Chapter 1.7

A Survey on Classical Teletraffic Models and Network Planning Issues for Cellular Telephony

Francisco Barcelo-Arroyo
Universitat Politècnica de Catalunya, Spain

Israel Martin-Escalona
Universitat Politècnica de Catalunya, Spain

ABSTRACT

Research on traffic characterization and analysis of cellular networks has been very active in the past decades. However, it is difficult for network planners to incorporate new results to network engineering. On the one hand, some models are very complex and need advanced programming and skills to be properly computed. On the other hand, reliability on those models is poor because there is a general lack of published field studies to corroborate them. This paper proposes simple well-known teletraffic models for cellular networks compared to the conventional Erlang-B frequently applied when a first estimate is needed. To this purpose, the latest results on the characterization of the arrival process and service time in cellular systems are reviewed. According to the arrival and service characteristics, three models are proposed to obtain a first approach to the performance characteristics of the cellular system. The first two models are extremely simple, allowing direct computation of performance through closed formulas, while the third requires simple programming.

INTRODUCTION

Motivation

In recent years, many papers have been published on models for personal communications in cellular networks. Mathematical analyses, simulations and field studies have been presented separately with little effort dedicated to the link between them and the engineering consequences of using a specific modeling tool. Most of these recent studies show that the classical Erlang-B theoretical hypotheses seldom occur in actual operative networks: arrive-
als might be not Poisson, channel-holding time not exponentially distributed, blocked handoff attempts not immediately lost if not attended, coverage overlapping areas, and so forth. Newer models try to overcome these issues through relaxing hypotheses and adding features to previous ones, but there is a general lack of comment on how the new hypotheses and features fit the real cellular world, what happens when these hypotheses are relaxed, and how to apply new models. The consequence is that the planner fails to take advantage of the huge amount of research work carried out in this field and often remains loyal to the conventional Erlang-B model.

Teletraffic modeling of cellular networks is a complex issue because there are many variables involved. Some of them are traffic related: the channel-holding time (CHT) is a fraction of the duration of the whole connection (i.e., unencumbered holding time), arrivals are not always Poisson (specifically handoff arrivals), and so forth. Others are mobility related: speed and direction of the Mobile Node (MN), different user patterns, and so forth. There are also radio constraints: propagation, multi-path, antenna radiation diagram, cell shape, and so forth. This is merely a very brief summary of related variables, since it is almost impossible to produce a comprehensive list of all of them.

In addition there are strong relations between variables. For instance, the cell shape obviously depends on all the variables related to the radio environment. The consequences of the traffic load on the cell shape are not so obvious, but the planner cannot overlook the fact that under heavy load, the MN is often connected to a base station (BS) that is not the nearest one. As explained below, MNs within overlapping areas may belong to different cells depending on the traffic circumstances.

Goals and Organization

This work deals with the first stage in network planning: applying simple teletraffic models to draw approximate figures of capacity-related performance figures. This first step is necessary before carrying out simulations, which consume a much greater amount of time and resources. The advantage of simple models is that they quickly produce a first approach to the system performance while allowing a high level of understanding about the impact of each single phenomenon. However, the estimates obtained through this analysis are always rough and never permit to elude the need for simulations that will provide more accurate results by allowing the designer to relax the necessarily simple hypotheses of the model.

The objective of this paper is to provide general considerations that help the planner to better understand:

- The reasons why a specific queueing model is applied. Simplicity and ease of use are major advantages for planners.
- The differences between the hypotheses in the model and the true network.
- The consequence of those differences on the achieved performance evaluation figures. An estimate of the level of accuracy provided by the model is also important.
- How to slightly change classical teletraffic models in order to apply them to a specific cellular network. Notice that most variables and hypotheses can significantly change between networks.

The paper is organized to highlight the main differences between cellular and non-cellular networks. We first present a review of the features of the arrival process, and then present the CHT. We follow with the QoS figures obtained from a teletraffic model and analyze them. We then highlight some aspects related to the use of the Erlang-B model and introduce other models that can be applied to cellular networks without losing simplicity. We offer several hints to generalize these models.