Asian Journal of Computer Science and Technology
ISSN: 2249-0701 (P) Vol.6 No.2, 2017, pp.13-17
© The Research Publication, www.trp.org.in
DOI: https://doi.org/10.51983/ajcst-2017.6.2.1786

Design and Development of an Energy-Efficient Sensory Data Collection with Mobile Sinks Consuming Cluster Constructed Rendezvous Node

S. Ravichandran[1] **and M. Umamaheswari**[2]
[1]Research Scholar, Department of Computer Science,
Bharathiar University, Coimbatore, Tamil Nadu, India
[2]Professor, Department of Information Technology,
RRASE College of Engineering, Chennai, Tamil Nadu, India
E-mail: ravi17raja@gmail.com & karpagaravi15@gmail.com
druma_cs@yahoo.com

(Received 10 June 2017; Revised 26 June 2017; Accepted 18 July 2017; Available online 26 July 2017)

Abstract **-** In **Wireless Sensor Networks (WSN) applications include an arrangement of separated urban zones secured by sensor hubs (SNs) checking ecological parameters. Single-bounce exchange of information from SNs that exist in the MS's range or overwhelming contribution of system outskirts hubs in information recovery, preparing, buffering and conveying errands. These hubs risk fast vitality fatigue bringing about the loss of system availability and diminished system lifetime. Proposed framework goes for limiting the general system overhead and vitality use related with the multihop information recovery handle while additionally guaranteeing adjusted vitality utilization among SNs and delayed system lifetime. This is accomplished through building bunch structures comprised of part hubs that course their deliberate information to their doled out group head (CH). CHs perform information separating upon crude information misusing potential spatial-transient information access and forward the sifted data to fitting end hubs with adequate lingering vitality, situated in nearness to the MS's direction. This approach fabricates a bunching structure on top of the sensor arrange. That way, high information collection proportions are conceivable since information from the hubs of a similar bunch, for the most part, are firmly connected and along these lines accumulation at each group head impressively diminishes the information sent to RNs. This thusly prompts much lower vitality utilization in the WSN and furthermore a great deal less information is cradled at RNs, diminishing so the likelihood of support floods at an RN.**

Keywords**: WSN, cluster Head, Rendezvous Node(RN)**

I. INTRODUCTION

A 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 [2]. This results in network disconnections and limited network lifetime. Network lifetime can be extended if the energy spent in relaying data can be saved. Recent research work has proved the applicability of mobile elements (submarines, cars, mobile robots, etc.) for the retrieval of sensory data from smart dust 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. A large class of monitoring applications involves a set of urban areas (e.g., urban parks or building blocks) that need to be monitored with respect to environmental parameters (e.g., temperature, moisture, pollution, light intensity), surveillance, fire detection, etc. In these environments, individual monitored areas are typically covered by isolated “sensor islands,” which makes data retrieval rather challenging since mobile nodes cannot move through but only approach the periphery of the network deployment region. In such cases, 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 when the latter approaches within radio range. 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 SNs. Herein, we investigate the use of MSs for efficient data collection from “sensor islands” spread throughout urban environments. We argue that the ideal carriers of such MSs are public surface transportation vehicles (e.g., buses) that repeatedly follow a predefined trajectory with a periodic schedule that may pass along the perimeter of the isolated sensor fields. Our proposed protocol called energy expenditure associated with the data retrieval process while also ensuring balanced energy consumption among SNs 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 (CH). The CHs perform data filtering upon the raw data exploiting potential spatial-temporal data redundancy and forward the filtered information to their assigned RNs, typically located in proximity to the MS's trajectory. We also introduce a sophisticated method for enrolling appropriate nodes as RNs taking into account the deployment pattern and density of sensor nodes. Last, we propose methods for building adaptable intercluster overlay graphs and techniques for fairly distributing sensory data among RNs and delivering data to MSs in nonintersecting time windows. The remainder of this paper is organized as follows: Section 2 reviews related work in the field. Section 3 details the design principles for DSR protocol and analyzes its implementation and execution phase.

II. RELATED WORK

A number of approaches exploiting sink mobility for data collection in WSNs have been proposed in recent years. The MS(s) may visit each SN and gather its data (single-hop communication), or may visit only some locations of the WSN and SNs send their data to MS through multihop communication. Apparently, since in the first solution only singlehop communication is required, energy consumption is minimized, however, at the expense of high data delivery delay. In the second solution, this delay is low but the energy consumption due to multihop communication is rather high. In addition, SNs should constantly be kept updated about the MS's current location thereby creating considerable routing overhead. A solution in between is to have SNs send first their data to a certain number of nodes (RNs) which buffer the received data and send them to MS when MS is within their transmission range or when they receive a query from MS asking for the buffered data. In the second approach, the MS does not necessarily pass near the RNs and the data stored at each RN are forwarded to MS by reversing the route of the received query packet. 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, controllable platforms to carry MSs. We also follow the first approach of the rendezvous-based solutions and the proposed protocol selects RNs that are in close proximity with the MS trajectory. In this context, the works presented in are mostly relevant to the research described herein as they are rendezvous-based solutions which both assume MS. In, 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, 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. Note that in both the cases of variable and fixed tracks, knowledge of network topology is necessary and the whole algorithm is performed centrally at the BS. Apart from, a number of other rendezvous-based solutions that assume variable MS trajectory have been proposed. These works determine the MS trajectory in such way that certain optimization criteria (e.g., minimum energy consumption for transferring the data to RNs) are met while obeying certain constraints.

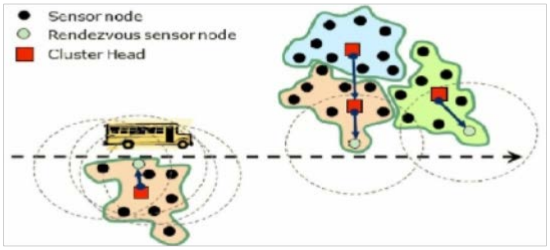

Fig.1 Rendezvous Sensor Nodes, Cluster Structures, And Data Forwarding Paths

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 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 and thus aggregation at each cluster head considerably reduces the data forwarded to RNs. This in turn leads to much lower energy consumption in the WSN and also much less data are buffered at RNs, reducing so the probability of buffer overflows at a RN.

III. THE DYNAMIC SEQUENCE ROUTING PROTOCOL

In the proposed protocol, MSs are mounted upon public buses circulating within urban environments on fixed trajectories and near-periodic schedule. Namely, sinks motion is not controllable and their routes do not adapt upon specific WSN deployments. Our only assumption is that sensors are deployed in urban areas in proximity to public transportation vehicle routes. 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.

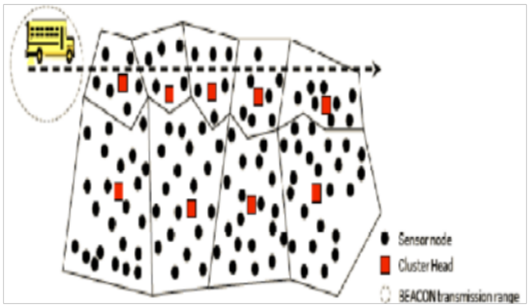

Fig.2 Unequal Cluster Formations

Raw sensory data are filtered within individual clusters exploiting their inherent spatial- temporal redundancy. Thus, the overhead of multihop data relaying (interclustering traffic) to the edge RNs is minimized (see Fig. 1). Given that the communication cost is several orders of magnitude higher than the computation cost, in-cluster data aggregation can achieve significant energy savings. The underlying assumption in this model is that nodes which are closer than a certain distance (transmission range R)can always communicate. However, in practice a message sent by a node is received by the receiver with only certain probability even if the distance of the two nodes is smaller than the transmission range. In Society Digital, we will describe how our protocol can be adapted so that it can still work on the top of a more realistic physical layer.. The first three phases comprise the setup phase while the last two comprise the steady phase. The setup phase completes in a single MS trip and during this trip, the MS periodically broadcasts BEACON messages which are used by SNs for determining a number of parameters important for the protocol operation. In the steady phase, data from SNs are routinely gathered to RNs and then sent to MS. During the steady phase, reselection of RNs and/or local re clustering is performed in case of energy exhaustion of some critical nodes. Most importantly, these operations take place in the background without disrupting the protocol's normal operation.

A. Phase 1: Clustering

The large-scale deployment of WSNs and the need for data aggregation necessitate efficient organization of the network topology for the purpose of balancing the load and prolonging the network lifetime. Clustering has proven to be an effective approach for organizing the network in the above context. Besides achieving energy efficiency, clustering also reduces channel contention and packet collisions, resulting in improved network throughput under high load. Our clustering algorithm borrows ideas from the algorithm of Chen et al. to build a cluster structure of unequal clusters. The clustering algorithm in constructs a multi sized cluster structure, where the size of each cluster decreases as the distance of its cluster head from the base station increases. We slightly modify the approach of to build clusters of two different sizes depending on the distance of the CHs from the MS's trajectory. Specifically, 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). 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 intracluster processing and communication tasks and thus they can afford to spend more energy for relaying intercluster traffic to RNs. During an initialization phase, the MS moves along its fixed trajectory broadcasting periodically a BEACON signals 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. A detailed description of the clustering algorithm (Algorithm CH_ELECTION) which is executed right after the MS completes its first trip can be available in the online supplemental material.

B. Phase 2: RNs Selection

RNs guarantee connectivity of sensor islands with MSs; hence, their selection 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. In practical deployments, the number of designated RNs introduces an interesting trade-off: A large number of RNs implies that the latter will compete for the wireless channel contention as soon as the mobile robot appears in range, thereby resulting in low data throughput and frequent outages. . A small number of RNs implies that each RN is associated with a large group of sensors. Hence, RNs will be heavily used during data relays, their energy will be consumed fast and they will be likely to experience buffer overflows. To regulate the numbers 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. As mentioned earlier, MSs follow a fixed trajectory. Each CH u receives RN_C and _Msgs from the entire candidate RNs ofits cluster, and then it proceeds to the selection of the appropriate RNs to build the set Ru of the final RNs associated with it. After the execution of this algorithm, it is guaranteed that RNs located within the same cluster will not compete with each other in the data delivery phase and each will start delivering its data after the previous ends. Hence, the wireless channel is more efficiently used, the number of packet collisions is reduced and data throughput is maximized. In addition, the employment of multiple RNs, wherever possible, implies lower demand for data buffering space and fair distribution of the energy expenditure associated with data delivery.

C. Phase 3: CHs Attachment to RNs

Note that not every CH u has a nonempty Ru set associated with it. CHs located far from the MS trajectories do not have any RNs within transmission range. An important condition for building intercluster overlay graphs is that CHs with no attached RNs, attach themselves to a CH u with nonempty Ru set so as to address their clusters' data to u. The description of the intercluster overlay graph building procedure can be found , available in the online supplemental material. It is noted that our approach typically requires a single MS trip to collect (through the receipt of BEACON messages) the information needed to execute the setup phase. Clustering (phase #1) starts upon the completion of the first MS trip. The RNs' selection process (phase #2) commences immediately afterward (the information needed for the execution of this phase, i.e., the number of beacons, their receipt time, and signal strength is also collected during the first MS trip). CHs attachment to RNs phase #3) follows next. All these phases complete in reasonably short period of time, typically within the time interval between two successive bus trips. As soon as the setup phase finalizes, sensory data collected at CHs from their attached cluster members are forwarded toward the RNs following an intercluster overlay graph (see Fig. 1). The selected transmission range among CHs may vary to ensure a certain degree of connectivity and to control interference.1

D. Phase 4: Data Aggregation and Forwarding to the RNs

The steady phase of DSR 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. Upon reaching the end CH u, filtered data are forwarded to u's local RNs in a pipeline fashion. In the case that multiple RNs exist in that cluster, data are not equally distributed among them. Instead, the CH favors the data delivery by the most suitable RNs, i.e., those with highest competence value (Compval). Data distribution among RNs should ensure that each RN will be able to accommodate its assigned data, i.e., to deliver all its buffered data and not experience an outage. Hence, CH u sorts the RNs in its Ru set in Compval decreasing order and delivers to each RN node vi 2 Ru the maximum amount of data Di it can accommodate, minus an "outage prevention allowance" amount O. The Di value is calculated taking into account the RN's data rate riand the length li of the time interval [vi.Tfirst, vi.Tlast] that vi remains within the MS's range. The process is repeated for each vi 2 Ru until all data available at u are distributed among its RNs. The algorithm executed by each CH u for distributing data to the RNs attached to it.

E. Phase 5: 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 andMSs. The MS, in all subsequent path traversals after the setup phase, periodically broadcasts aPOLLpacket, announcing its presence and soliciting data as it proceeds along the path. The POLL is transmitted at fixed intervals Tpoll(typically equal to Tbeacon). 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 cache. More details about the communication protocol between RNs and MS can be found in Appendix C, available in the online supplemental material. It should be emphasized the enrolment of specific nodes as RNs is subject to change during the steady phase. Thus, if the energy supply of a RN falls below a threshold, it may request the local CH to engage another node as RN so as to further extend the network's lifetime without affecting the current clustered infrastructure. To enable RNs substitution, the CH polls the candidate RNs of the setup phase (excluding the retiring RN) to be informed about their current residual energy status and then selects the new RN list following the procedure described in Section 3.2.In particular, new sophisticated methods are proposed for enrolling appropriate nodes as RNs, building adaptable intercluster overlay graphs, fairly distributing sensory data among RNs and delivering these data to the MS in nonintersecting time windows (Phase 2 through Phase 5).

IV. SIMULATION RESULTS

As discussed in the Section 2, a number of rendezvous-based approaches have been proposed which either assume a fixed MS trajectory or determine that trajectory according to some energy- related optimization criteria. As DSR assumes that MS moves on a fixed trajectory, a fair comparison of this protocol with other proposals should only consider the efficiency of routing structures for transferring data from SNs to RNs. In the simulation tests, we compare our method with the solutions proposed in which also assume fixed MS trajectory.2 In these tests, First, the three protocols are compared in terms of the network lifetime, the average residual energy as well as the variance of this energy across the network. Then, the protocols are compared in terms of the overall number of outages, i.e., the number of data packets cached in RNs, yet, not delivered to the MS due to buffer overflows, packet collisions or the movement of the MS away of the RNs' transmission range. Finally, the third group of tests concerns the total generated traffic as well as the network throughput of these protocols, i.e., the packets delivered to the MS over those sent from the RNs. Next, we present the results for the most representative performance metrics, namely the number of outages, the network lifetime and the average residual energy. The exact parameter values used in our simulations can be found in available in the online supplemental material. In the same appendix, we provide further justification for our methodology in the tests and we also discuss the results for the remaining performance metrics. Fig. 3 illustrates the output screenshots of our simulator. The dotted black line, in all subfigures, represents the MS's trajectory. The RNs in are denoted as "CHs" following the notation used in. DSR exhibits the best performance in all scenarios because of the more sophisticated selection of RNs; RNs have sufficient time to deliver their data and suffer low number of collisions since they are well separated spatially.

V. CONCLUSION

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. Unlike other approaches, 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. The performance gain of MobiCluster over alternative approaches has been validated by extensive simulation tests.

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

[4] 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.

[5] S. Greenberg (1988), 'Using Unix: Collected Traces of 168 Users', master's thesis, Dept. of Computer Science, Univ. of Calgary, Alberta, Canada.

[6] Y. Horman and Kaminka G.A.(2007), 'Removing Biases in Unsupervised Learning of Sequential Patterns', *Intelligent Data Analysis,* vol. 11, no. 5, pp. 457-480.

[7] J.A. Iglesias , A. Ledezma and A. Sanchis. (2009), 'Creating User Profiles from a Command-Line Interface: A Statistical Approach', *Proc. Int'l Conf. User Modeling, Adaptation, and Personalization* (UMAP), pp. 90-101.

[8] N. Kasabov .(Dec. 2001), 'Evolving Fuzzy Neural Networks for Supervised/ Unsupervised Knowledge-Based Learning', *IEEE Trans. Systems, Man and Cybernetics-Part B: Cybernetics,* vol. 31, no. 6, pp. 902-918.

[9] D. Kalles and T. Morris .(1996), 'Efficient Incremental Induction of Decision Trees,"'Machine Learning, vol. 24, no. 3, pp. 231- 242.

[10] Schonlau M. Dumouchel W. Ju W.H. Karr A.F. and Theus(2001), 'Computer Intrusion: Detecting Masquerades', *Statistical Science,* vol. 16, pp. 58-74.

[11] F.J.Ferrer-Troyano , J.S. Aguilar-Ruiz and J.C.R Santos (2006), 'Data Streams Classification byIncremental Rule Learning with Parameterized Generalization', *Proc. ACM Symp. Applied Computing* (SAC), pp. 657-661.

[12] T. Kohonen , J . Kangas , J. Laaksonen and K. Torkkola .(1992), 'Lvq pak: A Program Package forthe Correct Application of Learning Vector Quantization Algorithms', *Proc. IEEE Int'l Conf. Neural Networks,* pp. 725-730.

[13] D. Godoy and A. Amandi . (2005), 'User Profiling in Personal Information Agents: A Survey', *Knowledge Eng. Rev.,* vol. 20, no.4, pp. 329-361.