CLUSTER-BASED ENERGY-EFFICIENT SENSORY DATA COLLECTION WITH MOBILE SINKS

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Abstract— The ultimate goal of a sensor network is often to deliver the sensing data from all sensors to a sink node and then conduct further analysis at the sink node. Thus, data collection is one of the most common services used in sensor network applications. Wireless Sensor Networks applications involve a set of urban areas covered by sensor nodes which monitors environmental parameters. Mobile sinks mounted upon vehicles with fixed trajectories provide the ideal infrastructure to effectively retrieve sensory data from such isolated wireless sensor network fields. These nodes run the risk of rapid energy exhaustion resulting in loss of network connectivity and decreased network lifetime. Our proposed protocol aims at minimizing the overall network overhead and energy expenditure associated with the multihop data retrieval process while also ensuring balanced energy consumption among sensor nodes and prolonged network lifetime. This is achieved through building cluster structures consisted of member nodes that route their measured data to their assigned cluster head and by selecting number of representative nodes located in the periphery of the sensor field can be used as “rendezvous” nodes wherein sensory data from neighbor nodes may be collected and finally delivered to an mobile sink. Selection of rendezvous node and identification of the cluster Heads is done more efficiently by SVM algorithm.

Keywords— Mobile sinks, wireless sensor networks, information retrieval, clustering, sensor islands, rendezvous nodes.

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INTRODUCTION

The main purpose of a WSN is to provide users with access to the information of interest from data collected by spatially distributed sensors. In real-world applications, sensors are often deployed in high numbers to ensure a full exposure of the monitored physical environment. Consequently, such networks are expected to generate enormous amount of data. The desire to locate and obtain information makes the success of WSNs applications, largely, determined by the quality of the extracted information

The main reason of energy spending in WSNs relates with communicating the sensor readings from the sensor nodes (SNs) to remote sinks. These readings are typically relayed using ad hoc multihop routes in the WSN. A side effect of this approach is that the SNs located close to the sink are heavily used to relay data from all network nodes; hence, their energy is consumed faster, leading to a non uniform depletion of energy in the WSN. This results in network disconnections and limited network lifetime. Network lifetime can be extended if the energy spent in relaying data can be saved..

In this paper, a number of representative nodes located in the periphery of the sensor field can be used as "rendezvous" points wherein sensory data from neighbor nodes may be collected and finally delivered to an MS. In this context, the specification of the appropriate number and locations of rendezvous nodes (RNs) is crucial. The number of RNs should be equivalent (neither small nor very large) to the deployment density of Sensor Nodes(SN).Herein, we investigate the use of Mobile Sinks(MS) for efficient data collection from "sensor islands" spread throughout urban environments.

The remainder of this paper is organized as follows: Section 2 reviews related work in the field. Section 3 details the design principles for MobiCluster protocol and analyzes its implementation and execution phase and Section 4 concludes our work.

I. RELATED WORK

Our proposed protocol is a rendezvous-based solution and targets applications that involve monitoring of isolated urban areas (e.g., urban parks, building blocks, or large communal facilities) with respect to environmental parameters, surveillance, fire detection, etc. In such environments,MSs may be mounted upon city buses that repeatedly follow a predefined trajectory with a periodic schedule. The use of such existing infrastructure removes the unrealistic requirement for using dedicated mobile controllably dictated mobile sinks

Recent research work has proved the applicability of mobile elements (submarines, cars, mobile robots, etc.) for the retrieval of sensory data from smartdust motes [3] in comparison with multihop transfers to a centralized element. A mobile sink (MS) moving through the network deployment region can collect data from the static SNs over a single hop radio link when approaching within the radio range of the SNs or with limited hop transfers if the SNs are located further. This avoids long-hop relaying and reduces the energy consumption at SNs near the base station prolonging the network lifetime

In this context, the works presented in [20] and [24] are mostly relevant to the research described herein as they are rendezvous-based solutions which both assume MS. In [24], a MS is used to collect data from groups of SNs. During a training period, all the WSN edge nodes located within the range of MS routes are appointed as RNs and build paths connecting them with the remainder of sensor nodes. Those paths are used by remote nodes to forward their sensory data to RNs; the latter buffer sensory data and deliver them to the MS when it re approaches in range. The movement of mobile robots is controllable which is impractical in realistic urban traffic conditions. Most importantly, no strategy is used to appoint suitable nodes as RNs while selected RNs are typically associated with uneven numbers of SNs.

In [20], rendezvous-based solutions are presented for variable as well as fixed MS trajectories. The proposed technique assumes full aggregation. Apparently, this is not always possible and thus it is rather a strong assumption. The

solution presented for fixed MS track seeks to determine a segment of the MS track shorter than a certain bound such that the total cost of the trees connecting source nodes with RNs is minimized.In both the cases of variable and fixed tracks, knowledge of network topology is necessary and the whole algorithm is performed centrally at the Base station.

A common characteristic of all techniques described above is that the routing structures that carry data from SNs to RNs are built once and are used without any modification for the whole lifetime of the WSN. Most of these works are centralized approaches that try to minimize an energy related cost function without paying proper attention to the selection of nodes that will serve as RNs. Specifically, they do not take into account the contact time of a RN with the MS during which it can send the buffered data. Also, there is no special focus on the amount of data the RNs receive from the other nodes of the network. So, a heavily loaded RN that is in contact with the MS for only a short time may not manage to transfer all buffered data and this gradually may lead to buffer overflow or very long delivery delays. Also, they do not examine the proximity of the selected RNs and as a result, frequent collisions could arise due to concurrent transmissions from nearby RNs when the MS is approaching these RNs.

In our work, we deal with all these important issues. We propose a distributed protocol which selects as RNs only nodes with sufficient energy and in close proximity with MS for sufficiently long time. Also, only RNs with no overlapping contact intervals with MS are selected, eliminating so the collisions arising due to concurrent transmissions from nearby RNs. Furthermore, the operation of RNs is well coordinated and the right amount of data is distributed to each RN according to the contact time and data delivery rate of each RN. Most importantly, in case that a RN runs out of energy, it is quickly replaced by other available RNs and thus the data transmission to MS is not disrupted as in other rendezvous-based schemes. Also, in contrast to other schemes which use a flat network architecture, our approach builds a clustering structure on top of the sensor network. That way, high data aggregation ratios are possible since data from the nodes of the same cluster usually are strongly correlated [4] and thus aggregation at each cluster head considerably reduces the data forwarded to RNs.

II. MOBICLUSTER PROTOCOL

In this protocol, MSs are mounted upon public buses circulating within urban environments on fixed trajectories and periodic schedule. A basic assumption in the design of MobiCluster protocol is that SNs are location unaware, i.e., not equipped with GPS capable antennae. Also, we assume that each node has a fixed number of transmission power levels. Also, an adequate number of nodes are enrolled as RNs as a fair compromise between a small number which results in their rapid energy depletion and a large number which results in reduced data throughput. Finally, SNs are grouped in separate clusters. Raw sensory data are filtered within individual clusters exploiting their inherent spatial-temporal redundancy.

Thus, the overhead of multihop data relaying (inter clustering Traffic) to the edge RNs is minimized(see Fig 1)

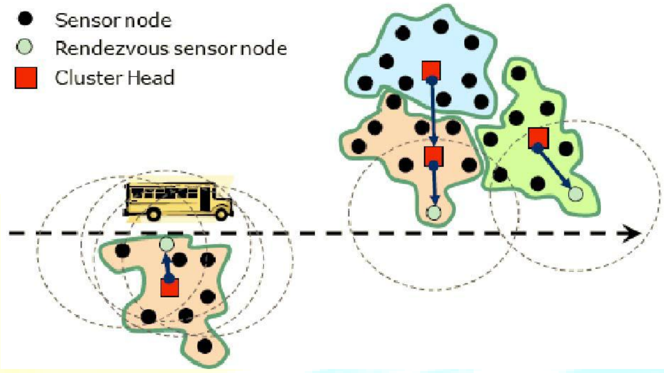

Fig 1

.Mobicluster protocol consist of five phases namely clustering,RNs selection,CHs attatchment to RNs,data aggregation and forwarding to RNs, communication between RNs and Mobile sinks.The first three phases comprise the setup phase while last two comprise steady phase

A. Clustering

In this phase multi sized cluster structures are build for the purpose of balancing the load and prolonging the network lifetime. Besides achieving energy efficiency, clustering also reduces channel contention and packet collisions, resulting in improved network throughput under high load.Then cluster heads are selected for every cluster structures.In this approach SNs located near the MS trajectory are grouped in small sized clusters while SNs located farther away are grouped in clusters of larger size (Fig. 2).

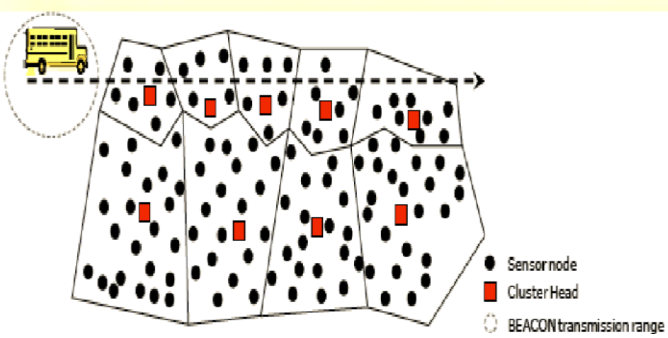

Fig2. Unequal cluster formation

The CHs near the MS trajectory are usually burdened with heavy relay traffic coming from other parts of the network. By maintaining the clusters of these CHs small, CHs near the MS trajectory are relatively relieved from intra cluster processing and communication tasks and thus they can afford to spend more energy for relaying inter cluster traffic to RNs. During an initialization phase, the MS moves along its fixed trajectory broadcasting periodically a BEACON signal to all SNs at a fixed power level. All nodes near the MS trajectory receive the BEACON message and thus they know that the clusters in their region will be small sized. Then, these nodes flood the BEACON message to the rest of the network.

B. RNs Selection

The selection of RN largely determines network lifetime.RNs lie within the range of traveling sinks and their location depends on the position of the CH and the sensor field with respect to the sinks trajectory. Suitable RNs are those that remain within the MS's range for relatively long time, in relatively short distance from the sink's trajectory and have sufficient energy supplies

To regulate the number of RNs and prevent either their rapid energy depletion or potential data losses, we propose a simple selection model whereby a set of cluster members (in vicinity to the MS's trajectory) from each cluster is enrolled as RNs. RN's role may be switched among cluster members when the energy level of a node currently serving as RN drops below a pre specified threshold. the euclidean distance among SNs and the MS should not be used as the only factor for selecting RNs. In addition to lying in a short distance from MS trajectories, the best candidates RNs are the SNs with sufficient residual energy that receive a relatively high number of BEACON packets and sensor nodes with less sufficient residual energy receives only less number of BEACON packets relatively

C. CHs Attachment to RNs

As soon as the setup phase finalizes through the receipt of beacon signals, sensory data collected at CHs from their attached cluster members are forwarded toward the RNs following an inter cluster overlay graph (see Fig. 1). The selected transmission range among CHs may vary to ensure a certain degree of connectivity and to control interference.

D. Data Aggregation and Forwarding to the RNs

The steady phase of MobiCluster protocol starts with the periodic recording of environmental data from sensor nodes with a Tr period. The data accumulated at individual source nodes are sent to local CHs (intracluster communication) with a Tc period (typically, Tc is a multiple of Tr). CHs perform data processing to remove spatial-temporal data redundancy, which is likely to exist since cluster members are located maximum two hops away. CHs then
forward filtered data toward remote CH they are attached to. Alongside the intercluster path, a second-level of data filtering may apply

E. Communication between RNs and Mobile Sinks

The last phase of MobiCluster protocol involves the delivery of data buffered to RNs to MSs. Data delivery occurs along an intermittently available link; hence, a key requirement is to determine when the connectivity between an RN and the MS is available. Communication should start when the connection is available and stop when the connection no longer exists, so that the RN does not continue to transmit data when the MS is no longer receiving it.

To address this issue, we use an acknowledgment-based protocol between RNs and MSs. The MS, in all subsequent path traversals after the setup phase, periodically broadcasts a POLLpacket, announcing its presence and soliciting data as it proceeds along the path. The POLL is transmitted at fixed intervals Tpoll . This POLL packet is used by RNs to detect when the MS is within connectivity range. The RN receiving the POLL will start transmitting data packets to the MS. The MS acknowledges each received data packet to the RN so that the RN realizes that the connection is active and the data were reliably delivered. The acknowledged data packet can then be cleared from the RN's

III. Conclusion

Presented an approach for increasing lifetime of the wireless sensor network and also aims at maximizing connectivity, data throughput,and enabling balanced energy expenditure. The connectivity objective is addressed by employing MSs to collect data from isolated urban sensor islands and also through prolonging the lifetime of selected peripheral RNs which lie within the range of passing MSs and used to cache and deliver sensory data derived from remote source nodes. Increased data throughput is ensured by regulating the number of RNs for allowing sufficient time to deliver their buffered data and preventing data losses. MobiCluster moves the processing and data transmission burden away from the vital periphery nodes(RNs) and enables balanced energy consumption across the WSN through building cluster structures that exploit the high redundancy of data collected from neighbor nodes and minimize intercluster data overhead

References

[1] E. Hamida and G. Chelius, "Strategies for Data Dissemination to Mobile Sinks in Wireless Sensor Networks," IEEE Wireless Comm., vol. 15, no. 6, pp. 31-37, Dec. 2008.

[2] S. Olariu and I. Stojmenovic, "Design Guidelines for Maximizing Lifetime and Avoiding Energy Holes in Sensor Networks with Uniform Distribution and Uniform Reporting," Proc. IEEE INFOCOM, 2006.

[3] X. Li, A. Nayak, and I. Stojmenovic, "Sink Mobility in Wireless Sensor Networks," Wireless Sensor and Actuator Networks, A. Nayak, I. Stojmenovic, eds., Wiley, 2010.

[4] B. Mamalis, D. Gavalas, C. Konstantopoulos, and G. Pantziou, "Clustering in Wireless Sensor Networks," RFID and Sensor Networks: Architectures, Protocols, Security and Integrations, Y. Zhang, L.T. Yang, J. Chen, eds., pp. 324-353, CRC Press, 2009.

[5] G. Chen, C. Li, M. Ye, and J. Wu., "An Unequal Cluster-Based Routing Protocol in Wireless Sensor Networks," Wireless Networks, vol. 15, pp. 193-207, 2007.

[6]s S. Soro and W.B. Heinzelman, "Prolonging the Lifetime of
Wireless Sensor Networks via Unequal Clustering," Proc. 19th
IEEE Int'l Parallel and Distributed Processing Symp., 2005.

[7] J. Luo and J-P. Hubaux, "Joint Mobility and Routing for Lifetime Elongation in Wireless Sensor Networks," Proc. IEEE INFOCOM, 2005.

[8] M. Demirbas, O. Soysal, and A. Tosun, "Data Salmon: A Greedy Mobile Basestation Protocol for Efficient Data Collection in Wireless Sensor Networks," Proc. Int'l Conf. Distributed Computing in Sensor Systems (DCOSS '07), pp. 267-280, 2007.

[9] Z. Vincze, D. Vass, R. Vida, A. Vidacs, and A. Telcs, "Adaptive Sink Mobility in Event-Driven Densely Deployed Wireless Sensor Networks," Ad Hoc and Sensor Wireless Networks, vol. 3, nos. 2/3, pp. 255-284, 2007.

[10] L. Friedmann and L. Boukhatem, "Efficient Multi-Sink Relocation in Wireless Sensor Network, Networking and Services," Proc. Third Int'l Conf. Networking and Services (ICNS '07), pp. 90-90, June 2007.

[11] S. Basagni, A. Carosi, E. Melachrinoudis, C. Petrioli, and Z.M. Wang, "Controlled Sink Mobility for Prolonging Wireless Sensor Networks Lifetime," ACM Wireless Networks, vol. 14, no. 6, pp. 831-858, 2008.

[12] R. Sugihara and R. Gupta, "Optimal Speed Control of Mobile Node for Data Collection in Sensor Networks," IEEE Trans. Mobile Computing, vol. 9, no. 1, pp. 127-139, Jan. 2010.

[13] A. Somasundara, A. Ramanoorthy, and M. Srivastana, "Mobile Element Scheduling with Dynamic Deadlines," IEEE Trans. Mobile Computing, vol. 6, no. 4, pp. 395-410, Apr. 2007.

[14] R. Shah, S. Roy, S. Jain, and W. Brunette, "Data MULEs: Modeling and Analysis of a Three-Tier Architecture for Sparse Sensor Networks," Ad Hoc Networks, vol. 1, nos. 2/3, pp. 215-233

[15] S. Nesamony, M. Vairamuthu, and M. Orlowska, "On Optimal Route of a Calibrating Mobile Sink in a Wireless Sensor Networks," Proc. Fourth Int'l Conf. Networked Sensing Systems (INSS), pp. 61-64, 2007.

[16] R. Sugihara and R. Gupta, "Improving the Data Delivery Latency in Sensor Networks with Controlled Mobility," Proc. Fourth IEEE Int'l Conf. Distributed Computing in Sensor Systems (DCOSS), pp. 386-399, 2008.

[17] A.K. Kumar and K.M. Sivalingam, "Energy-Efficient Mobile Data Collection in Wireless Sensor Networks with Delay Reduction Using Wireless Communication," Proc. Second Int'l Conf. Comm. Systems and Networks (COMSNETS), Jan. 2010.

[18] M. Ma and Y. Yang, "SenCar: An Energy-Efficient Data Gathering Mechanism for Large-Scale Multihop Sensor Networks," IEEE Trans. Parallel and Distributed Systems, vol. 18, no. 10, pp. 1476- 1488, Oct. 2007.

[19] G. Xing, T. Wang, Z. Xie, and W. Jia, "Rendezvous Planning in Wireless Sensor Networks with Mobile Elements," IEEE Trans. Mobile Computing, vol. 7, no. 12, pp. 1430-1443, Dec. 2008.

[20] G. Xing, T. Wang, W. Jia, and M. Li, "Rendezvous Design Algorithms for Wireless Sensor Networks with a Mobile Base Station," Proc. ACM Int'l Symp. Mobile Ad Hoc Networking and Computing (MobiHoc), pp. 231-239, 2008.

[21] J. Rao and S. Biswas, "Joint Routing and Navigation Protocols for Data Harvesting in Sensor Networks," Proc. Fifth IEEE Int'l Conf. Mobile Ad Hoc and Sensor Systems (MASS), pp. 143-152, 2008.

[22] J. Rao and S. Biswas, "Network-Assisted Sink Navigation for Distributed Data Gathering: Stability and Delay-energy Trade- Offs," Computer Comm., vol. 33, pp. 160-175, 2010.

[23] I. Chatzigiannakis, A. Kinalis, and S. Nikolitseas, "Efficient Data Propagation Strategies in Wireless Sensor Networks Using a Single Mobile Sink," Computer Comm., vol. 31, pp. 896-914, 2008.

[24] A.A. Somasundara, A. Kansal, D.D. Jea, D. Estrin, and M.B. Srivastava, "Controllably Mobile Infrastructure for Low Energy Embedded Networks," IEEE Trans. Mobile Computing, vol. 5, no. 8, pp. 958-973, Aug. 2006.

[25] I. Stojmenovic, A. Nayak, J. Kuruvila, F. Ovalle-Martinez, and E. Villanueva-Pena, "Physical Layer Impact on the Design and Performance of Routing and Broadcasting Protocols in Ad Hoc and Sensor Networks," Computer Comm., vol. 28, pp. 1138-1151,2005

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