Chapter 5

Mobility Prediction in Long Term Evolution (LTE) Femtocell Network

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ABSTRACT

The Long Term Evolution (LTE) femtocell has promised to improve indoor coverage and enhance data rate capacity. Due to the special characteristic of the femtocell, it introduces several challenges in terms of mobility and interference management. This chapter focuses on mobility prediction in a wireless network in order to enhance handover performance. The mobility prediction technique via Markov Chains and a user’s mobility history is proposed as a technique to predict user movement in the deployment of the LTE femtocell. Simulations have been developed to evaluate the relationship between prediction accuracy and the amount of non-random data, as well as the relationship between the prediction accuracy and the duration of the simulation. The result shows that the prediction is more accurate if the user moves in regular mode, which is directly proportional to the amount of non-random data. Moreover, the prediction accuracy is maintained at 0.7 when the number of weeks is larger than 50.

INTRODUCTION

Introduction of Long Term Evolution

Long Term Evolution (LTE) is introduced due to the emergence of new application such as Multimedia Online Gaming, Web 2.0 (i.e. Facebook, myspace) and high growth of consumer technology such as a laptop, tablet and smart phone. The LTE is the latest standard in a mobile network technology tree that was introduced by Third Generation Partnership Project (3GPP). The LTE whose radio access called as Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) is expected to improve end-user throughput, reduce user plane latency, and improve users experience with full
mobility. The LTE is provided for Internet Protocol (IP) based traffic with end-to-end Quality of Service (QoS) to meet a requirement of high peak data rate. Some of LTE requirements are as follows (Motorola, 2007):

1. Peak data rate of 100Mbps for downlink and 50Mbps for uplink (for 20MHz spectrum).
2. Scalable channel bandwidths of 1.4, 3, 5, 10, 15, and 20MHz in both downlink and uplink.
3. Mobility supports for up to 500kmph but optimized for low speeds from 0 to 15kmph.
4. Control plane latency is less than 100ms.
5. User plane latency is less than 5ms.
6. Can serve for more than 200 users per cell (for 5MHz spectrum).
7. Cell coverage from 5km to 100km with slight degradation after 30km.

The LTE has been developed based on orthogonal frequency-division multiplexing (OFDM) waveform for downlink and single-carrier FDM (SC-FDM) waveform for uplink, together with higher-order multiple-input multiple-output (MIMO) spatial processing techniques. In addition to the LTE, the 3GPP defines IP-based, flat core network architecture where this architecture is a part of System Architecture Evolution (SAE) that consists of Evolved Packet Core (EPC) and E-UTRAN. The EPC consists of Mobility Management Entity (MME), Serving Gateway (S-GW), and Packet Data Network Gateway (PDN GW). Some of the functions of the MME are: to control the signal between user equipment (UE) and core network (CN), to establish and release radio bearer services, responsible for paging and tracking the UE in idle mode, and to check the authorization of the UE to camp on the service provider’s Public Land Mobile Network (PLMN). The SGW is responsible to route and forward user data packets, and acts as mobility anchors for user plane during handovers. The PDN GW provides connectivity to the UE to external packet data networks and allocates IP addresses for the UE and quality of service (QoS) enforcement. The E-UTRAN consists of evolved Node B (eNB) where the terminology of base station in the LTE. The eNBs are interconnected with each other by means of X2 interface and S1 interface to the EPC.

The LTE can be used in both paired frequency division duplexing (FDD) and unpaired time division duplexing (TDD) spectrum (Ericsson, 2009). The FDD requires two separate carriers where one for downlink and another for uplink. Downlink and uplink share a single carrier, but separate in time domain for TDD. In general, FDD is more efficient but more complex where it is difficult to make antenna bandwidths broad enough to cover both sets of spectrum. For TDD, it is only required/needed a single carrier and no spectrum-wasteful guard bands or channel separation.

**Implementation of the LTE Femtocell**

Femtocell technology had attracted many industries in late 2007 and early 2008. As per survey on wireless usage, more than 50% of all voice calls and more than 70% of data traffic originates indoors (Chandrasekhar, 2008). Therefore it is significant for network provider to provide a good coverage in indoor environments. Femtocell is an effective solution to provide better coverage in the indoor environment as well as can improve macrocell reliability. Femtocell is a low-power wireless access points with small cell coverage and operates in a spectrum licensed to connect standard mobile devices to a mobile operator’s network using residential digital subscriber line (DSL) or cable broadband connections (see Figure 1). Femtocells have been devised for offering broadband services indoor (i.e. home and offices) and outdoor scenarios with a very limited geographical coverage (Capozzi, Piro, Grieco, Boggia, & Camarda, 2012). It is also called as a home based station which also known as home evolved Node B (HeNB) in 3GPP LTE. Femtocell
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