CELL OUTAGE COMPENSATION ALGORITHM FOR FREQUENCY REUSE ONE AND ICIC LTE NETWORKS

By

Mai Osama Ahmed Aboelfadl Said

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Electronics and Communications Engineering

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Title of Thesis: **Cell Outage Compensation Algorithm for Frequency Reuse One and ICIC LTE Networks**

Key Words: LTE; cell outage compensation; inter-cell interference coordination; load balancing; Self-Organizing Network

Summary: We propose an outage compensation algorithm based on reconfiguring the surrounding cells to recover the users in the coverage hole, and provide an adequate capacity for the victim users. We propose the base station total transmission power and the mobility parameters as control parameters to achieve our compensation objective. Our algorithm targets maximizing the capacity of the victim MUEs; reducing the degradation in the compensating cells and the aggregate network capacity and maintaining the coverage of network cells during the compensation process on the downlink for homogenous LTE networks under a full load scenario The algorithm works in both frequency reuse one (FRone), and soft frequency reuse (SFR) networks. The SFR configuration has another degree of freedom that can be used to enhance the compensation performance.

Simulation results show the effectiveness of the algorithm to rescue the victim users with minimal impact on the network performance.

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To my grandmothers

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List of Abbreviations

3GPP	3rd Generation Partnership Project
AMBR	APN Aggregated Maximum Bit Rate
ANR	Automatic Neighbor Relation
ACP	Automatic Cell Planning
ARQ	Automatic Repeat Request
COD	Cell Outage Detection
COC	Cell Outage Compensation
CRE	Cell Range Expansion
CQI	Channel Quality Indicator
CCU	Cell Center Users
CEU	Cell Edge Users
CP	Cyclic Prefix
CAPEX	Capital Expenditure
CCO	Coverage and Capacity Optimization
C-RS	Cell Specific Reference Signal
CGI	Cell Global Identifier
DL	Downlink
DM-RS	Demodulation Reference Symbols
eNodeB	Evolved NodeB
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
EPC	Evolved Packet Core
EPS	Evolved Packet System
E-RAB	E-UTRAN Radio Access Bearer
ECGI	E-UTRAN Cell Global Identifier
eICIC	Enhanced Inter-Cell Interference Coordination
ES	Energy Saving
FFR	Fractional Frequency Reuse
FRone	Frequency Reuse-one
FDD	Frequency Division Duplex

FFT	Fast Fourier Transform
GBR	Guaranteed Bit Rate
GERAN	GSM/EDGE Radio Access Network
HFR	Hard Frequency Reuse
HII	High Interference Indicator
HSS	Home Subscriber Server
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
ICI	Inter-Carrier Interference
ISI	Inter-Symbol Inference
ICIC	Inter-Cell Interference Coordination
IP	Internet Protocol
IoT	Interference-over-Thermal
KPI	Key Performance Indicator
LTE	Long Term Evolution
MUE	Mobile User Equipment
MCS	Modulation and Coding Scheme
MLB	Mobility Load Balancing
MBR	Maximum Bit Rate
MME	Mobility Management Entity
MIMO	Multiple-Input Multiple-Output
MU-MIMO	Multi-User MIMO
MAC	Media Access Control
MRO	Mobility Robustness/Handover optimization
NMS	Network Management System
OPEX	Operational Expenditure
OFDMA	Orthogonal Frequency Division Multiple Access
OAM	Operation Administration and Maintenance system
OI	Overload Indicator

PCI	Automatic Physical Cell ID
PCH	Paging channel
PDN	Packet Data Network
P-GW	PDN Gateway
PDCCH	Physical Downlink Common Channel
PMI	Pre-coding Matrix Information
PAPR	Peak-to- Average Power Ratio
PDSCH	Physical Downlink Shared Channel
PCI	Physical Cell Identifier
PSS	Primary Synchronization Signal
QoS	Quality Of Service
QCI	QoS Class Identifier
RS	Reference Signal
RLF	Radio Link Failure
RNTP	Relative Narrowband Transmit Power
RB	Resource Block
RE	Resource Element
RACH	Random Access Channel
RI	Rank Indicator
RAT	Radio Access Technologies
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
RSSI	Received Signal Strength Indicator
RRM	Radio Resource Management
RRC	Radio Resource Control
RAN	Radio Access Network
SAE	System Architecture Evolution
SC-FDMA	Single Carrier Frequency Division Multiple Access
S-GW	Serving Gateway

SON	Self-Organizing-Networks
SFR	Soft Frequency Reuse
SINR	Signal to Interference and Noise Ratio
SRS	Sounding Reference Symbols
SIB	System Information Blocks
SISO	Single-Input Single-Output
SDF	Service Data Flows
SSS	Secondary Synchronization Signal
TCP	Transmission Control Protocol
TFT	Traffic Flow Template
TP	Troubleshooting process
TDD	Time Division Duplex
TTI	Transmission Time Interval
UTRAN	Universal Terrestrial Radio Access Network
USIM	Universal Subscriber Identity Module
UL	Uplink
WCDMA	Wideband Code Division Multiple Access

Abstract

Long Term Evolution (LTE) is the latest mobile network standard in the 3rd Generation Partnership Project (3GPP) evolution path, promising to considerably increase the performance of mobile networks. Network operators are investing in the network infrastructure to maximize the revenue .This goal can be achieved by optimizing the network performance and reducing the Operational Expenditure (OPEX).

LTE offers higher spectral efficiency, simpler network architecture and lower operational expenditure compared to 3G system. In addition , LTE attempts to increase revenue and minimize OPEX by using the Self-Organizing-Networks (SON) concept which relies on optimizing the mobile network and automating the network management. This thesis tackles one of the SON concept in the LTE that helps in automatic healing of network faults. SON functions are divided into three main functionalities of self-configuration; self-optimization such as Inter-Cell Interference Coordination (ICIC) and Mobility Load balancing (MLB) and self-healing such as Cell Outage Compensation (COC).

The COC is a self-healing functionality in the overall SON vision, which is defined by 3GPP. Operation Administration and Maintenance system (OAM) triggers the COC for compensating the outage cell, e.g. out-of-service cell. The COC aims to alleviate the degraded performance due to the sudden loss of service and provides an adequate level of service to the victim users in the outage area. The previous studies are focused on healing the coverage hole rather than the capacity. Also, they did not study the whole network performance in terms of coverage and capacity.

We propose an outage compensation algorithm based on reconfiguring the surrounding cells to recover the users in the coverage hole, and provide an adequate capacity for the victim users. We propose the base station total transmission power and the mobility parameters as control parameters to achieve our compensation objective. Our algorithm targets maximizing the capacity of the victim MUEs; reducing the degradation in the compensating cells and the aggregate network capacity and maintaining the coverage of network cells during the compensation process on the downlink for homogenous LTE networks under a full load scenario. The algorithm works in both frequency reuse one (FRone), and soft frequency reuse (SFR) networks. The SFR configuration has another degree of freedom that can be used to enhance the compensation performance.

The proposed algorithm is based on modifying the base stations' powers until reaching the maximum possible network capacity while maintaining proper network coverage by monitoring the interference over Physical Data Shared Channel (PDSCH) between cells. Moreover, we propose adjusting cell-specific handover parameters to provide more resources for victim users, which was not studied before as a COC parameter. We propose a reconfiguration of the sub-bands for SFR networks to help in the recovery process of the victim users. The COC algorithm was not studied before for ICIC network.

The research, which was carried out using system level simulations, consists of investigating the effects of a typical outage and the effectiveness of our compensation algorithm. Simulation results show the effectiveness of the algorithm to rescue the victim users with minimal impact on the network performance in the downlink direction of homogeneous LTE FRone and SFR systems under full load scenario. The proposed algorithm is simple and effective as well as it can be applied for other mobile wireless networks such as 3G networks.