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Gateway Relocation and Admission Control in Mobile WiMAX Networks

Ritika Gupta

*Department of Electronics & Communication,
Chandravati Group of Institution, Bharatpur.*

Abstract

The wimax is a standard which define two tired mobility management service. This forum defined the service which leads to minimize the packet loss and handover delay. However, it leads to another problem: When to performASN GW(Access Service Network Gateway) relocation? The standards only define the ASN GW relocation procedures without specifying when the ASN GW relocation should be performed. It is left for vendors and operators to develop their own proprietary solutions. In this project, we propose an algorithm, which incorporates traditional Admission Control (AC) and Wiener Process (WP)-based prediction algorithms to determine when to carry out ASN GW relocation.

Keyword: Mobility management, resource management, admission control, WiMAX networks, statistics and stochastic process,and wireless networks.

1. Introduction

The Access Service Network (ASN) provides wireless radio access for WiMAX subscribers. Itconsists of one ASN Gateway (ASN GW) and many basestations (BSs). Each ASN is connected to Connectivity Service Network (CSN), which provides IP connectivity services. The WiMAX Forum has defined a two-tiered mobility management: ASN Anchored Mobility and CSN Anchored Mobility:

ASN Anchored Mobility refers to the procedures associated with the MS's movement between BSs, which may belong to the same or different ASNGWs. In ASN Anchored Mobility, the context of the designated MS is transferred from the previous BS to the new BS. Without performing CSN Anchored Mobility, ASN Anchored Mobility can minimize Handover delay and packet loss.

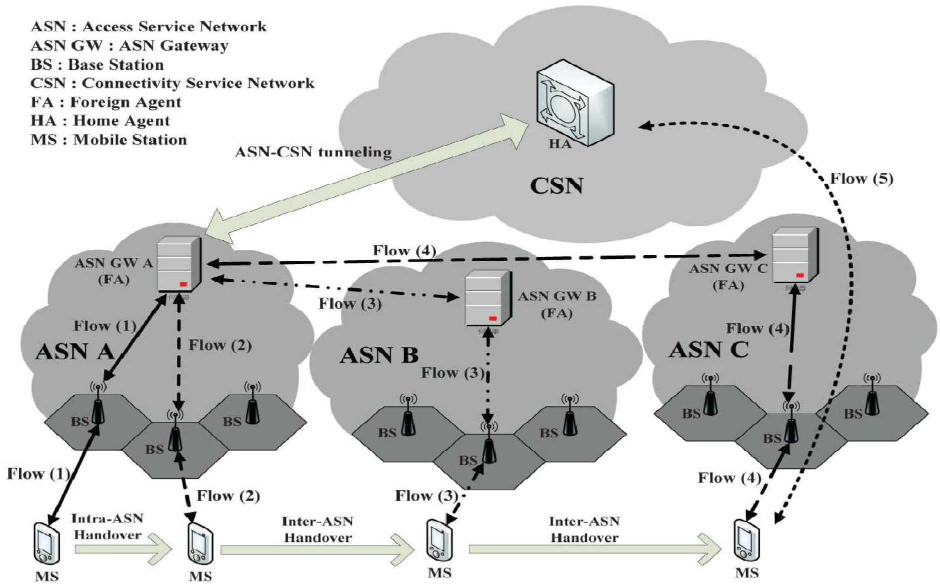

Fig. 1: ASN Anchored Mobility and CSN Anchored Mobility in WiMAX networks.

CSN Anchored Mobility refers to the process ofchanging the traffic anchor point and is independentof the MS's link layer handover. It is also calledASN GW relocation.

Although the two-tiered mobility management definedinWiMAX potentially can minimize handover delay andpacket loss, it leads to another problem: When to performASN GW relocation?

In this paper, we proposeGateway Relocation AC (GRAC),which combines ASN GW relocation and AC algorithm tomaximize system capacity. In GRAC, the AC algorithmcooperates with the ASN GW relocation. When a new MSarrives and there is no resource for the newly arrived MS,the proposed GRAC will request an Anchored MS toperform ASN GW relocation if there are Anchored MSs inthe system.

We also propose aprediction algorithm based on Wiener Process torequest Anchored MSs to perform ASN GW relocationearly. Thus, handover MSs are not dropped when thesystem load is full. In addition, handover MSs do not needto wait for the completion of ASN GW relocation sohandover latency can be reduced.

2. Related work

Admission Control (AC) is one of the resource management techniques to limit maximum amount of traffic in thenetwork to guarantee service quality for subscribers. Inwireless and mobile networks, the AC algorithms are muchmore complicated due to the movement of MSs. An MSserved in current network may move to another network. Theconnection of the MS may be dropped if the requiredresources in the target network cannot be supported. It isgenerally agreed that keeping an ongoing connection unbroken is more important than admitting a new MS. Here, we discuss twocommonly used priority-based AC algorithms:cutoff priorityalgorithmand new call bounding algorithm.

2.1. Gateway Relocationadmission Control (GRAC)

Our goalis to design astand-alonealgorithm such that each ASN GWcan determine when to request Anchored MSs to performASN GW relocation. The proposed algorithm does not needto exchange information between neighboring ASN GWs. Italso does not require centralized coordination and anyassistance from extra servers. In addition, the proposedalgorithm does not need to predict the movement of themobile stations. It combines AC algorithm with a predictiontechnique to determine when is necessary to perform ASNGW relocation. Thus, it is calledGateway Relocation AC (GRAC).

2.1.1 New Call Bounding AC with ASN GW Relocation

Algorithm for the two-tier mobility management in WiMAX. The proposed GRAC with the new call bounding algorithm is presented in Algorithm given below. In given Algorithm , we limit the number of Serving MSs and Anchored MSs in one ASN GW.

Table 2.1: List of parameters.

C	Maximum number of MSs in one ASN GW
T_{ncb}	Threshold for blocking a new MS
T_{wpr}	Threshold for carrying out WP-based prediction
$W(t)$	Number of MSs in one ASN GW at time t
$N_S(t)$	Number of serving MSs in one ASN GW at time t
$N_A(t)$	Number of anchored MSs in one ASN GW at time t
$N_H(t)$	Number of handover MSs in one ASN GW at time t
α	Standard normal random variable
Δt	Prediction time interval
τ	Sampling time interval
k	Number of latest samples
λ_n	Arrival rate of new MSs
λ_h	Arrival rate of handover MSs
$1/\mu_c$	Average connection holding time for new MSs
$1/\mu_n$	Average network residence time for new MSs and handover MSs
p^u_{nb}	Blocking probability of new MSs in upper-bound analysis
p^l_{nb}	Blocking probability of new MSs in lower-bound analysis
p^u_{hd}	Dropping probability of handover MSs in upper-bound analysis
p^l_{hd}	Dropping probability of handover MSs in lower-bound analysis
Θ_u	Average serving rate in upper-bound analysis
Θ_l	Average serving rate in lower-bound analysis
Λ_u	Average signaling overhead in upper-bound analysis
Λ_l	Average signaling overhead in lower-bound analysis

Algorithm 1.New call bounding AC with ASN GW relocation

Require:A new or handover MS is requesting to connectwith the ASN GW at timet.

1. ifa new MS arrivesthen
2. if Ns(t)+Na(t)<min(Tncb,C-Nh(t))then
3. Ns(t) =Ns(t)+1/* The new MS is accepted. */
4. else ifNs(t)+Na(t)=min(Tncb,C-Nh(t)) then
5. if Na(t)>0then
6. Na(t)=Na(t)-1/* Requesting one of the Anchored MSs to perform ASN GW relocation. */
7. NS(t) =NS(t)+1/* The new MS is accepted. */
8. else
9. The new MS is blocked.
10. end if
11. end if
12. else ifa handover MS arrivesthen
13. if W(t)<Cthen
14. Nh(t)=Nh(t)+1/* The handover MS isaccepted. */
15. else
16. The handover MS is dropped.
17. end if
18. end if

To adapt the new call bounding algorithm into WiMAXnetworks, the algorithm is modified as:

If Ns(t)+Na(t)<min(T’ncb,C’-Nh(t)) and a newMSarrives; the new MS is accepted.

Because one Anchored MS is relocated, the new MS canbe accepted. Otherwise, the new MS is blocked. Further-more, if a handover MS arrives at timet, it is always accepted unless W(t)=C’.

2.2.2WP-Based Prediction Algorithm

In the above algorithm, we can set C’ asCbecause a newcoming MS can be queued until the resource is availableafter ASN GW relocation is completed. However, thisapproach cannot be applied to handover MSs becausehandover MSs are sensitive to handover latency. Theacceptable handover delay is much less than the queuingdelay of a new MS. Assuming that a handover MS arrivesandCis reached. If the handover MS needs to wait for theASN GW relocation of one Anchored MS, the handoverlatency will be too high.

We propose a prediction algorithm based on Wiener Process(WP) which provides a systematic way to determine when to request Anchored MSs to perform ASN GW relocation. In addition, the algorithm can also estimate how many Anchored MSs should be relocated.

Algorithm WP-based prediction algorithm
Require: At each t time interval.

1. Ifthe number of samples is equal to kthen
2. The oldest sample is discarded.
3. End if
4. W(t)is recorded.
5. ifw(t)>=Twnrthen
6. /* Stage 1: Generating the expected drift rate and thestandard deviation rate */
7. μˆ is computed by using ksamples,W(t-it) , and (3).
8. δˆis computed by using ksamples,W(t-it),μˆ ,and (4).
9. /* Stage 2: Estimating the number of MSs */
10. Computing ΔW by using μˆ,δˆ and and (2).
11. Computing W(t+Δt)by using ΔW, W(t), and (1).
12. /* Stage 3: Determining when and how many to perform ASN GW relocation */
13. If ΔW(t-Δt)>Cthen
14. N ←Δ W(t+Δt)+C+1
15. N ←min(n, Na(t))
16. RequestingnAnchored MSs to perform ASN GWrelocation.
17. End if
18. End if

in the time interval $[t - i\tau - \tau, t - i\tau]$ are $W(t - i\tau) - W(t - i\tau - \tau)$, for $i = 0, \ldots, k - 1$. Hence, μ can be estimated by $\hat{\mu}$

$$\hat{\mu} = \frac{\sum_{i=0}^{k-1}(W(t - i\tau) - W(t - i\tau - \tau))}{k\tau} = \frac{W(t) - W(t - k\tau)}{k\tau}. \tag{3}$$

Also, $\hat{\delta}$, the estimation of δ, is given by

$$\hat{\delta} = \sqrt{\frac{\sum_{i=0}^{k-1}(W(t - i\tau) - W(t - i\tau - \tau) - \hat{\mu}\tau)^2}{k\tau}}. \tag{4}$$

Wiener Process has been proven effective in modelingstochastic processes where the values of the randomvariables are affected by a large number of independentor weakly dependent factors, each with a relatively smallimpact . The W(t) we want to model is impacted by alarge number of factors. These factors are either independent or weakly dependent of each other. For example, W(t) is impacted by the arrival rate of new MSs, arrival rate ofhandover MSs, average connection holding time, averagenetwork residence time, and so on. Based on the definitionsand properties of Wiener Process, W(t) is continuous and ΔW follows normal distribution.

3. Discussion

Comparing with traditional AC algorithms, the proposedGRAC decreases the blocking probability of new MSs inWiMAX networks. To see the reasons behind it, we useFlow (3) in Fig. 1 as an example. When deployingtraditional AC algorithms without considering ASN GWrelocation, a new incoming MS is blocked when Ns(t)+Na(t)=min(Tncb,C-Nh(t))in ASN GW A. However,there may be some Anchored MSs served in ASN GW A,thatis,Na(t)>0. In contrast, in the proposed GRAC, ASNGW A will request one of the Anchored MSs to performASN GW relocation to relocate the traffic anchor point fromASN GW A to ASN GW B. Therefore Na(t) in ASNGWAis decreased. Thus, NS(t)+Na(t)<min(Tncb,C-Nh(t)).

Therefore, a new incoming MS can be accepted by ASN GW A. Besides, theW(t) in ASN GW B is not increased.

4. Conclusion

In WiMAX standards, an ASN GW can decide when to perform ASN GW relocation. In this project, we consider that the system load is heavy, so Anchored MSs are forced to perform ASN GW relocation. We propose GRAC which considers admission control and ASN GW relocation jointly to improve the performance of WiMAX networks. The traditional AC algorithms cannot be used directly when the two-tiered mobility management is deployed in WiMAX because some MSs may be served by two ASN GWs. If there are many Anchored MSs, new incoming users will likely be rejected due to the lack of resources. In the proposed GRAC, the AC algorithm cooperates with the ASN GW relocation. When a new MS arrives and there is no resource for the newly arrived MS, the proposed GRAC will request an Anchored MS to perform ASN GW relocation. In addition, for handover MSs, the WP-based prediction algorithm can trigger the ASN GW relocation at an appropriate time.

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