were as in our proposed method handoff decision is done based on available bandwidth and power consumption detail. We have compared existing method and proposed method considering different parameters such as:

Table 1: Simulation Parameters for Available Bandwidth Estimation and Power Consumption

Parameter	Value
Standards	802.11, 802.16
Data rates tested	40 mbps
Frame Duration	13sec
No. of Nodes	20
Channel Bandwidth	40 MHz
Packet Interval	10 ms
Initial Energy	50 joule
Control packet	66 bytes

The figure 6 shows available bandwidth in WLAN and figure 7 and figure 8 shows the available uplink bandwidth and downlink bandwidth in WiMAX. In our method handoff is done only if available bandwidth is better which results in greater throughput. Relationship between available bandwidth with respect to time is shown. As we can see as time increases bandwidth decreases. Initially we have maximum bandwidth available which decreases with utilization**.**

Figure 6: Available Bandwidth in WLAN

The Figure 9 shows throughput obtained in existing system. Initially, the station was served by WLAN service domain and gives better throughput. But around 7 second, VHOM detected that the network traffic tended to be overloaded and we didn't get constant throughput. The NCDM module was initiated to estimate the available bandwidth of WiMAX. The estimated results showed that both the downlink and uplink available bandwidth of WiMAX could satisfy the requirements.

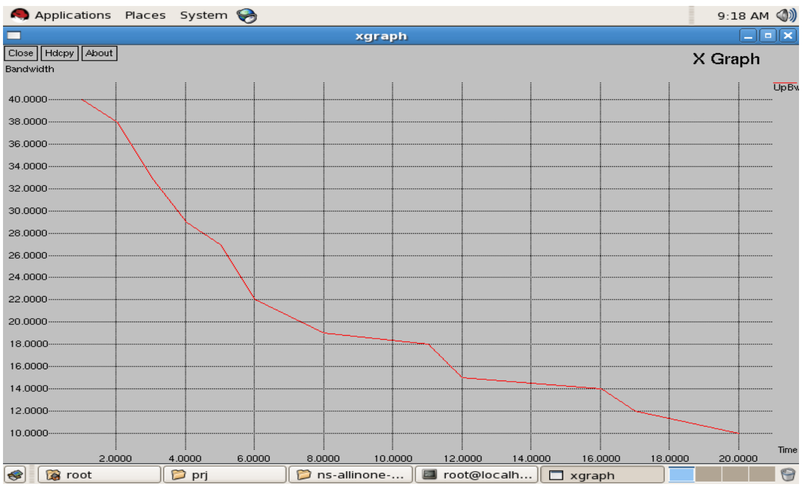

Figure 7: Available Uplink Bandwidth in WiMAX

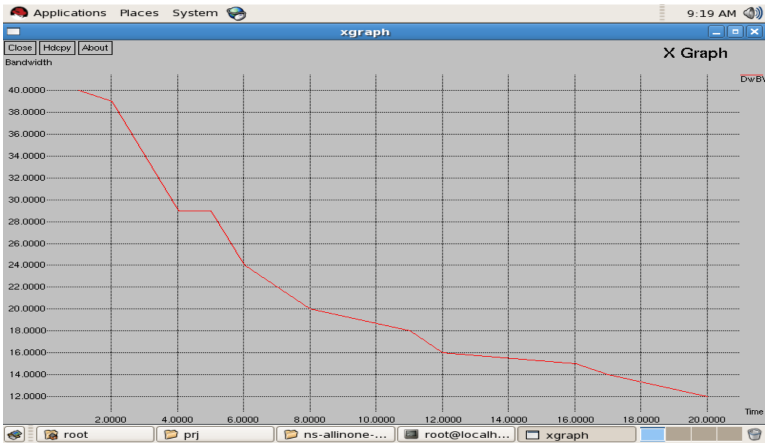

Figure 8: Available Downlink Bandwidth in WiMAX

Then the connections were transferred to the WiMAX domain immediately at the station. The throughput obtained at the station after estimating the bandwidth remain constant only for few seconds and again it decrease as the neighbouring node to whom connections are transferred is not having enough power. Then HDM again search for another network with available bandwidth. So in this graph we can see there is no constant throughput.

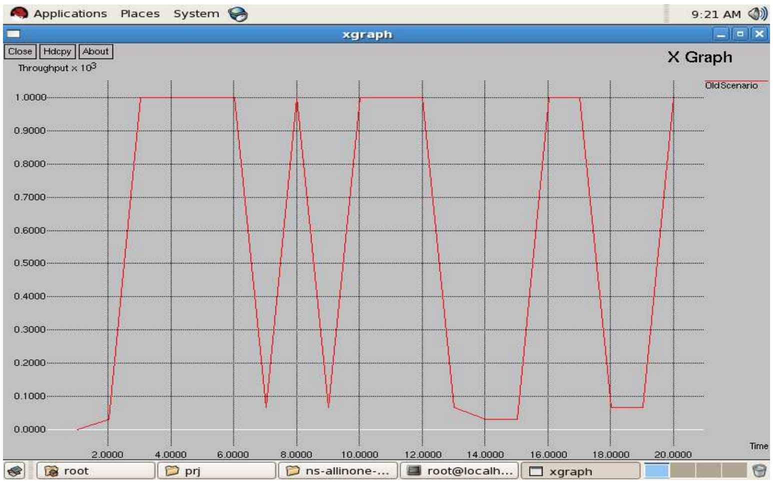

Figure 9: Throughput Obtained in Existing System

In Figure 10 the results show that larger throughput can be obtained by the proposed solution. Because in our proposed scheme after estimating available bandwidth we search for neighbouring node having enough power which shows throughput remains constant without decreasing.

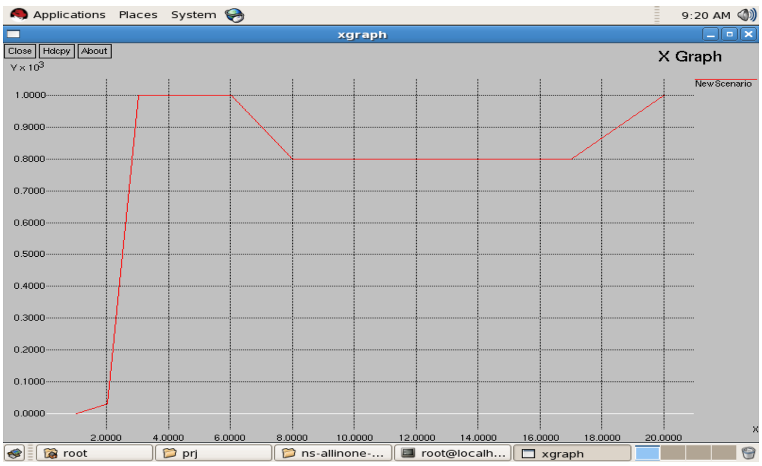

Figure 10: Throughput Obtained in Proposed Scheme

CONCLUSIONS AND FUTURE WORK

In this paper, we have proposed a novel VHOM scheme to make VHO decisions in the interworking architecture of WLANs and WiMAX networks. The scheme aims to provide always the best QoS in terms of throughput for both mobile users and fixed users. The available bandwidth and power consumption of node has been taken into account in making the vertical handoff decisions. Two existing bandwidth algorithms is used to estimate the available bandwidth in WLANs and WiMAX networks respectively, which are based on the inherent features of the bandwidth allocation schemes and the message transmission approaches in both networks. As well as in proposed scheme we calculate remaining power of neighbouring node so that we can get better throughput. The parameters required for the bandwidth evaluation and power consumption are easy to obtain in the real networks and the complexity of the evaluation is computationally low. Those make the proposed scheme to be feasible to implement. By the simulation experiments, we can prove the feasibility and effectiveness of our proposed VHO scheme.

In the future study, we can extend our proposed scheme by considering another factor of power consumption like power consumption attributed to base station equipments and power consumed during frequent interface activation.

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