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Dynamic pricing of call rates: Bayesian approach ☆

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ABSTRACT

In this paper, we present different cases and their possible solutions in the telecommunications market by incorporating dynamically changing call rates over the channel depending upon the network congestion. Since dynamic pricing of call rates is beneficial from both the perspectives of subscribers and service providers, our solution can significantly help to adapt this pricing mechanism in real market scenario. In order to deploy this scheme, we have incorporated the competing network provider's strategy into the mechanism of deciding dynamic price. Establishment of Nash equilibrium with the competing network provider has stabilized our pricing mechanism.

1. An overview of dynamic pricing of call rates

Our present cellular schemes for making calls are based on flat-rate pricing. This is clearly the best choice neither for the user nor for the network provider. The network provider wants to get most efficient use of the bandwidth and make the maximum profit out of it. So, he wants more users to use his network when it is under-utilized. Similarly at the time of congestion, he knows that the demand for his service has increased but he doesn't have any means to make extra profit out of it.

On the other side, the subscriber wishes to have the best possible service at the minimum possible price. But in static pricing scheme there is no incentive given to user to make calls in low congestion hours. And in the peak hours of the network, he faces a degradation in quality of service. So, we propose a solution to this problem with dynamic pricing scheme. This is profitable both to the user and the service provider. We show the use of the dynamic pricing at the extreme ends of the congestion in the network. At the peak hours of congestion, users face a degradation of QoS. The network providers even have to block calls to end the congestion. Using dynamic pricing, the users shall be guaranteed the asked level of service and the providers will be benefited with larger revenue due to increase in call rates coming from higher demand. When the network is under-utilized, the bandwidth of the network is wasted. So, the reduction in call rates due to the reduction in demand will increase the willingness of the users to use the service. Thus bandwidth shall be efficiently utilized and network provider shall earn larger profit.

1.1. What is dynamic pricing?

Dynamic pricing is an approach which facilitates network provider to regulate the network usage by controlling the Quality of Service to the existing users on network and varying the call rates to the new calls to ensure optimal usage of network resources. From subscriber's point of view, it provides options of switching among different networks available, which best satisfies the user's needs.

☆ Dynamic Pricing against Static Pricing to overcome the static scheme drawbacks.

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2. An overview of prior work

Lot of work has been done on dynamic pricing of call rates taking different scenarios into consideration. A major part of the research in [11,8,4] has been to create a pricing scheme taking only one network provider into consideration. The paper [4] by Dat Vo and Matthew Sorell presents a good approach on network provider which offers subscribers a continuous non-interrupting service by altering QoS of the call depending upon the network congestion. Reference [8] proposes scheme which employs dynamic pricing during all network conditions. In this case, the dynamic pricing component dynamically determines the prices of units of bandwidth for each class based on the user's demands in order to force the actual arrival rates to be less or equal to the optimal ones.

Reference [11] considers both service provider's revenue and user's satisfaction by using a flexible QoS based pricing approach for heterogeneous wireless access networks. Additionally, QoS DPA algorithm defines a dynamic pricing strategy that is applied when the QoS level is degraded.

In [7], a pricing policy for multiple competing ISPs (Internet Service Providers) using a threat strategy is presented. Even [2] tries to solve internet services pricing problem for multiple providers but not specifically using dynamic pricing approach. Reference [5] shows a proposal in which authors use game theory [3,12] to analyze the impact in the cost based on the economic interests of a wireless access point owner and his/her paying client. In [6] several problems for resource allocation and base-station assignment in CDMA (Code division multiple access) networks are studied. Reference [9] proposes two levels of service: Voice service and Data service. They show that making the decision of pricing unchangeable for voice service after the initial setting will lead to malicious use of the network by users. Similarly keeping the option of price change at later stage can lead to malicious network provider strategies. But the problem with their strategy is that they have made the decision of creating sub-games as static. There is no scheme describing how can we approximate the competitor network provider's pricing decision. They have also assumed that every provider shall provide the same service and this shows that every provider shall end up putting the same price by the end in order to avoid losing the game. We would like to incorporate, dynamic way of deciding as to how long a user must be given assured service without interruption. We would also approximate the contending provider's pricing strategy while taking the pricing decision.

3. Scope of our work

In the current scenario we assume that end-users have more freedom connecting to any WSP (Wireless service provider) for any service through their multi-mode devices and can disconnect anytime. This means that they do not have any strong bondation with service providers. So WSPs and end-user only interact on a per-service or per-session basis. From a user's perspective, the objective is to select the WSP that best satisfies his/her needs. From WSP's perspective the objective is to put up a pricing scheme which takes the demand into play while setting the prices. This is done as setting of lower prices attract more users and setting higher prices leads to better revenue during hours of demand. Added benefit is the maximum utilization of network resources.

For the analysis we have considered that only voice service is provided by the network service providers. Every service provider offers the information of call rates per bandwidth, which also depend on how much time the user wants the assured quality of service. The rate obviously shall be bigger if user wants it for longer time. The network service provider shall decide this change on call rates for different time period of assured service on the basis of congestion in the network.

4. Problem statement

It is a sequential system which uses previous output value as one of the current input value to calculate the current output. The call rates shall be decided using a game theoretic approach. We shall fix on a pricing scheme which is the maximum price that our concerned service provider can impose and still end up as the winner of the game involving other service providers.

The game consists of us and an opponent service provider with strategy and a utility function. The utility function takes into consideration both the Service Provider's revenue along with the cost of effort or resources to get that revenue. So it is his net utility. But a very important concern with our suggested system is that in any case the user must also have the maximum utility so that it sticks to our Service Provider.

5. Solution proposal

To come up with a solution to the problem, we would use a non-cooperative game theoretic approach. So we would like to define terms like utility function for the user, revenue for the network provider, user satisfaction, change in quality of service as per the equation in [9]

$$U(b) = \frac{\alpha}{1 + e^{1-b}} \tag{1}$$

where α is the value which depends upon the market economic conditions (in general it would behave like constant), b is normalized bandwidth serviced to the subscriber for a particular call, $0 \leq b \leq 2$, $U(b)$ is user's utility of service.

There are two games that we care about: Provider vs. Provider which can result in just one winner and Customer vs. Provider in which we are more concerned in the comparison of utility achieved by the user against unavailability of our proposed system. We would like our network provider to be the winner in the first game and even result in better utility to user due to competition and dynamic pricing approach.

The time period for which the user wants call rates can be taken as the time interval between successive games.

Using the utility function defined in previous work under the same title, we propose that in order to maximize

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