

# Contents

Abstract	page
Acknowledgments	v
Contents	vii
List of Figures	ix
List of Tables	xi
List of Symbols	xiii
List of Abbreviations	xv
<b>List of Symbols</b>	xv
<b>List of Abbreviations</b>	xvii
<b>Chapter 1: Introduction</b>	1
1.1 Resources and Dimensions for Wireless Access	3
1.2 Massive MIMO System: A New Hope	6
1.2.1 Massive MIMO System: Architecture	7
1.3 Summary of the Thesis	9
1.4 Objective and Organization of Thesis	10
<b>Chapter 2: System Model and Review of Literature</b>	11
2.1 Origin and Preliminary Research	11
2.2 Massive MIMO System Model	13
2.3 Channel Models	15
2.3.1 Correlation-Based Stochastic Channel Models	15
2.3.2 Geometry-Based Stochastic Channel Models	16
2.3.3 Need for a New Channel Model	16
2.4 Channel Estimation	17
2.4.1 Pilot-Based Methods and Associated Issues	18
2.4.2 Blind Methods and Associated Issues	18
2.5 Sum-Rate and Average Power-allocation	19
<b>Chapter 3: Channel Modeling for Massive MIMO Systems</b>	21
3.1 System Model	21
3.1.1 Underlying Propagation Phenomena	22
3.1.2 Simulation of Temporal or Spectral Variations	24
3.1.3 Simulation of Spatial Variations	24
3.1.4 Effect of Clusters	25
3.2 Insights on Simulated Channel	26
3.2.1 Histogram of Channel Coefficients	26
3.2.2 Histogram of Cross-correlation in MTs	27
3.3 Validation of Channel Model	28
3.3.1 User-Correlation	28
3.3.2 Distribution of Eigenvalues	29
3.3.3 Distribution of Power Over Antenna Array	30
<b>Chapter 4: Channel Estimation and Tracking in Massive MIMO Systems</b>	33
4.1 System Model	34
4.2 Channel Estimation Method	36
4.2.1 Communication Strategy and Settings	36
4.2.2 Channel Estimation Algorithm	36
4.2.3 Theory Behind the Algorithm	38
4.2.4 Estimation error analysis	41
4.2.5 Improvement in Spectral Efficiency	42
4.3 Complexity Analysis	43
4.4 Simulation Results and Discussion	45
4.4.1 SEP Verses Iteration Count	45
4.4.2 Impact of the Number of MTs	47
4.4.3 Impact of the Mobility	48

<b>Chapter 5: Power-allocation and Sum-rate in Massive MIMO Systems</b>	51
5.1 System Model	52
5.1.1 Sum-Rate with Perfect CSIR	55
5.1.2 Impact of the Assumptions of System Modeling	59
5.1.3 Sum-Rate with Imperfect CSIR	59
5.2 Power-allocation Optimization for K-users	60
5.3 Low Complexity Algorithm for Power-allocation Optimization	62
5.4 Results	63
5.4.1 Numerical Analysis of Sum-Rate for the K-Users Case	63
5.4.2 Performance Results of Algorithm	66
5.4.3 Complexity Analysis of Algorithm	68
<b>Chapter 6: Conclusion and Future Scope</b>	71
6.1 Channel Modeling	71
6.2 Channel Estimation and Tracking	71
6.3 Power-allocation and Sum-rate	72
A.1 Proof of the theorem 4.2.1	75
A.2 Complexity calculation for proposed channel estimation method and EVD based method	75
A.2.1 Complexity Calculation for equation 4.29	75
A.2.2 Complexity Calculation for equation 4.30	76
A.2.3 Complexity Calculation for EVD-based Channel estimation	76
B.1 Proof of lemma 5.1.1	77
B.2 Proof of lemma 5.1.2	77
B.3 Path loss model used in average power allocation scheme for massive MIMO	77
<b>References</b>	79