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Reducing Overall Channel Scanning Duration And Unbeneficial Handoffs In Wimax Networks For Mobile And Fixed Stations

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ABSTRACT

This paper propose an algorithm for reducing overall channel scanning time and number of unbeneficial handoffs in 802.16 networks. Our proposed channel scanning and handoff schemes works mutually for reducing the service disrupt time. Also, our handoff algorithm considers available bandwidth and latency along with RSS level for avoiding or encouraging unbeneficial and beneficial handoffs respectively. The simulation result shows that, the proposed algorithm reduces the overall channel scanning time and number of handoffs dramatically. Also, it increases the throughput, decreases the packet delay and handoff latency achieved by both mobile and fixed stations.

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INTRODUCTION

The implementation of IEEE 802.16 network also called as WiMAX network grows rapidly due to its wider coverage area and high bandwidth support. It is widely used for providing Internet services to the users specifically in urban areas. Comparing with 802.11 the added advantage in WiMAX is, its wider coverage area which is suitable for users moving with high speed. A single WiMAX Base Station (BS) may not enough to provide enough QoS in densely populated urban areas. So, to cover large area and to provide QoS, multiple overlapped BSs are used in WiMAX networks. The mobile station (MS) moving with high speed may goes out of coverage frequently. In this scenario the MSs have to perform handoff process with the nearby BS for continuing the ongoing services. Handoff is a process of connecting with new BS before or after disconnecting the old BS.

During the handoff process, the MS has to scan multiple channels for finding nearby BSs and selecting a best BS among the available BSs. The selection of target BS is based on criteria like measured signal strength, throughput, packet delay, error ratio, security levels, etc. It is preferable for a MS to scan the network before performing handoff, since, scanning is a time consuming activity. The 802.16e standard supports temporary suspension of communication between BS and MS by buffering uplink and downlink packets at MS and BS

respectively. This temporary suspension allows the MS to switch between channel scanning and normal data communication. The long scanning interval results in high packet jitter and end to end packet delay which reduces the QoS significantly, and short scanning interval requires multiple iterations for detecting all nearby BSs which increases the overall scanning duration.

Most of the related works in the literature tried to minimize the number of MSs that requires channel scanning to be performed. Only few works have been tried to minimize the scanning time instead of reducing the number of scanning. In this paper we focus mainly on reducing the overall scanning duration and in reducing the number of unbeneficial handoffs performed by MSs.

The 802.16 standard defines procedure for MS to connect with BS called as network entry phase (NEP). The NEP consists of synchronization and association operations as shown in Fig. 1. During the synchronization operation, the MS will receive downlink map (DL-MAP), uplink map (UL-MAP), downlink channel descriptor (DCD) and uplink channel descriptor (UCD) from the BS. The UL-MAP and DL-MAP contains burst allocation for each frames, and DCD and UCD contains transmission parameters for each burst. During the association operation, the MS adjust its transmitting power and timing according to the BS and it performs a step called initial ranging in which the MS will transmit a ranging request by selecting a ranging slot according

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to the truncated exponent algorithm (Jung-Ryun Lee, Dong-Ho Cho, 2007). Then, the MS will connect to the BS just after the successful completion of the processes like capability negotiation, authentication, and registration.

During every handoff, the network entry operations have to be performed by the MS which may disrupt the ongoing connections significantly. To overcome this issue, the 802.16e standard offers the DCD and UCD message exchange over the backbone. This information about the neighbor BSs will be sent to the MS by the currently serving BS periodically. This allows the MS to know about the channel information in advance to the scanning which will save the overall scanning time and reduce the service disrupt time.

Related Works:

We present a QoS based strategy for reducing the overall scanning time, faster network access during the network entry phase and delay during the handover procedure. In the literature, there are two classes of research, which are efficiently schedules the scanning operation and improves the handoff process. Those works neither attempt to reduce the number of frequencies checked during the scanning

operation. In (Rouil, R. and N. Golmie, 2006), Adaptive Channel Scanning (ACS) algorithm has been introduced which focused on estimating the time required to perform scanning a list of neighboring BSs and interleaving the scanning and data transmission intervals by the MS. The work in (Choi, S., *et al.*, 2005), specifically focused on improving handover performance and they introduced a new management message in order to receive downlink data during the handover process for reducing the downlink packet delay. Last packet marking technique is explored in (Kim, K., C. Kim, T. Kim, 2005), which require integration of layer 2 handover and layer 3 handover. It allows MS to notify the target BS in prior to the handover.

The work in (Sik Choi, *et al.*, 2005), proposes a link layer handover algorithm that improves the ranging of data streams between the serving BS and the neighboring BS. This enables the MS to receive the data downstream during synchronization with the neighbor BSs. The limitation of this scheme is, enhanced downstream from BS to MS will deteriorate the quality of VoIP communication, since it requires both downstream and upstream enhancement.

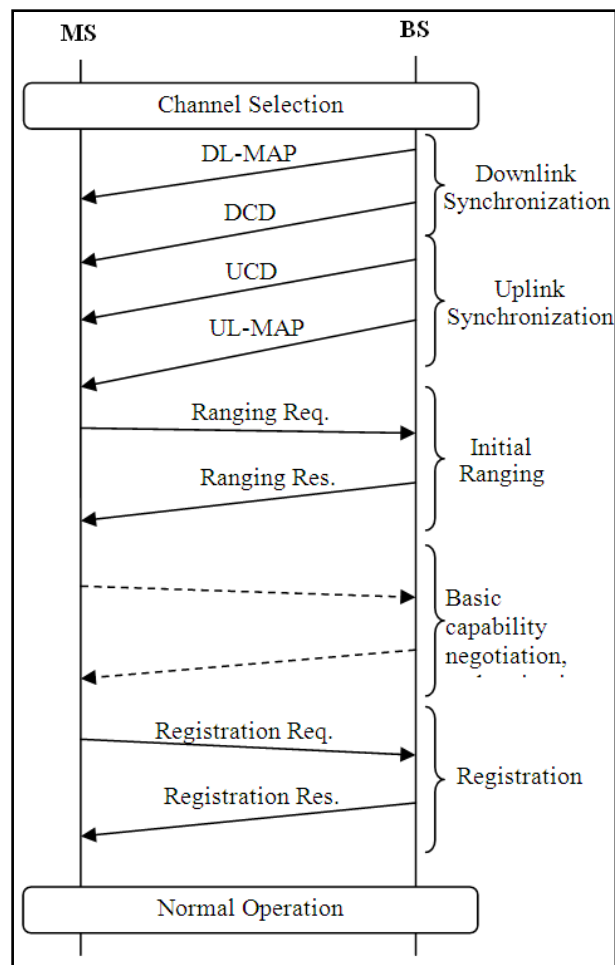


Fig. 1: Network Entry in WiMAX.

The cross layer approach for fast handover in (Speicher, S., C. Bunnig, 2006), depends on the extended MAC-layer information being sent via every channel between MS and BSs. The extended MAC layer information includes the IP address information which reduces overall handoff time. In this scheme, two important disadvantages are: 1) it will increase the security risk, since the IP address in this open way will increase the chance to an unsecure access device, and 2) the buffering of the probe message by an access device for certain amount of time may cause an additional delay for the MS to connect to its communicating channel.

As discussed in (Hwi Woon Jeong *et al.*, 2012), handover is a critical issue for wireless networks of various protocols including IEEE 802.16e. In that the authors proposed an efficient handover scheme to reduce the number of packets transmitted for handover and increase the channel availability. Their work is based on a concept of group-based channel scan and scheduled handover with the MSs. It allows efficient channel scan and considerable reduction of drop probability of handover requests compared to the existing scheme employing the MS grouping approach. They found that this improvement was more important while the rate of requests increased.

As presented in (Ray, S.K., *et al.*, 2007), the mobility framework of IEEE 802.16e, a MS should scan the neighbor BSs, for selecting the best BS for a potential handover. The standard does not specify the number of BSs to be scanned by the MS for unnecessary scanning. Also, the long scanning will interrupt data transmission and causes degraded QoS of an ongoing connection. Thus reducing the unnecessary scanning is more important. The authors proposed a scheme to reduce the number of BSs to be scanned for improving the overall handover time. By simulation they have shown that their hybrid predictive BS selection scheme for potential scanning is better than the usual IEEE 802.16e handover scheme in terms of handover delay and resource utilization.

Another work in (Kyung-ah Kim, *et al.*, 2005), BS sends information to neighbor BSs via backbone and the MS selects a target BS based on the signal strength and response time of the BS. But our work reduces the handoff latency by eliminating the number of BSs from the scanning process based on available bandwidth and packet delay.

Proposed Channel Scanning And Handoff Method:

In our proposed channel scanning and handoff method, the following changes are made: every BS has to exchange their own available uplink (UL) bandwidth (AUB), available downlink (DL) bandwidth (ADB), UL packet delay (UPD) and DL packet delay (DPD), along with DCD and UCD over the backbone to the nearby BSs periodically. A handoff decision module (HDM) is installed in MSs that works at MAC layer. During the application establishment, the HDM will classify the application in to real time application or non real time application based on the delay sensitivity of the application. Further, based on the transmission direction, it will classify the application in to UL application or DL application. The information like AUB, ADB, UPD and DPD about the nearby BS has to be updated to the MSs periodically by the serving BS. Method for calculating AUB, ADB, UPD and DPD is presented in next section. This information about the nearby BSs has to be utilized by the MS for channel scan and handoff decision. The scanning of channels and association process will be initiated only if the QoS provided by the current base station is not up to the required satisfaction level for a period of time F . The QoS may get degraded over time due to two reasons: 1) bad network condition of the current BS; and 2) bad condition of the networks in between the source and destination of the ongoing application. The bad network condition of the current BS may occur due to many reasons like poor signal strength, increased error ratio and insufficient bandwidth.

Algorithm (Main):

```

if application is loosing  $QoS$  for time  $> F$ 
  get the required uplink bandwidth  $UBW_{req}$ ;
  get the acceptable uplink packet delay  $UPD_{req}$ ;
  if the condition of current BS  $B_c$  is bad enough
    if the applicaion is a UL application
      call A1 algorithm
    else if the application is a DL application
      call A2 algorithm
    end if
  end if
  end if
  end if

```

Fig. 2: Proposed Scanning and Handoff Algorithm (Main).

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Algorithm (A2):
for each BS  $\beta \in B_0$ 
  get  $AUB_\beta$  and  $UPD_\beta$ 
  if  $AUB_\beta > UBW_{req}$  &  $UPD_\beta < UPD_{req}$ 
    add  $\beta$  to set  $B_1$ ;
  end if
end for
for each  $\beta \in B_1$ 
  scan the respective channel
  if  $\beta$  is Detected
    add  $\beta$  to set  $B_2$ ;
  end if
end for
if  $|B_2| > 0$ 
  if realtime application
     $B_t = \max_{\beta} \{ UPD_\beta \mid \beta \in B_2 \}$ ;
  else
     $B_t = \max_{\beta} \{ AUB_\beta \mid \beta \in B_2 \}$ ;
  end if
  perform handoff with  $B_t$ ;
else
  stay back in  $B_c$ ;
end if

```

Fig. 3: Proposed A2 Algorithm.

The MS has to initiate the handoff process only if the current BS's condition is bad enough. During the handoff process, the MS will compare the neighbor BS's AUB, ADB, UPD and DPD with the ongoing application's requirement. The list of available neighbor BSs B_0 will be shortlisted to a set B_1 if its AUB/ADB is greater than the ongoing application's required UL/DL bandwidth and UPD/DPD is lesser than the ongoing application's acceptable UL/DL packet delay. If $|B_1| > 0$, then, the MS has to scan the channels of every neighbor BS $\in B_1$. Else if $|B_1| = 0$, then the channel scanning and handoff process will be dropped. The detected BSs during the scanning process will be shortlisted in to another list B_2 . If $|B_2| > 0$, then the MS has to select a best BS among the B_2 as target network B_t , for performing handoff. If the ongoing application is a real time application, then, the BS with minimum UPD/DPD is considered to be the best BS. Else, if the ongoing application is a non real time application, then, the BS with maximum AUB/ADB is considered to be the best BS. The flow of our proposed channel scanning and handoff algorithm is given in Fig. 2. It invokes two more algorithms

namely A1 and A2 shown in Fig.3 and Fig.4 respectively in the form of pseudo code.

Our proposed algorithm has the following advantages over the existing legacy handoff algorithms in the literature.

- ❖ It uses wired backbone network for exchanging BS's information like maximum available bandwidth, packet delay along with UCD and DCD, which may not introduce additional traffic in wireless counterpart.

- ❖ The available bandwidth and packet delay calculation is done by BS, not by MS and hence the mobile need not to spend additional resources like computing power, battery power, memory etc. for estimating the neighbor BS's condition.

- ❖ The MS determines the number of BSs and channels for scanning based on the MS's QoS requirement in prior to the scanning process, hence, the overall scanning time reduced dramatically.

- ❖ The scanning or handoff process gets initiated only if the currently serving BS's condition is proved to be bad and at least any one of the neighbor BS's condition is proved to be good enough.

```

Algorithm (A3):

for each BS  $\beta \in B_0$ 
    get  $ADB_\beta$  and  $DPD_\beta$ 
    if  $ADB_\beta > DBW_{req}$  &  $DPD_\beta < DPD_{req}$ 
        add  $\beta$  to set  $B_1$ ;
    end if
end for
for each  $\beta \in B_1$ 
    scan the respective channel
    if  $\beta$  is Detected
        add  $\beta$  to set  $B_2$ ;
    end if
end for
if  $|B_2| > 0$ 
    if realtime application
         $B_t = \max_\beta \{ DPD_\beta \mid \beta \in B_2 \}$ ;
    else
         $B_t = \max_\beta \{ ADB_\beta \mid \beta \in B_2 \}$ ;
    end if
    perform handoff with  $B_t$ ;
else
    stay back in  $B_c$ 
end if

```

Fig. 4: Proposed A3 Algorithm.

Network Condition Detection Method:

The status of any BS may get change over time, due to many factors like sudden arrival of huge number of MSs into a particular geographical location covered by a specific BS, flow of unwanted traffics and some other reasons. In 802.16 WiMAX, network status can be detected by estimating two things: 1) available bandwidth and 2) network access delay. In this section we have presented numerical methods for estimating both available bandwidth and network access delay which are developed from the previous works in (Lim, W.S., *et al.*, 2009; Prasad, R., *et al.*, 2003; Kim, B., *et al.*, 2009; Chuck, D. and J. Chang, 2010; Dong Ma, Maode Ma, 2012).

In WiMAX the OFDMA-TDD contains number of DL and UL slots (Kim, B., *et al.*, 2009). The BS decides the number of DL and UL slots to be available for a station in one frame and broadcasts the same via DL-MAP and UL-MAP messages respectively. Using OFDMA-TDD frames, the available bandwidth for DL can be calculated as

$$DL_{abw} = \left(1 - \frac{ADS}{TDS}\right) \times \left(\frac{NOBD \times TDS}{DOF}\right) \quad (1)$$

Where, DL_{abw} is the available DL bandwidth, ADS is the number of allocated DL slots averaged from N number of frames, TDS is the total slots in a DL subframe, $NOBD$ is the number of bits transmitted in a DL slot and DOF is the duration of a frame. Similarly, the available bandwidth for UL can be calculated as

$$UL_{abw} = \left(1 - \frac{AUS}{TUS}\right) \times \left(\frac{NOBU \times TUS}{DOF}\right) \quad (2)$$

Where UL_{abw} is the available UL bandwidth, AUS is the number of allocated UL slots averaged from N number of frames, TUS is the total slots in a UL subframe, $NOBU$ is the number of bits transmitted in a UL slot and DOF is the duration of a frame. Also, the packet delay can be defined as the delay between the time that the packet arrives to the MAC layer and the time that the packet transmitted successfully. The packet delay PD can be divided in to three components as follows;

$$PD = D_{wb} + D_m + D_t \quad (3)$$

The waiting time in MAC layer buffer D_{wb} can be calculated as the time between the packet arrived to the MAC layer buffer and beginning of the frame allocated for transmitting the packet. The mapping delay D_m is the time between, the beginning of the allocated frame and the first time slot appointed to the station. The transmission delay D_t is the time spent to transmit the packet. The D_{wb} for UL can be calculated as

$$D_{wb} = \frac{3TOF}{2} + \left(\frac{E(e_q)TOF}{MPR}\right) \quad (4)$$

Where $E(e_q)$ is the equilibrium queue length derived from (Zhao, Y.Q. and L.L. Campbell, 1996; Janssen, A. and J.S.H. Van Leeuwen, 2005), MPR is the mean arrival packet rate. The mapping delay D_m will be zero if the packet length PL is greater than the number of bits NB that can be transmitted in one UL subchannel. If PL is less than NB then the D_t and D_m can be calculated jointly as

$$D_m + D_t = \left[\frac{1}{2} + \frac{PL}{NB} - \frac{1}{2} \left(\frac{PL}{NB} \right)^2 \right] D_{usf} \quad (5)$$

Where, D_{usf} is the total UL subframe duration. Similarly, for the DL delay, the D_{wb} can be calculated as

$$D_{wb} = \frac{TOF}{2} + \left(\frac{E(e_q)TOF}{MPR} \right) \quad (6)$$

The D_m for DL can be calculated as $D_p + u(D_{dsf} - D_p)/2$. Where D_{dsf} is the total DL subframe duration, D_p denotes the time duration of the preamble, u is utilization of DL resource. The D_t depends on the burst size and the number of bits transmitted by all subchannels in one slot duration, α . If the PL is larger than α , the packet will occupy the next time slots. If PL is less than or equal to α then the D_t can be taken as the duration of one DL time slot D_s , otherwise D_t can be taken as $(PL/\alpha)D_s$.

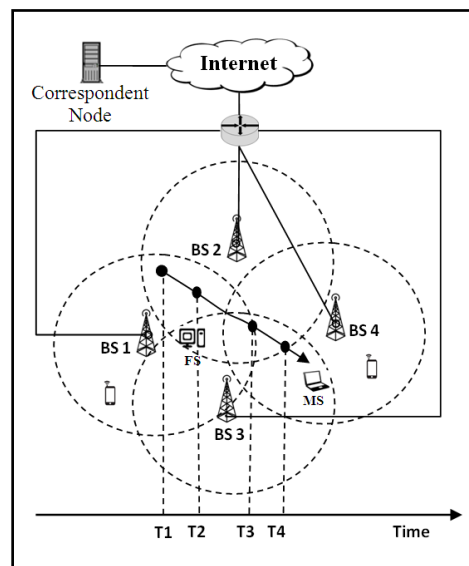


Fig. 5: Simulation Environment.

Simulation Results:

Our proposed algorithm is simulated and compared with legacy RSS based handoff algorithm in which RSS is the only criteria in handoff decision. The simulation topology is as shown in Fig. 5, in which four BSs are located, namely BS1, BS2, BS3 and BS4. Initially the MS was connected with BS1 whose condition is good at time T1 and goes bad at time T2. While moving, the MS detected that the condition of current BS is bad enough and it initiates handoff after analyzing the condition of neighbor BSs. At T2 the condition of BS1 and BS4 was bad and the condition of BS2 and BS3 was good. Hence, our proposed scheme scanned only two channels related to BS2 and BS3 instead of all neighbor BSs. Also, it selected BS2 as target network, since BS2 was the only BS detected during scanning and BS3 was not detected at T2. In the legacy RSS based scheme the handoff occurred only at T3 and it connected the MS with BS2, since the RSS of BS2

was greater than BS3 and BS4. The proposed handoff scheme performed no more handoff at T3 and continued its connection with BS3 till T4. At T4 the MS was connected with BS3, since the condition of BS4 is bad. After T4, the MS will remain connected with BS3 till the end of simulation. But, the legacy RSS based handoff scheme initiated handoff at T4 and it connected MS with BS4, since the RSS of BS4 is greater than the RSS of BS3 at time T4. The data rate achieved by the mobile station is compared with RSS based handoff algorithm in Fig. 6 and the packet delay achieved by the mobile is compared in Fig. 7. Similarly, the data rate and packet delay achieved by the fixed station is compared in Fig.8 and Fig.9 respectively. Also, the number of unbeneficial and beneficial handoffs achieved by both proposed and legacy RSS based scheme is presented in Fig. 10 and Fig. 11 respectively.

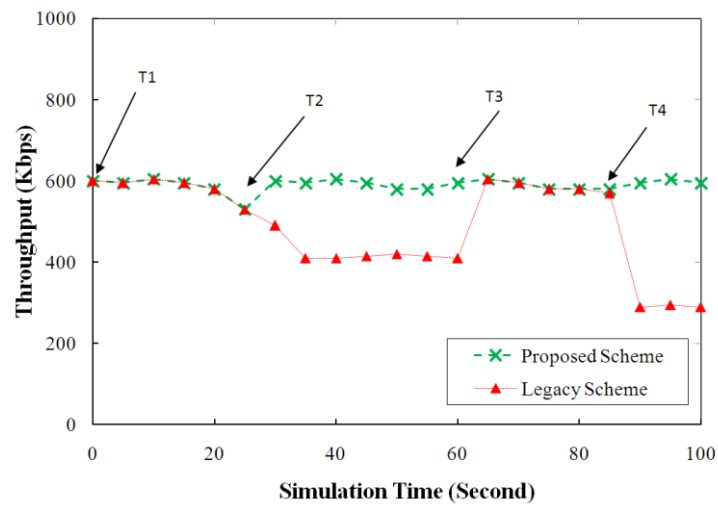


Fig. 6: Throughput Achieved by Mobile Station.

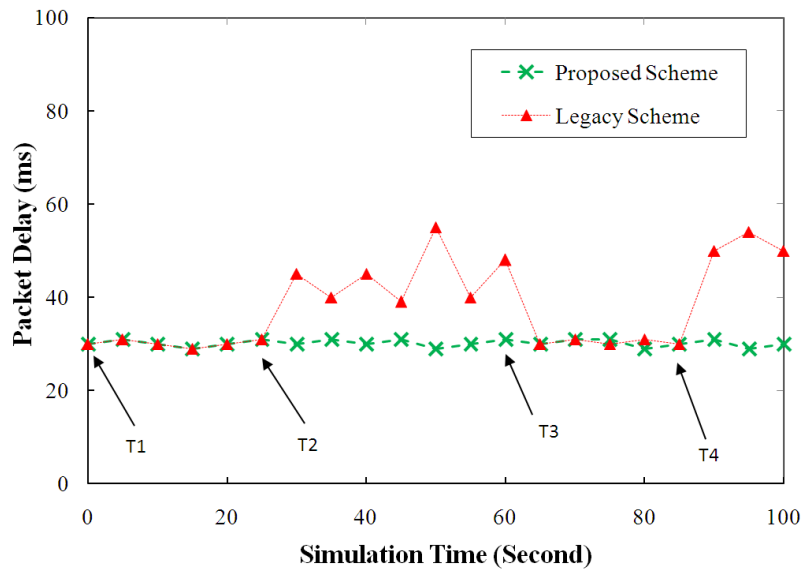


Fig. 7: Packet Delay Achieved by Mobile Station.

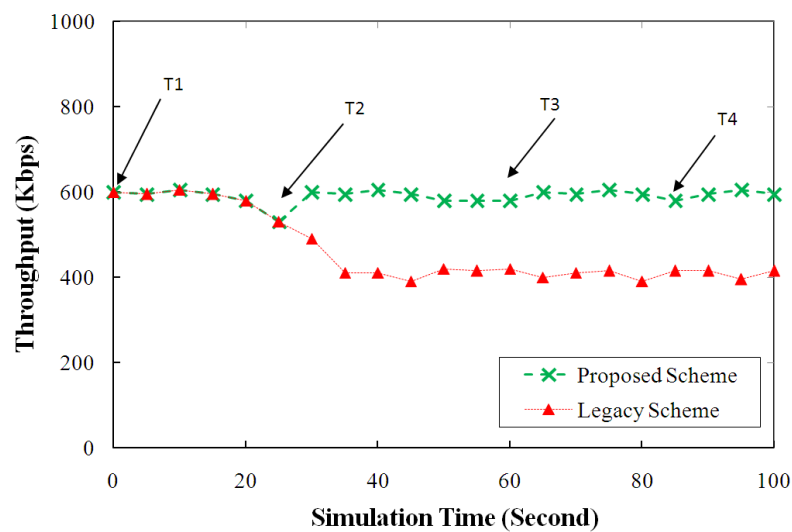


Fig. 8: Throughput Achieved by Fixed Station.

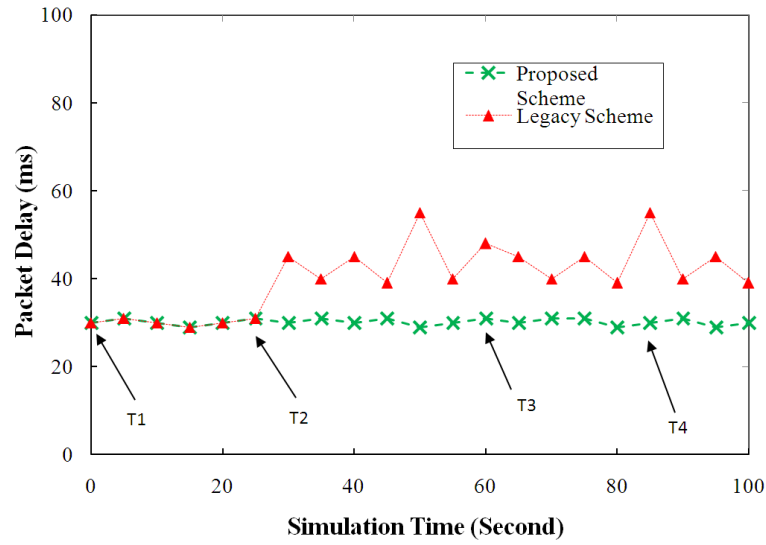


Fig. 9: Packet Delay Achieved by Fixed Station

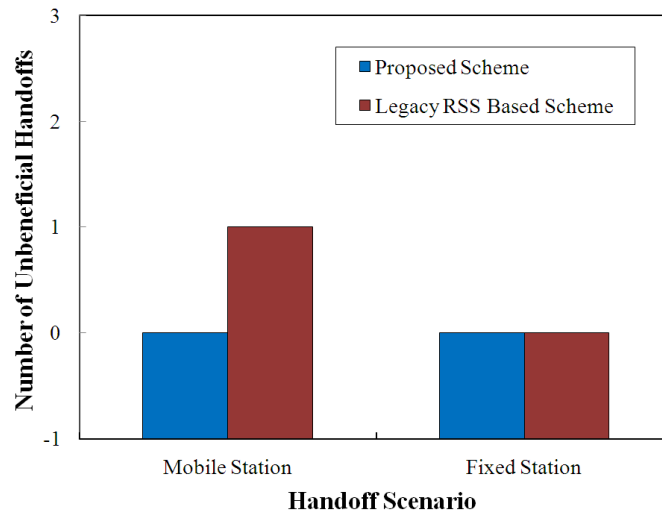


Fig. 10: Number of Unbeneficial Handoffs

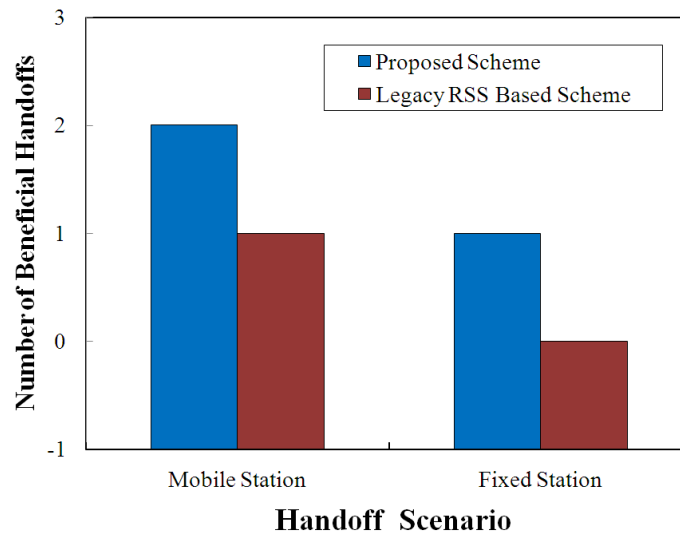


Fig. 11: Number of Beneficial Handoffs

Conclusion:

In this paper, we have proposed a handoff algorithm for 802.16 WiMAX networks which reduces the disruption time cause by channel scanning and the number of unbeneficial handoffs. Our algorithm considers available bandwidth, packet delay and RSS level for avoiding or encouraging unbeneficial and beneficial handoffs respectively. The simulation result shows that, the proposed algorithm performs better than the legacy RSS based algorithm in case of channel scanning time during the handoff process, throughput and packet delay achieved by both mobile and fixed stations, the number of unbeneficial handoffs and beneficial handoffs. In future our proposed handoff algorithm has to be updated to support seamless mobility in integrated heterogeneous overlay networks.

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