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LTE-Advanced DRX Mechanism for Power Saving

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Preface

Today, our everyday life is almost impossible to detach from the influence of wireless mobile communication technologies. This global trend is growing exponentially, and the mobile-only data traffic is expected to exceed stationary data traffic. However, for further development of mobile communication, there is a major obstacle to overcome, which is the resource-paucity of portable devices relative to stationary hardware. This is mainly because of the restricted computing power due to the small battery capacity of the mobile devices. To overcome this, the long-term evolution (LTE) system by the Third-Generation Partnership Project (3GPP) adopted the discontinuous reception (DRX) mechanism as a device energy conservation strategy.

The aim of this book is to introduce the basics of the DRX mechanism and strategies to optimize the DRX parameters for those who wish to study LTE power-saving techniques. Some of the key features of this book include (1) a detailed description of the DRX mechanism for easy understanding, (2) an introduction to analytical semi-Markov modeling and (3) a presentation of the empirical measurement of LTE network performance. The authors hope that this book will serve as a textbook for introductory level students in the field of wireless telecommunications and related areas. Especially, the book is targeted for those who wish to deepen their knowledge of the analytical modeling approach for optimal network performance.

This book would not have been possible without the hard work of the students at the Mobile Telecommunications group of the Communications and Transport Division at the department of Science and Technology (ITN) in Linköping University, Campus Norrköping, Sweden. The authors would like to especially thank the following people for their persistent research effort: Ranjeet S. Bhamber, Ahmed Omar Shahidullah, Mohammed Osman, Jalal Sarfraz, Muhammad Muddassir Abbas, Abdussalam Shahid and last, but not least, Muhammad Sajid Mushtaq.

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Introduction

The basic wireless mobile communication is, simply put, transfer of voice from one point to another without the use of wires. This simple wireless communication using analog radio frequency between the handsets and radio towers is called first-generation (1G) mobile communication. The second-generation (2G) mobile technologies increased system capacity by means of digital frequency between the handsets and towers, and enabled digitally encrypted phone conversations, greater mobile phone penetration, and data transfer (i.e. SMS text message). Technological advancement in improving data rate and bandwidth for mobile communication resulted in third-generation (3G) mobile technologies with an information transfer rate of at least 200 kbit/s. 3G empowers wireless communication with voice, Internet access, video calls and TV. The emergence of wireless mobile technology has come a long way, and now the time has come for the fourth-generation (4G) mobile technologies.

The requirements for 4G standards, called International Mobile Telecommunications Advanced (IMT-Advanced), were specified by the International Telecommunications Union-Radiocommunications sector (ITU-R) in 2008. The peak speed requirements at 100 Mbit/s for high mobility (e.g. trains and cars) and 1 Gbit/s for low mobility (e.g. walking and stationary users) were set by the specification since the emergence of new applications requires access to multimedia services with a high data rate such as games, voice, music and video in cellular networks. To fulfill the requirements of wireless data transmission, development of a novel transmission system was expected. The ITU-R invited the submission of candidate technologies that encompass the requirements, and based on that, long-term evolution (LTE) and worldwide interoperability for microwave access (WiMAX) have been developed to become 4G mobile technologies. While WiMAX is specified as IEEE 802.16 standard that requires a completely new network setup to comply with existing mobile networks, for example global system for mobile communication (GSM) and universal mobile telecommunications System (UMTS), LTE is the natural upgrade path for both carriers with GSM/UMTS networks and for Code Division Multiple Access (CDMA) holdouts as specified by the Third-Generation Partnership Project (3GPP).

3GPP is a united faction of telecommunication associations whose aim is to standardize radio, core network and service architecture of mobile communication to meet the specification defined by ITU-R. 3GPP's standards contain hundreds of technical documents that are compiled into "Releases". Releases from 96 to 99 were made up of technical specifications of 2G technologies known as GSM. Afterwards, Releases from 4 to 7 were composed of 3G technologies such as UMTS and high-speed downlink packet access (HSDPA). Release 8 and later releases shifted their focus from 3G to 4G.

According to the Release 8, the key features of LTE is to achieve 100 Mbps downlink peak data rate and 50 Mbps in uplink with a 20 MHz bandwidth, and support mobility up to 350 km/h. LTE is a completely packet-based system, and because it can coexist with previous technologies unlike its counterpart WiMAX, reduced complexity and cost can be achieved. Afterwards, in Release 9, the work to define true 4G candidate technologies began as the study phase of LTE-Advanced.

The advantage of having high data rates and high bandwidth is that new services such as voice, video and multimedia (e.g. Voice over Internet Protocol (VoIP) and video streaming) can be injected into the network. The drawback is that having these new services massively demands physical resources as well as the user equipment's power. To overcome these new challenges which have arisen along with the emergence of 4G LTE, development of new technologies became an immediate need.

A mechanism allocating physical resources among users is called a scheduler. Based on the scheduling decision, Quality-of-Service (QoS) parameters such as throughput, delay and packet loss rate can be altered. While real-time traffic (RT) has strict requirements in packet delay and jitter, non-real-time traffic (NRT) is not delay-sensitive. Therefore, requirements for QoS should be different between RT and NRT. Since LTE is intended to handle both RT and NRT, scheduler is a vital element of LTE system.

In addition to resource allocation for QoS provisioning, power saving on the end user devices has become a challenge because these services require more power than normal operations. One mechanism that can be used to prolong user equipment battery life is end devices turning off when there is no need for communication and turning on again when there is a need for communication. This technique for power saving in LTE is known as discontinuous reception (DRX), which was mentioned in 3GPP Release 7 but proper implementation specifications were provided in 3GPP Release 8. DRX is considered as a key feature of the LTE system.

Purpose: efficient power usage is essential for improving network efficiency, and it is especially prominent at the end user devices where power resources are limited. Therefore, the purpose of this book is to analyze the foregoing power-saving techniques and introduce examples of improved power-saving mechanisms. The emphasis will be put on mathematical analysis of various power-saving algorithms. In addition to the modeling approaches, empirical data