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Auction Based Bandwidth Allocation with Revenue Maximization for Achieving QOS in Mobile Cloud Environment

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Abstract: **In recent times mobile applications are increasingly used by people in their day to day life for not only as a tool for convenient communication but also mobile users use various services from mobile applications such as google apps, iPhone apps etc. which either run on the device or on remote server. In MCC each mobile user demands certain level of quality of service (QOS) while they request some services from the cloud. Each mobile user is associated with its interfacing gateway to communicate with the cloud. Bandwidth allocation to these mobile users is a challenging task. As the nodes are mobile in MCC bandwidth shifting is necessary for ensuring QOS guarantee to the mobile nodes. For maintaining QOS guarantee bandwidth shifting alone is not sufficient hence proper redistribution of bandwidth is also necessary because of protocol overhead and spectral efficiency associated with its channel. Bandwidth redistribution problem in MCC is solved by descending bid auction. In proposed scheme named as AQUMR (auction based quality of service guaranteed utility maximization and revenue maximization) each gateway sums the demands of all the mobile nodes connected to it and submits a bid for the required amount of bandwidth from cloud service provider(CSP). Each gateway maximizes its revenue during the auction process by introducing competition between gateways by setting the demand at different ranges using fuzzy auctioning.**

Keywords: **Cloud service provider, Mobile cloud computing, Quality of service, Bandwidth shifting, Bandwidth Redistribution, fuzzy auctioning.**

I. INTRODUCTION

Due to rapid reduction in cost of hardware, improved portability and increasing computational capability mobile devices are increasingly becoming an essential part of day to day life. Powerful web applications are run on mobile devices as it supports built in data exchange feature. Although there rapid advances in mobile devices the mobile devices are facing many challenges concerned with energy source such as battery life, storage, bandwidth and communications (mobility and security). Consequently executing applications that are computationally intensive remains challenging issue in mobile networks. MCC is an integration of cloud computing into the mobile environment. The data processing and storing application in the mobile devices are moved to the server in a cloud hence over coming constraints on resources and hence improving the efficiency and life time of the mobile devices. A gateway acts as an interface between the mobile devices and cloud service provider.

Then mobile users request services that include high computational resource and application requirements such as data services audio and video streaming, the mobile users interact with the gate way requesting this services and in turn these gate ways communicate with the CSP for allocating bandwidth which are required for satisfying the mobile users request. Bandwidth is an essential component to fulfil demand request of real time application and computation by mobile nodes. There are various cases when the services requested by the nodes are not satisfied by the servers. As the nodes are mobile, the corresponding gate way for maintaining the connectivity with the server also changes and hence it might happen the cloud server may provide services as per request but the mobile nodes are not able to receive it due to lack of bandwidth which creates the necessity of bandwidth shifting. Each gateway earns revenue from the mobile nodes for providing then with the requested bandwidth and QOS. Each gateway utilizes different percentage of allocated bandwidth from the cloud services provider hence redistribution of bandwidth is necessary to fulfil QOS guarantee to the mobile nodes.

II. RELATED WORK

Extensive growth of mobile applications and cloud computing concept [1], lead to the emergence of integration of mobile and cloud computing. Even though MCC provides many advantages there are still issues pertaining to service availability, low bandwidth, network management, QOS-guarantees, and pricing problem in MCC which are highlighted in Dinh et al. [11] combinatorial auction scheme for heterogeneous resource allocation in mobile cloud system in MCC id designed by Zhang et al. [37] .Bandwidth sharing solution for centralized mobile users using coalition game theory by Jin and Kwok [19] does not provide any information regarding the amount of bandwidth sharing among the users. To overcome this limitation, Jung et al. [21] extended the scheme by incorporating the distribution policy, which evaluates the amount of bandwidth usage among users using Markov Decision Process (MDP).

Allocation schemes were proposed for ensuring maintaining equal expected access delay [29], fair allocation [3], guaranteed bandwidth [12], delay guarantee [20], and service differentiation [33]. To achieve end-to-end fair bandwidth allocation, Tang et al. [34] proposed a max-min fair maximum throughput bandwidth allocation (MMBA) scheme followed by lexicographical max-min fair bandwidth allocation (LMMBA) scheme for wireless mesh networks integrated with cognitive radio. Fei et al. [13] has proposed his work on QOS guaranteed fair up-link dynamic bandwidth allocation algorithm for allocating bandwidth from base stations to relay stations in IEEE 802.16j-based vehicular networks. Chen et al. [7] addressed the spectrum sharing problem for multi-licensed primary users (PUs) using auction theory in which a licensed PU shares the unused spectrum to the unlicensed secondary user based on the interference temperature threshold of the PU of CRNs.

Three auction-based mechanisms were proposed for distributive allocation spectrum in CRN [9] in which they compared their own algorithms based on three characteristics—convergence, social welfare, and cheat-proof. Problems related to social surplus for efficient bandwidth allocation in wireless networks using generalized VCG auction mechanism with network coding are investigated by haikijwatana and Tachibana [6], the authors considers that the total required bandwidth is always greater than the total available bandwidth. Utility theory is used as a strategy for bandwidth allocation utility-based resource allocation problem is reported in [4], [8], [25] and [26].

[34] QOS ensured bandwidth shifting and redistribution in MCC has proposed an auction based QOS guaranteed utility maximization schema which allocates the bandwidth optimally but it has various drawbacks with respect to the bidding increment in the process of auction .In this paper we extend the work by implementing the AQUMR algorithm with optimal bidding strategy.

III. PRELIMINARIES

A. Auction theory:

In the process of buying and selling of commodities and services auction theory is commonly used. Auction as mainly categorized based on schemes of bidding namely ascending bid auction or descending bid auction. In the proposed scheme descending bid auction is used for solving the problem of bandwidth redistribution and shifting. In the process of auction there are two parties one is the auctioneer who is responsible for handling the auction and finally providing commodities and services to the bidder who wins the auction. The bidder is the one who bids the commodities and services needed. Each commodity seller in descending bid auction sets the maximum selling price (p_{max}) of an asset and each buyer submits a bid based on the utility and cost of the product. The price per unit allocation set by the seller is deceased by some positive value in each iteration of the auction process. This process of auctioning ends on two conditions when either the buyer accepts buy the asset at seller's price or the price becomes zero.

B. Channels spectral efficiency:

Spectral efficiency of a channel is obtained by Shannon`s spectral efficiency. In MCC adaptive modulation scheme is used by each gateway for adjusting the transmission rate depending on channel quality.

C. Fuzzy logic:

Traditional binary logic where variables may take values on true or false whereas fuzzy logic variables may have true value that ranges in degree between zero and one rather than fixed and exact reasoning fuzzy logic deals with approximation as it is form of many valued logic. To a given problem different membership curves are drawn or specified from either simple or sophisticated elicitation procedures. There are intended to model people`s cognitive states.

IV. MOBILE CLOUD NETWORK MODEL

In a mobile cloud environment there is one CSP and I single channel gateways G= {G_1, G2, G3,…….G_I} connected with the CSP. An assumption that spectral efficiency of each channel is different and represented By E(t)= {E_1(t),E_2(t),E_3(t),E_4(t)……,E_I(t)}. Further each gateway has K number of mobile nodes connected with it at time T via any mobile network. Quality of service is guaranteed with respect to service delay. B_{total} is considered as the total available bandwidth of the CSP. B(t)={B_1(t),B_2(t),…..B_I(t)} denotes the allocated bandwidth for the gateways G at time T for the bandwidth requirement of the gateways for the successful execution of the requested services by the mobile nodes.

A. Service Delay calculation:

We assume T_{ik} as the transmission delay required for accessing a service by the mobile node Nik, if the total available bandwidth B_{tot} is completely allocated to the gateway G_i.T_{ik} is the ideal transmission delay. Hence, the total transmission delay

For the gateway where | | indicates the cardinality of a set.

$$(Ti) = \sum_{k=1}^{|Ni|} Tik \qquad (1)$$

B. Bandwidth shifting:

In the mobile cloud network nodes are mobile this triggers the necessity of bandwidth shifting. However shifting alone is not sufficient for providing quality of service guarantee. Each mobile node is connected to its corresponding gateway. When the mobile nodes moves from one location to other the gateway that it is connected also changes so as to maintain the connectivity with the cloud. At the gateway the aggregated bandwidth requirement also changes as anew node may be attached or detached from it. The total transmission delay for all connecting nodes allocated bandwidth is checked by the present gate way for maintaining the quality of service in terms of delaying service.

D. Bandwidth redistribution:

A utility function is formulated for computing the overall benefit of each interfacing gateway. The utility function of gateway depends on the following points the service it provides to the mobile nodes associated with it and the bandwidth it buys from the clouds service provider for providing the services. A sophisticated pricing model is formulated where each gateway is supposed to pay a certain price to get services from the CSP. On the other hand these gateways demand certain amount of revenue from the mobile nodes so as they earn profit. In addition extra charge is being demanded from the mobile nodes so as to assure the quality of service in terms of service delay. The gateway always tries to attain maximum revenue by setting the price depending on the demand of bandwidth at the mobile nodes.

V. AQUMR (AUCTION-BASED QOS GUARANTEED UTILITY MAXIMIZATION AND REVENUE MAXIMIZATION)

Exchanging of commodities between two parties can be efficiently done using auction mechanism based on the bidding price hence auction theory based approach is used for solving the problem in MCC for QOS guarantee bandwidth redistribution and revenue maximization. There are two parties existing in the current context of auctioning one is the cloud service provider who is the seller and owns preserve bandwidth and the other is the gateway which submits the bid to the CSP to serve the mobile nodes. Depending price auction is used for optimal bandwidth allocation with utility and revenue maximization. The CSP is the seller sets unit price for each unit allocation initially and gradually the price is decreased over time until the price becomes zero or buyer accepts the price for buying the commodity.

As the requested bandwidth reduces with the increased price per unit allocation hence in the modified descending price auction process the price is decreased based on the demand of bandwidth at the gateway. If the demand is high then the price is considerably decreased until the total bid reaches the total available bandwidth else price per unit allocation is not decreased and remains same. This is implemented based on fuzzy logic. If the price p reduces less than the minimum price then the price is reset again for the maximum so as to continue the auction process. AQUMR is implemented based on the following by using modified descending price auction.

A. Initialization:

Each gateway Gi knows its Shannon spectral efficiency (Ei), protocol overhead (a_i), and revenue per unit service delay (r_i). We assume that r_i is determined based on the QoS-guarantee between the gateway and the connecting mobile nodes. Initially, the CSP broadcasts its reserve bid b, this is a positive constant value required for its own use and then it also broadcasts the price p per unit allocation to all the gateways, and sets the initial value of p as pmax.

B. Bid:

Each gateway Gi submits a bid bi (0 < bi <Btot), this represents the minimum required bandwidth at the initial stage required to meet the QoS-guarantee constraint. The submitted bid by the gateway Gi should satisfy two things, one is the service delay constraint, which considers the requests of all mobile nodes and the minimum bandwidth requirement for performing its own operation. Hence, the bid amount is computed as

bi = $\sum_{k=1}^{|Ni|} bik + \Phi$ (2)

Where Φ represents the minimum requirement of bandwidth to maintain its own operations and QoS in the network.

C. Allocation:

In each iteration, CSP aggregates all the bid values and adds the aggregated value to its own reserve bid b. bandwidth Btot. If the Finally, the CSP compares the computed value with the maximum availability of bid is greater total bid with the CSP then the CSP concludes the auction process, and allocates Bi to the gateway Gi.

D. Fuzzy auctioning:

At every bid, based on the participant past demands and past pricing acceptance ratio, we find whether to decrease the bid value of still keep it same. So that in next bid have high probability of win and maximum revenue can be earnt.We name this concept as Fuzzy Auctioning. In this, at every iteration, before decrementing the price. We predict the acceptance ratio for bid for all users based on past pricing vs demand acceptance. If all users have more than 60% acceptance ratio, then we will not decrease the price. By this way, we can increase the maximum revenue

AQUMR Algorithm
Input: P_{max}, β
Output: B
CSP broadcast P (t) to all gateways Gateway calculates b (t) and U (t)
For i =0 to I do
    If (U_i (t)> U_i (t-1)) then
    Gateway Gi submits bid (t)
    Else Gateway Gi submits bid b_i (t-1)
    End if
End for
If ($\sum_{i=1}^{I} bi(t) + \beta \geq Btot$) then
CSP calculates B and allocates to gateways
CSP confirms the final price p (t) to all gateways
Else if

$$\sum_{i=1}^{I} bi(t) < \sum_{i=1}^{I} bi(t-1)$$

Calculate the acceptance ratio = acper
if (acper<60)
CSP receives the price p (t+1) =P (t)-Δ
Else
CSP receives the price p (t+1) =P (t)
    If (p (t+1) <Pmin))

Then CSP reset the price p (t+1) = P_{max}
End if
Go to step 1 for next iteration
End if

Where

Gi-Gateway
Ui-Utility of each gateway
Pmax- maximum selling price
Bi- bid value
Btot- available bandwidth
p- Price per unit allocation
acper- acceptance ratio

VI. NUMERICAL RESULTS

In this Section, we present numerical simulation results of the proposed AAQUM algorithm for the MCC environment. Initially, we present an example scenario followed by the parameter settings. We show that revenue at the gateways is maximized at the cost of maintaining the QOS at the mobile nodes.

Let us consider an MCC environment, with one CSP and three gateways (G1…… G3). Each gateway Gi has five, seven and eight connected mobile nodes respectively. We consider the total available bandwidth Btot = 100Mbps, pmax =20, revenue per unit transmission rate qi = 10, revenue per unit service delay ri = 50. Initially, the ideal transmission time and bandwidth demand for the nodes of each gateway are 0.3

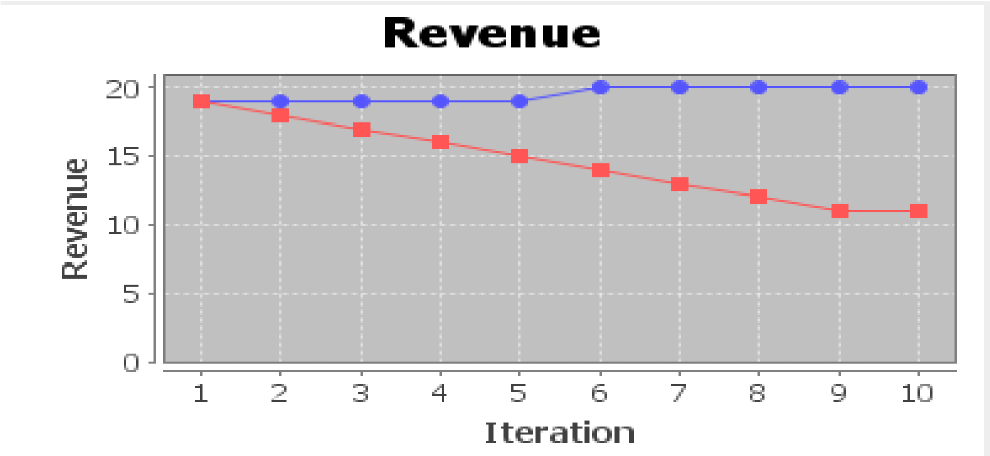

Fig 1: Revenue with fuzzy Auctioning in blue and without fuzzy auctioning in red

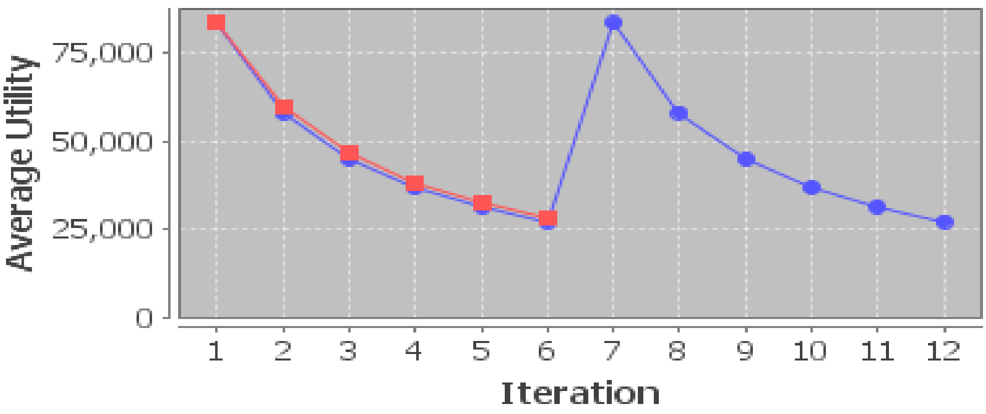

Fig 2 : Utility maximization at the gateways red in AQUM and blue in AQUMR

VII. CONCLUSION

In this paper the problems in bandwidth allocation is rectified and solved. In MCC due to the mobility of nodes bandwidth shifting and redistribution are necessary .The gateways satisfies the QOS constraint of mobile nodes by bidding the appropriate bandwidth to the CSP. The main aim of the paper is to maximize the revenue at the gateways .A novel bidding strategy is used which maximizes the revenue at the gateways in turn maintaining the QOS.

Even though the proposed algorithm maximizes the revenue and utility at the gateways but each gateway needs to know the bid value of other which is not feasible in real environment hence a distributed algorithm is necessary. In the current work, we consider QoS-guarantee in terms of service delay. Other aspects of QoS may be considered for extending this work in the future.

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