Channel Holding Time Characterization in real GSM network

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Abstract— This paper presents a realistic characterization of the channel holding time in an operating GSM network covering an urban area. Our approach is entirely statistical: the data set to be fitted has been provided by the OMC (Operations and Maintenance Center). The Kolmogorov Smirnov goodness of fit test is used in order to test the suitability of the exhibited distribution. From this statistical analysis, it can be concluded that the negative exponential distribution is a good approximation for describing the channel holding time.

Keywords—Cellular mobile communication, channel holding time, mobility modeling, traffic characterization.

I. INTRODUCTION AND MOTIVATION

As the number of cellular network subscribers is dramatically growing, system capacity and Quality of Service (QoS) can be pointed out as relevant figures from the operator point of view. Moreover, the overall aim of a cellular mobile communication system from a network provider’s viewpoint, is to carry the largest amount of traffic for a given number of channels at a specified level of service.

Careful dimensioning of the network and the underlying teletraffic analysis plays a major role in determining the different Grade of service (GoS) parameters. The channel holding time of a cell is one of the major parameters that needs to be accurately modeled in the teletraffic analysis and is particularly important for system design and dimensioning, as well as for frequency allocation [3]. The channel holding time of a cell is defined as the time during which a new or handover call occupies a frequency channel within a given cell.

In most analytical and simulation approaches, the performance evaluation of mobile networks is usually carried out by using some basic concepts of Queuing Theory as well as assuming certain statistical distribution for channel holding time [10].

A poor knowledge of this distribution contributes to an inefficient design of the network resources. On the other hand, the accurate knowledge of the channel holding time probability distribution function allows an accurate analysis of many teletraffic issues that arise in the planning and design of cellular mobile radio systems. This shows up in a better use of

the radio resources used in this kind of networks and makes it possible the development of new services offered through cellular networks such as data services.

In this paper we deal with the statistical modeling of the channel holding time in the presence of real traffic conditions within the service urban area.

Our motivation for channel holding time characterization research comes from the fact that it plays a very important role for our work where we aim to propose a generic model which can be customized and parameterized by any operator for planning and deployment of mobile networks. The framework includes the mobility modeling and traffic characterization. In this article, we focus on the characterization of the channel holding time. Interested readers can refer to [1, 2] for details of the general modeling framework.

Our approach starts with the extraction of the relevant parameters from measurements realized on an operating GSM network providing a conversational service to a population of mobile users in an urban area covered by 197 cells. The remainder of this paper is organized as follows: in section II we briefly describe some commonly used models for the distribution of the channel holding time. Section III introduces our statistical approach used and the measurements environment on which it relies. Section IV will present the channel holding time characterization for two examples of sub areas. Finally we present our conclusions in section V.

II. CHANNEL HOLDING TIME IN MOBILE COMMUNICATION NETWORKS

The channel holding time in a cell is defined as the time duration between the instant that a channel is occupied by a call and the instant it is released by either completion of the call or by handing over to another cell. The channel holding time depends on various system parameters such as cell size, speed and direction of mobiles. In addition, mobility has major effect on the channel holding time in circuit-switched services [3, 4, 5]. The latter has in turn huge influence on the call blocking and dropping probability.

In the fixed telephone network, the same telephone line is allocated to a given connection for its entire duration, so the
channel holding time is equal to the call duration. However, in the case of cellular mobile networks, mobile subscribers are provided with telephone service inside a given geographical area within which mobile units can communicate with each other via wireless links.

The geographic area is divided into multiple adjacent cells, where each one has been allocated a given number of frequency channels. When a mobile wants to communicate with another user, it must first obtain a channel from one of the base stations that hears it (usually, it will be the base station which hears it the best). If a channel is available, it is granted to the user. The user releases the channel under either of the following scenarios: (i) the user completes the call (ii) the user moves to another cell before the call is completed. Under these conditions, most often, the channel holding time only corresponds to a portion of the total call duration.

From classical teletraffic theories, it has been widely used the negative exponential distribution to model the channel holding time in large and single-cell systems for the sake of tractability [4].

Guérin [3] has extended this by attempting to describe the channel holding time by the negative exponential distribution and he has shown that the channel holding time can be seen as directly dependent on two other exponential processes. Namely, the total call duration and the crossing cell boundaries. However in [9] the hypothesis of exponentially distributed channel holding time is valid under certain circumstances. The channel holding time has been also showed to fit lognormal distribution better than the exponential [7, 8].

Various other methods such as the sum of hyper exponential [5] and general distributions [6] were proposed but complexity of the analysis has increased considerably with these techniques.

In [11] phase-type distributions of Generalized Erlang form have been used to model the channel holding time in a mobile environment.

III. DESIGN APPROACH AND MEASUREMENTS ENVIRONMENT

After giving an overview over state of the art models for describing the channel holding time, we are interested in this section to present our approach used to derive the statistical distributions of the mobility related traffic parameters in the presence of real traffic conditions in urban area.

In this paper, we focus our attention on the channel holding time characterization, which is a very important parameter in analyzing mobile communication networks.

Our approach focuses on the optimization of the real-world network of an urban area by an analysis of the BSS performance measurements collected and recorded in different counters according to a schedule established by the OMC (Operations and Maintenance Center) over the hours of a day. The urban area under study is covered by 197 cells gathered into 5 BSC.

In order to obtain an accurate traffic analysis, we have utilized the measurements collected over each hour of a day and for a period of 16 days.

In this work, one of the main contributions is to analyze the BSS measurements in order to propose a mobility model that constitute a systematic way to evaluate the radio performance of any cellular network.

In our approach we proceed in a first step called “macroscopic study” to split the urban area up to several sub areas (in our context we have found 8 activity areas: residential district, highways, business center, downtown, industrial zone, university campus, tourist zone and shopping center) according to the population activity and traffic characteristics. Each activity area gathers together a number of cells sharing the same characteristics (cell size, number of channels and traffic intensity). In this way all cells belonging to the same activity area present approximately the same qualitative and quantitative behavior of the traffic intensity (they achieve their busiest hour at the same times of the day).

After defining each activity area, we have been interested in defining certain statistical distributions of the traffic sources [2] namely fresh traffic and handover traffic. At this level called “microscopic study” we focus on the traffic modeling in the same way of macroscopic study but with more refinement in order to deduce the impact of each area on other areas and all kinds of interactions that can be established between them.

As mentioned earlier, our approach is entirely statistical to derive distributions to fit the measured data. This is done by means of the Kolmogorov Smirnov (K-S) goodness of fit test. The K-S test is very simple to apply and has been widely used to fit telecommunication traffic. The general approach was as follows. The basic parameters (mean value and standard deviation) of the hypothetical distribution function were estimated from the sample data by making use of the Maximum likelihood Estimation (MLE) [12]. Then we test the suitability of the fitting distribution by using the K-S test which is based on the differences between observed and theoretical cumulative distribution probabilities.

IV. CHANNEL HOLDING TIME CHARACTERIZATION IN THE DOWNTOWN AND IN THE BUSINESS CENTER

Given a perfect evaluation of a traffic distribution, based on the BSS measurements analysis, we notice that there are two busy hours during the work days in an urban area under study; the first busy hour is between 11:00 AM and 12:00PM and the second one is around 6:00 PM (between 5:00 PM and 6:00 PM). This reflects the activity hours of the users when they usually leave their works.

In order to characterize the channel holding time, we have examined averages over all days (16 days) and for each hour of the day. We have applied the K-S test to evaluate the agreement between the empirical data obtained from BSS measurements and the exponential distribution which has usually been considered as a suitable distribution to model the channel holding time in most of the analytical and simulation studies.

Fig. 1 is a plot of the empirical distribution function (the solid line) with an exponential cumulative distribution (the dashed line) in one cell belonging to the downtown. The observations
between 7AM and 8 AM come from the exponential distribution at the 0.05 level of significance.

**Figure.1** Exponential K-S test between 7 AM and 8 AM.

Fig. 2 and 3 display respectively the suitability of the exponential distribution for the two busy hours of the day, the first busy hour is between 11 AM and 12 PM and the second one is between 5 PM and 6 PM.

It’s important to note that our choice of these hours of the day came after applying the same test with a “fitted” exponential over each hour of the day. We deduced that empirical data satisfy the exponential distribution in each hour with a mean channel holding time different from one hour to another.

Between 7 AM and 8 AM, the mean channel holding time is 25.98 seconds or during the busy hour (between 11 AM and 12 PM) it is equal to 44.20 seconds and during the second busy hour (between 5 PM and 6 PM) the mean channel holding time is around 29.57 seconds.

**Figure.2** Exponential K-S test between 11 AM and 12 PM

**Figure.3** Exponential K-S test between 5 PM and 6 PM.

We followed the same process treating the channel holding time distribution in the cell belonging to the downtown, we have applied the K-S test to one cell of the business center between 7 AM and 8 AM as shown in Fig. 4. We found that the channel holding time follows an exponential distribution in each hour of the day.

**Figure.4** Exponential K-S test between 7 AM and 8 AM.

The behavior of the channel holding time depends on both the users density and the traffic intensity.

**V. CONCLUSION**

This paper has presented the statistical analysis of the channel holding time distribution in a real urban area covered by a GSM network. Our approach is based on the analysis and an extraction of interested information from BSS counters traces. It was found that for two cells belonging to two different activity areas namely for the downtown and the business center, the channel holding time can still be taken exponentially distributed in the presence of real conditions. This was achieved by means of the Kolmogorov Smirnov goodness of fit test.
This statistical approach provides guidelines for our framework study where the final goal is to propose a generic planning model that constitute a systematic way to evaluate the radio performance of the mobile networks.

REFERENCES


