

Contents

Certificate	ii
Dedication	iii
Acknowledgments	iv
Abstract	vi
List of Figures	xiii
List of Tables	xvii
List of Acronyms/Abbreviations	xviii
1 Introduction and Literature Review	1
1.1 Background	1
1.2 Device-to-Device Communication	2
1.3 Cooperative D2D Communication	3
1.3.1 Motivation	4
1.3.2 Relaying Policies	4
1.3.3 Literature Study on Relaying Policies	5
1.3.4 Relay Selection Policies	6
1.3.5 Literature Study on Relay Selection Policies	7
1.4 Green Cooperative D2D Communication	9
1.4.1 Simultaneous Wireless Information and Power Transfer	9
1.4.2 Literature Study on Relay Selection for EH Relay Assisted Co-operative System	10
1.5 Spectrum Sharing System	12
1.5.1 Literature Study on Relay Selection and Relaying Policy in C-SSS	13
1.6 Thesis Contributions	14
1.6.1 Probabilistic Relay Selection Policy	14
1.6.2 Power-adaptive Decode-and-Forward Relaying Policy	16
1.6.3 Outage-Constrained EH based Relay Selection Policy	17

1.6.4	Interference-Constrained PA-DAF Relaying Policy	18
1.7	Thesis Organization	20
1.8	Notations	21
2	Probabilistic Relay Selection Policy	22
2.1	System Model and Transmission Protocol	22
2.1.1	Transmission Protocol for System Model	23
2.2	Selection Policy and FASER Analysis	24
2.2.1	Relay Selection Policy: Small Scale Fading with Path Loss . .	25
2.2.2	Relay Selection Policy: Large Scale Fading with Path Loss . .	26
2.2.3	Relay Selection Policy: Small Scale Plus Large Scale Fading with Path Loss	27
2.2.4	FASER Analysis	27
2.2.5	FASE Analysis	29
2.2.6	Remarks on Energy Efficiency	30
2.3	Diversity Order Analysis	30
2.4	Results, and Discussion	31
2.5	Summary	35
3	Power-Adaptive Decode-and-Forward Relaying Policy	36
3.1	System Model and Transmission Protocol	36
3.1.1	Comments on the Usefulness of the Model	38
3.1.2	Transmission Protocol for System Model	38
3.1.3	Remarks on PA-DAF Relay Complexity	39
3.1.4	Remarks on CSI Requirement	40
3.1.5	Remarks on PRSP Design and Analysis	40
3.2	Fading Averaged Performance Measures, Optimization, and Analysis	42
3.2.1	FASER Minimization Problem and Analysis for MPSK	42
3.2.2	Diversity order analysis in a scaling regime:	45
3.2.3	FASER Analysis of MQAM	46
3.2.4	Fading Averaged Spectral Efficiency Analysis	48
3.2.5	Fading Averaged Energy Efficiency Analysis	50
3.2.6	Computational Time, Complexity and Efficiency	53
3.3	Simulation Results and Discussion	54
3.3.1	Simulation Methodology	54
3.3.2	Numerical Results on Performance Measures	56
3.4	Summary	61

4 Outage-Constrained Energy Harvesting Based Relay Selection	63
4.1 Green Cooperative D2D System Model	63
4.1.1 Time-Switching Based Transmission Protocol	65
4.1.2 EH Relay Node Tasks: Harvesting and Transmission	66
4.1.3 EH based Relay Selection and Remarks	67
4.1.4 Remarks on CSI	68
4.2 Order Statistics of Green Cooperative D2D Model	70
4.2.1 Large Scale Plus Small Scale Fading Model	70
4.3 Outage-Constrained Relay Transmission	72
4.4 Link Outage Analysis	73
4.4.1 Asymptotic Link Outage Analysis	75
4.5 Average Spectral Efficiency Analysis	75
4.5.1 Upper Bound for Exact FASE	77
4.5.2 Asymptotic FASE Analysis	77
4.6 Average Energy Efficiency Analysis	78
4.6.1 Closed-form Upper Bound for FAEE	79
4.6.2 Asymptotic FAEE Analysis	79
4.7 Numerical Results and Interpretation	80
4.7.1 Simulation Methodology and Parameters	80
4.7.2 Impact of Mean Channel Gain on $\overline{\mathcal{EH}}_{\max}$	82
4.7.3 Evaluation of Link Outage Probability	82
4.7.4 Numerical Results on FASE with Benchmarking	84
4.7.5 Numerical Results on FAEE with Benchmarking	88
4.8 Summary	91
5 Interference-Constrained Power-Adaptive Decode-and-Forward Relaying Policy	92
5.1 Non-EH Relay-Assisted C-SSS Model	92
5.1.1 Comparison of Different SSS modes	94
5.1.2 Non-EH Relay-Assisted C-SSS Transmission Protocol	95
5.1.3 Remarks on Relay Selection	96
5.1.4 Remarks on CSI	96
5.2 Optimization and Analysis for N-EH Relay-Assisted C-SSS	97
5.2.1 Optimal FASE of IC-PA-DAF	97
5.2.2 Optimal FAEE of IC-PA-DAF	100
5.3 Numerical Results and Benchmarking for N-EH C-SSS Model	102
5.4 EH Relay-Assisted C-SSS Model	104

5.4.1	Transmission Protocol	106
5.4.2	Remarks on TSP	107
5.4.3	Remarks on CSI	107
5.4.4	Remarks on complexity aspects while employing multiple relays	108
5.4.5	Remarks on EHRS	109
5.5	Optimization and Analysis for EH C-SSS	110
5.5.1	Optimal Relaying Policy for FASE and Its Analysis	111
5.5.2	Optimal Relaying Policy for FAEE and Its Analysis	112
5.6	Numerical Results and Benchmarking for EH C-SSS	115
5.7	Summary	119
6	Conclusion and Future Work	121
6.1	Conclusion	121
6.2	Future Research Scope	122
7	List of Publications	124
APPENDICES		127
A Chapter 2: Derivations and Proofs		127
A.1	Proof of Claim 1: Relay Selection Policy: Small Scale Fading with Path Loss	127
A.2	Proof of Claim 2: Relay Selection Policy: Large Scale Fading with Path Loss	127
A.3	Proof of Claim 3: Relay Selection Policy: Small Scale Plus Large Scale Fading with Path Loss	128
A.4	Proof of Result 1: FASER and its Upper Bound for MPSK Scheme.	129
A.5	Proof of Result 2: FASER and its Upper Bound for MQAM Scheme.	130
A.6	Proof of Result 3: FASE Analysis	132
A.7	Proof of Result 4: Diversity Order Analysis	132
A.8	FASER in High SNR Regime for PRSP	133
A.9	FASER in High SNR Regime for ORSP	134
B Chapter 3: Derivations and Proofs		137
B.1	Proof of Result 5: FASER Optimal Relaying Policy for MPSK	137
B.2	Proof of Result 6: Exact FASER and its Upper Bound for MPSK	138
B.3	Proof for Optimality of FASER MPSK	139
B.4	Proof of Result 7: FASER Optimal Relaying Policy for MQAM	139
B.5	Proof of Result 8: Exact FASER and its Upper Bound (MQAM)	140

B.6 Proof of Result 9: FASE Optimal Relaying Policy	142
B.7 Proof of Result 10: Exact FASE Expression and its Upper Bound	143
B.8 Proof of Result 11: FAEE Optimal Relaying Policy	144
B.9 Proof of Result 12: Exact FAEE Expression and its Upper Bound	144
C Chapter 4: Derivations and Proofs	146
C.1 Proof of Lemma 4.2.1: Statistical Average \mathcal{EH}_{\max}	146
C.2 Proof of Lemma 4.4.1: Link Outage Analysis	147
C.3 Proof of Result 13: Exact FASE	148
C.4 Proof of Result 14: Closed-Form FASE Upper Bound	149
C.5 Proof of Result 15: Asymptotic FASE	150
C.6 Proof of Result 16: Exact FAEE	150
C.7 Proof of Result 17: Closed-Form FAEE Upper Bound	151
C.8 Proof of Result 18: Asymptotic FAEE Expression	151
D Chapter 5: Derivations and Proofs	153
D.1 Proof of Result 19: Optimal FASE Relaying Policy	153
D.2 Proof of Result 20: Exact Optimal FASE Expression	154
D.3 Proof of Result 21: Optimal FASE Upper Bound Expression	154
D.4 Proof of Result 22: Optimal FAEE Relaying Policy	155
D.5 Proof of Result 23: Exact Optimal FAEE Expression	156
D.6 Proof of Result 24: Optimal FAEE Upper Bound Expression	156
D.7 Proof of Result 25: Optimal Relay Gain Function for FASE	157
D.8 Proof of Result 26: Exact Expression for FASE	157
D.9 Proof of Result 27: Optimal Relay Gain Function for FAEE	159
D.10 Proof of Result 28: Exact Expression for FAEE	160
D.11 Proof of Result 29: Upper Bound Expression for FAEE	160
Bibliography	161
Brief Biography of Supervisor	176
Brief Biography of Candidate	177