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QOS Ensured Bandwidth Allocation in Mobile Cloud Computing

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Abstract: ***Mobile Cloud Computing (MCC) is one of the significant technology trends that we have been observing for past few years, it brings rich computational capabilities to resource constrained mobile devices. The mobile users access services from the cloud service providers through interfacing gateways in terms of certain level of Quality Of Service(QOS) even if the interfacing gateways changes due to the mobility of the mobile node. In this paper we identify, formulate and address the problem of QOS ensured bandwidth allocation among the interfacing gateways for maximizing the utility. To ensure quality of service to the mobile users bandwidth shifting at the gateways is essential, but due to varying spectral efficiency across the associated channels only shifting is not sufficient for maintaining QOS. Hence bandwidth redistribution is formulated as utility maximization problem and solved using modified descending auction. In the proposed scheme, named as advanced auction based QOS ensured utility maximization (AAQUM) each gateway submits it required bandwidth to satisfy the QOS demand from the mobile users connected to it as a bid to the auctioneer cum seller cloud service provider (CSP). During the auction process the CSP distributes bandwidth among the gateways maximizing the profit and ensuring QOS to the mobile nodes. Simulation results establish the correctness of the proposed schema.***

Keywords: Cloud service provider, Mobile cloud computing, Quality of service, Bandwidth shifting, Bandwidth Redistribution

1. Introduction

Mobile devices play a vital role in our day to day life due to the rapid reduction in price of hardware, portability, and increasing computational capability. Mobile users accumulate rich experience of various services from mobile apps such as iPhone apps, google apps etc., which run on the devices on remote servers via wireless network. Mobile computing has become a powerful trend in the development of IT technology and various other fields However many challenges are being faced by the mobile devices such as battery life, storage, bandwidth, mobility etc. Cloud computing has been widely recognized for its computing infrastructure. It offers advantages by allowing the users to use the resources provided by the CSP at lower cost.

Cloud computing is an aggregation of computing as a utility and software as a service where a software is provided as service. In MCC the mobile users request for various services to the cloud service providers. The services requested may be real time applications and computations. To fulfil these demands bandwidth is an essential component that controls the rate of transmission. Bandwidth is a major issue in mobile cloud computing. Each user expects some QOS guarantee. The service providers should satisfy with these QOS. It may be a case that the CSP has provided the service to the mobile users but the mobile node is not able to access it due to its mobility. As the mobile nodes move from one location to the other the gateway that maintains the connectivity with the cloud service provider also changes. Hence the aggregated bandwidth at the gateway also changes In order to maintain the QOS bandwidth shifting is necessary. Bandwidth shifting alone cannot maintain QOS to the mobile node. In real time each gateway earns some revenue based on the service it is providing to the user and gateways are responsible for ensuring QOS to the users. Depending on various attributes such as channel spectral efficiency, and protocol overheads each gateway utilizes different percentages of allocated bandwidth from the CSP. Thus bandwidth utilization at the new gateway may differ from previous gateway. Hence bandwidth redistribution is necessary to fulfil the QOS requirements for computational services.

1.1 Contributions

In this paper we address the problems of bandwidth shifting and redistribution to meet the QOS demand from the mobile nodes. Each mobile node connected to its associated gateway requests certain amount of bandwidth with certain QOS criteria. QoS in terms of service delay is given prominence in this paper in future the research can be extended to other provide QoS in terms of other factors also. In the proposed work QOS is guaranteed in terms of service delay.

The proposed work mainly concentrates on initiating competition between the gateways in the process of auction so that the bandwidth is utilized to the maximum and in turn maximizing the revenue at each gateway while it maintains the QOS to the mobile nodes by purchasing the bandwidth by the CSP in the process of bidding.

2. 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 AAQUM algorithm with optimal bidding strategy.

3. Preliminaries

In the proposed approach we use two basic concepts auction theory and spectral efficiency of a channel. Basic understanding of these is important.

3.1 Auction theory

Auction theory is well known for modeling, buying and selling of commodities and services. There are various forms of auctions such as sealed-bid, open-cry, first-price, and second price etc. Conventional auction is more popular it is mainly classified in to two categories ascending or descending bid auction. For the descending auction the commodity seller sets the maximum selling price of an asset. Each buyer calculates the utility based on the valuation and cost of the product. In each iteration of the auction process the price per unit allocation decreases. The auction terminates when either the buyer accepts to pay the sellers price or the price becomes zero.

3.2 Channel Spectral efficiency

The information rate that can be transmitted over a given bandwidth in a specific communication system is called as Spectral efficiency. In MCC each gateway may use some adaptive modulation schema for adjusting their transmission rate depending on channel quality.

4. Mobile Cloud Network Model

Consider a simple mobile cloud network model where there is on CSP I single channel gateways $G=\{G_1, G_2 \ldots\ldots G_I\}$ connected to CSP through a wireless channel with an assumption that the spectral efficiency of the channels is different from one another represented by the vector $E(t)=\{E_1(t),\ E_2(t)\ldots..\ E_I(t)\}$.Further each gateway is connected to K number of nodes at a time t via some network. The total available bandwidth at the CSP is B_{total} .Each mobile node requests the required bandwidth to its associated gateway .Let $B(t) = \{ B_1(t)+ B_2(t)\ldots\ldots B_I(t)\}$

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4.1 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.

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

4.2 Bandwidth Shifting

In MCC the nodes are mobile and hence to ensure QOS guarantee bandwidth shifting is necessary however bandwidth shifting alone is not necessary for maintaining the QOS.

4.3 Bandwidth Redistribution

Each gateways pays certain amount to the CSP to meet the requirements of the mobile nodes connected to it on the other hand it also charges certain amount in terms of bandwidth it provides to other the mobile nodes. The utility function of the gateway depends on the service it provides it provides to the mobile nodes and the bandwidth it buys from the CSP to provide these services. The gateways with small service delay increases the overall revenue

4.4 AAQUM

Advanced Auction based QOS guaranteed utility with revenue maximization. An auction is a mechanism for buying and selling goods or services by offering them up for bid, taking bids and then selling item to the auction winner. Auction theory based approach is used for solving the QOS guaranteed bandwidth redistribution problem in MCC.During the auction process two parties one the auctioneer and the other bidder are involved throughout the auction process. In MCC each gateway participates as bidder and the CSP acts as an auctioneer-cum-seller. For allocating optimum bandwidth and maximizing the utility vector descending price option is used. In descending price option the seller sets the initial price for each unit allocation of bandwidth and gradually decreases the price over each iteration depending on the auction bid and the total reserved bandwidth. The auction process end with two conditions either the price becomes zero or the buyer accepts the price for buying the commodity.

We describe the basic steps of the modified AAQUM for the present problem

[1] 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.

[2] 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.

[3] 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.

[4] Pricing Mechanism: For each unit of allocation of bandwidth CSP confirms the price p.In each iteration if the total bid from all the gateways is less than that from the previous iteration then the price per unit allocation is reduced by certain amount assuming that there is no demand for its bandwidth .If the total bid from all the gateways is greater than the previous bid then there is no reduction in the bandwidth hence the revenue at the gateways is maximized.

AAQUM 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

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

Δ = (B_{tot} /$\sum_{i=1}^{I} bi(t)$)
CSP receives the price p (t+1) =P (t)-Δ
Else
CSP receives the price p (t+1) =P (t)
If (p (t+1) <))
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

5. 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

Figure 1: Revenue at the gateways in each iteration of the bidding in AQUM

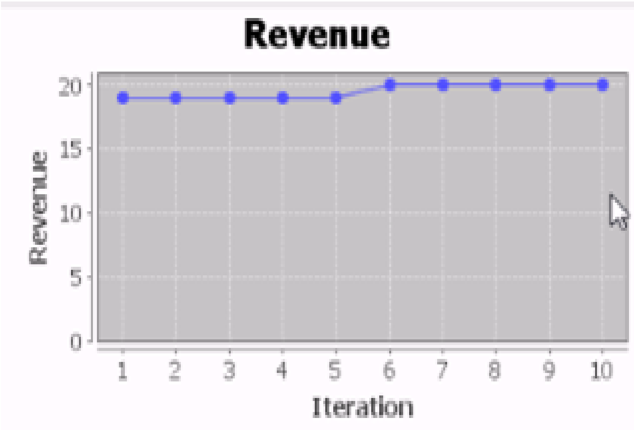

Figure 2: Revenue at the gateways in each iteration of the bidding in AAQUM

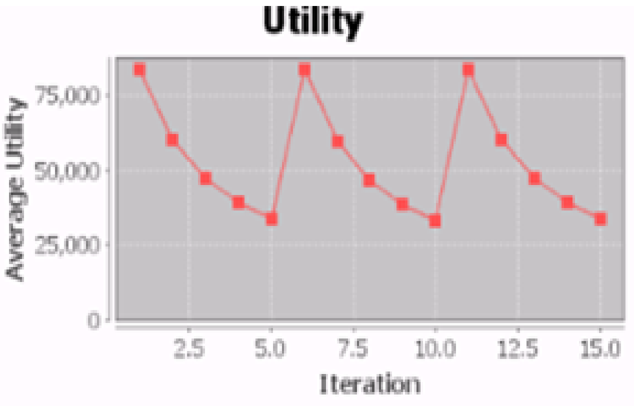

Figure 3: Utility at the gateways in each iteration of the bidding in AQUM

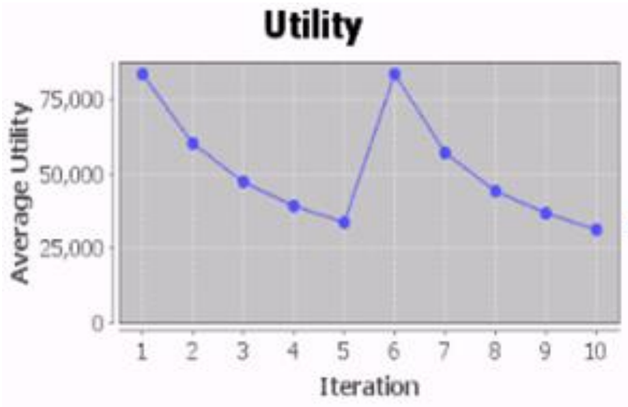

Figure 4: Utility at the gateways in each iteration of the bidding in AAQUM

6. 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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