Volume 4, Issue 11, November 2014 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Low Cost Disposable Mobile Relays to Reduce the Total Energy Consumption of Data-Intensive WSN

Miss Bhagyashree Thakur, Prof.Monika Rajput
P. R. Pote (Patil) Education and Welfare Trust's,College of Engineering & Management,
Amravati, Maharashtra, India

Abstract: Wireless Sensor Networks (WSNs) are increasingly used in data-intensive applications such as microclimate monitoring, precision agriculture, and audio/video surveillance. A key challenge faced by data-intensive WSNs is to transmit all the data generated within an application's lifetime to the base station despite the fact that sensor nodes have limited power supplies. We propose using low-cost disposable mobile relays to reduce the energy consumption of data-intensive WSNs. Our approach differs from previous work in two main aspects. First, it does not require complex motion planning of mobile nodes, so it can be implemented on a number of low-cost mobile sensor platforms. Second, we integrate the energy consumption due to both mobility and wireless transmissions into a holistic optimization framework. Our framework consists of three main algorithms. The first algorithm computes an optimal routing tree assuming no nodes can move. The second algorithm improves the topology of the routing tree by greedily adding new nodes exploiting mobility of the newly added nodes. The third algorithm improves the routing tree by relocating its nodes without changing its topology. This iterative algorithm converges on the optimal position for each node given the constraint that the routing tree topology does not change. We present efficient distributed implementations for each algorithm that require only limited, localized synchronization. Because we do not necessarily compute an optimal topology, our final routing tree is not necessarily optimal. However, our simulation results show that our algorithms significantly outperform the best existing solutions

Index Terms—Wireless sensor networks, energy optimization, mobile nodes, wireless routing

I. INTRODUCTION

WSNs have been deployed in a variety of data intensive applications including micro-climate nd habitat monitoring [2], precision agriculture, and audio/video surveillance [3]. A moderate-size WSNcan gather up to 1 Gb/year from a biological habitat [4]. Due to the limited storage capacity of sensor nodes, most data must be transmitted to the base station for archiving and analysis. However, sensor nodes must operate on limited power supplies such as batteries or small solar panels. Therefore, a key challenge faced by data-intensive WSNs is to minimize the energy consumption of sensor nodes so that all thedata generated within the lifetime of the application can be transmitted to the base station.

Several different approaches have been proposed to significantly reduce the energy cost of WSNs by using the mobility of nodes. A robotic unit may move around the network and collect data from static nodes through one-hop or multi-hop transmissions [5], [6], [7], [8], [9]. The mobile node may serve as the base station or a "data mule" that transports data between static nodes and the base station [10], [11],[12]. Mobile nodes may also be used as relays [13] that forward data from source nodes to the base station. Several movement strategies for mobile relays have been studied in [13], [13].Although the effectiveness of mobility in energy conservation is demonstrated by previous studies,· Fatme El-Moukaddem, Eric Torng, and Guoliang Xing are with the Department of Computer Science, Michigan State University. the following key issues have not been collectively addressed. First, the movement cost of mobile nodesis not accounted for in the total network energy consumption. Instead, mobile nodes are often assumed to have replenish able energy supplies [7] which is not always feasible due to the constraints of the physical environment. Second, complex motion planning of mobile nodes is often assumed in existing solutions which introduces significant design complexity and manufacturing costs. In [8], [9], [15], [16], mobile nodes need to repeatedly compute optimal motion paths and change their location, their orientation and/or speed of movement. Such capabilities are usually not supported by existing low-cost mobile sensor platforms. For instance, Robomote [17] nodes are designed using 8-bit CPUs and small batteries that only last for about 25 minutes in full motion. In this paper, we use low-cost disposable mobile relays to reduce the total energy consumption of data intensive WSNs. Different from mobile base station or data mules, mobile relays do not transport data; instead, they move to different locations and then remain stationary to forward data along the paths from the sources to the base station. Thus, the communication delays can be significantly reduced compared with using mobile sinks or data mules. Moreover, each mobile node performs a single relocation unlike other approaches which require repeated relocations.

II. LITERATURE REVIEW

We review three different approaches, mobile base stations, data mules, and mobile relays that use mobility to reduce energy consumption in wireless sensor networks. A mobile base station moves around the network and collects data from

© 2014, IJARCSSE All Rights Reserved

the nodes. In some work, all nodes are always performing multiple hop transmissions to the base station, and the goal is to rotate which nodes are close to the base station in order to balance the transmission load [5], [6], [7]. Another work, nodes only transmit to the base station when it is close to them (or a neighbor). The goal is to compute a mobility path to collect data from visited nodes before those nodes suffer buffer overflows [8],[9], [15], [16]. In [9], [20], [21], several rendezvous based data collection algorithms are proposed, where the mobile base station only visits a selected setof nodes referred to as rendezvous points within deadline and the rendezvous points buffer the data from sources. These approaches incur high latencies due to the low to moderate speed, e.g. 0.1-1 m/s [15],[17], of mobile base stations. Data mules are similar to the second form of mobile base stations [10], [11], [12]. They pick up data from the sensors and transport it to the sink. In [22], the data mule visits all the sources to collect data, transports data over some distance, and then transmits it to the static base station through the network. The goal is to find a movement path that minimizes both communication and mobility energy consumption. Similar to mobile base stations, data mules introduce large delays since sensors have to wait for a mule to pass by before starting their transmission. In the third approach, the network consists of mobile relay nodes along with static base station and data sources. Relay nodes do not transport data; instead ,they move to different locations to decrease the transmission costs. We use the mobile relay approaching this work. Goldenberg et al. [14] showed that an iterative mobility algorithm where each relay node moves to the midpoint of its neighbours converge son the optimal solution for a single routing path. However, they do not account for the cost of moving the relay nodes. In [23], mobile nodes decide to move only when moving is beneficial, but the only position considered is the midpoint of neighbours.

III. RELATED WORK

In this paper, lot of work defined by earlier researchers is presented and discussed .We review three different approaches, mobile base stations, data mules, and mobile relays that use mobility to reduce energy consumption in wireless sensor networks. A mobile base station moves around the network and collects data from the nodes. In some work, all nodes are always performing multiple hop transmissions to the base station, and the goal is to rotate which nodes are close to the base station in order to balance the transmission load [5], [6], [7]. Another work, nodes only transmit to the base station when it is close to them (or a neighbor). The goal is to compute a mobility path to collect data from visited nodes before those nodes suffer buffer overflows [8],[9], [15], [16]. In [9], [20], [21], several rendezvous based data collection algorithms are proposed, where the mobile base station only visits a selected setoff nodes referred to as rendezvous points within a deadline and the rendezvous points buffer the data from sources. These approaches incur high latencies due to the low to moderate speed, e.g. 0.1-1 m/s [15],[17], of mobile base stations. Data mules are similar to the second form of mobile base stations [10], [11], [12]. They pick up data from the sensors and transport it to the sink. In [22], the data mule visits all the sources to collect data, transports data over some distance, and then transmit it to the static base station through the network. The goal is to find a movement path that minimizes both communication and mobility energy consumption. Similar to mobile base stations, data mules introduce large delays since sensors have to wait for a mule to pass by before starting their transmission. In the third approach, the network consists of mobile relay nodes along with static base station and data sources. Relay nodes do not transport data; instead, they move to different locations to decrease the transmission costs. We use the mobile relay approaching this work. Goldenberg et al. [14] showed that an iterative mobility algorithm where each relay node moves to the midpoint of its neighbours converge son the optimal solution for a single routing path. However, they do not account for the cost of moving the relay nodes. In [23], mobile nodes decide to move only when moving is beneficial, but the only position considered is the midpoint of neighbors.Unlike mobile base stations and data mules, ourOMRC problem considers the energy consumption of both mobility and transmission. Our approach also relocates each mobile relay only once immediately after deployment. Unlike previous mobile relay schemes[14] and [23], we consider all possible locations as possible target locations for a mobile node instead of just the midpoint of its neighbors.Mobility has been extensively studied in sensor network and robotics applications which consider only mobility costs but not communication costs. For example, in [24], the authors propose approximation algorithms to minimize maximum and total movement of the mobile nodes such that the network becomes connected. In [25], the authors propose an optimal algorithm to bridge the gap between two static nodes by moving nearby mobile nodes along the line connecting the static points while also minimizing the total/maximum distance moved. In [26], [27], the authors propose algorithms to find motion paths for robots to explore the area and perform a certain task while taking into consideration the energy available at each robot. These problems ignore communication costs which add an increased complexity to OMRC, and consequently their results are not applicable. Our OMRC problem is somewhat similar to a number of graph theory problems such as the Steiner tree problem [29], [29], [30] and the facility location problem [31], [32]. However, because the OMRC cost function is fundamentally different from the cost function for these other problems, existing solutions to these problems cannot be applied directly and do not provide good solutions to OMRC. For example, there is no obvious way to include mobility costs in the Steiner tree problem.

We review three different approaches, mobile base stations, data mules, and mobile relays, that use mobility to reduce energy consumption in wireless sensor networks. A mobile base station moves around the network and collects data from the nodes. In some work, all nodes are always performing multiple hoptransmissions to the base station, and the goal is to rotate which nodes are close to the base station in order to balance the transmission load [5], [6], [7]. Another work, nodes only transmit to the base station when it is close to them (or a neighbor). The goal isto compute a mobility path to collect data from visited nodes before those nodes suffer buffer overflows [8],[9], [15], [16]. In [9], [20], [21], several rendezvousbaseddata collection algorithms are proposed, where the mobile base station only visits a selected setoff nodes

© 2014, IJARCSSE All Rights Reserved

referred to as rendezvous points within a deadline and the rendezvous points buffer the data from sources. These approaches incur high latencies due to the low to moderate speed, e.g. 0.1-1 m/s [15],[17], of mobile base stations. Data mules are similar to the second form of mobile base stations [10], [11], [12]. They pick up data from the sensors and transport it to the sink. In [22], the data mule visits all the sources to collect data, transports data over some distance, and then transmit it to the static base station through the network. The goal into find a movement path that minimizes both communication and mobility energy consumption. Similar to mobile base stations, data mules introduce large delays since sensors have to wait for a mule to pass by before starting their transmission. In the third approach, the network consists of mobile relay nodes along with static base station and data sources. Relay nodes do not transport data; instead, they move to different locations to decrease the transmission costs. We use the mobile relay approaching this work. Goldenberg et al. [14] showed that an iterative mobility algorithm where each relay node moves to the midpoint of its neighbours converge so on the optimal solution for a single routing path. However, they do not account for the cost of moving the relay nodes. In [23], mobile nodes decide to move only when moving is beneficial, but the only position considered is the midpoint of neighbors.Unlike mobile base stations and data mules, ourOMRC problem considers the energy consumption of both mobility and transmission. Our approach also relocates each mobile relay only once immediately after deployment. Unlike previous mobile relay schemes [14] and [23], we consider all possible locations as possible target locations for a mobile node instead of just the midpoint of its neighbors.Mobility has been extensively studied in sensor network and robotics applications which consider only mobility costs but not communication costs. For example, in [24], the authors propose approximation algorithms to minimize maximum and total movement of the mobile nodes such that the network becomes connected. In [25], the authors propose an optimal algorithm to bridge the gap between two static nodes by moving nearby mobile nodes along the line connecting the static points while also minimizing the total/maximum distance moved. In [26], [27], the authors propose algorithms to find motion paths for robots to explore the area and perform a certain task while taking into consideration the energy available at each robot. These problems ignore communication costs which add an increased complexity to OMRC,and consequently their results are not applicable. Our OMRC problem is somewhat similar to a number of graph theory problems such as the Steiner tree problem [28], [29], [30] and the facility location Problem [31], [32]. However, because the OMRC cost function is fundamentally different from the cost function for these other problems, existing solutions to these problems cannot be applied directly and do not provide good solutions to OMRC. For example, there is no obvious way to include mobility costs in the Steiner tree problem

We now describe the main idea of our approach using a simple example. Suppose we have three nodes P1,P2,P3 located at positions D1,D2,D3, respectively(Fig. 1), such that P2 is a mobile relay node. The objectives to minimize the total energy consumption due to both movement and transmissions. Data storage node P1 needs to transmit a data chunk to sink s3through relay node P2. One solution is to have s1transmit the data from D1 to node P2 at position D2 and node s2 relays it to sink P3 at position D3; that is, node P2 does not move. Another solution, which takes advantage of P2's mobility, is to move P2 to the midpoint of the segment D2,D3, which is suggested in [13]. This will reduce the transmission energy by reducing the distances separating the nodes. However, moving relay node s2 also consumes energy. We assume the following parameters for the energy models: $k = 2$, $a = 0.6 \times 10^{-7}$, $b = 4 \times 10^{-10}$.

In this example, for a given data chunk mi, the optimal solution is to move s2 to xi2 (a position that we can compute precisely). This will minimize the total energy consumption due to both transmission and mobility. For small messages, s2 moves very little if at all. As the size of the data increases, relay nodes2 moves closer to the midpoint. In this example, its beneficial to move when the message size exceeds4 MB. We illustrate in Table 1 the energy savings achieved using our optimal approach and the other two approaches for the relevant range of data sizes. For large enough data chunks (≈ 13 MB), one relay node can reduce total energy consumption by 10%compared to the other two approaches. As the data chunk size increases further, the energy savings decrease, and the optimal position converges to the midpoint when the data size exceeds 43 MB. In general, the reduction in energy consumption is higher when there are multiple mobile relay nodes

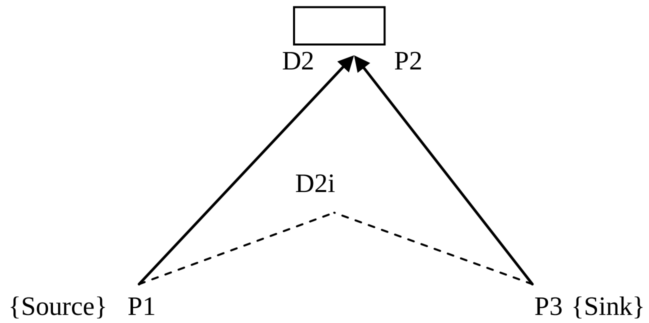

Fig. 1. Reduction in energy consumption due to mobile Relay. As the data chunk size increases, the optimal Position converges to the midpoint of P1,P3.

Table 1 Energy consumption comparison

Data Size (MB)	Costs at Original Points.	Costs at Mid Points	Costs at Optimal Points	Reduction.
5.00	42.78	70.71	42.04	1.73
11.00	94.12	101.93	88.39	6.09

© 2014, IJARCSSE All Rights Reserved

12.00	102.68	107.13	94.71	7.75
13.00	111.23	112.33	100.87	9.30
14.00	119.87	117.53	106.89	9.06
15.00	128.35	122.74	112.80	8.09
16.00	136.90	127.94	118.62	7.28
17.00	145.46	133.14	124.37	6.58
18.00	154.01	138.34	130.06	5.98
40.00	342.26	252.77	247.58	2.05

The above example illustrates two interesting results. The optimal position of a mobile relay is not the midpoint between the source and sink when both mobility and transmissions costs are taken into consideration. This is in contrast to the conclusion of several previous studies [13], [14] which only account for transmission costs. Second, the optimal position of a mobile relay depends on not only the network topology (e.g., the initial positions of nodes) but also the amount of data to be transmitted. Moreover, as the data chunk size increases, the optimal position converges to the midpoint of s1 and s3. These results are particularly important for minimizing the energy cost of data-intensive WSNs as the traffic load of such networks varies significantly with the sampling rates of nodes and network density.

IV. CONCLUSION

In this paper, we proposed a holistic approach to minimize the total energy consumed by both mobility of relays and wireless transmissions. Most previous work ignored the energy consumed by moving mobile relays. When we model both sources of energy consumption, the optimal position of a node that receives data from one or multiple neighbors and transmits it to a single parent is not the midpoint of its neighbors; instead, it converges to this position as the amount of data transmitted goes to inanity. Ideally, we start with the optimal initial routing tree in a static environment where no nodes can move.

REFERENCES

[1] Fatme El-Moukaddem, Eric Torng, Guoliang Xing “Mobile Relay Configuration in Data-intensiveWireless Sensor Networks”

[2] R. Szewczyk, A. Mainwaring, J. Polastre, J. Anderson, andD. Culler, “An analysis of a large scale habitat monitoring application,” in SenSys, 2004.

[2] L. Luo, Q. Cao, C. Huang, T. F. Abdelzaher, J. A. Stankovic,and M. Ward, “Enviromic: Towards cooperative storage and retrieval in audio sensor networks,” in ICDCS, 2007, p. 34.

[3] D. Ganesan, B. Greenstein, D. Perelyubskiy, D. Estrin, andJ. Heidemann, “An evaluation of multi-resolution storage for sensor networks,” in SenSys, 2003.

[4] S. R. Gandham, M. Dawande, R. Prakash, and S. Venkatesan,“Energy efficient schemes for wireless sensor networks withmultiple mobile base stations,” in Globecom, 2003.

[5] J. Luo and J.-P. Hubaux, “Joint mobility and routing for lifetimeelongation in wireless sensor networks,” in INFOCOM,2005.

[6] Z. M. Wang, S. Basagni, E. Melachrinoudis, and C. Petrioli,“Exploiting sink mobility for maximizing sensor networkslifetime,” in HICSS, 2005.

[7] A. Kansal, D. D. Jea, D. Estrin, and M. B. Srivastava, “Controllablymobile infrastructure for low energy embedded networks,”IEEE Transactions on Mobile Computing, vol. 5, pp. 958–973, 2006.

[8] G. Xing, T. Wang, W. Jia, and M. Li, “Rendezvous design algorithms for wireless sensor networks with a mobile basestation,” in MobiHoc, 2008, pp. 231–240.

[9] D. Jea, A. A. Somasundara, and M. B. Srivastava, “Multiplecontrolled mobile elements (data mules) for data collection in sensor networks,” in DCOSS, 2005.

[10] R. Shah, S. Roy, S. Jain, and W. Brunette, “Data mules: Modeling a three-tier architecture for sparse sensor networks,” in IEEE SNPA Workshop, 2003.

[11] S. Jain, R. Shah, W. Brunette, G. Borriello, and S. Roy, “Exploiting mobility for energy efficient data collection in wireless sensor networks,” MONET, vol. 11, pp. 327–339, 2006.

[12] W. Wang, V. Srinivasan, and K.-C. Chua, “Using mobile relays to prolong the lifetime of wireless sensor networks,” in MobiCom, 2005.

[13] D. K. Goldenberg, J. Lin, and A. S. Morse, “Towards mobility as a network control primitive,” in MobiHoc, 2004, pp. 163–174.

[14] A. A. Somasundara, A. Ramamoorthy, and M. B. Srivastava, “Mobile element scheduling with dynamic deadlines,” IEEE Transactions on Mobile Computing, vol. 6, pp. 395–410, 2007.

[15] Y. Gu, D. Bozdag, and E. Ekici, “Mobile element based differentiated message delivery in wireless sensor networks,” in WoWMoM, 2006.

[16] K. Dantu, M. Rahimi, H. Shah, S. Babel, A. Dhariwal, and G. S. Sukhatme, “Robomote: enabling mobility in sensor networks,” in IPSN, 2005.

[17] http://www.k-team.com/robots/khepera/index.html.

[18] J.-H. Kim, D.-H. Kim, Y.-J. Kim, and K.-T. Seow, Soccer Robotics. Springer, 2004.

© 2014, IJARCSSE All Rights Reserved

[19] G. Xing, T. Wang, Z. Xie, and W. Jia, "Rendezvous planning in wireless sensor networks with mobile elements," IEEE Transactions on Mobile Computing, vol. 7, pp. 1430–1443, 2008.

[20] ——, "Rendezvous planning in mobility-assisted wireless sensor networks," in RTSS '07: Proceedings of the 28th IEEE International Real-Time Systems Symposium, 2007, pp. 311–320.

[21] C.-C. Ooi and C. Schindelhauer, "Minimal energy path planning for wireless robots," in ROBOCOMM, 2007, p. 2.

[22] C. Tang and P. K. McKinley, "Energy optimization under informed mobility," IEEE Trans. Parallel Distrib. Syst., vol. 17, pp. 947–962, 2006.

[23] E. D. Demaine, M. Hajiaghayi, H. Mahini, A. S. Sayedi- Roshkhar, S. Oveisgharan, and M. Zadimoghaddam, "Minimizing movement," in Proceedings of the eighteenth annual ACM-SIAM symposium on Discrete algorithms, ser. SODA '07, 2007, pp. 258–267.

[24] O. Tekdas, Y. Kumar, V. Isler, and R. Janardan, "Building a communication bridge with mobile hubs," in Algorithmic Aspects of Wireless Sensor Networks, S. Dolev, Ed. Springer- Verlag, 2009, pp. 179–190.

[25] Y. Mei, Y.-H. Lu, Y. Hu, and C. Lee, "Deployment of mobilerobots with energy and timing constraints," Robotics, IEEETransactions on, vol. 22, no. 3, pp. 507 – 522, june 2006.

[26] A. Sipahioglu, G. Kirlik, O. Parlaktuna, and A. Yazici, "Energy constrained multi-robot sensor-based coverage path planning using capacitated arc routing approach," Robot. Auton. Syst., vol. 58, pp. 529–538, May 2010.

[27] M. Karpinski and A. Zelikovsky, "New approximation algorithms for the steiner tree problems," J. Comb. Optim., vol. 1,no. 1, pp. 47–65, 1997.

[28] G. Robins and A. Zelikovsky, "Tighter bounds for graph steiner tree approximation," SIAM J. Discrete Math., vol. 19,no. 1, pp. 122–134, 2005.

[29] S. Arora, "Polynomial time approximation schemes for Euclidean traveling salesman and other geometric problems," J.ACM, vol. 45, pp. 753–782, September 1998.

[30] K. Jain and V. V. Vazirani, "Approximation algorithms for metric facility location and k-median problems using the primaldual schema and lagrangian relaxation," J. ACM, vol. 48, pp. 274–296, March 2001.

[31] M. Mahdian, Y. Ye, and J. Zhang, "Improved approximationalgorithms for metric facility location problems," in Proceedingsof the 5th International Workshop on Approximation Algorithms forCombinatorial Optimization, ser. APPROX '02, 2002, pp. 229–242.

[32] L. Wang and Y. Xiao, "A survey of energy-efficient schedulingmechanisms in sensor networks," Mob. Netw. Appl., vol. 11,pp. 723–740, 2006.

[33] G. Wang, M. J. Irwin, P. Berman, H. Fu, and T. F. L. Porta,"Optimizing sensor movement planning for energy efficiency,"in ISLPED, 2005, pp. 215–220.

[34] "Cc2420 datasheet,"http://inst.eecs.berkeley.edu/cs150/Documents/CC2420.pdf.

[35] "Cc1000 single chip very low power rf transceiver."http://focus.ti.com/lit/ds/symlink/cc1000.pdf.

[36] M. Sha, G. Xing, G. Zhou, S. Liu, and X.Wang, "C-mac: Modeldrivenconcurrent medium access control for wireless sensornetworks," in INFOCOM, 2009.

[37] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan,"Energy-efficient communication protocol for wireless microsensornetworks," in HICSS, 2000.

[38] S. Ratnasamy, B. Karp, S. Shenker, D. Estrin, R. Govindan,L. Yin, and F. Yu, "Data-centric storage in sensornets with ght,a geographic hash table," MONET, vol. 8, pp. 427–442, 2003.

[39] C. E. Perkins and E. M. Royer, "Ad-hoc on-demand distancevector routing," in WMCSA '99: Proceedings of the Second IEEE Workshop on Mobile Computer Systems and Applications.Washington, DC, USA: IEEE Computer Society, 1999, p. 90.Fatme

© 2014, IJARCSSE All Rights Reserved