AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electronics and Communication Engineering Department

Signal Processing Techniques for Coordinated Multipoint (CoMP)

A thesis submitted in partial fulfillment of the requirements of
a Master of Science in Electrical Engineering
Electronics and Communication Engineering Department

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Thesis Title: Signal Processing Techniques for Coordinated Multipoint (CoMP).

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Degree: Master of Science in Electronics and Communication Engineering.

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Statement

This thesis is submitted as a partial fulfillment of Master of Science in Electrical Engineering, Faculty of Engineering, Ain Shams University. The author carried out this work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Abstract

Coordinated multipoint (CoMP) is a multiple-input-multiple-output (MIMO) technique used in the fourth generation (4G) cellular networks in order to enhance edge user services. Coordination among different base stations (network nodes) is done through exchange of information among base stations over the backhaul of the network. In this dissertation, we model CoMP as an adaptive diffusion network, with the base stations as the network nodes. In adaptive diffusion networks, one of the main challenges is the large volume of data exchange among nodes needed to arrive at a collective decision. We first introduce an overview of the adaptation and learning process over a network through non-cooperative, centralized, and distributed manners. A comparison of the steady-state mean square deviation (MSD) performance for all strategies is provided. Two new algorithms for adaptive diffusion networks are proposed which offer a tradeoff between the mean-square error performance of the system and the volume of data exchanged among network nodes while preserving the network convergence rate. A study of the mean-square-stability of the network under the proposed algorithms is provided. Also, a study of the mean-error dynamic behavior of the network is carried out. A closed-form expression for the overall network steady-state mean-square-error is derived and verified against simulated data. The proposed algorithms is finally applied to a cellular network location estimation problem, and delivers good performance even under 75% reduction in data exchange volume.

Thesis Summary

The thesis structure consists of six chapters and organized as follows.

Chapter 1

Chapter 1 provides motivation and insights from the thesis topics. In addition, the contributions of the thesis and thesis organization are provided.

Chapter 2

Chapter 2 discusses adaptation and learning over non-cooperative, centralized, and diffusion modes of operations. In addition, the steady-state mean square deviation (MSD) performance for all modes is provided.

Chapter 3

In Chapter 3, two distributed algorithms based on diffusion strategy are proposed. The proposed algorithms provide a tradeoff between the mean-square-error (MSE) performance and data exchange volume over the network while preserving the convergence of the mean network error. Also, the simulated MSD evolution for the proposed algorithms were conducted.

Chapter 4

Chapter 4 provides a mean-square-error (MSE) analysis of the proposed algorithms. In addition, the convergence analysis of the mean-error of the network is carried out. Also, the steady-state mean-square error (MSE) of the network under the proposed algorithms is derived and verified against simulated data. Finally, the computational complexity of the proposed algorithms are compared to the traditional adapt-then-combine (ATC) diffusion algorithm.

Chapter 5

In chapter 5, the proposed algorithms are applied to a distributed point target estimation problem as a case study, where multiple base stations exchange information and act as coordinated multipoint (CoMP) system.

Chapter 6

In chapter 6, the thesis is concluded and suggested future directions are provided.

Keywords: CoMP, distributed optimization, adaptive networks, diffusion adaptation, synchronous behavior, asynchronous behavior, target localization.

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Thanks, must go to Allah creator of universe who ordered us to study and explore his creations to know Allah better. However, as I come to understand more, I find that there is so much more knowledge to absorb and to get to grips with. The author takes this opportunity to gratefully his supervisors, Prof. Dr. Salwa El-Ramly, Dr. Mirette Sadek, and Dr. Mona Zakaria for their guidance, constant supervision, and constructive suggestions on the matter of this research.

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Table of Contents

Abstract ..... **V**

Thesis Summary ..... **VI**

Acknowledgment ..... **VIII**

Table of Contents ..... **IX**

List of Figures ..... **XI**

List of Tables ..... **XIII**

List of Abbreviations ..... **XIV**

List of Symbols ..... **XVI**

1 Introduction **1**

1.1 Insights from CoMP through Distributed Adaptive Network 1

1.2 Contributions 6

1.3 Organization 7

2 Adaptation and Learning Processing **9**

2.1 Introduction 9

2.2 Non-Cooperative Processing 10

2.3 Centralized Processing 12

2.4 Distributed Diffusion Process 16

2.4.1 Eigen-Properties of the Combination Matrix A 25

2.4.2 The MSD Performance of the Distributed Diffusion Techniques 26

2.4.3 Optimal MSD performance 27

2.5 Summary 29

3 Proposed Algorithms **30**

3.1 Introduction 30

3.2 Proposed Limited-Exchange Algorithm 30

3.3 Proposed Nodes Selection Algorithm 39

3.4 Conclusion 46

4 Performance Analysis **47**

4.1 Introduction 47

4.2 Mean-Square-Stability 48

4.3 Convergence of the Mean Network Error 52

4.4 Steady-State-Error-Performance 57

4.5 Computational Complexity and Communication Cost 62

4.6 Conclusion 65

5 CoMP Localization - A Case Study **66**

5.1 Introduction 66

5.2 Inter-Cell-Interference (ICI) 67

5.3 Coordinated Multipoint (CoMP) Architecture 69

5.4 Coordinated Multipoint (CoMP) Techniques 71

5.5 Positioning in wireless networks 72

5.6 Distributed Point Target Estimation 74

5.7 Simulation Results 78

5.8 Conclusion 85

6 Conclusions and Futures Work **86**

6.1 Conclusions 86

6.2 Future Work 87

References **90**

List of Figures

Figure 1.1: Convex weight a_{lk}, scales the incoming data in node k……..5

Figure2.1: Central processor receives and analyze streaming data, $\{\underline{\boldsymbol{d}}_K(i), \underline{\boldsymbol{u}}_{k,i}, i \geq 0\}$ from N nodes……..……..13

Figure 2.2: MSD level comparison for the centralized stochastic-gradient and the non-cooperative solutions (2.5) operating on real-data. (All vertical axis points are scaled by $\mu M, N = 3$ nodes).……...15

Figure 2.3: Network topology showing the neighborhood of node k ($\mathcal{N}_k = \{6, l, k, 8\}$). ..…….....…….....17

Figure 2.4: A high-level block diagram of the ATC diffusion update (2.13) at node k with neighbors $\mathcal{N}_k$……...……..20

Figure 2.5: A high-level block diagram of the CTA diffusion update (2.14) at node k, with neighbors $\mathcal{N}_k$…….....21

Figure 3.1: A high-level block diagram of the proposed limited-exchange update (3.3) at node k, with neighbors $\mathcal{N}_{k,i}$……....…….33

Figure 3.2: Network MSD learning curve over 100 experiments for skipping factors [1 2 3 4]……38

Figure 3.3: The main network topology of all nodes…….. 41

Figure 3.4: The network topology for case I……... 42

Figure 3.5: Network MSD learning curve over 100 experiments for skipping factors [1 2 3 4] for case I…….. 43

Figure 3.6: The network topology for case II……. 44

Figure 3.7: Network MSD learning curve over 100 experiments for skipping factors [1, 2, 3, 4] for case II……. 45

Figure 4.1: Network MSD learning curve over 100 experiments for

skipping factors [1 2 3 4]…….....62
Figure 5.1: Structure of inter cell interference (ICI) between two neighbor cells…….....68
Figure 5.2: Centralized control coordination……...70
Figure 5.3: Distributed coordination architecture…….……..70
Figure 5.4: Illustration of distance and direction from node k towards the actual target location $\boldsymbol{w}^o$ in two-dimensional space, $\mathbb{R}^2$.....77
Figure 5.5: Noise and data power profile across all nodes for the topology depicted in Fig. 5.7)…… …….....79
Figure 5.6: Statistical profile (top) and signal-to-noise ratio levels (bottom), across all nodes for the topologies depicted in Fig. 5.8, Fig. 5.9, respectively……..81
Figure 5.7: Network topology including the exact target position, (black node) and the estimated target positions for skipping factors [1 2 3 4]. Colored nodes have the same color key of learning curves in Fig. 3.2).....82
Figure 5.8: Network topology including the exact target position, (black node) and the estimated target positions for skipping factors [1 2 3 4]. Colored nodes have the same color key of learning curves in Fig. 3.5)…….....83
Figure 5.9: Network topology including the exact target position, (black node) and the estimated target positions for skipping factors [1 2 3 4].Colored nodes have the same color key of learning curves in Fig. 3.7)……...84

List of Tables

Table 2.1: Classical rules for selecting the coefficient matrix $\boldsymbol{A} = [a_{lk}]$…….. 23

Table 2.2: Optimized rules for selecting the coefficient matrix $\boldsymbol{A} = [a_{lk}]$…….. 25

Table 4.1: Performance comparison between our proposed algorithms (3.3), and (3.4) and the traditional ATC algorithm (2.13)…. 64

Table 5.1: Comparison of Position errors for the proposed algorithms, (3.2), and (3.3) relative to reduction data volume……..84

List of Abbreviations

3GPP **T**hird **G**eneration **P**artnership **P**roject

4G **F**ourth **G**eneration of Mobile Systems

ATC **A**dapt-**T**hen-**C**ombine

AOA **A**ngle **O**F **A**rrival

AMPOA **Amp**litude **O**F **A**rrival

BDLMS **B**lock **D**iffusion **L**east-**M**ean-**S**quare

CoMP **C**oordinated **M**ultipoint

CTA **C**ombine-**T**hen-**A**dapt

CSI **C**hannel **S**tate **I**nformation

CS/CB **C**oordinated **S**cheduling or **B**eamforming

eNBs **e**volved **N**ode **B**ase stations

eICIC **e**nhanced **I**nter-**C**ell **I**nterference **C**oordination

GPS **G**lobal **P**ositioning **S**ystem

ICI **I**nter-**C**ell-**I**nterference

ICIC **I**nter-**C**ell **I**nterference **C**oordination

JP **J**oint **P**rocessing

LTE **L**ong **T**erm **E**volution

LTE-A **L**ong Term **E**volution-**A**dvanced

LMS **L**east-**M**ean-**S**quares

MIMO **M**ultiple-**I**nput-**M**ultiple-**O**utput

MSE **M**ean-**S**quare-**E**rror

MSD **M**ean-**S**quare-**D**eviation

PDLMS **P**artial **D**iffusion **L**east-**M**ean-**S**quare

QoS **Q**uality **o**f **S**ervice