Chapter 12
Handover Analysis and Dynamic Mobility Management for Wireless Cellular Networks

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ABSTRACT

Dynamic location of mobile users aims to deliver incoming calls to destination users. Most location algorithms keep track of mobile users through a predefined location area. The design of these location algorithms is focused to minimize the generated signaling traffic. There are three basic approaches to design location algorithms, namely distance-based, time-based and movement-based. In this Chapter we focus only on the movement-based algorithm since it achieves a good compromise between complexity and performance. We minimize a cost function for this dynamic movement-based location algorithm in order to find an optimum threshold in the number of updates. Counting the number of wireless cell crossing during inter-call times is a fundamental issue for our analysis. We use renewal theory to capture the probabilistic structure of this model, and it is general enough to include a variety of probability distributions for modeling cell residence times (CRT) in exponentially distributed location areas and hyperexponentially distributed intercall times. We present numerical results regarding some important distributions.

1. INTRODUCTION

Counting the number of handovers (or wireless cell crossings) is an important problem in cellular wireless networks. In a typical cellular topology, the area to cover a city is designed as an irregular or regular layout having non-overlapping hexagon-shaped wireless cells. During a random duration call, mobile users will cross several cell boundaries spending a random time in each of the cells. The handover process is a complex function of many factors such as: size of wireless cells, user's mobility path, call patterns, (i.e., the number of renewals or handovers in random interval of duration T or CHT). This problem has been solved in several specific cases by Cox in his monograph. The CRTs are denoted by the sequence

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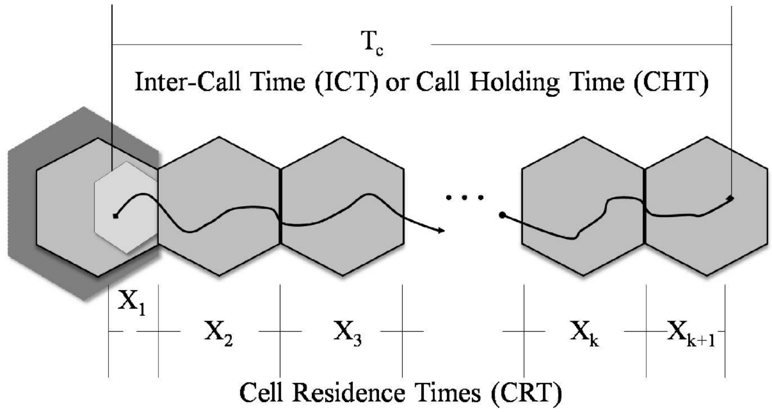
Figure 1. Cellular cell layout and cell residence time $X_i\,; i=1,2,\ldots,k+1$.



of random variables $X_1, X_2, \ldots$ or renewal times, see Figure 1. Most of the results studied by Cox are based on the *ordinary* renewal process, i.e., all the random variables $X_i;\ i=1,2,\ldots,$ come from the same distribution with probability density function (pdf) $f_X(x)$. We denote $N(t)$ as the number of renewals in a fixed time interval (0, t], and the first renewal X_1 is started at time 0. We assume that T is independent of $\left\{X_1, X_2, \ldots, X_i \ldots\right\}$. Hence, $N(T)$ gives the counts of the number of renewals (handovers) in a random interval (0, *T*]. This basic model studied by Cox results restrictive in common cellular networks scenarios. It is common that a mobile user begins his call somewhere inside a wireless cell. Thus, we should consider the case in which only $X_i = X;\ i=2,3,\ldots$ have pdf $f_X(x)$ while X_1 may come from a different distribution. When X_1 is the residual life or forward recurrence-time of $X_2 = X$ (Cox, 1962, page 27), we have the *equilibrium* renewal process, which we have studied in (Rodríguez-Dagnino, Takagi, 2003). Another important situation occurs when X_1 has a different pdf from the remaining CRTs $X_2, X_3, \ldots$ and it is called the *modified* or *delayed* renewal process. We have also studied a more general case where all the pdf's of the CRTs $X_1, X_2, \ldots$ may be different. We call this case as the generalized renewal process (Rodríguez-Dagnino, Takagi, 2005) that is applicable to irregular layout typologies. In Figure 1 we show a basic layout where we emphasize the fact of a different pdf for the first CRT.

We have extended this basic approach in many directions, and we will discuss these counting handover methods in this Chapter and related results that can be found in (Yeung, 1997; Zonoozi, 1997; Orlik, 1998; Rodríguez-Dagnino, Leyva-Valenzuela, 1999; Rodríguez-Dagnino, Hernández-Lozano, Takagi, 2000; Rodríguez-Dagnino, Takagi, 2001; 2002).

Besides its importance in dimensioning wireless networks, counting the number of cell crossing boundaries is also important for location of mobile users in a specific location area.

The main goal in the location algorithms is to minimize the signaling cost resulting from the users updates in a database serving the location area. In spite of the fact that the user is not active in conversation, it is necessary to keep track of it by updating the database. This is a dynamic process and there have been several strategies to achieve this goal. The most studied strategies for this purpose are: Distance-based, time-based, and movement-based (Bar-Noy, Kessler, Sidi, 1994; Akyildiz, Ho, Lin, 1996).

Our analysis is aimed to find an optimal cost to reduce signaling traffic and database loads. In typical wireless networks the Mobile Switching

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