Phase Synchronization Impact on Throughput Performance in LTE Network

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ABSTRACT

This paper presents a study of phase synchronization impact on throughput in Long Term Evolution (LTE) network with different transport protocols. Phase synchronization is needed for advanced features in LTE and other precise technologies with minimal clock error of Nano seconds. An End to End LTE testing environment is built by using real User Equipment (UE) and LTE core network for studying the throughput impact due to Phase Synchronization in different transport modes. This experimentation is carried out for comparing the throughput of the system with Frequency Synchronization Mode (FM) and Frequency & Phase synchronization Mode (FPM). A novel study has been conducted on throughput for TCP and UDP traffic in different LTE bandwidths, based on real traffic conditions. The study shows that system performance in Uplink (UL) and Downlink (DL) throughput has improved by using Frequency along with Phase synchronization in LTE network using GPS as a clock source.

KEYWORDS
Clock Error, Clock Source, Downlink (DL), Frequency and Phase Synchronization Mode (FPM), Frequency Synchronization Mode (FM), Uplink (UL)

1. INTRODUCTION

Frequency synchronization is achieved by deriving the clock source from GPS (Global Positioning System). GPS clock is the oscillator source for producing proper accurate frequency since \( t = 1/f \) (Wu, Chen, Zeng, & Min, 2007); correlating the oscillator output frequency with GPS clock source to eliminate the frequency error is called frequency synchronization and maintaining relative phase angle with source frequency called as phase synchronization (Hadjicic, Dzaferagic, and Raca, 2012). Once the frequency synchronizes with clock source, then phase synchronization can be carried out. Achieving +/- 50 parts per billion(ppb)as the clock drift between source (GPS) and oscillator is the ideal instance for frequency synchronization. Similar way attaining clock accuracy with +/- 1500 Nano seconds variance in time is ideal for phase synchronization (Morelli, 2014; Gour & Upadhyay, 2012). Phase synchronization is the process of correcting the clock of a system to match the master clock source with the accuracy of 1500 Nano seconds as clock drift in ideal conditions (“Network

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Phase synchronization (also known as relative-time synchronization) implies that all the network elements have access to the same clock signal, thereby resulting in rising edges occurring at the same times (Lorca, 2013). It provides the accurate clock precision which helps to achieve the performance gain in data transmission by minimizing retransmissions and adjacent channel interference (Zou et al., 2015).

This paper precisely aims at throughput measurements carried out at Application layer with TCP and UDP transport protocols. The paper is organized as follows. In section 2, we describe the system overview of the Phase Synchronization system. In section 3, we present the downlink link and uplink link throughput comparison with and without Phase synchronization. In section 4, we will focus on results, discussions and conclusions are drawn in section 5. LTE advanced features like eICIC (Bataaa, 2012), eMBMS (Pederson, Wang, Soret, & Frederiksen, 2012) etc. uses Phase synchronization. Phase synchronization is primarily required for LTE-TDD. LTE-FDD requires Phase synchronization mainly for advanced features. The accurate Phase synchronization will be the pre-requisite for all 5G advanced demanding services which needs phase accuracy of below 50 Nano seconds (Iovanna, Ruffini., Forsman., & Thyni, 2016).

2. SYSTEM ARCHITECTURE

2.1. LTE System Overview

The standard LTE Architecture shows the components and standard interfaces to connect different Network elements (NE’s) in the network. Figure 1 shows the End-to-End system architecture of the LTE network.

2.2. Phase Synchronization Overview

Phase synchronization implies that all associated nodes have access to a reference timing signal whose rising edges occur at the same instant. It is primarily required in the case of TDD systems because uplink and downlink transmission use the same frequency bands but different time slots. In order to avoid interference between adjacent cells, the base stations need to be phase aligned.

Figure 1. System architecture of LTE system
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