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Integrating Quality of Service, Call Admission Control and Pricing for User Classes in Next Generation Wireless Networks

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Abstract: Call Admission Control (CAC) is a challenging problem in Next Generation Wireless Networks (NGWN) the objective of which is to guarantee the Quality of Service (QoS) requirements while taking into account the limited number of channels available. CAC plays a very important role in NGWN as it directly controls the number of users in the network and hence must be carefully designed to guarantee the QoS requirements. As wireless resources are scarce, we propose to add pricing as an additional dimension for CAC and QoS inorder to use the scarce resources of the wireless networks in an optimal way.

Keywords: call admission control; user class; quality of service; next generation wireless networks; pricing;

I. INTRODUCTION

The wireless communication field is fast growing with several wireless networks deployed around the world. The number of users and their expectation towards better services is increasing alarmingly. Users are demanding for communication services at the wire line quality on move [1]. The wireless world is looking forward for the next generation technologies to replace the current generation limitations such as bandwidth scarcity, intermittent connectivity and multimedia support. This scenario is ideal for exploring potential of NGWN. NGWN are expected to provide better speed, higher bandwidth and low cost services supporting a variety of applications including web transfer, file transfer, email, sms, real time audio/video applications, streaming applications and gaming.

The NGWN are envisioned to be heterogeneous in nature and introduction of QoS to this heterogeneous network environment is a challenging problem. This is because networks are no longer seen as mere connection providers for data transfer, In addition they provide multiple services to users categorized under different classes. QoS is the ability to measure, improve, and to some extent guarantee in advance certain characteristics of the network like response time, delay, error rate and loss rate. This is accomplished by providing priority based on applications, users or data flow.

Different users exhibit varied network access behavior. Some users require unlimited connectivity with low bandwidth service. Some users require high bandwidth connectivity for a short span of time. Some users are always on move and connectivity with mobility is important for them. QoS with same parameters does not apply to all users as their usage pattern differs. Therefore providing QoS model with a user-centric approach will cater to larger needs of users.

We can classify users based on network usage behavior. Static users connect to the network from a fixed location and they are least concerned about QoS on mobility. Whereas an user who will be frequently traveling and accessing network from different Access Points (AP) need a service that provides efficient QoS during mobility. Some users utilize heterogeneous networks to access connectivity on move, for them seamless QoS service from heterogeneity networks is important. Also users have become increasingly dependent on the services offered by the providers and may be willing to pay more to attain better QoS especially when they are running critical business applications and there is a fear of getting badly degraded service.

A model that collects users' pattern and suitably provide a service that is apt for the user will ensure greater user satisfaction. Hence we propose to assign priority to users and classify them as platinum class users, gold class users and silver class users wherein users with highest priority (platinum class users) are provided with maximum QoS service at any point of time and lowest priority users are provided with QoS that can exhibit degradation to an extent (within allowable limits).

The paper emphasizes the need for integrating QoS, CAC and pricing for user classes in NGWN and is organized as follows. In Section II, the core idea of utilizing QoS in CAC is discussed. The role of pricing in telecommunication services is put forth in Section III. Section IV emphasizes the need for integrating QoS, CAC and pricing along with the benefits of integration. Pointers to further research and conclusion are given in Section V.

II. QOS AND CAC

QoS requirements vary amongst users. Users demand for different QoS at different interval of time in NGWN and also various players offer plethora of services to market themselves. Though services offered by these providers look alike they vary significantly when minute details are observed. This is substantiated with the following scenario of three service providers, viz. Player-A, Player-B and Player-C offering broadband services of 10Mbps. It looks like all the three players are identical with respect to their offered service. The following assumptions are made with respect to the throughput of these three players.

a. Player-A provides a constant and consistent throughput of 10Mbps throughout.
b. Player-B provides a variable and inconsistent throughput of 20Mbps, 5Mbps, 8Mbps, 12Mbps and 5Mbps in the first, second, third, fourth and fifth second respectively.
c. Player-C provides a variable and inconsistent throughput of 20Mbps, 15Mbps, 3Mbps, 5Mbps and 7Mbps in the first, second, third, fourth and fifth second respectively.

The throughput versus time graph for these three service providers for a period of 5 seconds is as shown in figure 1.

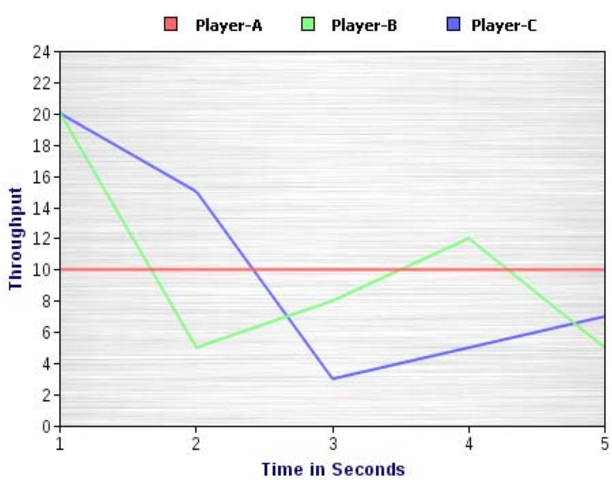

Figure1: Throughput Versus Time graph of three service providers.

An important observation made here is that all the three players have delivered 50Mbps of data in a period of 5 seconds. But who is best among three will depend on the type of the user and the application using the service. If the user is using the service for simple web browsing or downloading of a file then no significant difference is observed between the three players. However Player-B and Player-C might provide a better service due to high speed at the first second making initial startup fast for web browsing or downloading. If the user is using the service for bandwidth hungry multimedia applications such as video conferencing or live video broadcast, consistent and constant service offered by Player-A will be good when compared to fluctuating service offered by other two players. While all three players provide the same throughput over a given period of time their QoS vary significantly and is given by

$$QoS = \frac{Minimum\ \ speed}{Maximum\ \ speed} \qquad (1)$$

With this the QoS of Players A, B and C is 100%, 25% and 15% respectively. Even though all the three players offer 10Mbps service, their QoS vary significantly. Users of Player-B and Player-C may experience more breaks while using multimedia applications such as video conferencing and live video broadcasting when compared to users serviced by Player-A. Providing QoS guarantee is therefore an important issue in NGWN and it varies widely amongst users and applications. Hence it would be appropriate for the service providers not to consider all users as same and QoS needs to be provided based on user's needs and requirements.

An important aspect of providing differentiated services in NGWN is to design an effective CAC framework [2]. In QoS based networks CAC is usually specified as a traffic contract between the user and the network. When ever a user call requests for service if sufficient resources are available to accommodate the user call, the call is admitted by the CAC else the user call gets rejected thus guaranteeing the QoS of existing user calls. CAC is a strategy for accepting, rejecting or negotiating connection to the network [3]. However with the introduction of user classes all user calls are not treated equally. Service differentiation will become necessary so that service providers can provide differing service levels based on user classes [4]. High priority user calls are given more importance than other class of users and obviously based on the class of service opted by the users the tariff of service will be fixed by the service provider.

III. ROLE OF PRICING

Users act independently and unknowingly on the services provided by the network without considering the current network traffic conditions. Hence, system overload situations are unavoidable. In NGWN the situation will become worse as users are allowed to use more bandwidth and transmit large volumes of data. CAC plays a significant role in providing the desired QoS in NGWN. The main focus of traditional CAC is to reduce the new call blocking probability and handoff call blocking probability [5, 6]. However less work has been reported on user class based CAC in NGWN.

Pricing for the use of telecommunication services is an issue widely treated in the literature. It has recently been embraced by researchers as not only an economic issue covering the infrastructure expenses and operational expenses for generating income to service providers by charging the end users, but also as a resource management issue for efficiently using the available resources in NGWN. An effective way to encourage users to choose the service that is most appropriate for their needs is through network pricing [7]. Hence pricing can be added as a new dimension for CAC and QoS inorder to use the scarce resources of the wireless networks in an optimal way. However the service provider should be very cautious in pricing QoS as the objective is not just to maximize the revenue earned but to achieve greater user satisfaction and as a word of caution the price for QoS should not be too high as many users may get turned away.

IV. INTEGRATING QOS, CAC AND PRICING

The main driving force of service providers is revenue and their main objective is to use the available resources optimally and provide best services to users by maintaining the agreed upon QoS leading to greater user satisfaction. User differentiation is becoming important in NGWN and it demands for pricing differentiation among users. This is because some users may be willing to pay more for getting better QoS. This calls for having multiple pricing levels. Once the pricing for different class of users is fixed the next way to optimize revenue of the service provider is through CAC. Service providers need to use efficient resource management mechanisms in order to keep existing clients satisfied and attract new customers, so that they can increase their revenue [8]. This is done by giving higher priority for more profitable users. Pricing can be used with admission control to improve the effectiveness of admission control [9]. Pricing affects the behavior of users, and therefore can be used for QoS provisioning in NGWN. CAC and pricing are interrelated in a QoS enabled network and CAC can be utilized to derive optimal revenue for multiple user classes in NGWN. Hence we propose to integrate QoS, CAC and pricing. The following would be the benefits of this integration.

A. Greater User Flexibility:

Users will have greater flexibility as they can choose and change their class based upon their needs and requirements. This will be very helpful to users as pricing is based on their chosen class. A user in platinum class can migrate to gold or silver class and vice versa.

B. Greater User Satisfaction:

Users will be highly satisfied as long as the service providers are able to provide the agreed upon service with proper QoS and pricing. It is a win-win situation to both the parties.

C. Performance Gaurantee:

This integration will allow service providers to offer services to the users with guarantee on minimum level of network characteristics like delay, throughput, error rate and loss rate. It helps in slowing low priority user classes or even dropping them away entirely during extreme network traffic thereby leaving room for high priority user classes to avail the service. This leads to an efficient system in delivering the agreed upon QoS to users.

D. Optimal Revenue Generation:

With the introduction of differential user classes and integration of CAC and pricing in a QoS enabled wireless network, service providers will be able to earn optimal revenue as high priority users are priced more for their usage of the service.

E. Optimal Resource Utilization:

As wireless resources are scarce this integration will also help in using these scarce resources in an optimal way. The users will be always conscious about the price of utilizing network resources and will be judicious in choosing their class of service leading to reduced congestion.

V. CONCLUSION AND FUTURE WORK

In this paper we have articulated the need for integrating QoS, CAC and pricing along with their benefits. Future work will include the investigation of mechanisms to integrate QoS, CAC and pricing for different user classes allowing the service provider to provide greater user satisfaction and to earn optimal revenue. Our plans for future work also include the examination and comparative evaluation of different methods for integrating QoS, CAC and pricing, as well as their impact on resource utilization in the network.

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