

Modeling of Customer Retrial Phenomenon in Cellular Mobile Networks

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Abstract— In the planning of modern cellular mobile communication systems, the impact of customer behavior has to be carefully taken into account. In this paper, two models dealing with the call retrial phenomenon are presented. The first model considers a base station with a finite customer population and repeated attempts. A Markov chain modeling is proposed, and an efficient recursive solution of the state probabilities is presented. The second model focuses on the use of the guard channel concept to prioritize the handover traffic. Again, the retrial phenomenon plays an important role. The influence of the repeated attempt effect on the quality of service experienced by the mobile customers is discussed by means of numerical results.

Index Terms— Cellular mobile networks, call blocking probabilities, guard channels, handover priority, performance, retrial.

I. INTRODUCTION

IN modern cellular mobile communications networks, the quality of service (QoS) experienced subjectively by individual customers or mobiles is the crucial factor to determine the system performance. Thus, a proper modeling of customer behavior is essential in order to gain realistic input for network planning. Due to the increasing number of customers and network complexity, the customer behavior in general, and the retrial phenomenon in particular, may have a nonnegligible impact on the network performance. In this paper, we focus on the effect of the customer retrial phenomenon on the QoS in a cellular mobile network.

The modeling of repeated attempts has been a subject of numerous investigations dealing with the performance analysis of switching systems and communication networks. Under overload conditions, caused by the retrial phenomenon, a snowballing effect of call arrival processes can occur, which leads to dramatic degradations of the call completion performance of single switching systems, and subsequently of the whole network.

We observe a mobile communication system where a supported area is divided into cells, each of them served by a base station having a limited number of channels. In future mobile networks, where microcells are under consideration, the cell size gets smaller, and thus the number of mobiles served in a cell also will be relatively smaller, such that traffic models with a finite number of sources should be

considered. These two aspects, customer retrial and finite number of sources, will be dealt with in the first model of this paper, presented in Section II. A Markov chain modeling is proposed, and we develop a recursive method that gives the state probabilities. Such a recursive scheme is much more efficient than simply solving the balance equations that are generated by the Markov chain. The algorithm does not require maintaining and storing the entire state space during the calculation, but only the normalization constants. This implies that even for considerably large state spaces, the relevant performance measures can be calculated, in this way coping with the "state-space explosion." The influence of the customer retrial phenomenon on the QoS is discussed by means of numerical results. We conclude this section by showing that for a large population, the model can be replaced by an infinite-population model, where the approximation accuracy is reasonable for practical purposes. Notably, the approximation is conservative, i.e., the blocking probabilities in the infinite-population model set an upper bound for the blocking probabilities of the corresponding finite-population models.

There is a large number of papers dealing with customer repeated attempts; most of them model retrials in conventional wireline telephone networks. The literature on retrial queues is summarized in [4] and [11]. Significant early references on (statistical issues of) the retrial effect are [6] and [7], whereas [1] and [9] treat the performance analysis of these systems. In [10], an efficient recursive algorithm is given in order to calculate performance measures. A more recent paper is [3], considering a retrial group of $M/G/1$ type that is particularly suitable for analyzing mobile telephone.

Another important issue is the modeling of the handover call process. This process consists of call requests caused by mobile users moving from one cell to another. The current ongoing call has to be handed over between base stations. Taking into account the customer mobility and the handover effect, the cell faces two kinds of call arrival processes: *fresh calls*, i.e., calls originating in that cell, and *handover calls*. Since handover calls already use network resources, they should be completed first. Normally, they are prioritized with respect to fresh calls since blocking a handover call, i.e., a call being processed where customers expect continuous service will degrade the QoS more seriously.

Nowadays, with mobile handsets, redialing of blocked fresh calls is only a matter of pushing one button. The time spent by users before starting a retrial becomes shorter compared to the conventional telephone systems. These retrials, of course,

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