An Adaptive Call Admission Control in WiMAX Networks with Fair Trade off Analysis

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Abstract. In wireless cellular network with heterogeneous services, providing guaranteed Quality of Service (QoS) poses a great challenge due to the scarce radio bandwidth. Often researchers in this field have tried to reduce the handoff call dropping probabilities (HCDP) in a cell at the sacrifice of increasing the new call blocking probabilities (NCBP). In this paper we propose a call admission control (CAC) scheme for WiMAX networks to achieve a fair trade-off between NCBP and HCDP. Numerical results showed that the proposed CAC scheme shows improvement in NCBP without affecting HCDP.

Keywords: WiMAX, QoS, Markov chain, CAC, Trade off.

1 Introduction

Worldwide Interoperability for Microwave Access (WiMAX), a wireless networking standard based on IEEE 802.16 std. [1,2] is a broadband wireless access (BWA) solution for providing fixed, nomadic, portable and eventually mobile wireless broadband connectivity in the last mile. It is designed to support QoS in order to enhance end user performance in terms of bandwidth, jitter, latency, throughput etc. The standard defines five scheduling classes or service flows (Unsolicited Grant Service (UGS), Real Time Polling Service (rtPS), Extended Real Time Polling Service (ertPS), Non Real Time Polling Service (nrtPS) and Best Effort (BE)). In order to fulfill the service differentiation and QoS provisioning defined in IEEE 802.16 std., an efficient CAC algorithm has a key role. In a wireless networks with mobility support, the handoff calls are always given the highest priority irrespective of the service class they belong. The popular methods proposed for assigning priority such as bandwidth reservation and degradation policies can be found in the literatures [3-5]. Degradation is possible in variable bit rate traffic like rtPS and nrtPS connections. The bandwidth of these connections may vary between Maximum

V.V. Das and J. Stephen (Eds.): CNC 2012, LNICST 108, pp. 426–430, 2012.

sustained traffic rate (MSTR) and Minimum reserved traffic rate (MRTR).In [6], the authors proposed a CAC policy called adaptive bandwidth degradation CAC (ABDCAC) that provides bandwidth and delay guarantees and improves Bandwidth utilization of the system compared to the previous schemes. But by giving priorities to handoff calls the HCDP is reduced but increases NCBP. It may be not fair to block new originating calls within the cell while allowing more handoff calls from the neighboring cells. Therefore a fair trade-off between HCDP and NCBP is necessary. Some recent studies on CAC schemes can be found be in [7-9].The authors in [7] proposed fuzzy logic based partitioning of the bandwidth however the bandwidth utilization is poor compared to scheme in [6].

In this paper the algorithm in [6] is further extended to achieve a fair trade off between HCDP and NCBP. The propose algorithm is called ABDCAC with fairness.

2 Proposed Algorithm

In this section we present algorithm for extended ABDCAC with fairness. The arrival process of the handoff and newly originated UGS, rtPS, and nrtPS connections are assumed Poisson with rates λ_{hu}, λ_{hr}, λ_{hn}, λ_{nu}, λ_{nr}, and λ_{nn} respectively, where the subscript h represents handoff calls and the subscript n represents new calls originated within a cell. The service times of UGS, rtPS and nrtPS calls are exponentially distributed with mean $1/\mu_u$, $1/\mu_r$ and $1/\mu_n$ respectively. Each base station can be modeled as a five dimensional Markov chain [3, 5, 6], s= (n_u,n_r,B_r,n_n,B_n) where n_u, n_r, n_n represents number of UGS, rtPS and nrtPS calls admitted and B_r, B_n represents current available bandwidth of rtPS and nrtPS calls respectively.

The summary of the proposed algorithm is given below.

Begin

(new UGS call) **if** $(n_u+1)*B_u+n_r*(B_r^{max}-B_{th})+n_n*B_n^{min}<B$ accept the new UGS call request **else** reject it;

(new rtPS call) **if** $n_u*B_u+(n_r+1)*(B_r^{max}-B_{th})+n_n*B_n^{min}<B$ accept the new rtPS call request **else** reject it;

(new nrtPS call) **if** $n_u*B_u+n_r*B_r^{max}+(n_n+1)*(B_n^{max}-B_{th})<B$ accept the new nrtPS call request **else** reject it;

(handoff UGS call) **if** $(n_u+1)*B_u+n_r*B_r^{min}+n_n*B_n^{min}<B$ accept the handoff UGS call request **else** reject it;

(handoff rtPS call) **if** $n_u*B_u+(n_r+1)*B_r^{min}+n_n*B_n^{min}<B$ accept the handoff rtPS call request **else** reject it;

(handoff nrtPS call) **if** $n_u * B_u + n_r * B_r^{min} + (n_n + 1) * B_n^{min} < B$ accept the handoff nrtPS call request **else** reject it;
end.

The degradation variable B_{th} is optimized to minimize a cost function (CF) and it varies for different traffic conditions. When $B_{th}=0$, the algorithm degenerates to simple ABDCAC algorithm.

3 Trade Off Analysis

Using the concept proposed in [10] we defined two metrics: Grade of Service (GoS) and cost function (CF).

GoS is defined as $GoS_k = NCBP_k + \beta_k . HCDP_k, \quad k \, \varepsilon \{u,r,n\}$ (1)

Where u, r, n denotes UGS, rtPS and nrtPS connections respectively and β_k indicates penalty weight for handoff calls relative to new calls. In general, β_k should be more greater than 1 because handoff call should be given higher priority over new calls. Smaller GoS means better performance in session layer for the related type traffic.

$$CF = w_1 * GoS_u + w_2 * GoS_r + w_3 * GoS_n \quad (2)$$

Where w_1, w_2 and w_3 means different priority of the services. Therefore the weights are selected such that $w_1 > w_2 > w_3$ and $w_1 + w_2 + w_3 = 1$.Because of the dynamic characteristic of traffic flow the value of CF changes with traffics, so the threshold B_{th} is periodically adjusted such that CF is minimized. B_{th} can be varied in the interval $0 < B_{th} < B_n^{min}$ .For a particular arrival rate every feasible value of B_{th} is used to evaluate CF. Value of B_{th} that corresponds to the smallest CF is the optimal value of B_{th} for that arrival rate.

4 Simulation Analysis

The simulation analysis of the proposed CAC scheme is implemented in MATLAB R2008 platform. The traffic load configurations are taken as same with [6]. The comparative results of ABDCAC scheme and the proposed scheme for different weights are presented. For simulation study we assume the value of $\beta_k = 10$ giving more priority to the handoff calls.

The simulation results are shown in Fig.1-Fig. 2. Fig.1 (a) shows the change in optimal value of B_{th} for different arrival rates. As the arrival rates increases the network is stressed and since Handoff connections are given higher priorities the degradation threshold is lower and finally equals to zero. This lower in B_{th} is necessary to maintain minimum CF when the arrival rate increases. Fig.1 (b) - (d) shows the comparative results of NCBP of UGS, rtPS and nrtPS respectively. It can be observed that with the introduction of degradation threshold the blocking

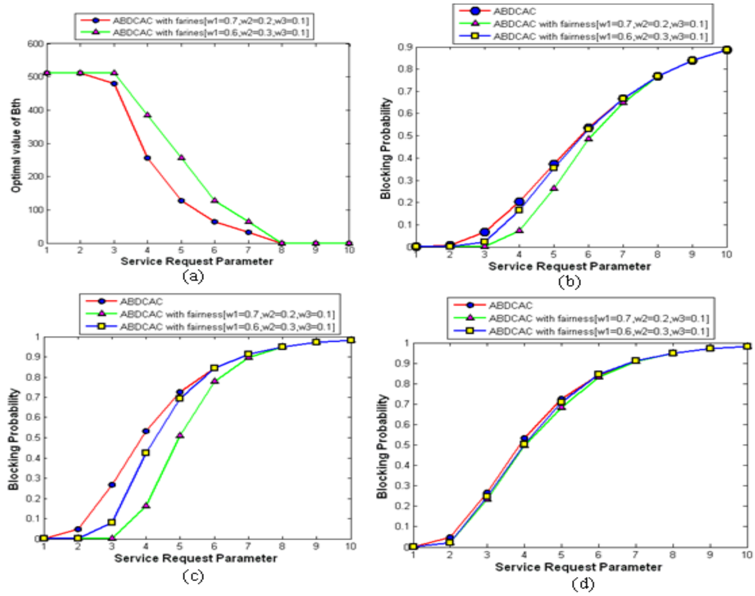

Fig. 1. (a) Optimal value of B_{th} (b) Comparison of NCBP of UGS connections (c) Comparison of NCBP of rtPS connections (d) Comparison of NCBP of nrtPS connections

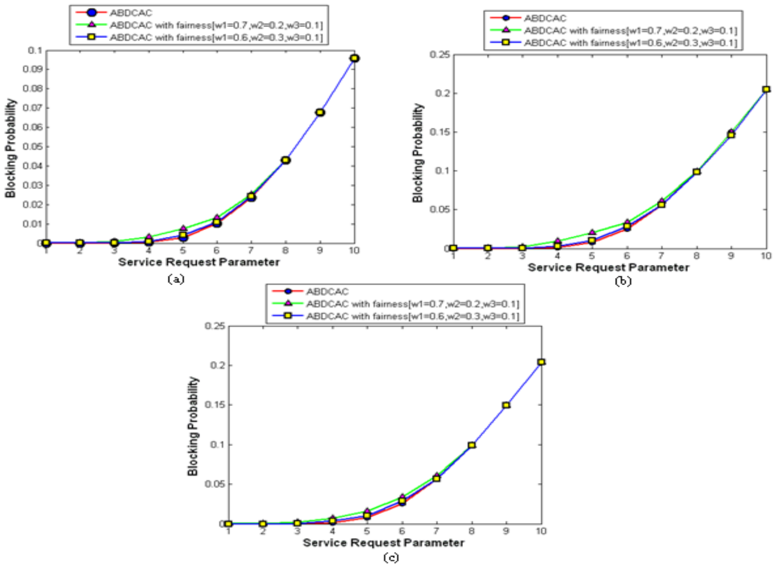

Fig. 2. (a) Comparison of HCDP of UGS connections (b) Comparison of HCDP of rtPS connections (c) Comparison of HCDP of nrtPS connections

probabilities of the different service flows are reduced in the proposed scheme compared to simple ABDCAC scheme at lower arrival rates. And the blocking probabilities with ABDCAC scheme with fairness are different for different weights w_1, w_2 and w_3. However as the arrival rate the proposed scheme degenerates to the simple ABDCAC scheme. This is because the degradation threshold is zero at higher arrival rates as indicated in Fig. 1(a).The effect of the degradation threshold on nrtPS connections are minimal because it is the lowest priority connections.Fig.2 (a)-(c) shows the HCDP for UGS, rtPS and nrtPS connections respectively. Although the degradation threshold reduces the NCBP of different connections the dropping probabilities are increased. But the increase in HCDP is not as significant as the decrease in NCBP. Hence it will not degrade the performance of the network.

5 Conclusion

In this paper we propose a CAC scheme to provide fairness between new calls and handoff calls. Simulation results showed that the proposed scheme is able to achieved improvement in NCBP without affecting too much on HCDP. Thus the proposed ABDCAC scheme with fairness satisfies both the requirement of service providers and subscribers. However tuning of the parameters used in tradeoff analysis is required which may be done using robust optimization techniques.

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