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Ensuring QoS-Guaranteed Bandwidth Shifting and Redistribution using Mobile Cloud Environment

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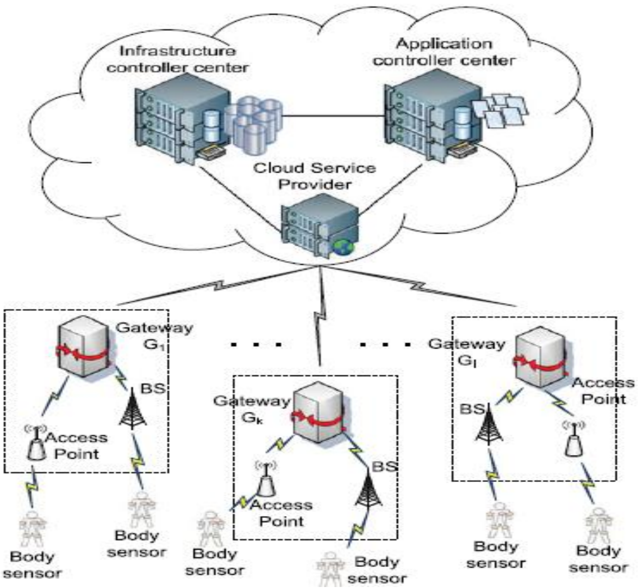
Abstract: ***Mobile Cloud Computing (MCC) an integration of Cloud Computing in mobile devices improves the computational capabilities of resource- constrained mobile devices. Now-a-days the users of mobile devices are demanding for Quality-of-service to run powerful web applications such as online shopping, mobile banking, online gaming, health and finance management and many more, especially when the user move from one location to another location. Though, the latest mobile devices are provided with improved hardware and software technologies, still there is a limited persistent resource. As the mobile users or nodes shift from one place to another, dynamic bandwidth shifting is necessary for quality-of-service. Although, shifting alone is not sufficient - because of varying spectral efficiency across the associated channels are coupled with the corresponding protocol overhead involved with the computation of utility, thus we formulate, and address the problem of Quality-of-Service(QoS) guaranteed bandwidth shifting and redistribution among the interfacing gateways for maximizing their utility using Cloud Service Provider(CSP). In the proposed System, we used AQUM theorem - where each gateway aggregates the bandwidth demand of mobile nodes which are connected and calculates a bid for the required amount of bandwidth utilized by each mobile node. Analyzed Nash Equilibrium (NE) and theoretically deduce the maximum and the minimum selling prices of bandwidth and also prove the convergence of AQUM***

Keywords: Mobile cloud computing, quality-of-service, bandwidth shifting, bandwidth redistribution, auction theory, Nash equilibrium

1. Introduction

Mobile devices (e.g., smart phones, tablets) are increasingly becoming an essential part of our life, as it is the most effective and handy communication tools, not restricted by location and time (in other words, it supports portability) . Mobile users build up with rich experience of various services from mobile applications (e.g., iPhone apps, Web apps, online banking etc) which run on the devices on remote servers using wireless networks. The users of Smart phones are often expected to function like a PC or Computer mainly- in terms of accessing web applications or online banking. Still today, the mobile devices do not have a solution for providing quality of service (QoS) while accessing web apps.
Cloud computing is an ever growing new technology aimed to provide various computing and storage services over the Internet. In addition, CC enables users to utilize resources elastically in an on-demand fashion i.e., pay-per-usage. **Mobile Cloud Computing** (MCC) is an addition of cloud computing into the mobile environment. Mobile Cloud Computing is an apt solution to bridge the widening gap between the mobile Quality-of -service (QoS) demand and the bandwidth shifting and redistribution in mobile devices. Mobile Cloud Computing is referred in simple in terms as, an infrastructure where both the data storage and the data processing occur outside of the mobile device.

It may be a case that the Cloud Service Provider (CSP) has provided the service to the mobile users, but the mobile node is unable to access it due to its mobility. As mobile node, moves from one location to another, then the gateway which maintains the connectivity with the Cloud Service Provider also changes. The gateway communicates with the Cloud Service Provider (CSP) to allocate shared resources which are required for resolving the mobile user's request. Thereafter, the connection is set up between the mobile user and the cloud server through an interfacing gateway. So, that the mobile user is capable enough to use the resources on the cloud servers. At this stage, we refer those words as "node", "device", and "user" is used in the document. Therefore, the aggregated bandwidth at these gateways also changes. In order, to sustain the QoS, bandwidth shifting is necessary. Bandwidth shifting alone cannot maintain Quality-of-Service to the mobile node. In Real Time, each gateway earns revenue based on the service it is providing to the user and gateways are accountable for ensuring QoS to the users. Depending on a variety of attributes such as Channel Spectral Efficiency and Protocol overheads of each gateway utilizes different percentages of allocated bandwidth from CSP. Thus, bandwidth usage at the new gateway may differ from previous gateway. Hence, bandwidth redistribution is crucial to fulfill the QOS requirements for computational services.



In this paper, we address the problem of bandwidth shifting and redistribution to meet up the QOS demand from the mobile nodes. Each mobile node is connected to its associated gateway request certain amount of bandwidth with Quality-Of-Service. In the proposed work, Quality-of-Service is guaranteed in terms of service delay. The proposed work mainly concentrates on initiating contest between the gateways in the process of auction so that, the bandwidth is utilized to the maximum and consecutively maximizing the revenue or profits at each gateway while it maintains the QoS to the mobile node by acquiring the bandwidth by the CSP in the process of bidding.

Further, we theoretically deduce the extreme of selling price of bandwidth, and prove that the algorithm converges in finite number of iterations. We summarized the main contributions in this paper as follows:

1) We theoretically prove the requirement of bandwidth shifting followed by bandwidth redistribution in a typical mobile cloud environment.
2) We propose an auction theory-based QoS-guaranteed utility maximization (AQUM) algorithm that redistributes the total available bandwidth optimally.
3) We analyze the existence of Nash equilibrium and the convergence criteria of the redistribution algorithm.

1.1 Motivation:

As mobile computing an ever growing and emerging technology, will continue to be a core service in computing, Information Communications and Technology (ICT) or Information Technology (IT). In an up-to-date computing time, there is a rapid increase in mobile devices, as it has many advantages such as flexibility in terms of location (which means - people can work comfortably from any location), thus saves time and also enhances the ease in search etc. For making mobile communications effectively and seamlessly, a proper infrastructure is required to ensure that, there is a need to include devices such as Protocols, Bandwidth and Service Provider.

In real time there are many Mobile Service Providers but still they lack with many limitations. Suppose, when a user accessing the web application(or)mobile banking in their respective mobile at a certain location, whenever the user moves from a location, then the user finds difficulty in accessing the web application (or) mobile banking. This is due to insufficient bandwidth, which is internally due to not shifting of bandwidth which was allocated to the user initially and also due to the non-redistribution of bandwidth. (This is the major difficulty facing by the mobile users whenever they are changing certain location.) Moreover, the mobile users demand for a certain level of QoS while accessing the internet as the mobile users find - ***service*** delay, jitter, response time, and reliability, while they use services. It happens due to the variation in the spectral efficiency across channels, and the communication protocols across devices

In order to overcome this we are using cloud environment in mobile devices. The Cloud computing enables providers to deliver software, platform and infrastructure as a service to remote customers over the network. The necessity of using cloud computing is, it allows deployment of large scale data centers at low costs. Cloud computing offers high availability and cost effectiveness of resources.

We consider that the gateway earns revenue from the users for providing requested bandwidth and QoS guarantee, while paying for accessing the amount of bandwidth from the cloud servers. We further assume that the gateways are responsible for ensuring such QoS requirements. Depending upon different attributes such as channel spectral efficiency and protocol overheads, each gateway uses different percentages of allocated bandwidth from the CSP. Thus, bandwidth utilization of the previous interfacing gateway may differ from that of the current one. This difference violates the QoS requirement in the newly connected gateway, while the previous gateway can provide more QoS than its present requirement. Therefore, proper redistribution of bandwidth is essential in real-time applications for fulfilling the QoS requirements for computational services.

2. Literature Survey

Although MCC provides many advantages, some drawbacks or issues such as service availability, low bandwidth, network management, QoS-guarantee, and pricing problem in MCC. The background of these issues offers the motivational platform of our present work on QoS-guaranteed optimal bandwidth redistribution in MCC.

A Dynamic Bandwidth Allocator in Cloud Environment for Virtual Machines: [1]

Cloud computing is a budding paradigm that allows to customers to rent infrastructure, platforms and software as a service. With resource sharing and reuse, the virtualization technology, cloud environments have become more effective and flexible. However, networking within virtualized cloud still possesses some challenges in the performance and resource allocation. As Virtualized clouds are definitely a compelling technology for both users and providers.

Cloud computing technology offers flexible services to the customer, according to pay-as-per-use model. Virtualization allows providers to optimize hardware through resource sharing and reuse and thus, it reduces hardware and power costs.

For this, an SLA-based Dynamic Bandwidth Allocator (DBA) integrated in a virtualized cloud environment. DBA manages bandwidth allocation efficiently according to the application requirements. It also adjusts the allocated bandwidth dynamically upon the change and reduces the usage of physical resources, by dropping packets in the virtual machines rather than driver domain. Through experimental evaluation showed the efficacy of the proposed algorithm and the agreements respect.

Thus it prevents transferring packets destined to be dropped. Experimental evaluation of module shows that DBA certainly respects the Service Level Agreements and significantly reduces the packet loss.

Dynamic Bandwidth Allocation for providing Quality-of-Service over Ethernet PONs:

Using the paper [ref: 3], we addressed the problem of dynamic bandwidth allocation in Ethernet-based PONs and also augmented the bandwidth allocation algorithms in order to support QoS in a differentiated services framework. In this paper, it was proved with a strict priority-based bandwidth allocation, under certain assumptions (such as traffic behavior), which resulted in an unexpected behavior for traffic classes (light-load penalty) and by using an appropriate queue management with priority scheduling to reduce this problem. Additionally, it proved that DBA algorithms perform early bandwidth allocation for lightly loaded Optical Network Units (ONU) results in better performance in terms of average and maximum packet delay, as well as network throughput when compared with some other dynamic allocation algorithms.

(**EPON**) Ethernet-based Passive Optical Network technology is a promising solution for next-generation broadband access network due to convergence of low-cost Ethernet equipment and low-cost fiber infrastructure. An EPON architecture supports differentiated services into three priorities namely, the best effort (BE), the assured forwarding (AF), and expedited forwarding (EF). One advantageous feature that broadband EPON is that it supports the ability to deliver services to transpiring IP-based multimedia traffic with diverse quality-of-service (QoS) requirements. Priority queuing is a simple and relatively useful method for supporting differentiated service classes.

PON is abbreviated as Passive Optical Network. It is a point-to-multipoint Optical access Network, with no active elements from source to destination in the signal path. In this, all transmissions are performed between an optical line terminal (OLT) and optical network units (ONUs).

A priority-based scheduler algorithm is required for scheduling packet transmission. A strict priority scheduling mechanism is used, where it schedules packets from the head of a given queue only if all higher priority queues are empty. This, situation will penalize the traffic with lower priority at the expense of uncontrolled scheduling of higher priority traffic which results in increasing the level in packet delay, higher packet loss, uncontrolled access to the shared media, etc.

Thus a dynamic bandwidth allocation (DBA) algorithm with QoS support over EPON-based access network. In addition, we scrutinized how gated transmission mechanisms [e.g., multipoint control protocol (MPCP)] and DBA schemes could be incorporated with priority scheduling and queue management to implement a cost-effective EPON network with differentiated services support.

Utility-based Bandwidth Allocation Algorithm for Heterogeneous Wireless Network

Next generation wireless network (NGWN) is regard to provide high-bandwidth connectivity with guaranteed quality-of-service to mobile users in a logical manner. In NGWN, mobile users are capable of connecting to the core network through various heterogeneous wireless access networks, like as cellular network, wireless metropolitan area network, wireless local area network and ad hoc network. In this paper, the problem of joint bandwidth allocation for heterogeneous desegregated networks is defined based on utility function theory and bankruptcy game. The proposed bandwidth allocation scheme comprises of two consecutive stages, i.e., service bandwidth allocation and user bandwidth allocation. At service bandwidth allocation stage, the excellent amount of bandwidth for different types of services in each network is allocated based on the exemplar of joined utility maximization, then, at user bandwidth allocation stage, the service bandwidth in each network is optimally designated among users in the network according to bankruptcy game theory. Numerical results demonstrate the efficiency of the proposed algorithm.

When a mobile node changes its location, the corresponding gateway for maintaining connectivity with the cloud changes. Therefore, the accumulated bandwidth requirement for the gateway also changes. For maintaining QoS in terms of service delay, the present gateway checks the total trans-mission delay for all connecting nodes, and the allocated bandwidth

3. Preliminaries

3.1 Necessity in Bandwidth Shifting

When a mobile node changes its location, the corresponding gateway for maintaining connectivity with the cloud changes. Therefore, the aggregated bandwidth requirement for the gateway also changes. For maintaining QoS in terms of service delay, the present gateway checks the total trans-mission delay for all connecting nodes, and the allocated bandwidth.

3.2 Service Delay Calculation

Definition of Service delay: Service delay is the total time required for providing a service from CSP to a mobile node.

We formulate it as utility maximization problem for gateways. For solving the problem, we use the concepts of auction theory from applied economics. Each gateway submits a bid to the CSP, based on the requested bandwidth and QoS demand from the mobile nodes connected to it. The CSP allocates the required bandwidth through a payment system. We formulate the utility of a gateway with the help of revenue function and cost function. The gateway defines the revenue function based on the revenue per unit allocation of effective bandwidth, and the revenue per unit service delay for the QoS requirement. The revenue of a gateway completely depends on the allocated bandwidth and QoS-guarantee between the mobile nodes and the gateway. In other words, it is postulated that higher revenue leads to increased QoS protection. It may be clarified that our focus in this work is not on the revenue maximization aspects of CSP. The cost function explains the pricing strategy between the gateway and the CSP. We prove the existence of Nash Equilibrium (NE) in the proposed scheme

3.3 Auction

Auction is well known model to buy and sell services &commodities. In a similar manner, auction theory is also useful for exchanging commodities in network applications [7]. There are various auctions such as Open-Cry, Sealed-Bid, First-Price, and Second-Price are present out of which conventional auction is more popular in the context of exchanging network commodities due to its ease and simplicity. The conventional auction is mainly classified into two segments or category based on the bidding schemes such as ascending or descending bid auction. In our project & proposed scheme we are going to use descending bid auction to solve the problem of bandwidth redistribution

4. Modules Description

4.1 Mobile Cloud Network

Consider a simple mobile cloud environment in which all operations follow the discrete time model with normalized time-slots t € {0; 1; 2; . . .}. There are one CSP and I single channel gateways G = {G1;G2; . . .;GI} connected with the CSP through wireless channel. Let us assume that spectral efficiency of each channel is different and represented by the vector E(t)={E1(t); E2(t); . . . ; EI(t)g. We further consider that each gateway has K number of mobile nodes connected with it at time t via any mobile network. Hence, Ni(t) = {Ni1(t);Ni2(t); . . .;NiK(t)}, thus N= UI i=1 Ni (t). In this work, we consider QoS-guarantee in respect of service delay. Let us consider that the total available bandwidth of the CSP equals Btot. If a mobile node requests any service from the cloud server, the service is provided through a gateway. We consider the adequate bandwidth requirement of the gateways for successful execution of the requested services by the mobile nodes. Let B(t)={B1(t);B2(t); . . .;BI(t)} denote the allocated bandwidth vector for the gateways G at time t.

4.2 Bandwidth Shifting

We consider a mobile cloud network. It may be stressed that the nodes are mobile in such environment. In this section, we theoretically prove that node mobility triggers the necessity of bandwidth shifting, if the cloud server does not have any unused reserved bandwidth for future use. Subsequently, we prove that bandwidth shifting alone is not always sufficient for providing QoS-guarantee

4.3 Bandwidth Redistribution

We design an utility function for computing the overall benefit of each interfacing gateway. The utility function of the gateway depends on the service it provides to the mobile nodes and the bandwidth it buys for providing the services. Each gateway pays certain price for getting the required bandwidth from the CSP. On the other hand, each gateway charges certain amount of revenue from the mobile nodes for providing the services to them. Additionally, the gateway demands an extra charge from the mobile nodes for assuring the QoS in terms of service delay. Taking into account the above three factors contributing to the gateway utility.

4.4 Convergence and Nash Equilibrium

We present numerical simulation results of the proposed AQUM (auction theory-based QoS-guaranteed utility maximization) algorithm for the MCC environment. Initially, we present an example scenario followed by parameter settings. We show the necessity of bandwidth redistribution, and establish results of convergence and Nash equilibrium. Each experiment was executed 30 times, and the ensemble average values are plotted with 95 percent confidence interval.

5. Implementation Details Proposed Method

We formulated on bandwidth redistribution as a utility maximization problem. To overcome this problem, we have presented modified descending bid auction. In the proposed scheme, we are implementing AQUM, where each gateway aggregates the demand of all the connecting mobile nodes and makes a bid for the required amount of bandwidth.

Distributed AQUM (Auction-Based QoS-Guaranteed Utility Maximization)

An auction is a mechanism/process or a set of business rules for exchanging commodities based on the bidding price. In our proposed work, we use the auction theory-based approach for solving the QoS-guaranteed bandwidth redistribution problem in mobile cloud computing, following the methodology similar to the one described in [7]. In this auction each gateway participate as a bidder and the cloud service provider acts as an auctioneer cum-seller. Here we use descending price auction theory for determining the optimum bandwidth allocation this maximizes the utility vector. At beginning, in descending price auction theory, the Cloud Service Provider or seller sets the initial ceiling price for each unit allotment& allocation, It keep on decreases the price over time till the price becomes zero or some other buyer agreed on the price for buying the services or commodity. In this problem statement, we consider a tradeoff between the unit price and the bandwidth request, as in general the requested amount of bandwidth reduces with the increase in price per unit allocation/allotment. For executing the tradeoff condition, we modified the termination classes of the descending price auction. In our modified distributed descending price auction process, price decreases over time until the total bid reaches the total available bandwidth. In the meantime, if the price p becomes less than p*min*, the ceiling price is again reset for continuing the auction process. We described the basic procedure of the modified descending price auction for the present problem/concern. In distributed algorithm we overcome and resolve the issues present in the existing AQUM like now we are allowing all users to view the bidding value for bandwidth of each bidder.

Mathematical formulation

Set B requested bid vectors which are as follows: Set B= {b1, b2,bi-1,bi,bi+1 … bi)}
Formulae used for calculating the requested bandwidths availability and the efficiency and delay are as follows:
Utility function U ( ) = -C.
So, these are the following set required for calculating U
Set c = {c1,c2,c3…..Cn}
Where, it is set of the capacity of each channel where it can be calculated by using the Shannon's capacity formula which is as follows and it decides the workflow of the existing system.

Mentioned above is the one part of our existing system. Moving further in details considers the sets declared below to enhance the description of our existing system:

G = { is set of all the gateways available}. I = { | I is no. of gateways available}.
U = { is utility of gateway G}
N = { set of nodes connected to the CSP}

But in the existing system there is no term of bandwidth redistribution means if one element from the gateway changes the requirements of bandwidth then it will affect the entire flow of the allocation of the bandwidth to various nodes in the set N.

Algorithm:-Distributed AQUM
Input:-
Pmax,
β
Output
: B
Steps:

For gateways

1. CSP broadcast p(t) to all gateways
2. Gateways calculates b(t) and u(t)
3. Gateways view bids of other bidders
4. For(i=1 ti I do
5. If(Ui (t)) >Ui (t-1)) then
6. Gateway Gi submits bid bi(t)
7. Else
8. Gateway Gi submits bid bi(t-1)
9. End if
10. End for
For CSP
11. If ( ) then
12. CSP calculates B and allocates to the gateways
13. CSP confirms the final price p(t) to the gateways
14. Else
15. CSP revise the price
16. p(t+1) = p(t) – Δp
17. if (p(t+1) <Pmin) then
18. CSP reset the price
19. P(t+1) = Pmax
20. End if
21. Go to Step 1 for new Iteration
22. End if
)

6. Experimental Results

A. Input and output

Input: CSP to distributed AQUM algorithm

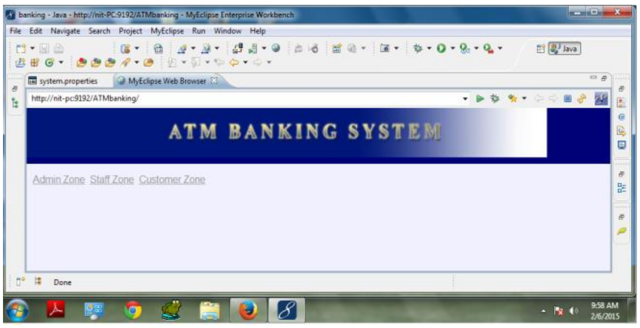
Pmax and β

Where Pmax- Per unit price
allocation β- Total Bandwidth

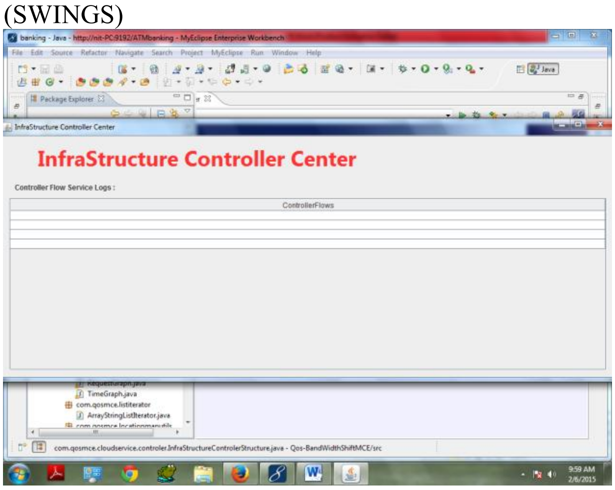
Output: Redistributed Bandwidth to each gate ways

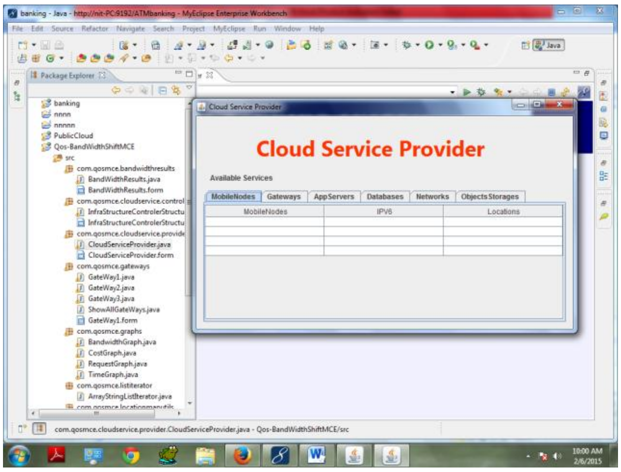
Step by Step Procedure:

1. First we need to run a banking application or any other web application developed in java (or any URLs) as shown below:

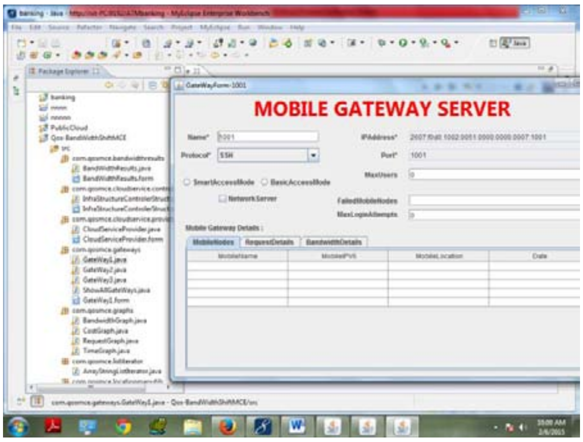


2. Then need to run Infrastructure Controller application and Cloud Service Provider which is developed using java (SWINGS)

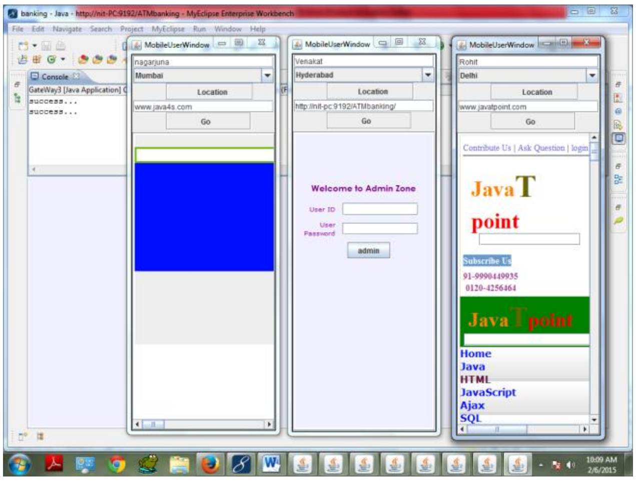




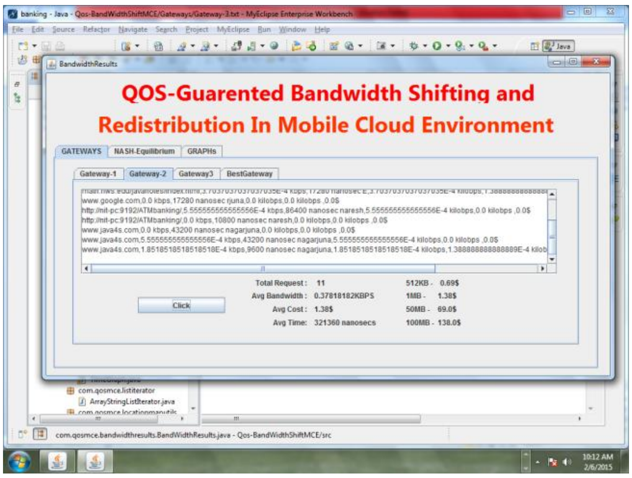
3. Then we run all the Gateways (suppose here we used 3 Gateways)



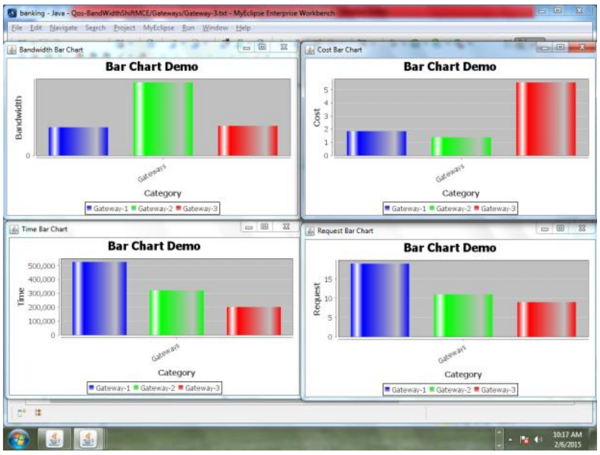
4. When we run 3 web applications in different locations using different mobile nodes as shown below:



5. At Cloud Service Provider, the details of each gateway and the details of bandwidth provided for each application



6. We also calculated the Best Gateway in terms of Cost, Bandwidth, Time and Request as shown below:



7. Conclusion

We have identified and addressed the problem of bandwidth shifting and redistribution in an MCC environment. The bandwidth redistribution problem differs from traditional bandwidth allocation problem in that while the former concerns allocating proportional (equal) bandwidth to all the gateways (which is in turn, to the users), even if only a few gateways change their bandwidth demand, the latter concerns allocating bandwidth to that gateways who have changed the bandwidth demand. We have proposed an auction-based QoS-guaranteed utility maximization algorithm for maximizing the revenue of each gateway, while it maintains QoS of mobile nodes by purchasing bandwidth from the service provider.

8. Scope for Future Enhancements

In terms of future work, we plan to add key revocation and subscription privacy support. Bethencourt et al. show how time-based key revocation would be possible using the current construction, and more recently Hur et al. presented a more efficient construction. Protecting the privacy of subscriber interests requires no leakage about the subscriber's query to third parties. CASCADE protects privacy of interests to the most part simply because user queries are satisfied locally. However, when a user fetches the content from the responsible node(s), the latter might learn what a specific user is interested in by examining the user's fetch requests over time. Recent system and cryptographic solutions for protecting subscriber privacy might be relevant here, see and references there in.

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