

MOBILE NODES PATH DESIGN AND
DEPLOYMENT FOR DATA
COLLECTION IN WIRELESS SENSOR
NETWORKS

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ABSTRACT

Recent years have seen the deployments of wireless sensor networks (WSNs) in data-intensive applications. WSNs in these applications often produce high-bandwidth sensor data that need to be collected under stringent delay constraints. On the other hand, sensors in such applications must operate on limited power supplies like batteries for extended lifetime up to years. Therefore, a fundamental challenge for these WSNs is to support Time-sensitive data collection with minimum network energy consumption. Motivated by these factors, we introduce mobile nodes (MNs) for collecting high-bandwidth data which can greatly save the energy of sensor nodes since the energy consumption of mobile nodes is less constrained as they can replenish their energy supplies because of the mobility. The major work of this thesis can be summarized as follows.

First, we introduce mobile elements (MEs) to collect data to the base station (BS). A subset of nodes serve as the rendezvous points (RPs) that buffer data originated from sources and transfer to MEs when they arrive, which can achieve a desirable balance between network energy saving and data collection delay. We prove that the optimal schedule problem is NP-hard and develop two rendezvous planning algorithms: *RP-CP* and *RP-UG*. *RP-CP* finds the optimal RPs when MEs move along the data routing tree, while *RP-UG* greedily chooses the RPs with maximum energy saving to travel distance ratios. Our approach is validated through extensive simulations.

Second, some urgent data may need to be sent to the BS through a routing tree before the arriving of MEs, but the nodes on this tree may consume much more energy, which is a bottleneck for the whole network. Our solution is to make some

mobile nodes (MNs) to “cover” the routing paths for forwarding data originally transferred by sensors. We study two MN deployment problems that aim to maximize the MN coverage and to minimize the MN deployment cost, respectively. Both problems are proved to be NP-hard and we design optimal solution and approximation algorithm with provable bounds. The effectiveness of our algorithm is validated through both theoretical analysis and simulations.

Third, we investigate the issue of data collection when the base station itself is mobile. A rendezvous-based data collection approach is proposed and we jointly optimize data routing paths and the BS tour. Furthermore, data aggregation model is considered. We propose efficient rendezvous design algorithms with provable performance bounds for mobile base stations with both variable and fixed tracks, respectively. The effectiveness of our approach is validated through both theoretical analysis and extensive simulations.

Finally, when mobile base stations are used to collect data, they are required to inform sensor nodes about their new location information since the urgent data can be sent to BSs directly through routing methods. However, frequent location updates from mobile BSs may lead to both rapid energy consumption of sensor nodes and increased collisions in wireless transmissions. We propose a new solution with adaptive location updates for mobile BSs to resolve this problem. When a BS moves, it only needs to broadcast its location information within a local area other than among the entire network. In this way, lots of energy can be saved. Both theoretical analysis and simulation studies show that this solution consumes less energy.

TABLE OF CONTENTS

ABSTRACT	i
ACKNOWLEDGMENTS.....	iii
TABLE OF CONTENTS.....	iv
LIST OF FIGURES.....	viii
Chapter 1 Introduction	1
1.1 Background and Motivation.....	1
1.2 Related work	3
1.3 Research Contributions	6
1.4 Organization of the Thesis	7
Chapter 2 Rendezvous Planning in Wireless Sensor Networks with Mobile Elements.....	9
2.1 Introduction	9
2.2 Problem Formulation.....	10
2.2.1 A Numerical Example	11
2.2.2 Assumptions	12
2.2.3 The Minimum-Energy Rendezvous Planning Problem	12
2.3 Optimal Rendezvous Planning with Constrained ME Path	16
2.4 Rendezvous Planning with Unconstrained ME Path.....	20
2.5 Extensions	23
2.5.1 Frequency-Based Multi-deadline Rendezvous Planning	24
2.5.2 Schedule-Based Multi-deadline Rendezvous Planning.....	26
2.5.3 Rendezvous Planning with Multiple MEs.....	30
2.6 Rendezvous-based Data Collection Protocol	31
2.6.1 Initialization	32

2.6.2 Handling Unexpected Delays.....	32
2.7 Performance Evaluation	34
2.7.1 Simulation Methodology.....	34
2.7.2 Performance under Single Deadline.....	36
2.7.3 Performance under Multiple Deadlines.....	39
2.7.4 Impact of Speed Variance	42
2.8 Summary	44
Chapter 3 Mobile Nodes Deployment for Covering Routing Tree.....	45
3.1 Introduction	45
3.2 Coverage Model	45
3.3 MNs Deployment for Maximum Coverage	47
3.3.1 Problem Formulation.....	47
3.3.2 Optimal Algorithms.....	48
3.3.3 Approximation Algorithms	49
3.4 MNs Deployment with Minimum Cost.....	56
3.4.1 Problem Formulation.....	56
3.4.2 Optimal Algorithm	57
3.4.3 Approximation Algorithm.....	57
3.5 Performance Evaluation	60
3.6 Summary	62
Chapter 4 Rendezvous Design Algorithms for Wireless Sensor Networks with a Mobile Base Station	64
4.1 Introduction	64
4.2 Basic Approach and Assumptions.....	66
4.2.1 Problem Description.....	66
4.2.2 Network Model	66
4.2.3 Overview of the Approach	67

4.3 Rendezvous Design with a Variable BS Track	68
4.3.1 A SMT-based Approximation Algorithm	69
4.3.2 Performance Analysis	71
4.4 Rendezvous Design with a Fixed BS Track.....	75
4.4.1 An Approximation Algorithm.....	75
4.4.2 Performance Analysis	78
4.5 Performance Evaluation	82
4.5.1 The Performance of <i>RD-VT</i>	82
4.5.2 The Performance of <i>RD-FT</i>	86
4.6 Summary	87
Chapter 5 Adaptive Location Updates for Mobile BSs in Wireless Sensor Networks	89
5.1 Introduction	89
5.2 Protocol Design	89
5.2.1 Assumptions	89
5.2.2 <i>LURP</i> Protocol	90
5.2.3 Remark on the Size of the Destination Area	93
5.2.4 <i>ALURP</i> Protocol.....	94
5.3 Performance Analysis	97
5.3.1 Analysis Model	97
5.3.2 Cost of Updating the Location Information of the BS	98
5.4 Simulation Studies.....	100
5.4.1 Simulation Model.....	100
5.4.2 Simulation Results.....	101
5.5 Summary	106
Chapter 6 Conclusions	108
LIST OF REFERENCES	110
ABBREVIATIONS	121

PUBLICATIONS	123
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LIST OF FIGURES

Figure 2.1 ME-based data collection in a $500 \times 500 \text{ m}^2$ field.....	10
Figure 2.2 The actual routing tree, the geometric approximation tree and the ME tour	14
Figure 2.3 An example of <i>RP-CP</i> 's execution	17
Figure 2.4 <i>RP-CP</i> : an optimal rendezvous planning algorithm	18
Figure 2.5 Two line segments composed of the edges	19
Figure 2.6 <i>RP-UG</i> : a utility-based greedy rendezvous planning algorithm	21
Figure 2.7 An example of <i>RP-UG</i> 's execution.....	23
Figure 2.8 An example of the frequency-based rendezvous planning	25
Figure 2.9 <i>RP-Schedule</i>	27
Figure 2.10 The <i>EDF</i> algorithm finds the visit schedule of a given set of RPs and deadlines.....	29
Figure 2.11 An example of utilizing three MEs	31
Figure 2.12 Energy consumption versus speed of MEs	37
Figure 2.13 Energy consumption versus number of nodes	37
Figure 2.14 Energy consumption versus number of MEs.....	38
Figure 2.15 Total energy consumption versus number of deadlines when there is only one ME	39
Figure 2.16 Total energy consumption versus number of deadlines when there are two MEs	40
Figure 2.17 Total energy consumption versus number of deadlines when there are three MEs	41
Figure 2.18 Total energy consumption versus ME speed variance	42
Figure 2.19 Percentage of deadline misses (in percentages) versus variance of ME speed.....	43

Figure 3. 1 An example of the coverage model.....	46
Figure 3.2 $MC_Select(I, M)$ algorithm.....	49
Figure 3.3 An example of the $MC_Combine$	50
Figure 3.4 $MC_Combine$ algorithm	51
Figure 3.5 An example of the MC_Group algorithm	52
Figure 3.6 MC_Group algorithm.....	54
Figure 3.7 MDC_opt algorithm.....	57
Figure 3.8 $MDC_Select(I, Q)$ algorithm.....	58
Figure 3.9 MDC algorithm.....	58
Figure 3.10 Percentage achieved VS. number of MNs.	60
Figure 3.11 Comparison of computation time.....	61
Figure 3.12 Number of MNs VS.....	62
Figure 4.1 An example of BS-based data collection in a $500 \times 500 \text{ m}^2$ sensing field	65
Figure 4.2 The pseudo code of the $RD-VT$ algorithm	70
Figure 4.3 An example of the $RD-VT$ algorithm's execution.....	70
Figure 4.4 Illustration for proof of Theorem 4.2.....	71
Figure 4.5 The pseudo code of the $RD-FT$ algorithm	77
Figure 4.6 Illustration for proof of Lemma 4.1 and 4.2	79
Figure 4.7 Illustration for proof of Theorem 4.3.....	80
Figure 4.8 Total length of routing trees vs. L	83
Figure 4.9 Total length of routing trees vs. the number of sources.....	84
Figure 4.10 Performance ratio of $RD-FT$ vs. L	84
Figure 4.11 Two tracks used for performance evaluation	85
Figure 4.12 Performance of $RD-FT$ with BS track I.....	86
Figure 4.13 Performance of $RD-FT$ with BS track II.....	87
Figure 5.1 Two stages of the $LURP$ protocol	91

Figure 5.2 Switch between two destination areas	92
Figure 5.3 The new routing path after the BS switches from area <i>A</i> to area <i>B</i>	92
Figure 5.4 The pseudo code of the <i>LURP</i> protocol.....	93
Figure 5.5 An example of <i>ALURP</i> protocol	95
Figure 5.6 The problem occurs when the BS moves closer towards <i>VC</i>	96
Figure 5.7 The pseudo code of the <i>ALURP</i> protocol	97
Figure 5.8 The comparison of communication energy.....	101
Figure 5.9 Energy comparison of updating the location information of the mobile BS.....	102
Figure 5.10 The total energy comparison among <i>ALURP</i> , <i>LURP</i> and <i>FLUP</i>	103
Figure 5.11 Energy consumption over the velocity of the mobile BS	104
Figure 5.12 Energy consumption over the radius of the destination area	104
Figure 5.13 Energy consumption over the sojourn-hops	105